(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 December 2024 (19.12.2024)

WIPO | PCT

(10) International Publication Number
WO 2024/256840 A2

(51) International Patent Classification:
B62K 27/12 (2006.01)

(21) International Application Number:
PCT/GB2024/051539

(22) International Filing Date:
17 June 2024 (17.06.2024)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2308955.0 15 June 2023 (15.06.2023) GB

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,

(54) Title: CARGO ADD-ON DEVICE

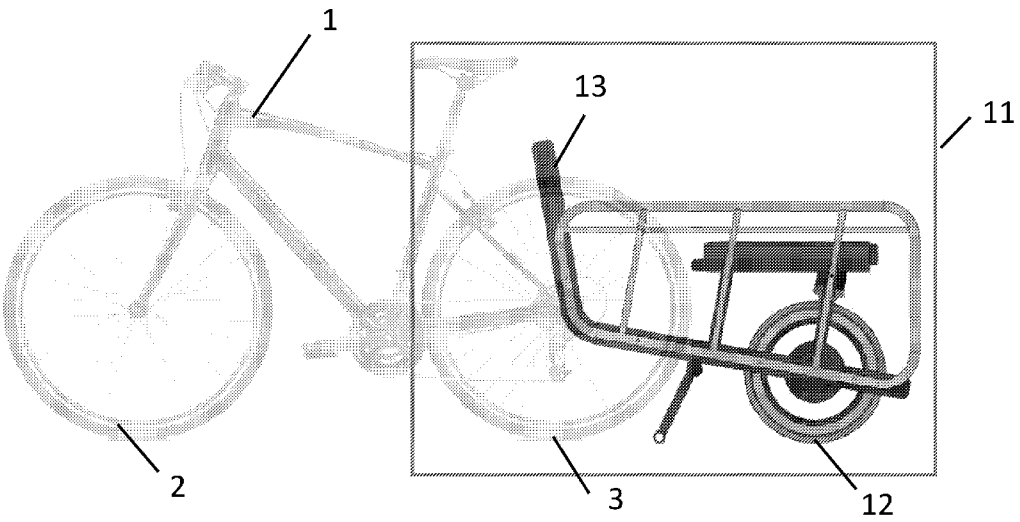

Figure 1

(57) **Abstract:** There is provided a cargo add-on device for attaching onto a parent vehicle, the parent vehicle having a front wheel and a rear wheel. The cargo add-on device comprises: a frame that is configured, in use, to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle; and a device wheel that is capable of pivoting relative to the frame. The cargo add-on device is configured to convert the parent vehicle into a cargo vehicle.

WO 2024/256840 A2

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SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

— *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

CARGO ADD-ON DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The field of the invention relates to a cargo add-on device that is attachable to a parent vehicle, such as a bike. The cargo add-on device is configured to increase the loading capacity of the parent vehicle. It relates in particular to a device configured to convert any ordinary vehicle into a cargo vehicle or an e-cargo vehicle and to systems or methods for improving stability, manoeuvrability and/or steering of cargo vehicles or e-cargo vehicles.

2. Description of the Prior Art

In the UK, 68% of journeys span a mere 1-5 miles. The school run in the UK produces an astonishing half a million tons of CO2 annually yet 73% of families reside within 2 miles of their schools. To offset this carbon footprint, the UK would need to plant 2.5 billion trees every year; the entire UK tree count currently stands at just 3 billion. Furthermore, car tire wear-and-tear produces 21,420 tons of microplastics/year which drains into local waterways and our oceans. This is equivalent to the creation of 1.1 billion water bottles each year.

Why are we using cars to travel these short distances? Regrettably, when it comes to transporting children or precious cargo, viable alternatives are scarce. There is a big gap in the market for transportation solutions focused around families.

The rise of e-cargo bikes is gaining notable momentum as a promising direction in transportation (CARG EU 4.86, North America 5.85). Some issues with large-scale adoption of e-cargo bikes include:

- Cost: Typical between £2,000 - £5,000;
- Weight: Longtails average 30kg while a cargo box can weigh up to 70kg;
- Manoeuvrability: with bike lengths between 2 - 3 metres e-cargo bikes can be hard to ride in the city;
- Storage: Their large size and weight make them difficult to carry upstairs or keep at home;
- Additionally, the lack of proper on-street storage infrastructure puts them at risk of damage or theft.

Hence, existing cargo bikes solutions tend to be expensive, offer unstable steering, become inconvenient to use in adverse weather conditions, and are often heavy and bulky, making manoeuvring and storage a difficult task.

Trailer attachable to bikes are also available, but often result in decreased stability as they protrude far from the rear of the parent bike, making manoeuvring and steering challenging. The weight distribution is also concentrated towards the rear, placing excessive weight on the rear axle of the parent bike. This also impacts the balance and stability of the bike and causes the trailer to swing from side to side. Higher speeds may amplify this swinging effect. As a result, bikes with attachable trailers often impact the rider's ability to steer effectively.

Trailers also have no mechanism other than their own weight to keep their wheels in contact with the ground, such that at high speeds a resonance oscillation can occur causing the trailer to 'hop' resulting in poor ride quality.

Electrical e-bike conversion kits are also available. However, existing solutions often necessitate a significant amount of tinkering and cable management to successfully convert a regular bike into an e-bike. Furthermore, existing solutions do not increase the loading capacity of the bike. They also increase the vehicle weight and average traveling speed but do nothing to improve the system's braking ability.

The present invention addresses the above vulnerabilities and also other problems not described above.

5

SUMMARY OF THE INVENTION

An aspect of the invention is cargo add-on device for attaching onto a parent vehicle, the parent vehicle having a front wheel and a rear wheel, and in which the cargo add-on device comprises:

(a) a frame that is configured, in use, to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle; and

(b) a device wheel that is capable of pivoting relative to the frame,

and in which the cargo add-on device is configured to convert the parent vehicle into a cargo vehicle

Another aspect of the invention is a cargo add-on device for attaching onto a parent vehicle, the parent vehicle having a front wheel and a rear wheel, and in which the cargo add-on device comprises:

(a) a frame that is configured, in use, to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle;

(b) a device wheel that is capable of pivoting relative to the frame; and

(c) an electronics module including a battery, a motor, control electronics for the motor;

and in which the cargo add-on device is configured to convert the parent vehicle into a e-cargo vehicle.

Another aspect of the invention is a cargo add-on device for attaching onto a parent vehicle, the parent vehicle having a front wheel and a rear wheel, and in which the cargo add-on device comprises:

(a) a frame that is configured, in use, to remain substantially parallel or align with a plane that is perpendicular with the rear wheel axis of the parent vehicle;

(b) and an independent device wheel that is capable of pivoting relative to the frame, and in which the movement or positioning of the device wheel is controlled by an actuator, such as a motor;

and in which the cargo add-on device is configured to convert the parent vehicle into a cargo vehicle.

Another aspect of the invention is a cargo add-on device for attaching onto a parent vehicle, the device comprising a device wheel and a frame;

in which the cargo add-on device is configured to convert the parent vehicle into a cargo vehicle, the parent vehicle having a front wheel and a rear wheel, and in which, whilst turning, (i) the frame is configured to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle and (ii) the steering direction of the device wheel is determined to be in the opposite direction from the front wheel steering direction.

Another aspect of the invention is a cargo add-on device for attaching onto a parent vehicle, the cargo add-on device comprising a frame and a wheel mounted on or attached to the frame;

in which the device is configured to convert the parent vehicle into a cargo vehicle, and in which the device wheel is configured to turn such that its axis is substantially aligned with the parent vehicle's instantaneous center of steering.

Another aspect of the invention is a cargo add-on device for attaching onto a parent vehicle, the cargo add-on device comprising a frame and a wheel mounted on or attached to the frame;

in which the device is configured to convert the parent vehicle into a cargo vehicle and in which, when the cargo vehicle is following a straight line, the device wheel is configured to remain substantially aligned with the rear wheel of the parent vehicle with a preload force of about 10N to 100 N.

Another aspect of the invention is a cargo add-on device for attaching onto a parent vehicle, the cargo add-on device comprising a wheel, a frame, and a cargo platform;

in which the device is configured to convert the parent vehicle into a cargo vehicle, and in which the cargo add-on device is attachable or detachable from the parent vehicle using one or more quick-release actions, such as press on/snap and click mechanisms.

Another aspect of the invention is a cargo add-on device for attaching onto a parent vehicle, the device comprising a wheel, a frame and a cargo platform, in which the

device is configured to convert the parent vehicle into a cargo vehicle, and in which, when riding the cargo vehicle, the device wheel is configured to maintain a minimum contact force to ensure traction on the ground.

Another aspect of the invention is a cargo add-on device for attaching onto a parent vehicle, the device comprising a wheel, a frame and a cargo platform, in which the device is configured to convert the parent vehicle into a cargo vehicle, and in which the device wheel axle height is always lower than the axis of rotation between the parent vehicle and the device rigid frame.

Another aspect of the invention is a cargo add-on device for attaching onto a parent vehicle, the device comprising a wheel, a frame and a cargo platform, in which the device is configured to convert the parent vehicle into a cargo vehicle, and in which the cargo add-on device further includes a brake actuator subsystem that is configured to control the device wheel brake based on a detected braking event of the parent vehicle.

Another aspect of the invention is a pedal assist system (PAS) for controlling an electrical motor of an e-vehicle, in which the PAS includes an audio sensor that determines when a rider is not pedalling.

BRIEF DESCRIPTION OF THE FIGURES

Aspects of the invention will now be described, by way of example(s), with reference to the following Figures, which each show features of the invention:

Figure 1 shows a side view of a parent bike 1 with the cargo add-on device 11 attached onto the parent bike.

Figure 2 shows a perspective view of the cargo add-on device, removed from a parent bike.

Figure 3 shows the cargo add-on device with the platform/utility rack 14 removed from the device.

Figure 4 shows a perspective view of the cargo add-on device, removed from a parent bike, with the kickstand 21 folded.

Figure 5 shows a perspective view of the cargo add-on device, removed from a parent bike, with the kickstand 21 folded.

Figure 6 shows a perspective view of the cargo add-on device, removed from a parent bike, with the kickstand 21 extended.

Figure 7 shows a perspective view of the cargo add-on device, removed from a parent bike, with the kickstand 21 extended.

Figure 8 shows a top view of the cargo add-on device, removed from a parent bike, with the kickstand 21 extended.

Figure 9 shows a rear view of the cargo add-on device, removed from a parent bike, with the kickstand 21 extended.

Figure 10 shows a front view of the cargo add-on device 11, removed from a parent bike, with the kickstand 21 extended.

Figure 11 shows a bottom view of the cargo add-on device 11, removed from a parent bike, with the kickstand 21 extended.

Figure 12 shows a rear view of the cargo add-on device 11, removed from a parent bike, with the wheel 12 turned clockwise.

Figure 13 shows a bottom view of the cargo add-on device 11, removed from a parent bike, with the wheel 12 turned clockwise.

Figure 14 shows a rear view of the cargo add-on device 11, removed from a parent bike, with the wheel 12 turned counterclockwise.

Figure 15 shows a bottom view of the cargo add-on device 11, removed from a

parent bike, with the wheel 12 turned counterclockwise.

Figure 16 shows a side view of the cargo vehicle including the parent bike 1 and the cargo add-on device 11, on a flat surface.

Figure 17 shows a side view of the cargo vehicle including the parent bike 1 and the cargo add-on device 11, on an uneven surface.

Figure 18 shows a side view of the cargo vehicle including the parent bike 1 and the cargo add-on device 11, on an uneven surface.

Figure 19 shows an illustration of the movement of a conventional trailer attached to a parent bike.

Figure 20 shows a side view of the cargo add-on device, removed from a parent bike, illustrating the reclining angle of the cargo add-on's steering fork.

Figure 21 shows top views of the cargo add-on device attached to a parent bike that illustrate the active rear steering.

Figure 22 shows top views of the cargo add-on device attached to a parent bike, with the bike going on a straight line (22A) and with the handlebars turned clockwise combined with a fork with a negative trail value (22B) and a fork with a positive trail value (22C).

Figure 23 shows a diagram illustrating the trail value.

Figure 24 shows a diagram illustrating the rotational angle movement of the device wheel.

Figure 25 shows different views of the range of motion of the wheel of the cargo add-on device within the rigid frame 13 of the cargo add-on device.

Figure 26 shows the self-centering mechanism that is positioned along the steering axis of the cargo add-on device wheel or connected to the steering axis via a mechanical connection such as a belt.

Figure 27 shows a diagram of the wheel lock out mechanism.

Figure 28 shows a side view of the cargo vehicle including the parent bike 1, the cargo add-on device 11 and a wireless PAS sensor 281.

Figure 29 shows examples of multiple configurations of the cargo add-on device.

Figure 30 shows the cargo add-on device placed stably on a surface in a storage position.

Figure 31 shows a diagram illustrating the cargo vehicle including a flexible attachment point 311 between the cargo device and the parent bike seat post.

Figure 32 shows a diagram illustrating the cargo vehicle including a rigid attachment point 321 to attach to the parent vehicle seat post and a compliance swing arm 322.

Figure 33 shows a diagram illustrating a cargo frame with a castor wheel that is able to pivot around the back of the device frame

Figure 34 shows a diagram illustrating a top view of a device wheel that can pivot around its own central axis

Figure 35 shows a diagram illustrating a mechanism that can pivot around the bike's seat post.

Figure 36 shows a diagram illustrating device wheel mounted via a single sided 'lefty' hub.

Figure 37 shows a diagram illustrating device wheel mounted implementing a hub centre steering, with the pivot moved to the centre of the wheel or hub motor.

Figure 38 shows a diagram illustrating a seat post mounted trailer with a sprung biased pivot mechanism.

Figure 39 shows a diagram illustrating a spring mechanism attached to the frame of the towing vehicle.

Figure 40 shows a diagram illustrating a pre compression spring mount utilising available pannier mount.

Figure 41 shows a diagram illustrating a device wheel frame attachment point at different positions.

Figure 42 shows a diagram illustrating a smaller wheel positioned closer to the rear wheel of the parent bike.

Figure 43 shows diagram illustrating a bike attached to a cargo add-on device including two pivoting wheels.

Figure 44 shows diagrams illustrating the cargo add-on device being able to accommodate multiple wheel sizes.

Figure 45 shows diagrams illustrating the cargo add-on device being able to function as a powered hand trolley once removed from the parent bike.

Figure 46 shows diagrams illustrating the cargo add-on device including a kick stand leg including a configurable foot or wheel.

Figure 47 shows diagrams illustrating the cargo add-on device including kick stand legs and an angled hinge.

Figure 48 shows diagrams illustrating the cargo add-on device including another example of a kick stand leg.

Figure 49 shows diagrams illustrating the cargo add-on device including a kick stand featuring a locking feature that is easily released by a rider when riding the cargo vehicle.

Figure 50 shows diagrams illustrating the cargo add-on device including UI buttons housed near the seat post clamp.

Figure 51 shows a diagram illustrating the cargo add-on device including a strain gauge built into the cargo add-on device frame or fork.

DETAILED DESCRIPTION

An implementation of the invention is a cargo add-on device, called CONVOY or cargo add-on device or cargo device.

CONVOY is a zero-emissions mode of transportation tailored for short distances, catering to the needs of families. CONVOY is a longtail e-cargo add-on that is configured to up-cycle underused bikes by transforming them into light weight flexible zero emissions utility vehicles. CONVOY allows riders to carry up to two children or up to 50kg. Alternatively, CONVOY may allow riders to carry up to 80kg.

It attaches and disconnects to the parent bike in seconds for effortless storage in the home or alongside a current bike.

The cargo-add on device may be configured to convert a parent vehicle into a cargo vehicle or into an e-cargo device.

The cargo add-on device may include a wireless pedal sensor for seamless device installation, 250W electric assist, integrated battery and regenerative braking. Riders can ride with confidence, whatever they carry. Overall, the device promotes a healthier and greener lifestyle for families.

The cargo add-on device may include a camera recognition system (replacing Pedal Assist Systems). It can be powered by cutting-edge AI that offers smart power assist which adapts to the rider and terrain, seamlessly enhancing a ride.

Examples of advantages include one or more of the following:

- Affordable: <£1,500 vs. existing e-cargo bikes at ~£2000 - £5,000;
- Accessible: 80% of households have access to a bike;
- Lightweight & compact: 30% the weight and 20% the size of a typical e-cargo bike;
- Useful utility: carry up to 2 children or a weekly shop;
- High maneuverable steering;
- Smart safe power assist;

- Quiet mode of transportation, generating minimal noise.
- Fully contained device that can be attached onto a parent vehicle as a single unit, with minimum modification to the original parent bike or no modification that would void manufacturing warranties.

In the examples provided, the solution is described as attached to the rear of a parent bike, having a front wheel and back wheel. However, the solution can be generalised to other types of parent vehicle, such as tricycle, motorcycle, trike or any other vehicles that can attach a cargo load.

Figure 1 shows a side view of a parent bike 1 with the cargo add-on device 11 attached onto the parent bike**.** When attached onto the parent bike, the cargo-add on device converts the parent bike into a cargo bike. The parent bike has a front wheel 2 and a rear wheel 3. The cargo add-on device has a device wheel 12 and a frame 13 that attaches onto the parent bike to convert the parent bike into a cargo bike.

Figure 2 shows a perspective view of the cargo add-on device, removed from a parent bike. The cargo add-on device includes a device wheel 12, a frame 13 and a cargo platform or utility rack 14. A fork 15 is connected to the frame 13. The cargo add-on device is easily attachable and/or removable from the parent bike. The cargo add-on device includes one or more attachment mechanisms or quick-release mechanisms for easy attachment and detachment from the parent vehicle.

A first engagement mechanism 16 may be configured to easily clip onto or near the rear axle of the parent bike and a second attachment mechanism 17 may be configured to engage with or near the seat post of the parent bike.

A triangle formed by three mount points (2 points on device frame 16 or wheel axle and 1 seat post mount 17) provides a stiff connection on a single plane, that makes the cargo add on device a rigid extension of the bike frame. The seat post connection is compliant such that the cargo frame can pivot to ensure the device wheel is always in contact with the ground. This also ensures a normal bike ride feel when riding the cargo vehicle with the cargo add-on device attached.

The cargo add-on device may also include an electronics module 18. A camera PAS module 19 may also be mounted on the cargo add-on device's frame.

The second attachment mechanism 17 near the seat post is also easily accessible from a standing position and provides a level of security and reassurance that the cargo add-on device and the bike are safely tethered. It can also be easily adjusted such that it can accommodate any geometry variance in the parent vehicle.

Figure 3 shows the cargo add-on device with the platform/utility rack 14 removed from the device.

Figure 4 shows a perspective view of another example of the cargo add-on device, removed from a parent bike. The cargo add-one device may include a compliant linkage and a pre-compression spring anchored at the parent bike's seat post. This ensures that the parent bike and attached add-on cargo device maintain three points of ground contact, enhancing stability.

The compliant linkage to the seat post also determines the maximum upper and lower angles of travel from a horizontal plane of the device around the bike's rear wheel axle. This angle or tilt may be based on several factors, such as cargo load, terrain or obstacle.

The pre-compression spring force required for optimal functionality may be approximately 50-150N.

Additionally, the reaction force required at the device wheel contact point may be approximately 10-100N (1kg -10kg).

The compliant linkage allows the device to be installed on different vehicles, including suspension bike, and to accommodate the dynamic rear travel of a bike in motion.

Figures 5 to 7 show perspective views of the cargo add-on device, removed from a

parent bike, with the kickstand 21 folded (Figure 5) and extended (Figures 6 and Figure 7).

Figure 8 shows a top view of the cargo add-on device, removed from a parent bike, with the kickstand 21 extended.

Figure 9 shows a rear view of the cargo add-on device, removed from a parent bike, with the kickstand 21 extended. The cargo add-on device may also include a locking mechanism 91 for preventing the cargo frame becoming detached from the parent bike. The cargo frame is still free to rotate around its axis allowing the entire cargo add-on device to articulate (as shown in Fig. 17).

The cargo add-on device may attach to the parent bike via a custom rear axle cap on the rear wheel of the parent bike, such that the cargo add-on device can snap fit onto it. When using a modified, rear axle cap, it may remain on the bike for the cargo add-on device to quickly attach or detach from the bike.

Loading the parent bike via the rear wheel axle provides a strong connection not reliant upon the stiffness or the availability of common bike frame mount points, such as mudguard or pannier mounts.

The rear wheel axle locking mechanism is configured to provide a robust connection of cargo add-on device - bike, while still allowing the cargo add-on device to pivot around the bike's rear wheel to maintain all three wheels in contact with the ground.

Figure 10 shows a front view of the cargo add-on device 11, removed from a parent bike.

Figure 11 shows a bottom view of the cargo add-on device 11, removed from a parent bike.

Figure 12 shows a rear view of the cargo add-on device 11, removed from a parent bike, with the wheel 12 turned clockwise.

Figure 13 shows a bottom view of the cargo add-on device 11, removed from a parent bike, with the wheel 12 turned clockwise.

Figure 14 shows a rear view of the cargo add-on device 11, removed from a parent bike, with the wheel 12 turned counterclockwise.

Figure 15 shows a bottom view of the cargo add-on device 11, removed from a parent bike, with the wheel 12 turned counterclockwise.

Figures 16-18 shows a side view of the cargo vehicle including the parent bike 1 and the cargo add-on device 11. The cargo vehicle is shown on a flat surface (Figure 16) and on an uneven surface (Figure 17 and 18). The cargo add-on device wheel is configured to maintain a contact point with the ground thanks to a single pivot between the parent bike and the rigid frame of the cargo add-on device. The rigid frame is pivotable around a single axis that is parallel with the rear wheel axis of the parent vehicle. As the cargo vehicle goes over bumps or any other features on the floor, the rigid frame pivots up or down around a single pivot and remains aligned with the plane perpendicular with the axes of the rear wheel of the parent bike.

The cargo add-on device is also configured to provide an end stop to the pivot angle to prevent the cargo add-on device crashing into the bike frame should the device wheel hit a bump which pivots it upwards.

As compared, when a parent bike is attached to a conventional trailer, as shown in **Figure 19**, the pivot point is at the linkage point between the trailer and the parent vehicle. Hence, the trailer moves up and down relative to the parent bike as well as left and right relative to the parent bike.

Active rear steering

A typical bike including two wheels has two contact points with the ground, the front wheel and rear wheel, providing stability and support. When attached onto a parent bike, the device wheel provides a third point of contact to help distribute any cargo load. Additionally, the turning circle of the cargo vehicle with the cargo-add on device attached is maintained such that attached cargo add-on device does not

significantly alter the ride feel of the parent bike. In comparison, a traditional cargo bike with a longer wheelbase has a wider turning circle and a less nimble ride feel that a normal bike.

The wheel 12 is mounted on the frame and can pivot relative to the frame. When the cargo add-on device is attached to a parent bike, the cargo vehicle implements active rear steering, allowing the wheel 12 of the cargo add-on device to steer, preserving manoeuvrability at low speeds and enhancing stability and traction at high speeds.

Additionally, at higher speeds the bike may also turn via carving. In this configuration, the device wheel may include mechanisms to prevent steering actions at higher speeds.

Figure 20 shows a side view of the cargo add-on device 11, removed from a parent bike, illustrating the reclining angle of the fork 15. The reclining angle of the fork against the direction of movement of the cargo vehicle is illustrated. This may also be referred to as positive caster. The reclining angle defines the angle at which the fork 15 reclines as compared to the frame of the parent bike and ranges from about 0° to up to 60°.

Figure 21 shows top views of the cargo add-on device attached to a parent bike that illustrate the active rear steering. The cargo vehicle is illustrated riding on a straight line (21A) and with the front wheel/ handlebar of the bike turning counterclockwise (21B). The rigid frame 13 is configured to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle, even when the bike is turning. The cargo add-on device wheel dynamically steers (left or right) within the rigid frame. The device wheel steering 12 is configured to be in the opposite direction from the front wheel 2 steering. Hence when the front wheel 2 direction of movement is counterclockwise, the direction of movement of the device wheel 12 is clockwise.

When the bike steers the point at which the axis of the front wheel 2 and the axis of the rear wheel 3 converges is the instantaneous center of rotation. The device wheel 12 also turns such that its axis is substantially aligned with the instantaneous center, with for example the alignment being correct in an X and Y coordinates but differing

in a Z coordinate, thus the turning circle of the unmodified parent vehicle is preserved with the cargo add-on attached.

Figure 22 shows top views of the cargo add-on device attached to a parent bike, with the bike going on a straight line (22A) and with the handlebars turned clockwise (22B and 22C). Figure 22B shows the front wheel turned clockwise and the device wheel turned also clockwise. This is a non-working scheme caused by a negative trail, illustrated here with 0 offset and an inclined fork angle of the device wheel (towards the bike). Figure 22C shows the front wheel turned clockwise and the device wheel turned counterclockwise. This is a working scheme caused by a positive trail value, illustrated here with a 0 offset and reclined for angle (away from the bike).

The cargo add-on device steering geometry also features a positive trail value between about 1 and 100mm, such that the passive steering action of the cargo add-on fork / wheel is opposite to the direction of the steering input of the parent vehicle. The trail value is defined as the distance where the cargo add-on wheel touches the ground and where the steering axis intersects the ground, as illustrated in **Figure 23**. Trail value can be achieved with both negative and positive castor. However, a positive castor angle is preferred as it gives smaller scrub radius and better handling at speed. Further combining active rear steering and a positive trail result in a more balanced, maneuverable and stable cargo vehicle.

Hence the cargo add-on device wheel 12 is configured to turn in an opposite direction to the parent bike steering because of its steering geometry (positive trail).

Active steering may be achieved using several solutions, such as, but not limited to:

- Mechanical steering: active steering is achieved with mechanical components, such as springs and/or damping devices.
- Active damping: active steering is achieved using the steering geometry combined with a dynamic mechanical system, such as a motor that constantly tries to return the cargo add-on device wheel to its centre with variable force and speed dependent on the vehicle speed or cargo load.

- Steer by wire: the steering input of the bike is evaluated by an electronic system, which in turn updates the cargo add-on device wheel position via a mechanical actuator such as a motor.
- Assisted steering feature: the evaluated steering input is filtered by smart algorithms, such that the system can recognise 'wobble' and position the cargo add-on device wheel to counter the undesirable steering inputs of the rider to deliver an assisted steering feature.

Figure 24 shows a diagram illustrating the rotational angle movement of the device wheel. In this implementation, the entire turning motion of the device wheel is configured to remain within the constraints of the maximum width of the device frame.

Figure 25 shows different views of the range of motion of the wheel of the cargo add-on device within the rigid frame 13 of the cargo add-on device. The wheel of the cargo add-on device is shown turned about 26 degrees CW and turned about 26 degrees CCW. The wheel 12 of the cargo add-on device is configured to rotate freely without extending from the rigid frame 13 of the cargo add-on device.

The rigid frame 13 may be tapered to increase the width of the frame base to maximise wheel clearance and may be narrower at the top to fit for example a standard rack mounted child seat.

As described above, the cargo add-on device wheel 12 of the cargo add-on device is configured to automatically counter steer. Additionally, the cargo add-on device wheel 12 is also configured to self-center**. Figure 26** shows a self-centering mechanism 261 that connects with the fork of the cargo add-on device and that is configured to enable the device wheel 12 to stay aligned along the centre when the rider is following a straight line. The self-centering mechanism 261 is configured to keep the device wheel into a biased position. Optionally the force of the bias may be dynamically adjusted based on riding characteristics.

The self centering mechanism may use cam profiles and a spring mechanism. The bottom cam profile may remain stationary and does not move with the wheel, while the top cam profile may be attached to the wheel and may turn as the wheel turns. As the wheel turns, the relative movement between the top and bottom cam profiles may cause a spring between them to compress, the compressed spring generating a force trying to push the cam profiles back into their original alignment, thus centering the wheel. By tuning these profiles, the force to start turning and amount of turn achieved may also be tuned.

The self centering mechanism may also include a fluid damping mechanism to prevent rapid changes of wheel direction - 'flicker' when the bike is tracking at speed.

The self centering mechanism may also include sensor, such as a hall effect or any other sensors, to monitor when the device wheel is turned and modify the motor profile accordingly, such as turn off when steering angle is greater than X. This angle may be pre-defined by the user, or selected depending on the user profile or it may also be dynamically adjusted.

The self centering mechanism 261 may be connected to the fork via a mechanical drive, such as a belt, as shown in Figure 26 and 27. Alternatively, the self-centering mechanism may also be directly integrated to the headset stack, such as the bearing that supports the fork.

Hence, the device wheel of the cargo add-on device enables automatic counter-steering, while simultaneously providing a self-centering mechanism. The range of motion and force required to more or recentre the wheel are influenced by many factors, such as the parent bike's design parameters, the maximum load capacity, the detected load and the design specifications of the cargo add-on device.

Advantageously, the cargo add-on device offers:

- an optimum turning circle that is comparable to the turning cycle of the parent bike, ensuring manoeuvrability at low speeds; and

- high speed stability, with the device wheel remaining aligned with the rear wheel of the bike, and steering adjustments accomplished through carving rather than direct turning.

The cargo add-on device may also include a wheel lock out mechanism (mechanical or actuated) 271 that locks the device wheel in a forward position when a speed threshold is crossed, as shown in **Figure 27**. The speed threshold may be selected or programmed by the user. It also may be dynamically adjusted.

The lock out mechanism can also be used when the cargo add-on device is in trolley mode such that the counter steering action is removed and the cargo add-on device acts like a wheel barrow (as illustrated in Fig. 45B).

Figure 28 shows a side view of the cargo vehicle including the parent bike 1 and the cargo add-on device 11. A wireless pedal assist system (PAS) sensor 281 that is able to track the direction and speed of pedalling of the rider is shown mounted on the parent vehicle. The wireless PAS sensor may also evaluate incline such that more power is delivered when climbing.

The cargo add-on device may be outfitted with multiple cargo platform or cargo frame designs. The cargo add-on device may also include a dual frame design, with a lower frame including a drive mechanism, and an upper frame supporting different loads and/or configurations.

Figure 29 shows examples of multiple configurations of the cargo add-on device, including two child seats (29A), with side panniers (29B) and with a single child seat and a weather-resistant canopy (29C).

Advantageously, the cargo add-on device is configured to be easily removable from a parent vehicle using quick-release actions. The cargo add-on device is also configured to have a compact form for easier storage when not in use. The frame of the cargo add-on device may also comprise a flat portion, such that the cargo add-on device can then be placed stably on a surface in a storage position, as shown in **Figure 30**.

Further alternatives of the cargo add-on device are described.

Figure 31 shows a diagram illustrating the cargo vehicle including a flexible attachment point 311 between the cargo device and the parent bike seat post, hence allowing the cargo add-on device to pivot around the rear wheel of the parent bike. The cargo vehicle is shown on a flat surface and an uneven surface.

Figure 32 shows a diagram illustrating the cargo vehicle including a rigid attachment point 321 to attach to the parent vehicle seat post and a compliance swing arm 322, allowing the cargo add-on device wheel to move in a vertical plane independently.

Figure 33 shows a diagram illustrating a cargo frame with a castor wheel 12 that is able to pivot around the back of the device frame, the frame remaining aligned with the rear wheel of the parent bike.

Figure 34 shows a diagram illustrating a top view of a device wheel 12 that can pivot around its own central axis such as with two arced linear bearings that are positioned concentric to the desired wheel movement. The frame also remains aligned with the rear wheel of the parent bike.

Figure 35 shows a diagram illustrating a mechanism that can pivot around the parent bike's seat post allowing the entire frame to pivot around the back of the bike.

Figure 36 shows a diagram illustrating a device wheel mounted via a single sided 'lefty' hub. That enables a single pivot to describe the range of motion of the counter steering required. The pivot may also include a self centering mechanism as described above.

Figure 37 shows a diagram illustrating a device wheel mounted via a single sided 'lefty' hub, with the pivot moved to the centre of the wheel or hub motor. This may be referred to as hub centre steering.

The cargo add-on device may also include alternatives to the spring-loaded compliance force mounted on the seat post described above. **Figure 38** shows a diagram illustrating a seat post mounted trailer with a sprung biased pivot mechanism.

As an alternative, a pre-compression spring may also be mounted near a top tube, rear stays or seat tube, rather than the seat post. **Figure 39** shows a diagram illustrating a spring mechanism attached to the bike's rear stay. **Figure 40** shows a diagram illustrating a compliant linkage utilising available pannier mount.

Figure 41 shows a diagram illustrating a device wheel frame attachment point at different positions. When the device wheel axle is lower than the device pivot, its moment around the device pivot serves to try and drive the device wheel underneath the bikes rear wheel to develop traction. If the device wheel axle raises above the pivot, its moment serves to drive the wheel over the top of the bike rear wheel causing the wheel to 'skip / jump'. This then requires a greater amount of precompression to ensure traction.

Additionally, a cargo add-on device wheel with a small diameter will also allow for the cargo rack surface to be lower, lowering the centre of gravity and improving the stability of the ride. A small wheel may also have a greater range of counter steering motion within the width of the device frame.

A smaller wheel driven by a hub motor of approximately 40Nm will have greater effective torque and thus deliver improved weight hauling and improved gradient climbing, than the same motor mounted within a larger wheel.

Figure 42 shows a diagram illustrating a smaller wheel positioned closer to the rear wheel of the parent bike. The closer the device wheel is to the rear wheel of the parent bike, the smaller the amount of motion is required from the active rear wheel steering mechanism such that its axis is substantially convergent with the instantaneous centre of steering of the parent bike. In other words, a wheel positioned closer to the rear wheel of the bike requires less rotation to match the bikes instantaneous centre of steering.

The cargo add-on device may be configured to allow for the attachment of various types of wheels or other rotational elements. **Figure 43** shows diagrams illustrating a bike attached to a cargo add-on device including two wheels. A linkage mechanism is located between the two wheels that causes both wheels to counter steer at the same time.

Figure 44 shows diagrams illustrating the cargo add-on device being able to accommodate multiple wheel sizes (700c, 29", 27.5", 26"). As an example, a movable rear axle lock mount or angle adjustable rack top surface may be used.

Figure 45 shows diagrams illustrating the cargo add-on device being able to function as a powered hand trolley once removed from the parent bike.

The cargo add-on device may also include optional 'quick attach' luggage mounts that would enable the best possible UX via a customized luggage.

The cargo add-on device may also incorporate integrated footrests, such as for larger passengers, these would also support the base of panniers for the most secure cargo haulage.

The cargo add-on device may also feature an integrated kickstand, to provide self-standing stability whilst loading.

Figure 46 shows diagrams illustrating the cargo add-on device including a kick stand leg including a configurable foot or wheel. A user may easily configure the kick stand leg via a simple mechanism to enable stability or off bike manoeuvrability.

Figure 47 shows diagrams illustrating the cargo add-on device including kick stand legs and an angled hinge such that the widest possible footprint of the deployed kick stand legs is achieved.

Figure 48 shows diagrams illustrating the cargo add-on device including a kick stand leg linked to the rear wheel axle lock mechanism such that when folded the rear axle mechanism is locked to prevent accidental detachment of device and bike. The kick

stand further acts to lock the attachment of the cargo add-on device to the parent bike when folded, and unlock it when deployed.

Figure 49 shows diagrams illustrating the cargo add-on device including a kick stand featuring a locking feature that is easily released by a rider when riding the cargo vehicle.

Figure 50 shows a diagram illustrating the cargo add-on device including UI buttons housed near the seat post clamp. Examples of UI buttons may include power on/off. Advantageously, the cargo add-on device is fully contained and does not require additional electronic products or wires/cables mounted on the parent bike.

Figure 51 shows a diagram illustrating the cargo add-on device including a strain gauge built into the cargo add-on device frame or fork.

Key Features

In the following, we outline several features of CONVOY; we also list various optional sub-features for each feature. Note that any feature can be combined with one or more other features; any feature can be combined with any one or more sub-features (whether attributed to that feature or not) and every sub-feature can be combined with one or more other sub-features.

Feature A: Removably attachable cargo add-on device for attaching onto a parent vehicle and for converting the parent vehicle into a cargo vehicle.

A cargo add-on device for attaching onto a parent vehicle, the parent vehicle having a front wheel and a rear wheel, and in which the cargo add-on device comprises:

(c) a frame that is configured, in use, to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle; and

(d) a device wheel that is capable of pivoting relative to the frame,

and in which the cargo add-on device is configured to convert the parent vehicle into a cargo vehicle.

A cargo vehicle comprising a parent vehicle having a front wheel and a rear wheel, and a cargo add-on device for attaching onto the parent vehicle, in which the cargo add-on device comprises:

(a) a device frame that is configured, in use, to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle; and

(b) a device wheel that is capable of pivoting relative to the frame.

Method of steering or riding a cargo vehicle, the cargo vehicle comprising a parent vehicle having a front wheel and a rear wheel, and a cargo add-on device for attaching onto the parent vehicle, in which the cargo add-on device comprises:

(a) a device frame that is configured, in use, to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle; and

(b) a device wheel that is capable of pivoting relative to the frame.

Feature B: Removably attachable cargo add-on device for attaching onto a parent vehicle that converts the parent vehicle into a powered cargo vehicle.

A cargo add-on device for attaching onto a parent vehicle, the parent vehicle having a front wheel and a rear wheel, and in which the cargo add-on device comprises:

(d) a frame that is configured, in use, to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle;

(e) a device wheel that is capable of pivoting relative to the frame; and

(f) an electronics module including a battery, a motor, control electronics for the motor;

and in which the cargo add-on device is configured to convert the parent vehicle into a e-cargo vehicle.

Feature C: Removably attachable cargo add-on device for attaching onto a parent vehicle that converts the parent vehicle into a cargo vehicle with active damping and or assisted steering

A cargo add-on device for attaching onto a parent vehicle, the parent vehicle having a front wheel and a rear wheel, and in which the cargo add-on device comprises:

(c) a frame that is configured, in use, to remain substantially parallel or align with a plane that is perpendicular with the rear wheel axis of the parent vehicle;

(d) and an independent device wheel that is capable of pivoting relative to the frame, and in which the movement or positioning of the device wheel is controlled by an actuator, such as a motor;

and in which the cargo add-on device is configured to convert the parent vehicle into a cargo vehicle or ecargo vehicle.

Feature D: Active rear steering

On typical trailer bikes with an attached trailer, the turning of the trailer is delayed, it's a following action, thus the rider has to evaluate where both the bike and the trailer are positioned, making them harder to manoeuvre. The pivot point at the linkage point between the trailer and the bike enables pivoting around two axis (using a ball joint for example) such that there is relative movement between the parent vehicle and trailer frame - up, down, left and right.

As compared, the cargo add-on device implements active rear steering. The cargo add-on device has a rigid frame that is constrained to be substantially inline with the rear wheel of the parent vehicle and able to pivot up and down in relation to a plane that is perpendicular to the rear wheel axis of the parent vehicle. The cargo add-on device wheel dynamically steers (left or right) within the rigid frame. Advantageously, when the cargo add-on device is rigidly attached to the bike, it has minimal impact on the stability of the parent bike, even while carrying a heavy load. Riding the converted cargo-bike therefore provides very similar stability, manoeuvrability as when riding the non-converted parent vehicle. As a result, the rider's confidence is improved even with the additional frame length.

Additionally, the cargo add-on active rear steering includes mechanisms to manage its rate of change of steering angle, such as a fluid damper to filter steering motion. Or a motor, which enables active damping to be configured to match vehicle speed or load being carried or provide active wheel position for assistive steering.

A fork is connected to the frame of the cargo add-on device. The device fork holds the device wheel and allows the device wheel to rotate freely. The relationship between the device fork and the device wheel is crucial for implementing the active rear steering and for the overall performance and handling of the converted cargo-vehicle or e-cargo vehicle.

The device steering geometry features a positive trail value between 1 and 100mm, such that the passive steering action of the cargo add-on fork / wheel is opposite to the direction of the steering input of the parent vehicle

We can generalise as follows:

A cargo add-on device for attaching onto a parent vehicle, the device comprising a device wheel and a frame;

in which the cargo add-on device is configured to convert the parent vehicle into a cargo vehicle, the parent vehicle having a front wheel and a rear wheel, and in which, whilst turning, (i) the frame is configured to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle and (ii) the

steering direction of the device wheel is determined to be in the opposite direction from the front wheel steering direction.

Feature E: Turning angle of the cargo add-on device

A typical bike including two wheels has two contact points with the ground, the front wheel and rear wheel, providing stability and support. With the add-on cargo device attached to the parent bike, the rear wheel device can provide a third contact point with the ground. When the bike steers the point at which its front and rear wheel axis converge is the instantaneous center of rotation. The device wheel also turns such that its axis also converges with the instantaneous center, thus the turning circle of the unmodified parent vehicle is preserved with the cargo add-on attached.

We can generalise as follows:

A cargo add-on device for attaching onto a parent vehicle, the cargo add-on device comprising a frame and a wheel mounted on or attached to the frame;

in which the device is configured to convert the parent vehicle into a cargo vehicle, and in which the device wheel is configured to turn such that its axis is substantially aligned with the parent vehicle's instantaneous center of steering.

Feature F: Self-centre alignment control

A rider will often ride at low speed when attempting a turn, for example a 90° turn when approaching a junction. At higher speed, when the rider is following a straight line, the device wheel needs to stay aligned without abruptly changing direction. Hence a mechanism needs to keep the device wheel aligned along the centre to ensure stability and a comfortable ride. As an example, a spring-like mechanism is included that brings the device wheel into a biased position. The force of the bias (1-10kg or 10-100Newtons) required may be automatically adjusted based on riding characteristics.

We can generalise as follows:

A cargo add-on device for attaching onto a parent vehicle, the cargo add-on device comprising a frame and a wheel mounted on or attached to the frame;

in which the device is configured to convert the parent vehicle into a cargo vehicle and in which, when the cargo vehicle is following a straight line, the device wheel is configured to remain substantially aligned with the rear wheel of the parent vehicle with a preload force of about 10N to 100 N.

Feature G: Cargo add-on device is attachable to a parent vehicle using two simple quick-release actions, such as press on/snap and click mechanism, whilst the cargo add on device is freestanding on an integrated kickstand.

A cargo add-on device for attaching onto a parent vehicle, the cargo add-on device comprising a wheel, a frame, and a cargo platform;

in which the device is configured to convert the parent vehicle into a cargo vehicle, and in which the cargo add-on device is attachable or detachable from the parent vehicle using one or more quick-release actions, such as press on/snap and click mechanisms.

Feature H: cargo add-on device attachable to a parent vehicle, in which the device wheel is maintained in contact with the ground by a single pivot between the parent vehicle and the rigid frame of the cargo add-on

The device wheel is configured to always maintain a point of contact with the ground, even when a cargo load is added or removed from the device, and even when the ground is an uneven surface or includes bumps. As an example, the engagement mechanism with the seat post of the parent bike may be flexible and may include pre-compression springs that provide a contact force measured at the wheel of the cargo device of 1-10kg or (10-100N).

We can generalise as follows:

A cargo add-on device for attaching onto a parent vehicle, the device comprising a wheel, a frame and a cargo platform, in which the device is configured to convert the parent vehicle into a cargo vehicle, and in which, when riding the cargo vehicle, the device wheel is configured to maintain a minimum contact force to ensure traction on the ground.

Feature I: A small rear wheel with its axle always lower than the device pivot (low center of gravity COG and drive under rear bike axle)

A cargo add-on device for attaching onto a parent vehicle, the device comprising a wheel, a frame and a cargo platform, in which the device is configured to convert the parent vehicle into a cargo vehicle, and in which the device wheel axle height is always lower than the axis of rotation between the parent vehicle and the device rigid frame.

Feature J: Cargo add-on device wheel braking

The cargo-add on device is configured such that the cargo wheel can brake to match the braking events of the parent vehicle to enhance rider safety. Braking of the cargo wheel may be done via mechanical systems such as a disc brake or regenerative braking via a hub motor. Braking events of the parent vehicle might be evaluated by on bike sensors or smart algorithms that compare vehicle deceleration vs. calculated natural decay of vehicle velocity.

A cargo add-on device for attaching onto a parent vehicle, the device comprising a wheel, a frame and a cargo platform, in which the device is configured to convert the parent vehicle into a cargo vehicle, and in which the cargo add-on device further includes a brake actuator subsystem that is configured to control the device wheel brake based on a detected braking event of the parent vehicle.

Feature K: Audio based pedal assist

A pedal assist system (PAS) for controlling an electrical motor of an e-vehicle, in which the PAS includes an audio sensor that determines when a rider is not pedalling.

Generally applicable optional features:

- Frame is substantially rigid.
- Frame is pivotable around a single axis that is parallel to the rear wheel axis of the parent vehicle.
- The device wheel is configured to pivot within the rigid frame.

- Device is fixed or attached onto the rear axle of the parent vehicle.
- Additional cargo load can be up to approximately 50kg.
- Additional cargo load can be up to approximately 80kg.
- Additional cargo load can be up to approximately 100kg.
- Cargo vehicle is configured to carry up to 2 kids.
- When attached to the parent vehicle, the cargo add-on device protrudes by approximately less than 650 mm from the rear of the vehicle.
- The device has a maximum cargo rack height of approximately 600 mm.
- Device provides the parent vehicle with an elongated frame that protrudes from the rear of the parent vehicle.
- When attached to the parent vehicle, the device protrudes by approximately less than 1000 mm from the rear of the vehicle.
- When attached to the parent vehicle, the device protrudes by approximately less than 1500 mm from the rear of the vehicle.
- Distance between the rear wheel contact point with the ground and the device wheel contact point with the ground is approximately less than 1000 mm.
- Device weight is approximately less than 15kg.
- Device is configured to easily fit inside a train, taxi, or boot of a car.
- Device is configured to be easily swappable between different vehicle s.
- Device is configured to be easily attachable to any types or sizes of vehicles.

e-cargo add-on device

- E-cargo vehicle is configured to have up to approximately 30-mile range between charges.
- Electronics module includes: motor driver, battery, battery management system, accelerometer, UI.
- Electronics module includes: a battery, a motor, control electronics for the motor,
- Motor drives the device wheel to propel the e-cargo vehicle forward.
- Electronics module includes a rechargeable battery.
- Rechargeable battery is easily swappable to provide unlimited range.
- Electronics module is configured to fit inside a single housing.

- Housing includes contact points attached or located near an external surface of the housing and that are in communication with the device wheel.
- Housing is configured to have a box-shape structure to be easily attachable or detachable from the device's frame.
- Housing includes a LED or light that provides the e-cargo vehicle with a rear-facing light.
- Motor and drive electronics module to enable regenerative braking.

Active rear steering

- Device wheel steering angle is determined as a function of the movement of the handlebar.
- Sensor determines the front wheel steering angle, based on the handlebar movement.
- Device wheel steering angle is determined as a function of the front wheel steering angle.
- Device wheel steering angle is further a function of one or more of: speed, weight or shape of the vehicle and cargo add-on device, dimensions of the wheels, stiffness of the wheels etc.
- Device is configured to dynamically follow the rider's intended steering path.
- Device includes a fork that holds the device wheel, with the fork being reclined at an angle that ranges from 0° to up to 60° from the frame of the parent vehicle.
- Reclining angle is less than 90°.

Turning angle or rotational angle movement

- Maximum width of the device frame is approximately 300-500mm.
- Frame is tapered with a minimum width being approximately 100-150mm and a maximum width being approximately 300-500mm.
- The device wheel has +/- 10 - 40 degrees of rotational angle movement.

Bias mechanism and contact force

- Device includes a bias mechanism to keep the device wheel into a biased position.
- Contact force is between 1-10kg or 10-100N.

Self-centre alignment control

- Steering response of the device wheel, such as steering ratio, is dynamically adjusted based on the speed of the cargo vehicle.
- A sensor module is able to sense 'wobble' or an unwanted steering input and a feedback subsystem subsequently positions the device wheel based on the measurements of the sensor module.
- Steering response of the device wheel, such as steering ratio, is dynamically adjusted based on an input from the rider. For example, at high speed, low steering ratios are provided, and at low speed, high steering ratios are provided. To change steering ratios in one of these stats involve user input.
- Device includes a bias mechanism, such as a compressed spring, to keep the device wheel into a biased position.
- Device includes a sensor that measures or estimates the speed of the parent vehicle, and when the measured speed is higher than a pre-defined threshold, then the device wheel automatically remains substantially aligned with the rear wheel of the parent vehicle.
- Device including a sensor that measures fork turning angle past a threshold and limits power delivered to the motor.
- Force of the bias delivered depends on the handlebar movement or steering angle of the front wheel.
- When the speed is higher than a pre-defined threshold, steering of the vehicle is achieved by carving.

Engagement mechanisms

- First engagement mechanism engages with or near the rear axle of the parent vehicle using one or more of a hook, snap, or clip.
- Second engagement mechanism engages with or near the seat post of the parent vehicle using one or more of a hook, snap, or clip mechanism.
- First engagement mechanism is configured to fit any axle type, such as threaded, quick release or thru axle.
- Audible or visible feedback confirms that cargo add-on is properly attached.

- First mechanism engages with skewer caps located on the rear axle of the parent vehicle.
- Parent vehicle includes modified skewer caps and seatpost mount.

Device wheel maintains contact with the ground

- Triangle formed by three mount points (2 points on device frame or wheel axle and 1 seat post mount) provides a stiff connection on a single plane.
- Engagement point with the parent vehicle near the seat post is flexible and is configured to dynamically maintain the device wheel in contact with the ground.
- Engagement point with the parent vehicle near the seat post is rigid and the device wheel is flexibly mounted on the device frame to dynamically maintain the device wheel in contact with the ground.
- Device includes a suspension subsystem to stabilise the device when riding on different types of terrain.
- the cargo vehicle is configured to go over varying sizes of bumps or dips, such as +/- 100 mm or +/- 300 mm size of bumps/dips.
- the device frame is configured to automatically tilt or rotate in response to a vertical displacement of the device wheel, thus allowing the cargo vehicle to maintain stability while navigating a bump or dip.
- suspension subsystem is configured to allow the device to return to its normal position after going over a bump or dip.

Braking actuator subsystem

- A sensor module is configured to detect a braking event of the parent vehicle based on the actuation of one or more brakes of the parent vehicle.
- a sensor module is configured to measure the cargo vehicle deceleration and to determine a braking event of the parent vehicle based on the measured vehicle deceleration.
- Measured vehicle deceleration is compared to a baseline, such as a calculated natural decay of vehicle velocity.

PAS

- Cargo add-on device includes PAS above.

- PAS comprises an additional sensor that is tracking the rotation of either the vehicle's cassette or an additional component attached to the vehicle's cassette.
- Additional sensor is a magnetic or inductive proximity sensor.
- PAS is a wireless sensor that is able to track with the direction and speed of pedaling.
- PAS is configured to evaluate incline, such that more power is delivered when climbing.

UI

- Device further includes a user interface (UI) in communication with the electronics module, that enables the rider to provide an input to control the electrical motor.
- UI enables a user to select a rider profile that allows for the rider to adjust or customise their preferences.
- Preferences include one or more of the following: amount of torque or power output, top speed, acceleration.
- Rider profile is selectable from a list of pre-programmed profiles, such as first-time rider profile or skilled rider profile.
- First time rider profile is designed to boost riding confidence and includes for example, reduced top speed and low acceleration.
- Skilled rider profiles include higher speed and higher acceleration.
- Multiple rider profiles are stored, and UI automatically selects a rider profile based on the vehicle it is installed upon or based on the detected rider or based on the detected load.
- UI includes a launch button that is configured to initiate the vehicle's movement before the motor kicks in.
- UI is easily accessible to a user riding the vehicle.
- UI is located near the seat post engagement point.

Load sensing

- Device includes a sensor that senses load.
- Device is configured to automatically adjust the power delivered from the motor based on the measured load.

- Device is configured to automatically adjust the rider profile based on the measured load.Device is configured to automatically adjust steering damping based on the measured load.
- Device includes sensors or control systems for monitoring and adjusting the movement of the cargo add-on device, such as the pivoting movement.

Orientation sensor

- Device includes an orientation sensor, such as a 3-axis gyroscope sensor, that provides push notification warning if the cargo vehicle is being tampered with whilst parked.
- Device includes an orientation sensor, such as a 3-axis gyroscope sensor, that increases motor assistance automatically when a gradient is sensed.

Camera Assist System

- Device includes a computer vision subsystem configured to determine one or more of the following: whether the user is pedalling, gear used, pedalling speed and type of terrain being traversed.
- Device is configured to automatically adjust power delivered from the motor based on the outputs from the computer vision subsystem.
- Device is configured to automatically adjust the rider profile based on the outputs from the computer vision subsystem.
- Device is configured to have almost no lag from pedal input and asset output.
- Computer vision subsystem is mounted on the device's frame.

Motorised trolley

- When detached from the parent vehicle, the cargo add-on device is configured to convert into a motorised trolley.

Note

It is to be understood that the above-referenced arrangements are only illustrative of the application for the principles of the present invention. Numerous modifications

and alternative arrangements can be devised without departing from the spirit and scope of the present invention. While the present invention has been shown in the drawings and fully described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred example(s) of the invention, it will be apparent to those of ordinary skill in the art that numerous modifications can be made without departing from the principles and concepts of the invention as set forth herein.

CLAIMS

1. A cargo add-on device for attaching onto a parent vehicle, the parent vehicle having a front wheel and a rear wheel, and in which the cargo add-on device comprises:

(a) a device frame that is configured, in use, to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle; and

(b) a device wheel that is capable of pivoting relative to the frame,

and in which the cargo add-on device is configured to convert the parent vehicle into a cargo vehicle.

2. The device of claim 1, in which the device frame is substantially rigid.

3. The device of claim 1 or 2, in which the device frame is pivotable around a single axis that is parallel to the rear wheel axis of the parent vehicle.

4. The device of any preceding claim, in which the device wheel is configured to pivot within the rigid frame.

5. The device of any preceding claim, in which the device wheel is configured to turn such that its axis is substantially aligned with the parent vehicle's instantaneous center of steering.

6. The device of any preceding claim, in which the steering direction of the device wheel is determined to be in the opposite direction from the front wheel steering direction.

7. The device of any preceding claim, in which the device includes a sensor module that detects the parent vehicle's steering movement, such as handlebar movement, and the device wheel steering angle is determined as a function of the detected movement of the handlebar.

8. The device of any preceding claim, in which the device wheel steering angle is configured to be a function of one or more of: speed, weight or shape of the vehicle and cargo add-on device, dimensions of the wheels and stiffness of the wheels.

9. The device of any preceding claim, in which the device includes a fork that holds the device wheel, with the fork being reclined at an angle that ranges from 0° to up to 60° from the frame of the parent vehicle.

10. The device of any preceding claim, in which when the cargo vehicle is following a straight line, the device wheel is configured to remain substantially aligned with the rear wheel of the parent vehicle.

11. The device of any preceding claim, in which the device includes a bias mechanism to keep the device wheel into a biased position, with a pre-loaded force of about 10-100N.

12. The device of any preceding claim, the device including a sensor module that is configured to measure the speed of the cargo vehicle, and a steering response of the device wheel is dynamically adjusted based on the speed of the cargo vehicle.

13. The device of any preceding claim, the device including a sensor module that is able to sense 'wobble' or an unwanted steering input and a feedback subsystem including an actuator subsequently positions the device wheel based on the measurements of the sensor module.

14. The device of any preceding claim, the device including a sensor module that measures or estimates the speed of the parent vehicle, and when the measured speed is higher than a pre-defined threshold, then the device wheel is automatically configured to remain substantially aligned with the rear wheel of the parent vehicle.

15. The device of any preceding claim, in which the device is attachable or detachable from the parent vehicle using one or more quick-release actions, such as press on/snap and click mechanisms.

16. The device of any preceding claim, in which the device includes a first engagement mechanism that engages with or near the rear axle of the parent vehicle using one or more of a hook, snap, or clip.

17. The device of any preceding claim, in which the device includes a second engagement mechanism that engages with or near the seat post of the parent vehicle using one or more of a hook, snap, or clip mechanism.

18. The device of Claim 17, in which the second engagement mechanism is flexible and that is configured to dynamically maintain the device wheel in contact with the ground.

19. The device of Claim 17, in which the second engagement mechanism is rigid, and the device wheel is flexibly mounted on the device frame to dynamically maintain the device wheel in contact with the ground.

20. The device of any preceding claim, in which an audible or visible feedback confirms that the device is properly attached to the parent vehicle.

21. The device of any preceding claim, in which, when riding the cargo vehicle, the device wheel is configured to maintain a minimum contact force to ensure traction on the ground.

22. The device of any preceding claim, in which the device frame is configured to automatically tilt or rotate in response to a vertical displacement of the device wheel, thus allowing the cargo vehicle to maintain stability while navigating a bump or dip.

23. The device of any preceding claim, in which the device wheel axle height is always lower than the axis of rotation between the parent vehicle and the device rigid frame.

24. The device any preceding claim, in which the device includes an electronics module including a battery, a motor, control electronics for the motor; and in which

the cargo add-on device is configured to convert the parent vehicle into a e-cargo or powered vehicle.

25. The device of any preceding claim, in which the device wheel is an independent device wheel; and the device includes an actuator, such as a motor, that controls the movement or positioning of the device wheel as evaluated by a sensor module.

26. The device of Claim 25, in which the device wheel is an independent device wheel; and the actuator is also configured to act as a mechanical damper or a self-centring mechanism.

27. The device of any preceding claim, in which the device further includes a brake actuator subsystem that is configured to control the device wheel brake based on a detected braking event of the parent vehicle.

28. The device of any preceding claim, in which a sensor module is configured to detect a braking event of the parent vehicle based on the actuation of one or more brakes of the parent vehicle.

29. The device of any preceding claim, in which a sensor module is configured to measure the cargo vehicle deceleration and to determine a braking event of the parent vehicle based on the measured parent vehicle deceleration.

30. The device of any preceding claim, in which the measured vehicle deceleration is compared to a baseline, such as a calculated natural decay of vehicle velocity.

31. The device of any preceding claim, in which the device includes a pedal assist system (PAS) for controlling an electrical motor of an e-vehicle, in which the PAS includes an audio sensor that determines when a rider is not pedalling.

32. The device of claim 31, in which the PAS system comprises an additional sensor that is tracking the rotation of either the parent vehicle's cassette or an additional component attached to the parent vehicle's cassette.

33. The device of 32, in which the additional sensor is a magnetic or inductive proximity sensor.

34. The device of any of preceding claim 32-33, in which the PAS is a wireless PAS that is able to track with the direction and speed of pedalling.

35. The device of any of preceding claim 32-34, in which the PAS is configured to evaluate incline, such that more power is delivered when climbing.

36. The device of any preceding claim, in which an additional cargo load is up to approximately 50kg.

37. The device of any preceding claim, in which the device provides the parent vehicle with an elongated frame that protrudes from the rear of the parent vehicle.

38. The device of any preceding claim, in which the device protrudes by approximately less than 650 mm from the rear of the parent vehicle.

39. The device of any preceding claim, in which the device has a maximum cargo rack height of approximately 600 mm.

40. The device of any preceding claim, in which the distance between the rear wheel of the parent vehicle contact point with the ground and the device wheel contact point with the ground is approximately less than 1000 mm.

41. The device of any preceding claim, in which the device weight is approximately less than 15kg.

42. The device of any preceding claim, in which the device further includes a user interface (UI) in communication with an electronics module, that enables the rider to provide an input to control the electrical motor.

43. The device of claim 42, in which the UI enables a user to select a rider profile that allows for the rider to adjust or customise their preferences, including one or more of the following: amount of torque or power output, top speed, acceleration.

44. The device of any of preceding claim 42-43, in which the UI enables a user to select a rider profile from a list of pre-programmed profiles, such as first-time rider profile or skilled rider profile.

45. The device of any of preceding claim 42-44, in which multiple rider profiles are stored, and the UI automatically selects a rider profile based on one or more of the following: the parent vehicle it is installed upon, the detected rider or based on the detected load.

46. The device of any of preceding claim 42-45, in which the UI includes a launch button that is configured to initiate the vehicle's movement before the motor kicks in.

47. The device of any of preceding claim 42-46, in which the UI is easily accessible to a user riding the vehicle.

48. The device of any of preceding claim 42-47, in which the UI is located near the seat post engagement point.

49. The device of any preceding claim, in which the device includes a sensor module that senses and measures load on the device.

50. The device of claim 49, in which the device is configured to automatically adjust the power delivered from the motor based on the measured load.

51. The device of any of preceding claim 49-50, in which the device is configured to automatically adjust steering damping based on the measured load.

52. The device of any preceding claim, in which the device includes sensors or control systems for monitoring and adjusting the movement of the cargo add-on device including the pivoting movement.

53. The device of any preceding claim, in which the device includes an orientation sensor, such as a 3-axis gyroscope sensor, that provides push notification warning if the cargo vehicle is being tampered with whilst parked.

54. The device of any preceding claim, in which the device includes an orientation sensor, such as a 3-axis gyroscope sensor, that increases motor assistance automatically when a gradient is sensed.

55. The device of any preceding claim, in which the device includes a computer vision subsystem configured to determine one or more of the following: whether the user is pedalling, gear used, pedalling speed and type of terrain being traversed.

56. The device of any preceding claim, in which the device is configured to automatically adjust power delivered from the motor based on the outputs from the computer vision subsystem.

57. The device of any preceding claim, in which the computer vision subsystem is mounted on the device's frame.

58. The device of any preceding claim, in which the cargo add-on device is configured to convert into a motorised trolley, when detached from the parent vehicle.

59. A cargo vehicle comprising a parent vehicle having a front wheel and a rear wheel, and a cargo add-on device for attaching onto the parent vehicle, in which the cargo add-on device comprises:

(c) a device frame that is configured, in use, to remain substantially parallel to a plane that is perpendicular to the rear wheel axis of the parent vehicle; and

(d) a device wheel that is capable of pivoting relative to the frame.

60. The cargo vehicle of claim 59, in which the cargo add-on device includes any of the features defined in claims 2-58.

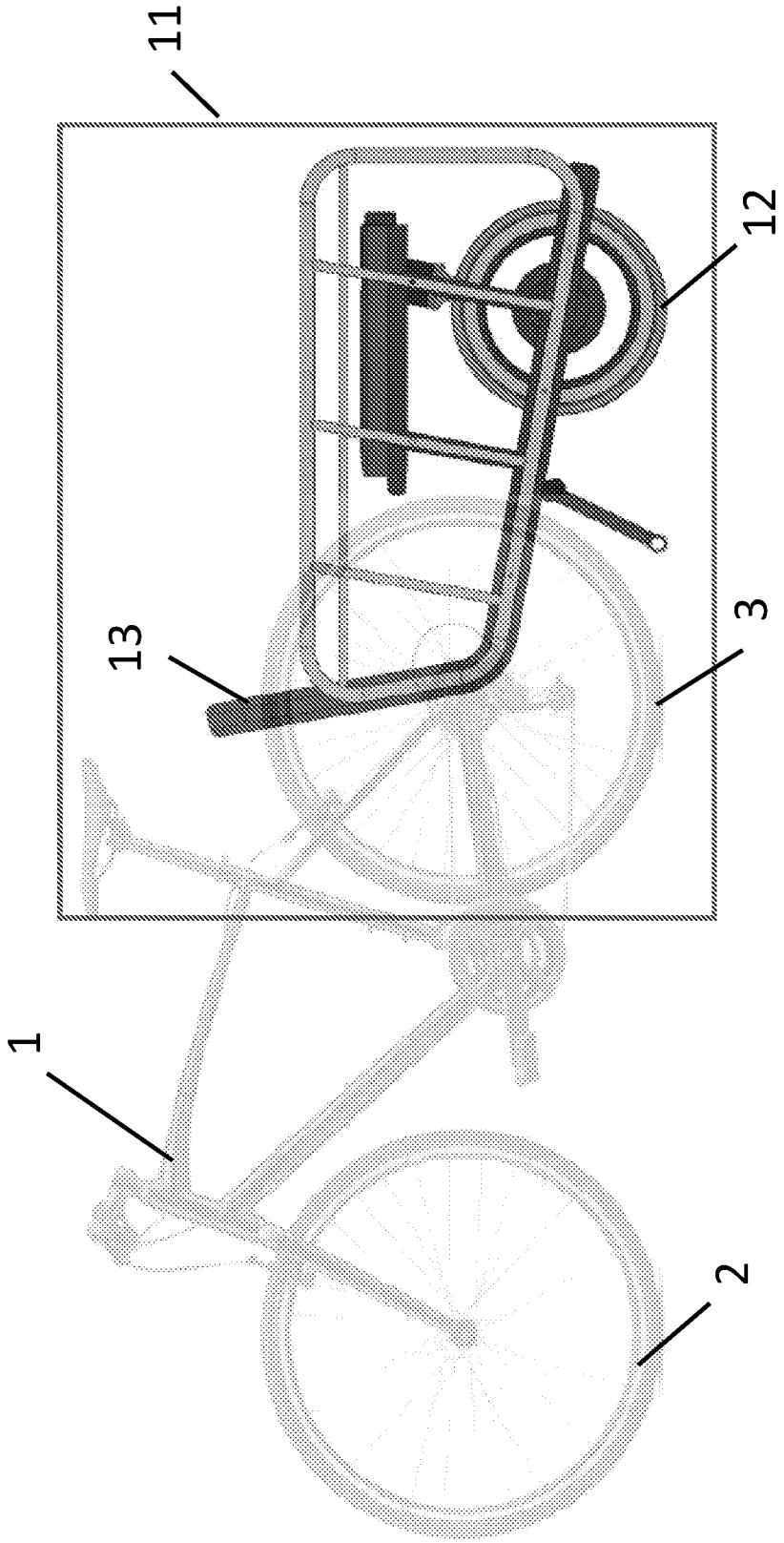


Figure 1

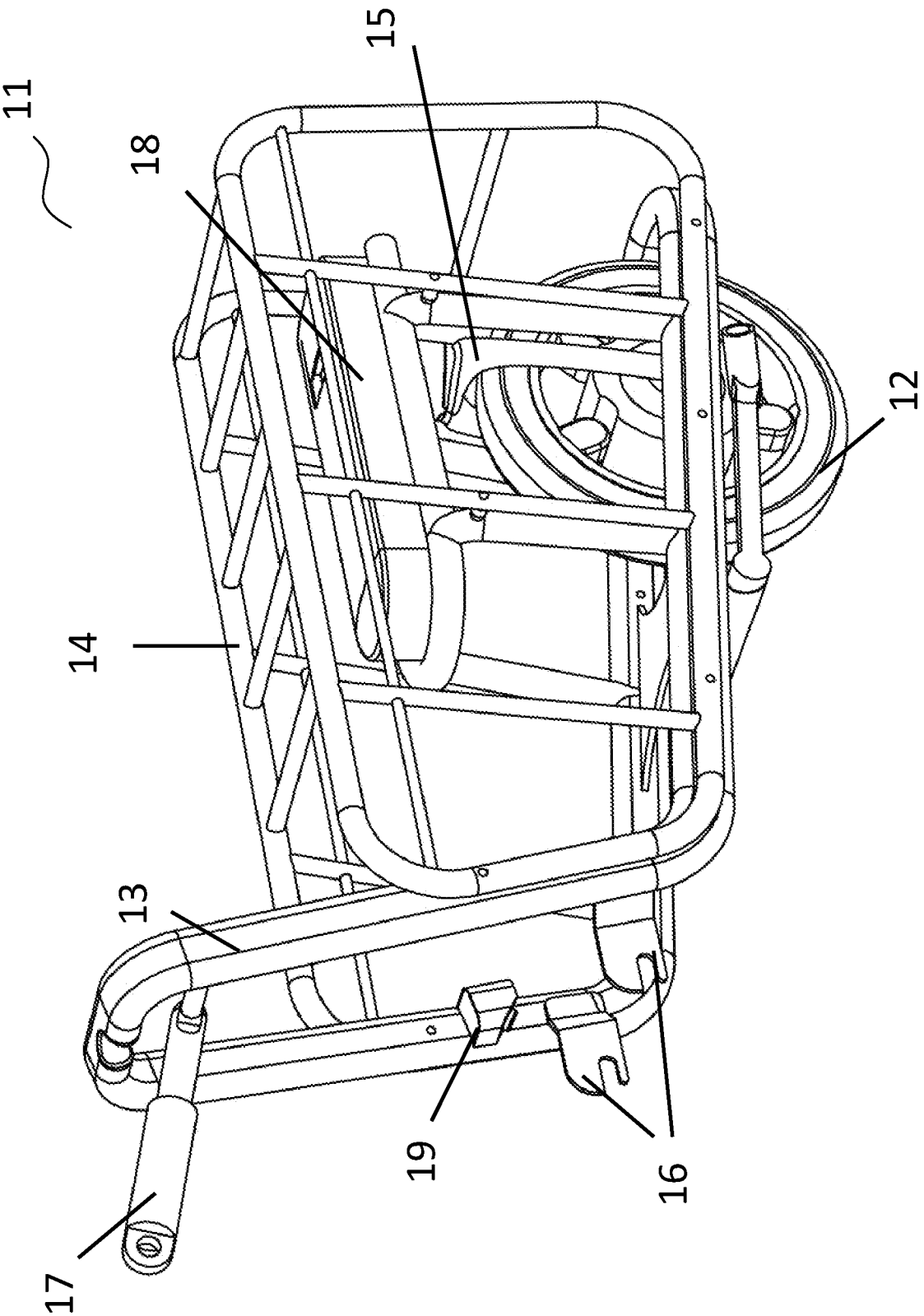


Figure 2

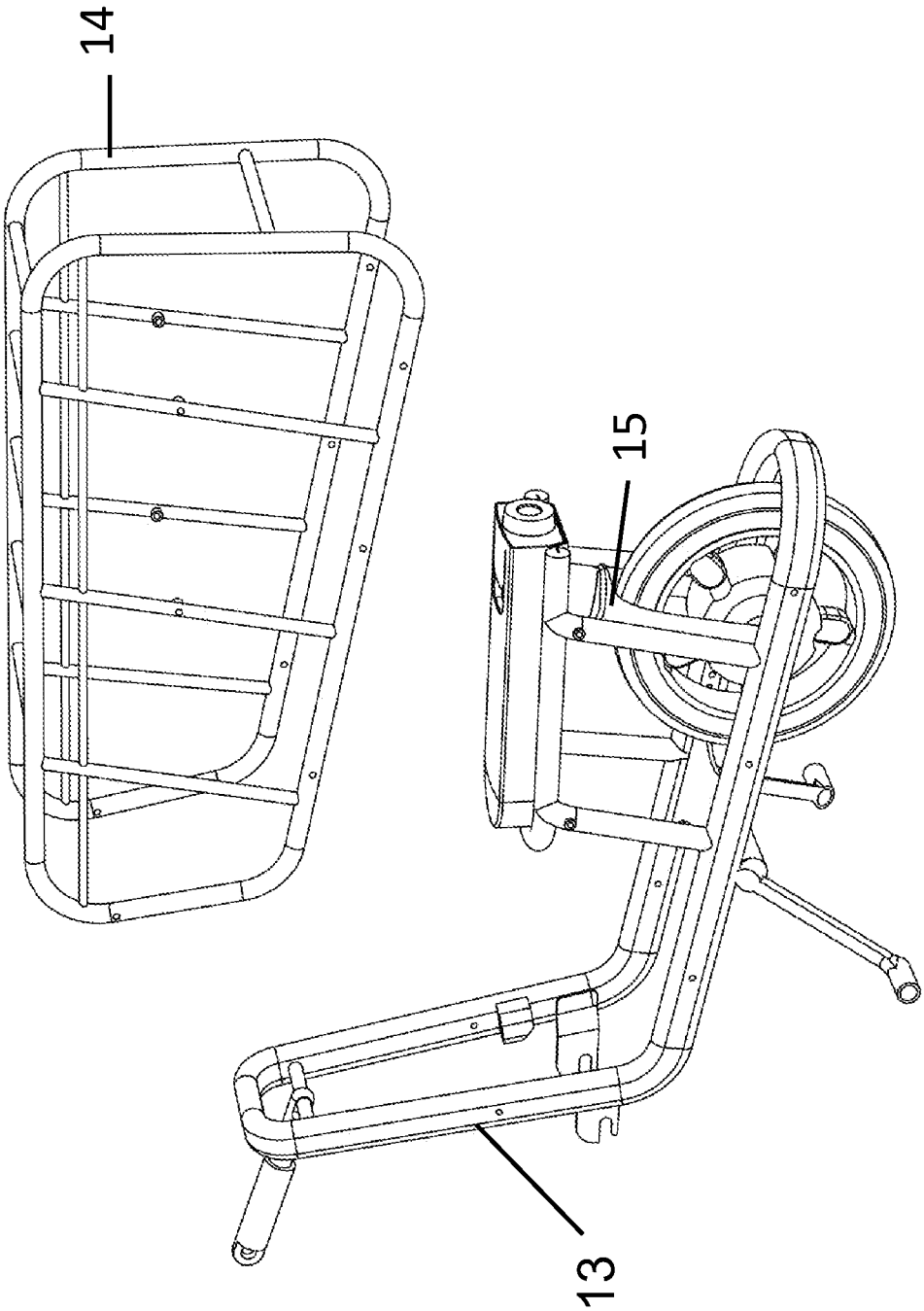


Figure 3

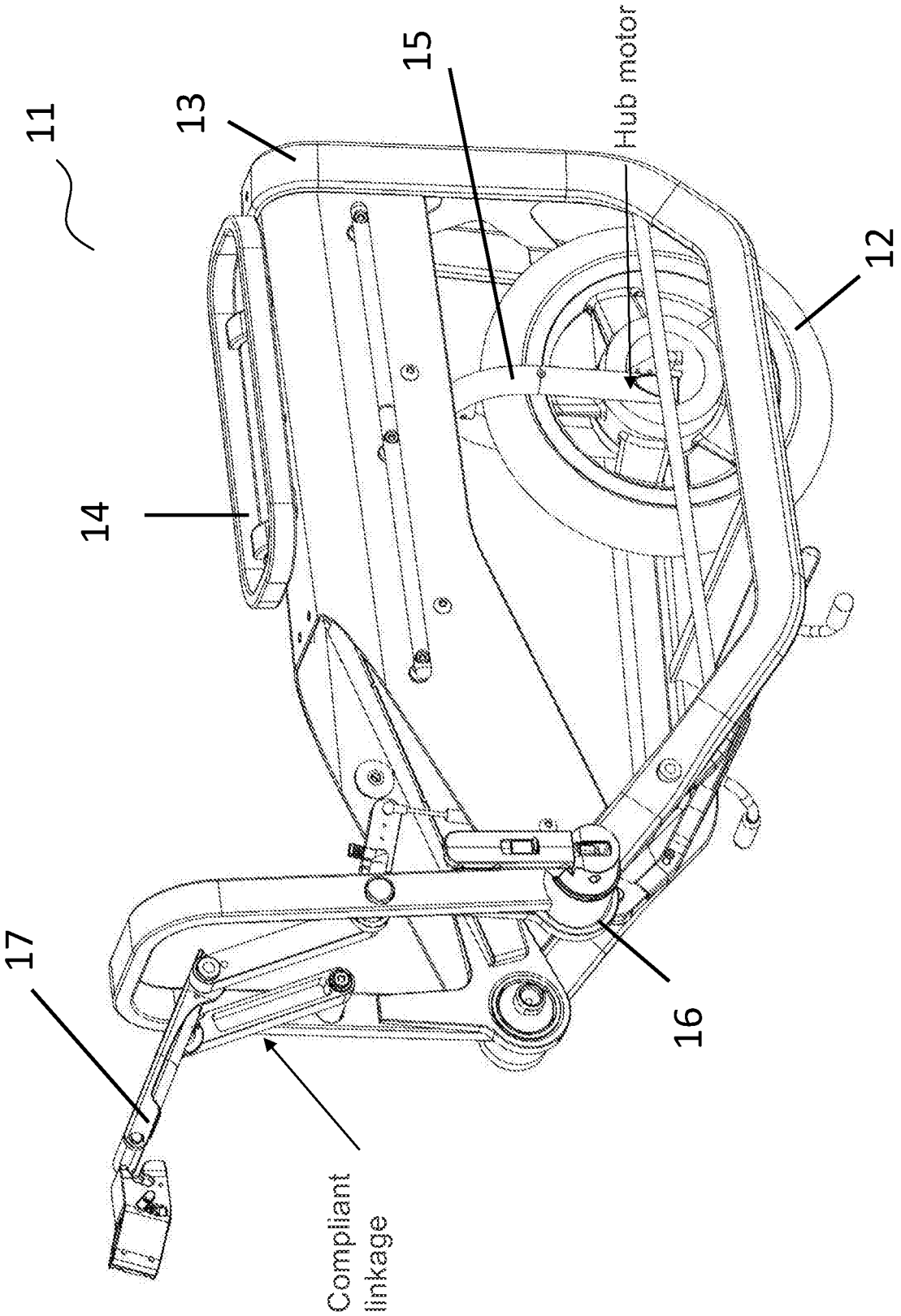


Figure 4

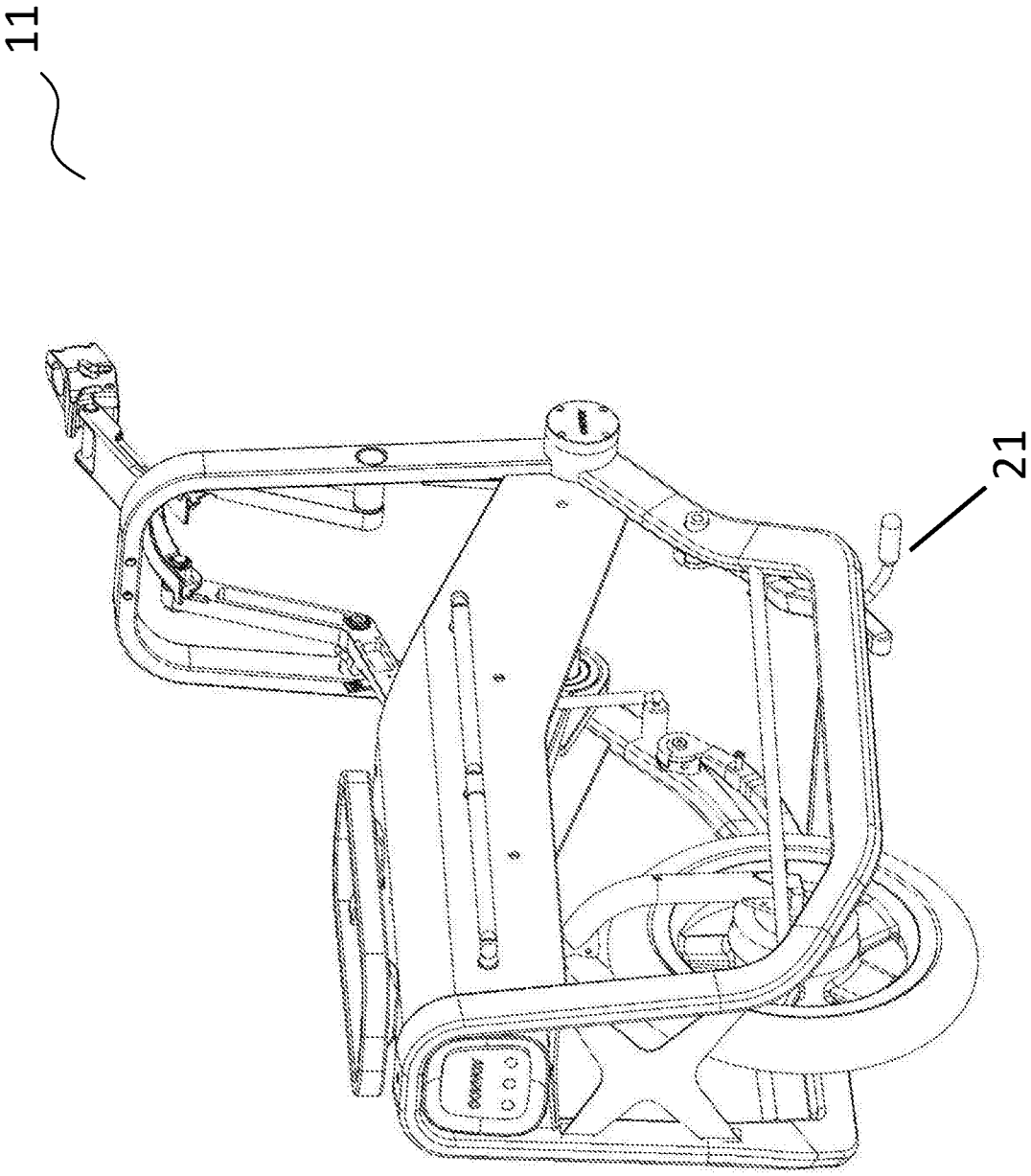


Figure 5

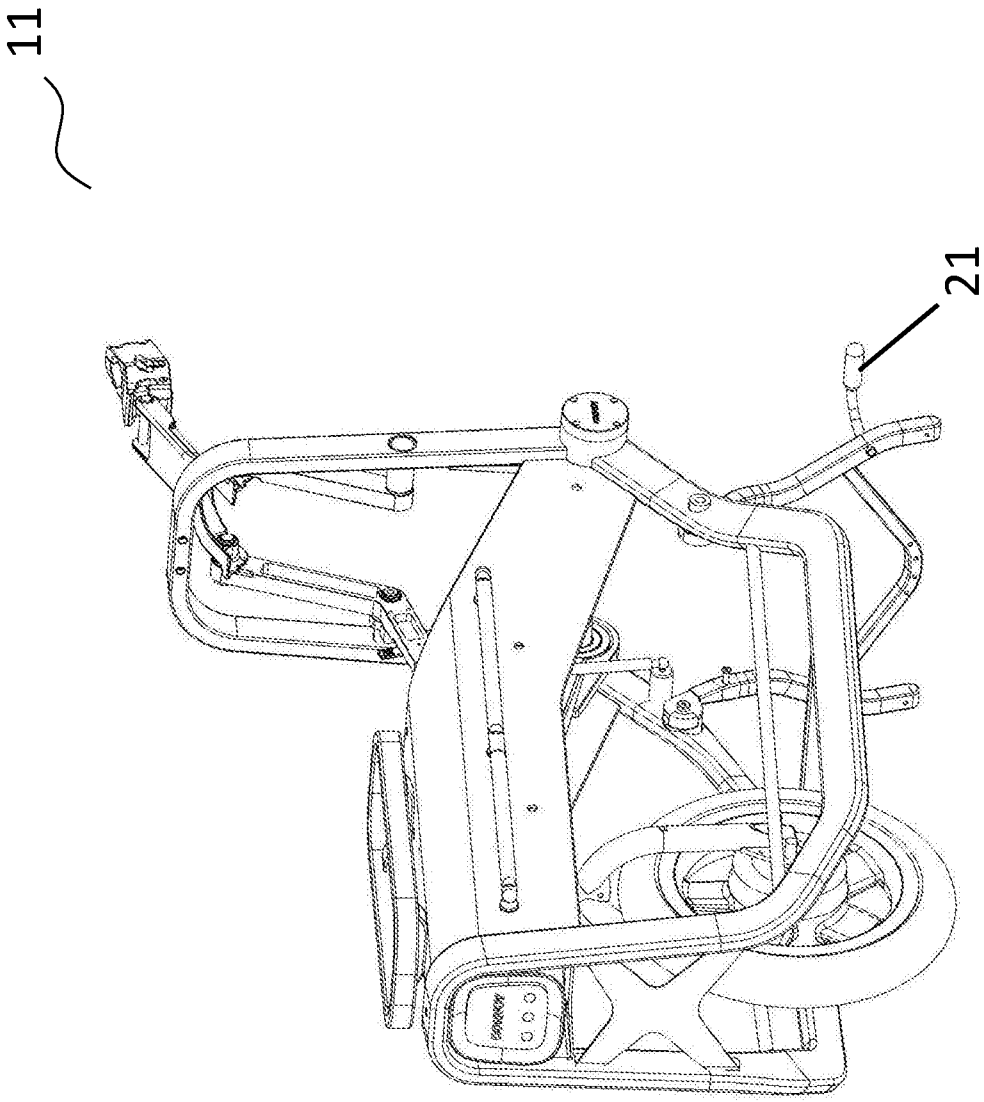


Figure 6

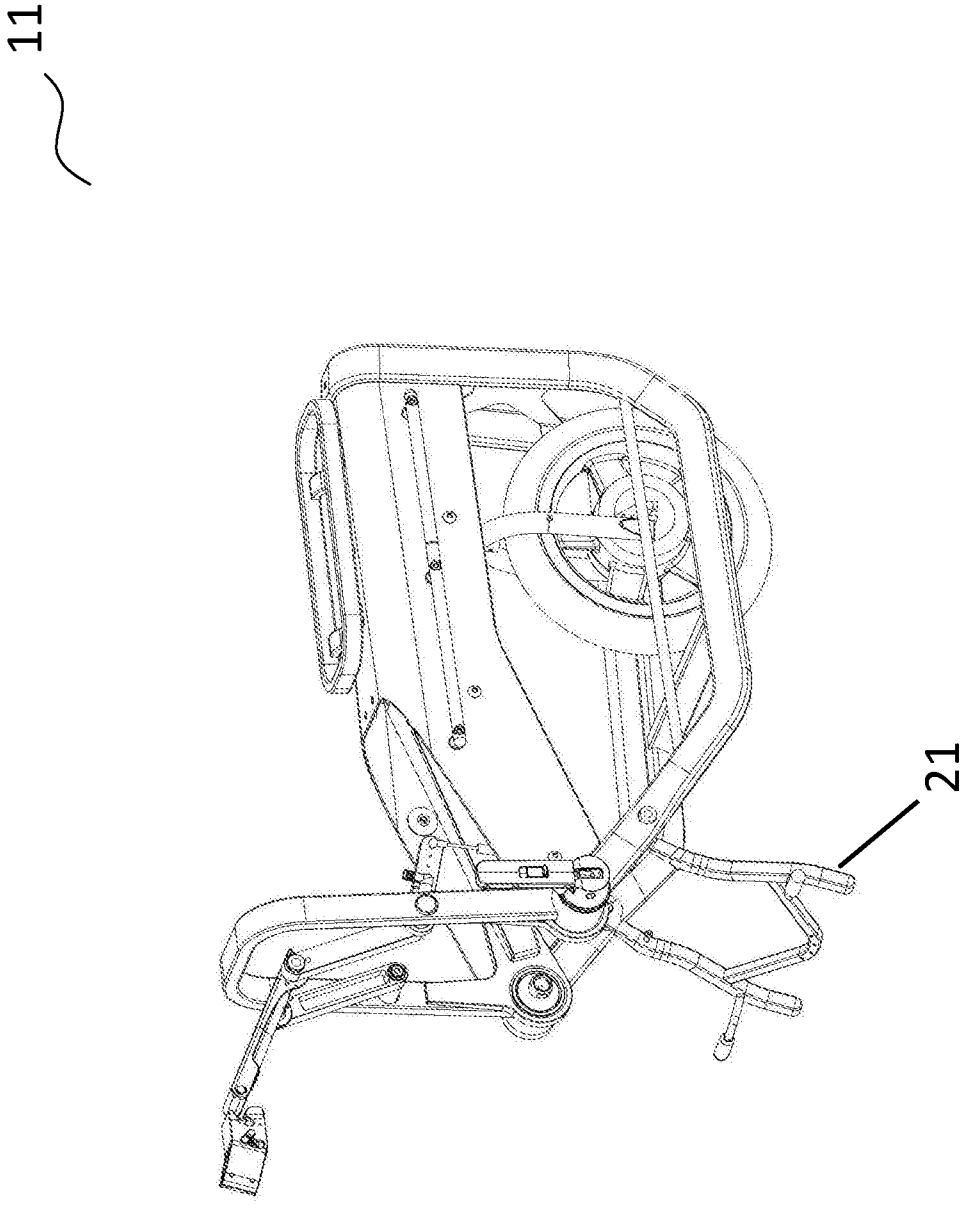


Figure 7

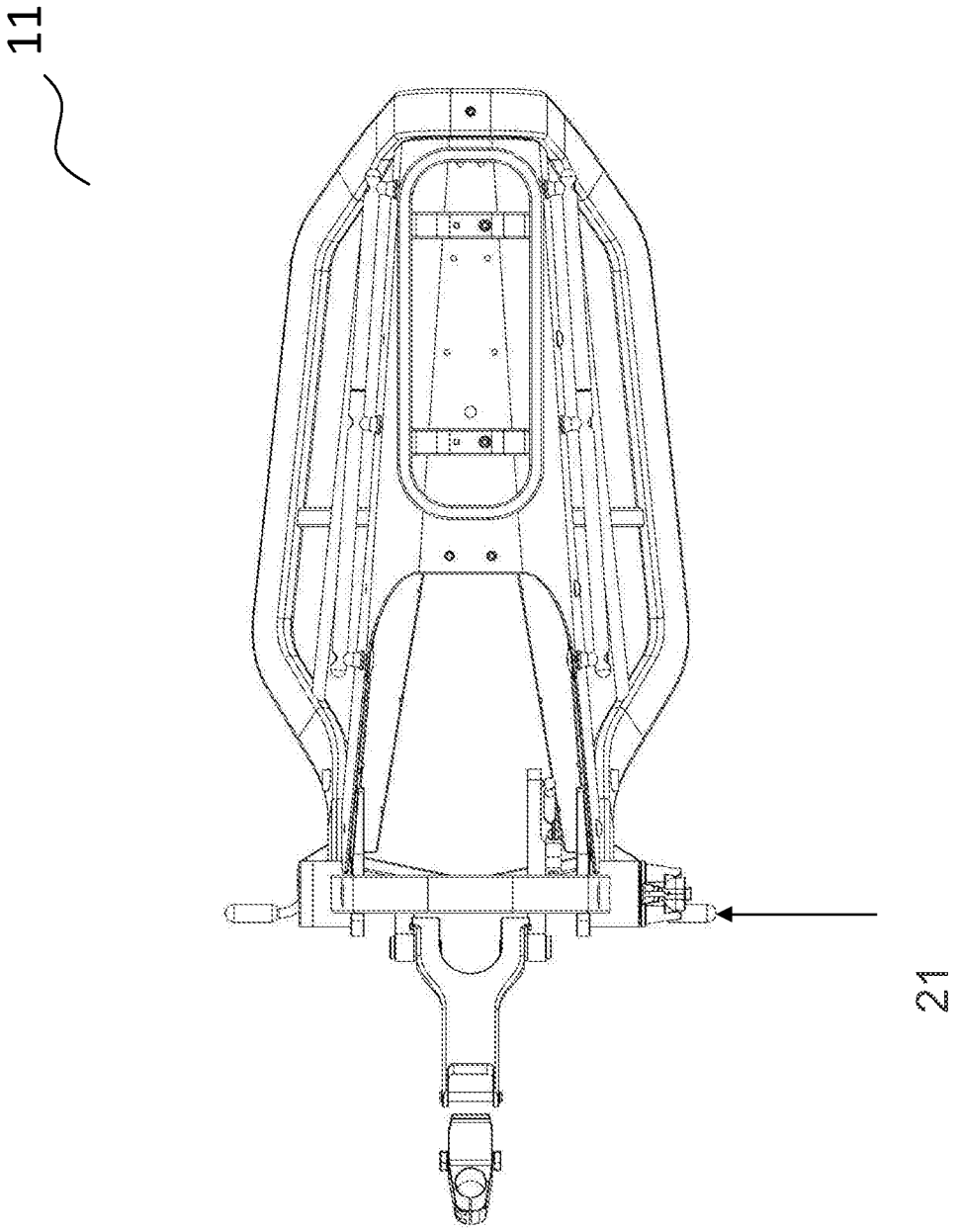


Figure 8

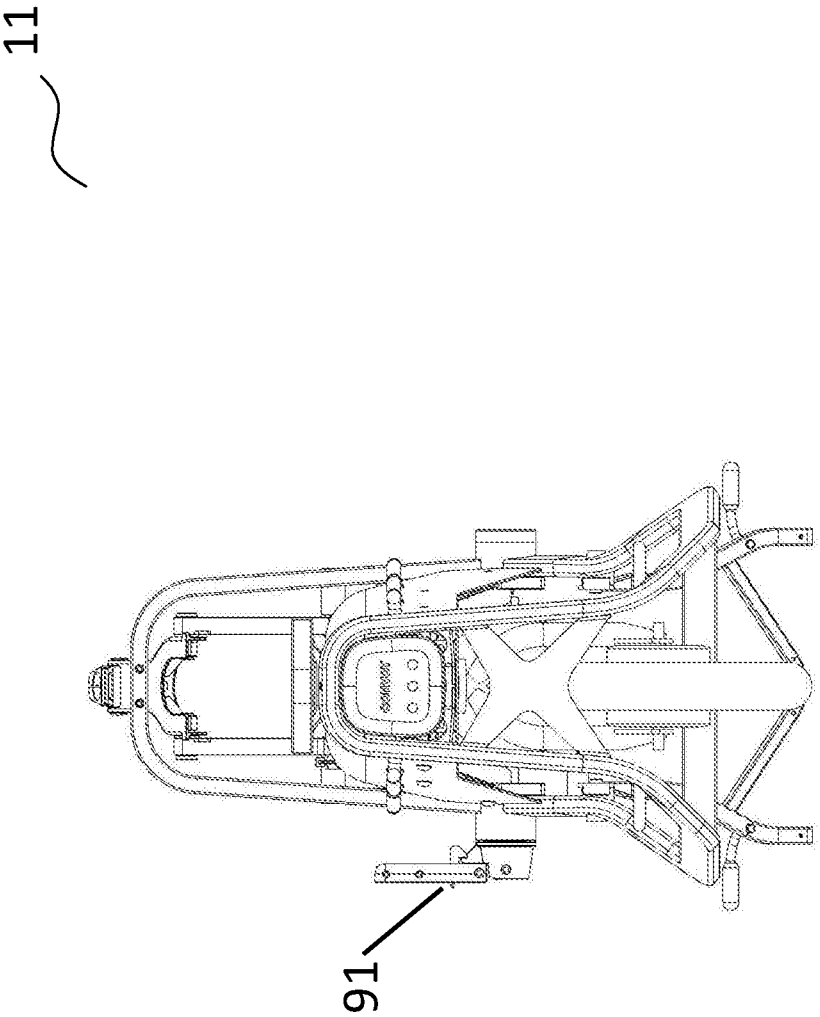


Figure 9

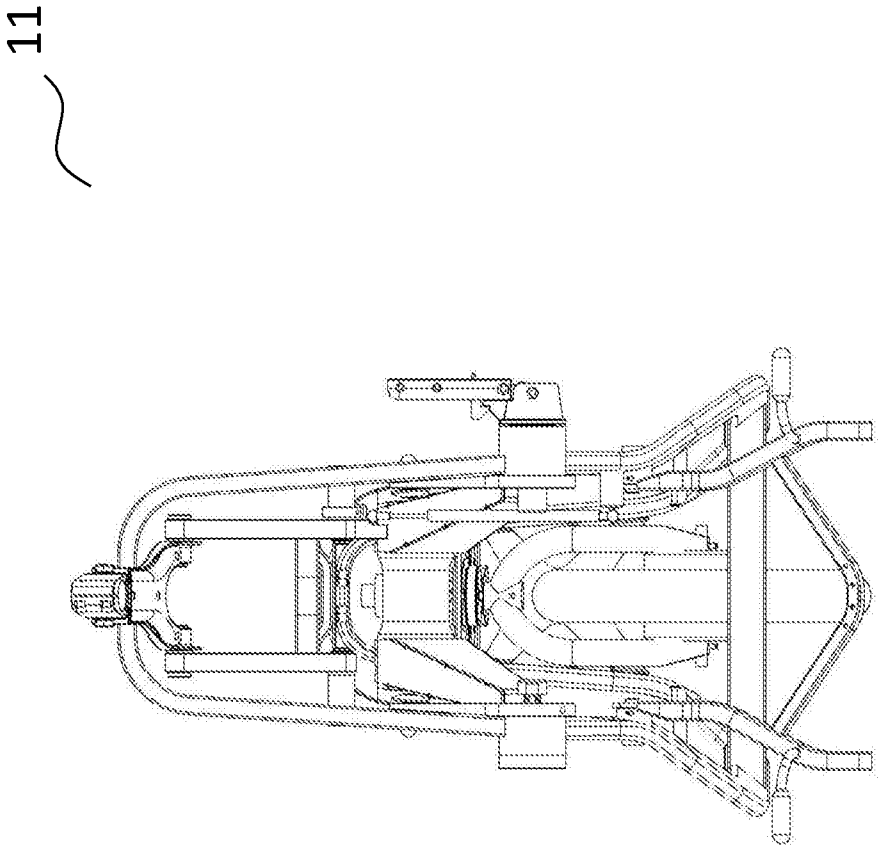


Figure 10

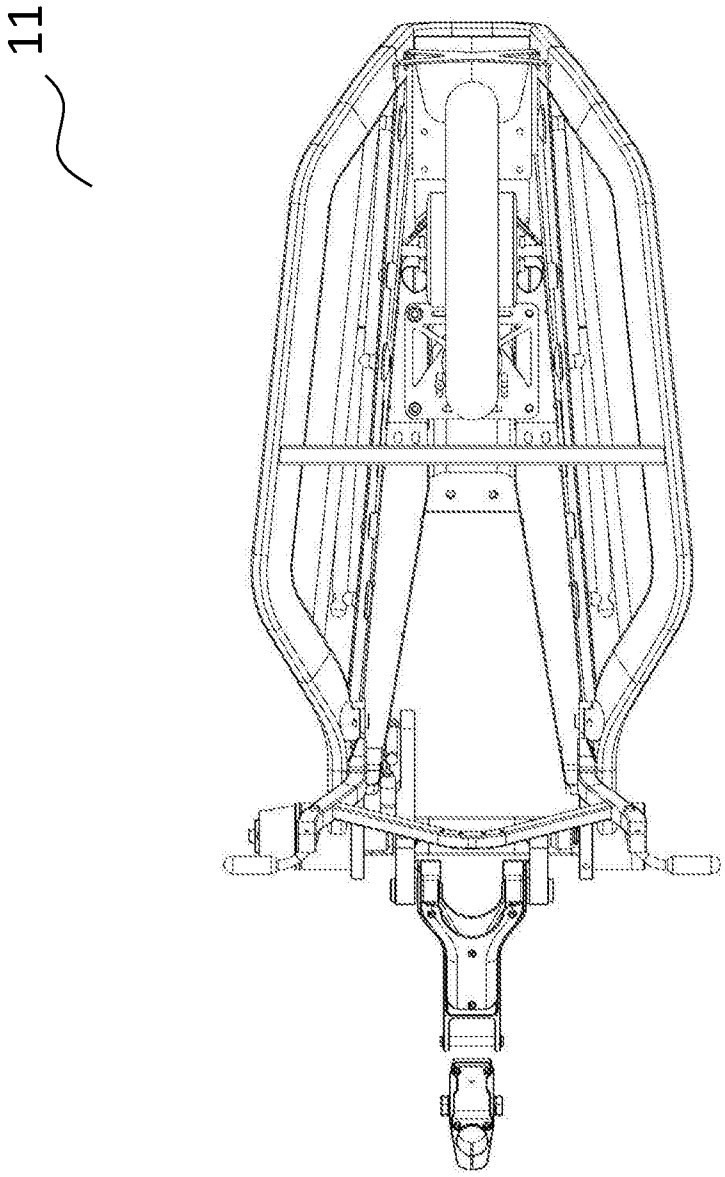


Figure 11

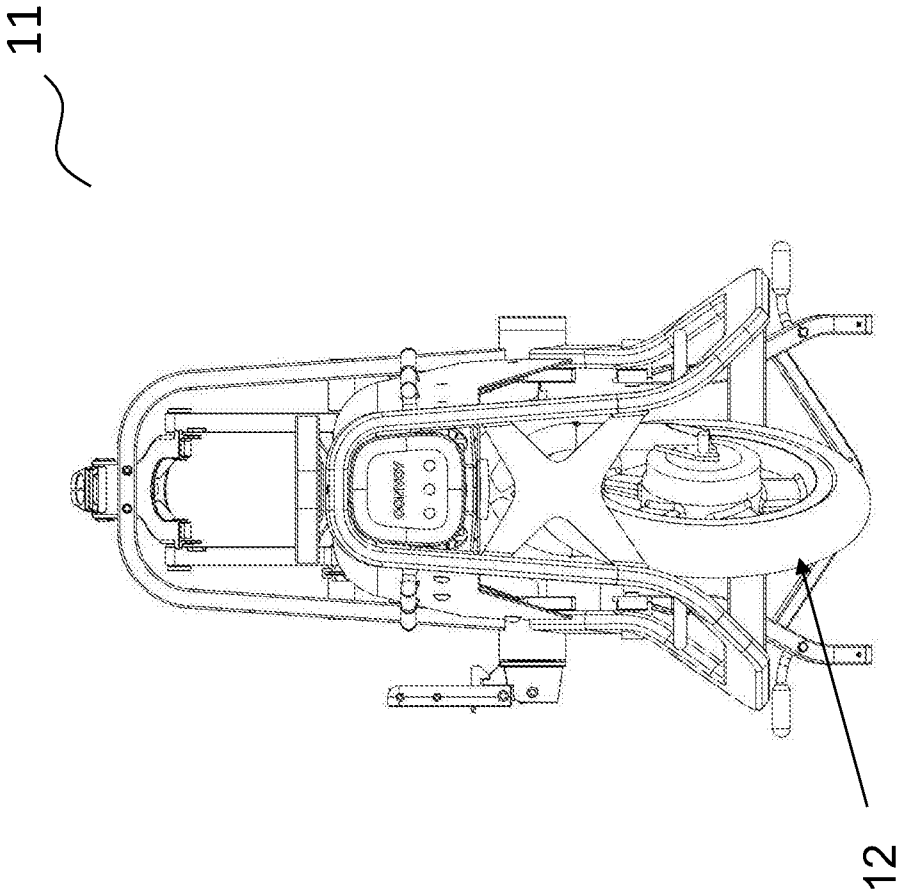


Figure 12

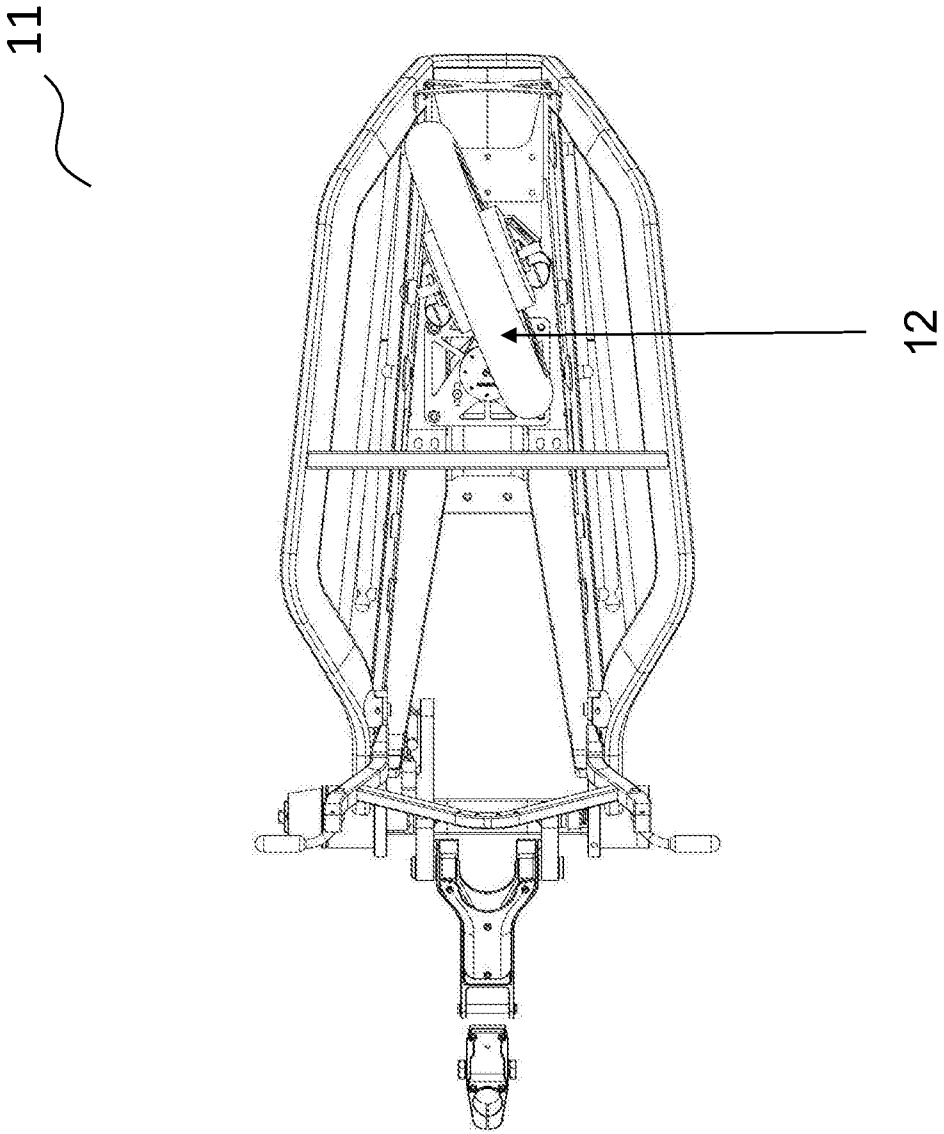


Figure 13

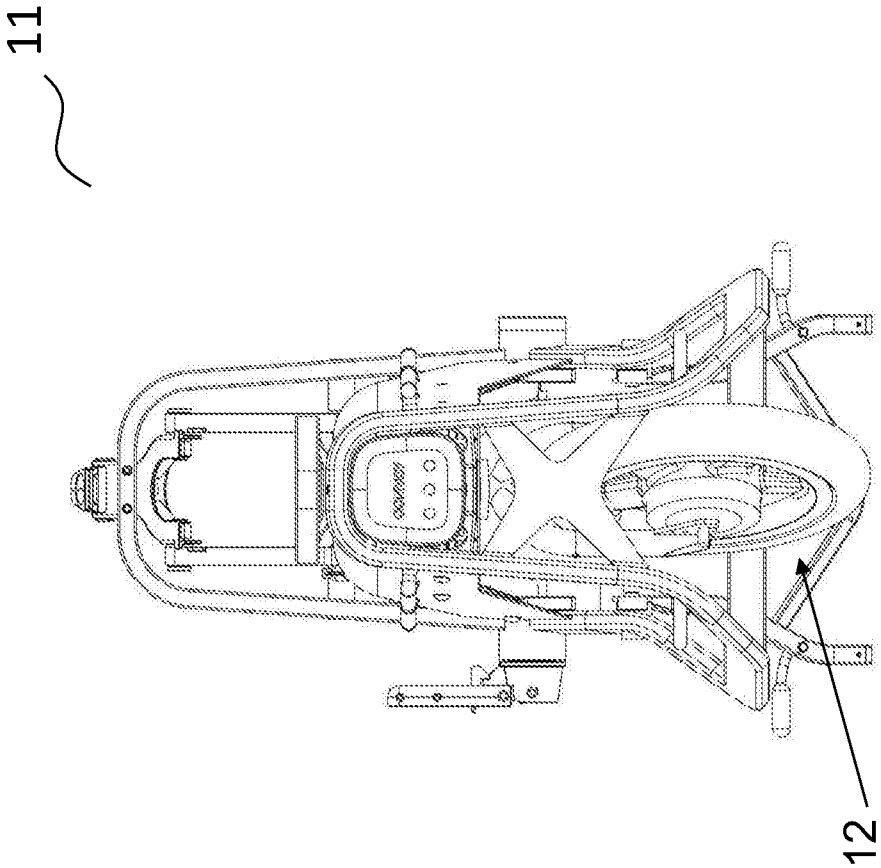


Figure 14

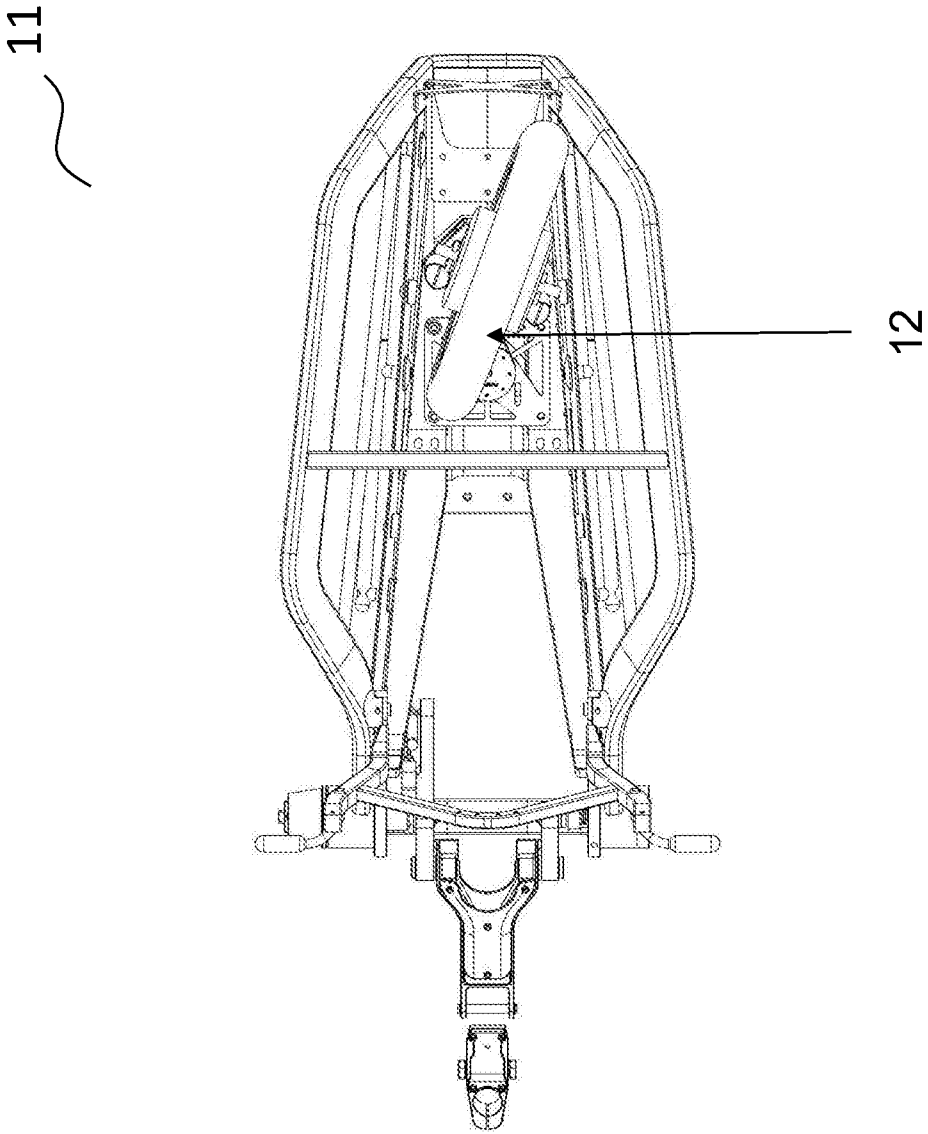


Figure 15

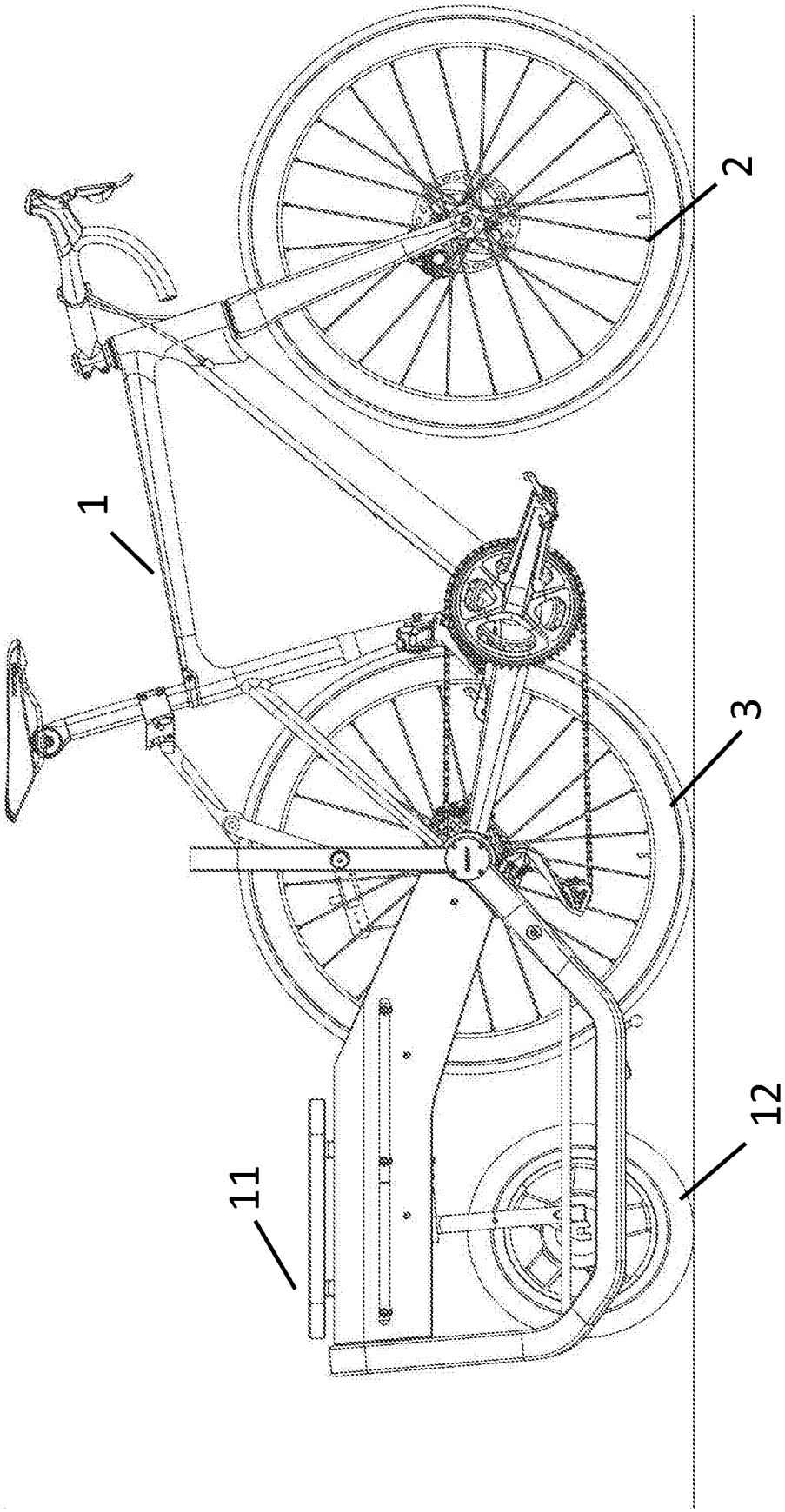


Figure 16

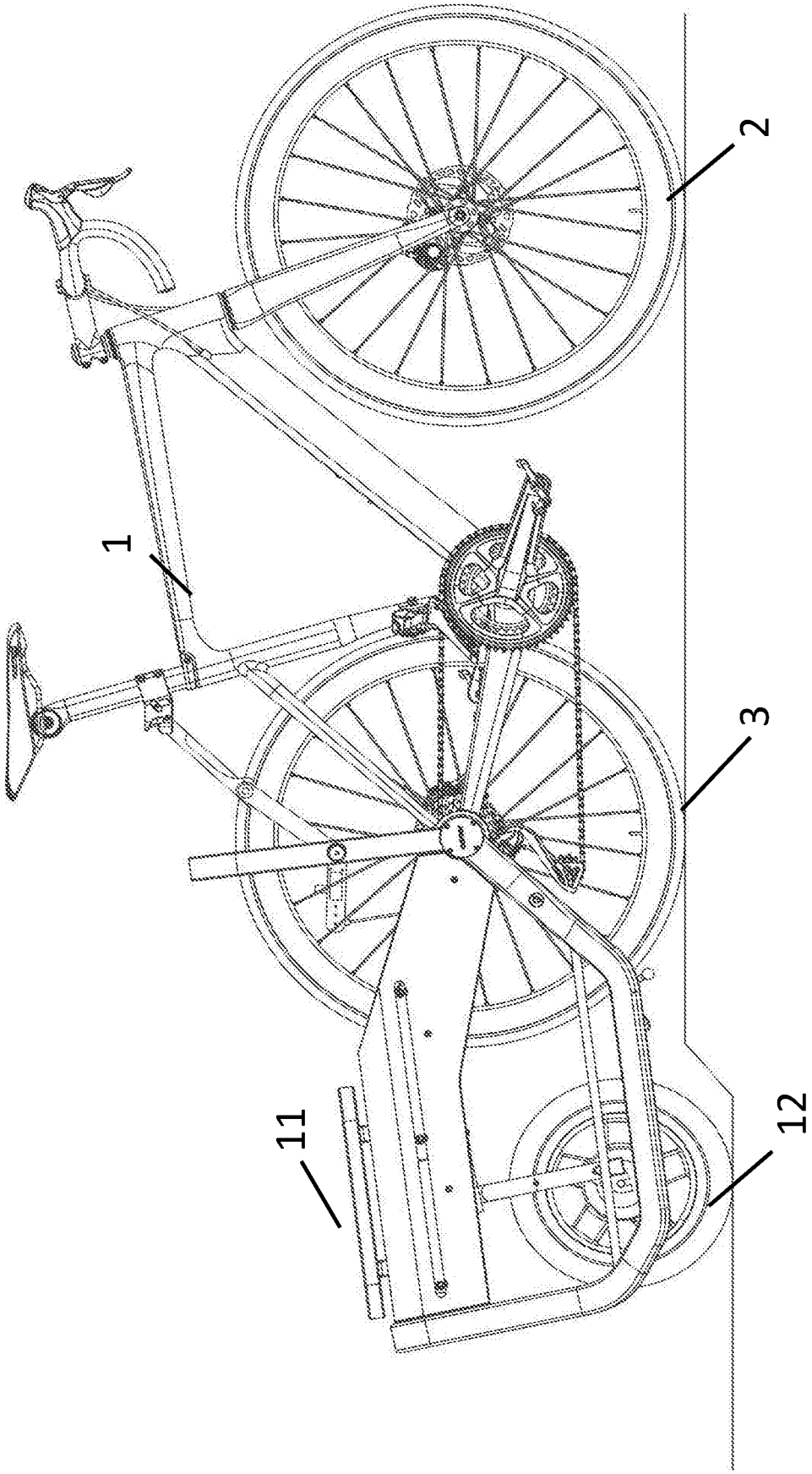


Figure 17

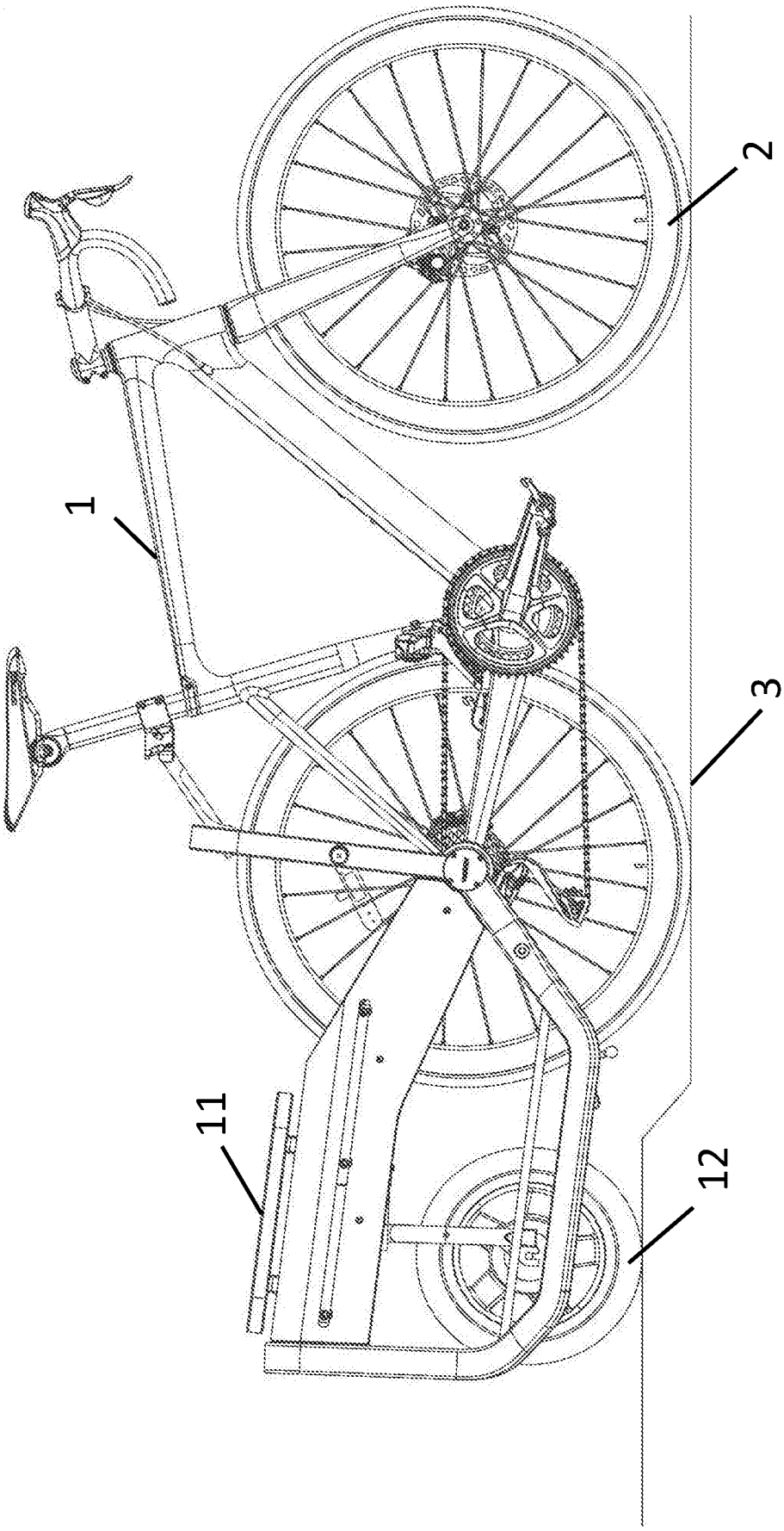


Figure 18

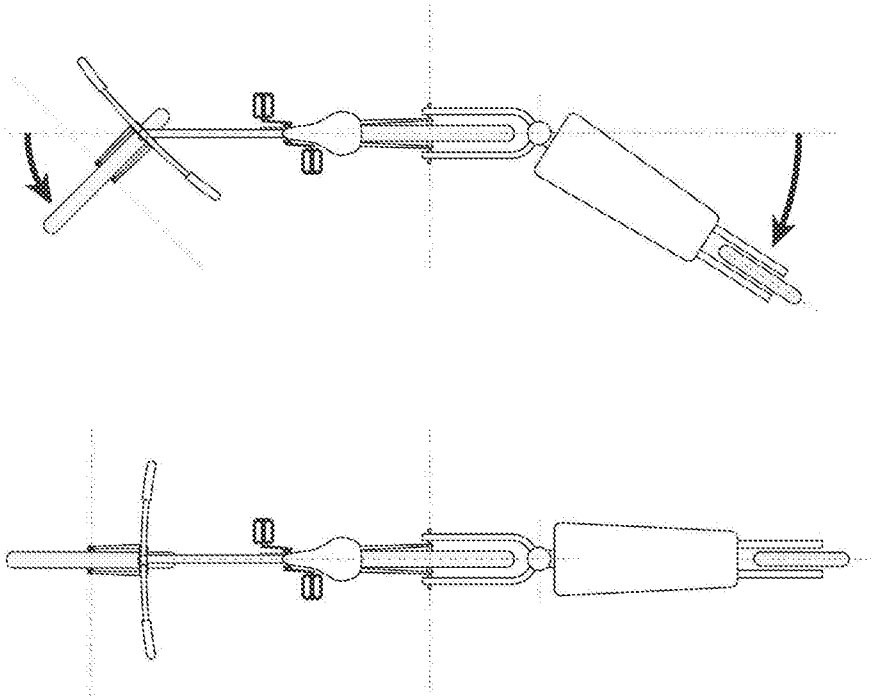


Figure 19

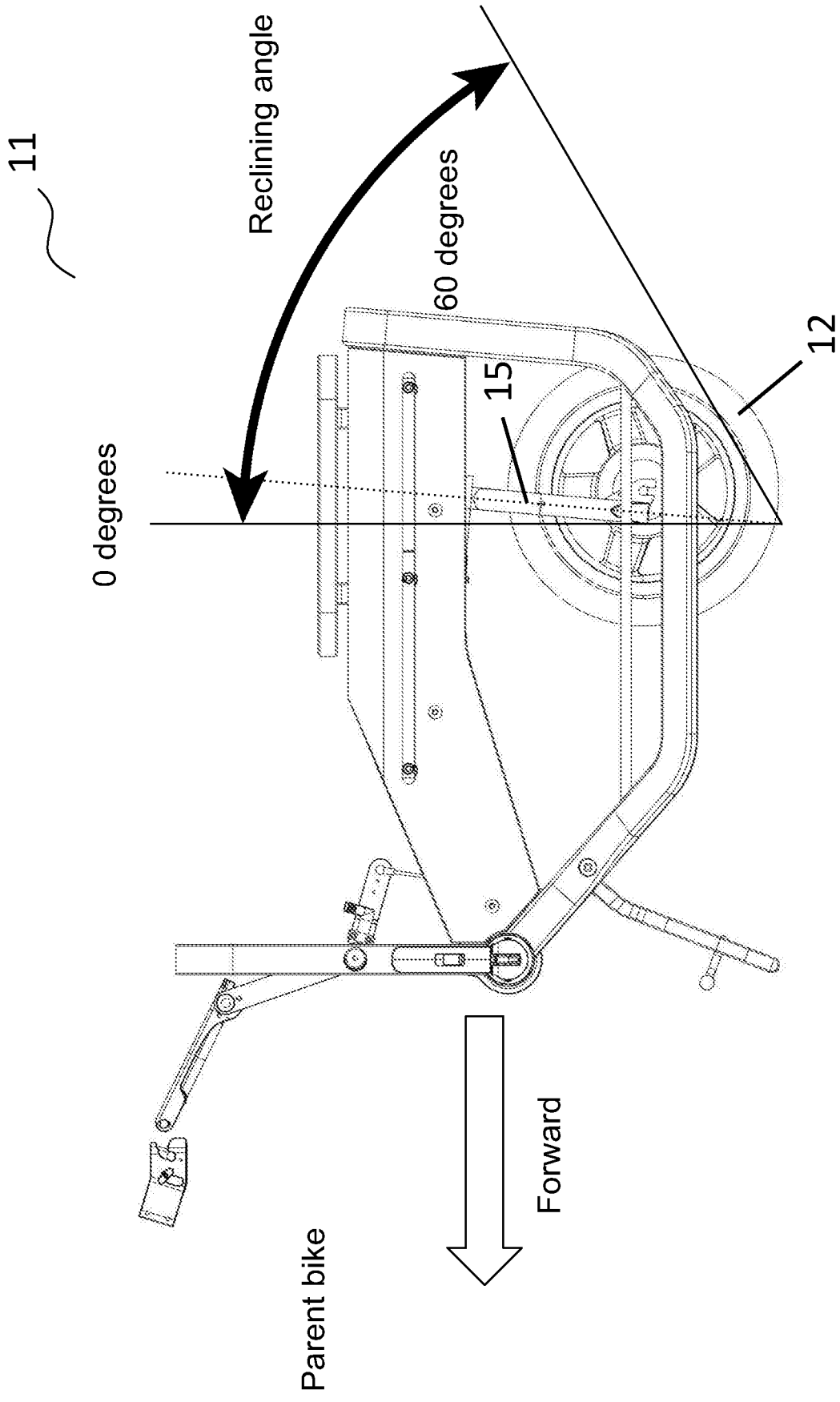

11
Reclining angle
60 degrees
0 degrees
15
12
Forward
Parent bike

Figure 20

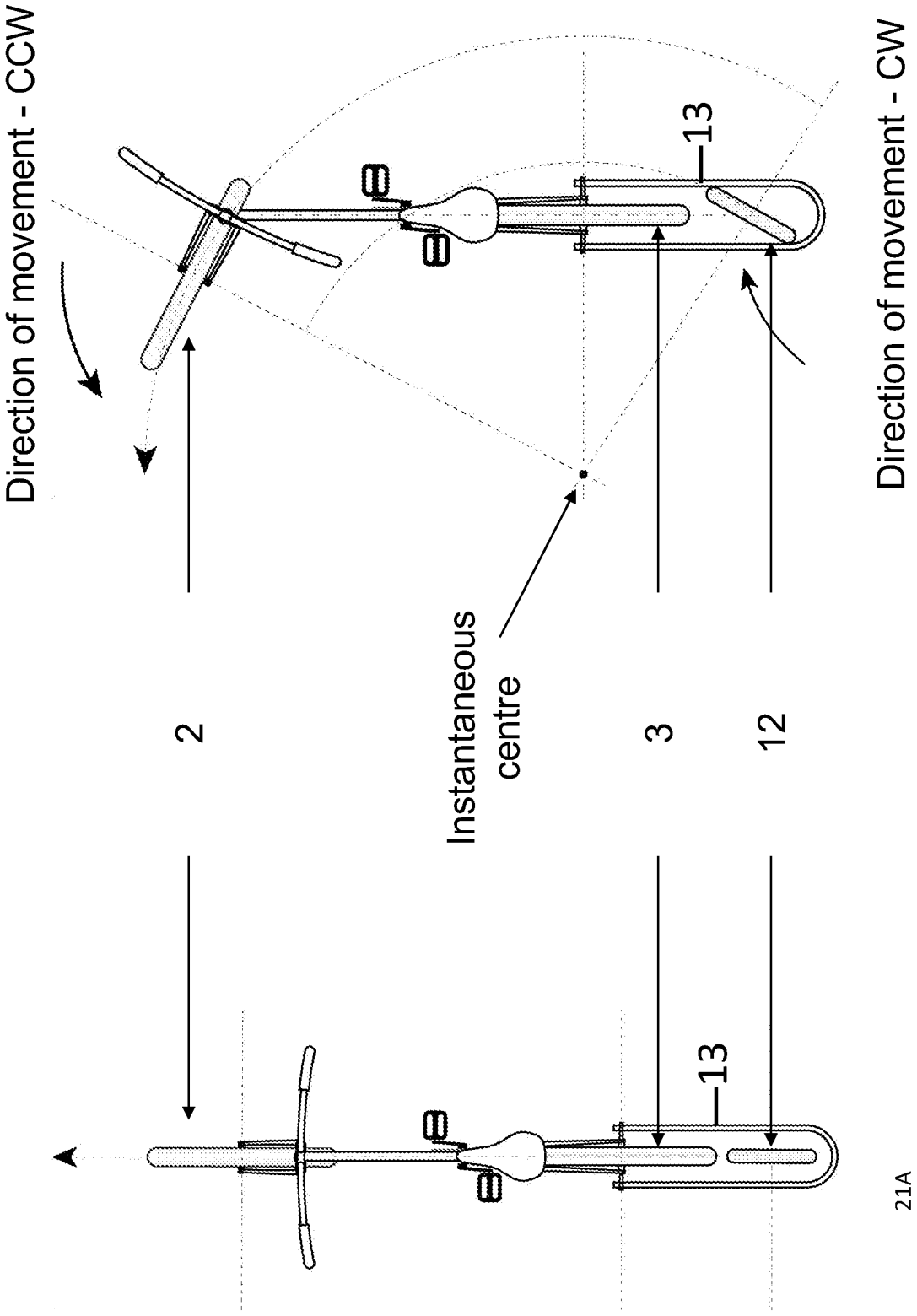

Direction of movement - CCW
Direction of movement - CW
13
13
2
3
12
Instantaneous centre
21A
21B

Figure 21

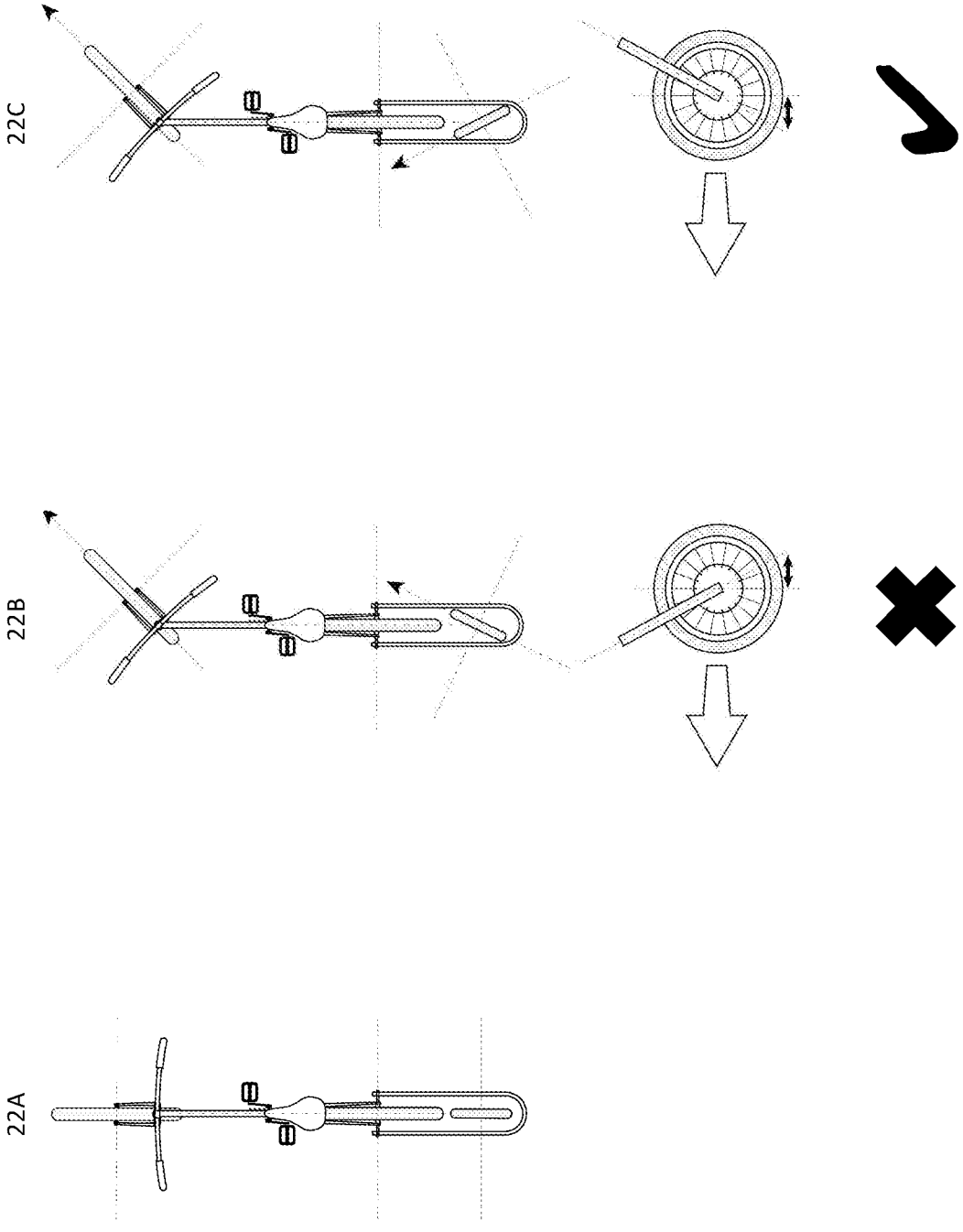


Figure 22

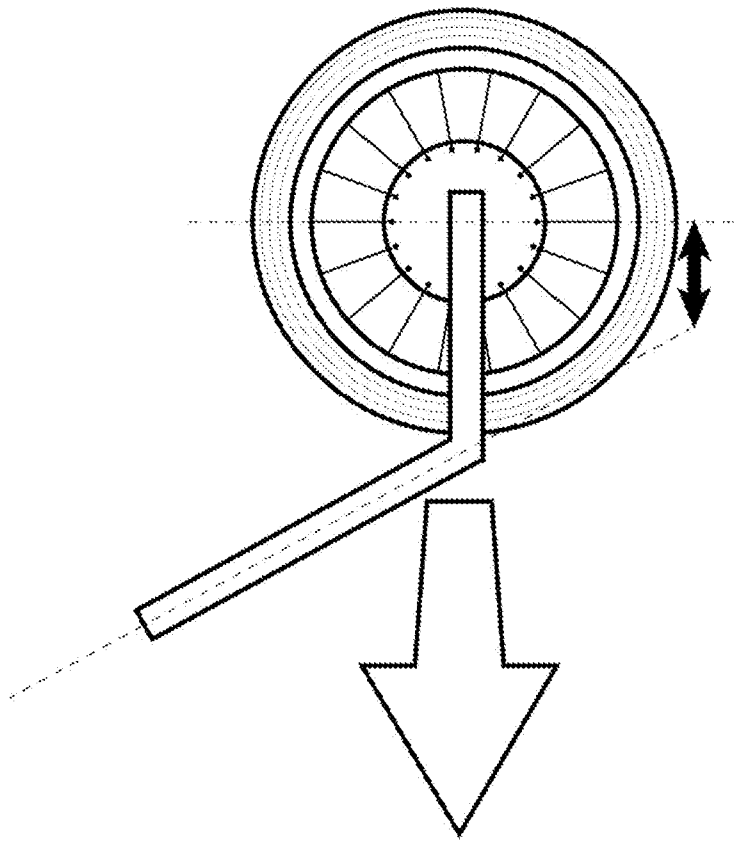


Figure 23

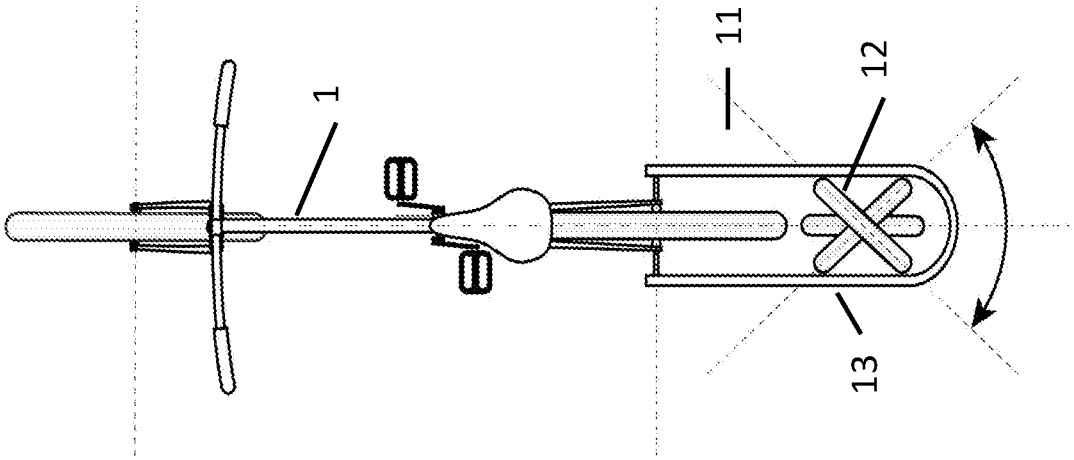


Figure 24

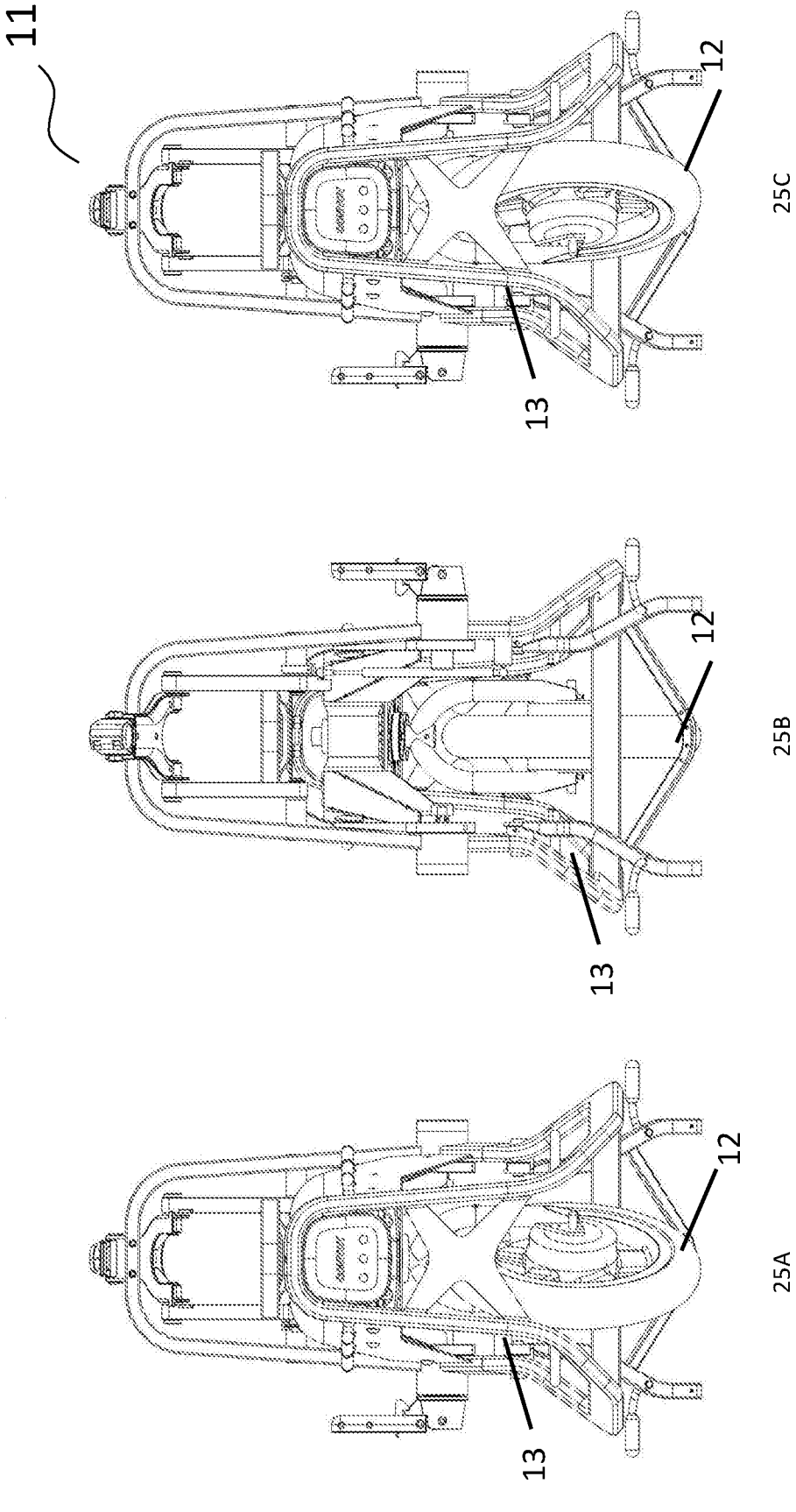


Figure 25

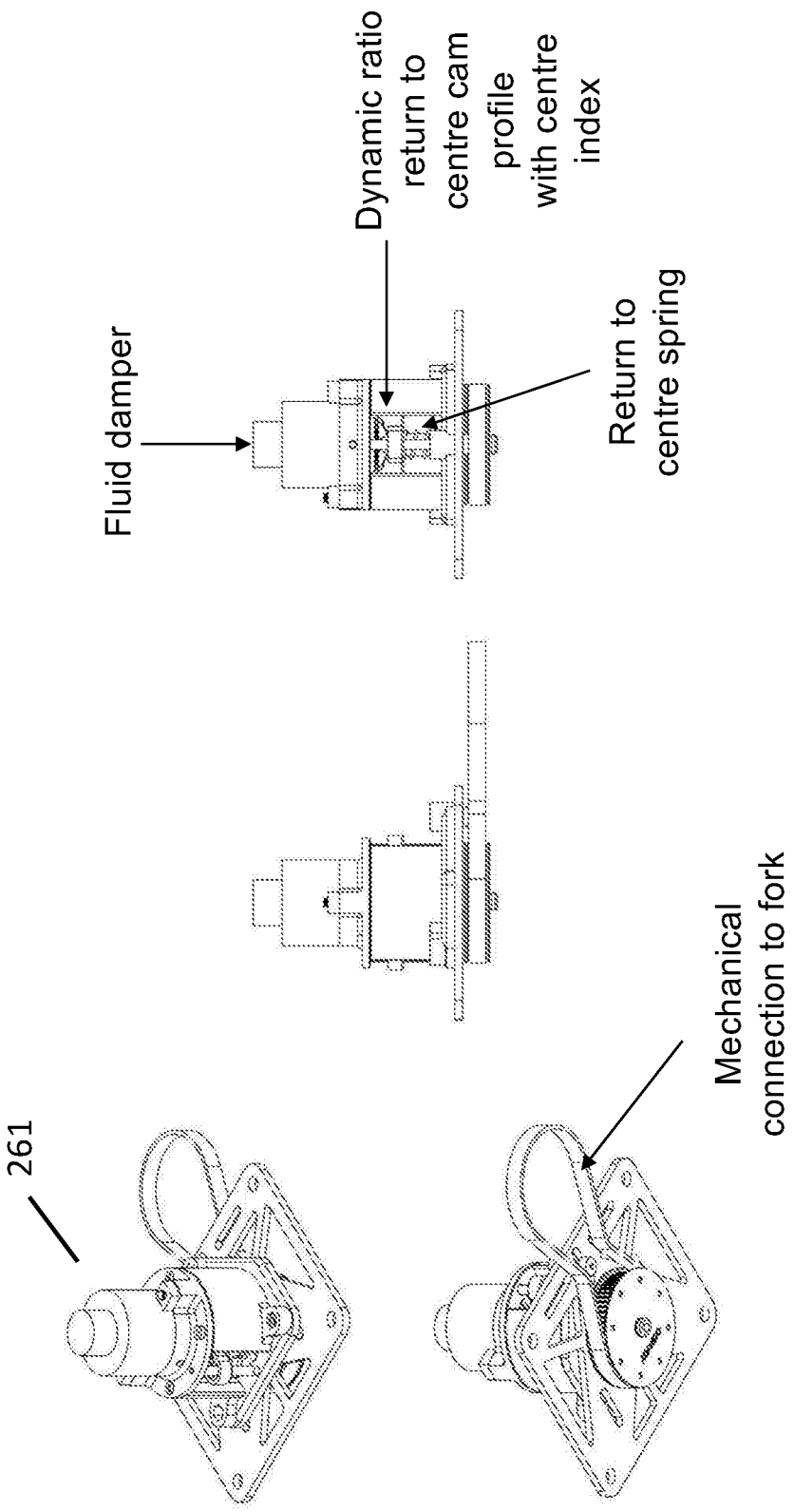

Dynamic ratio return to centre cam profile with centre index
Fluid damper
Return to centre spring
261
Mechanical connection to fork

Figure 26

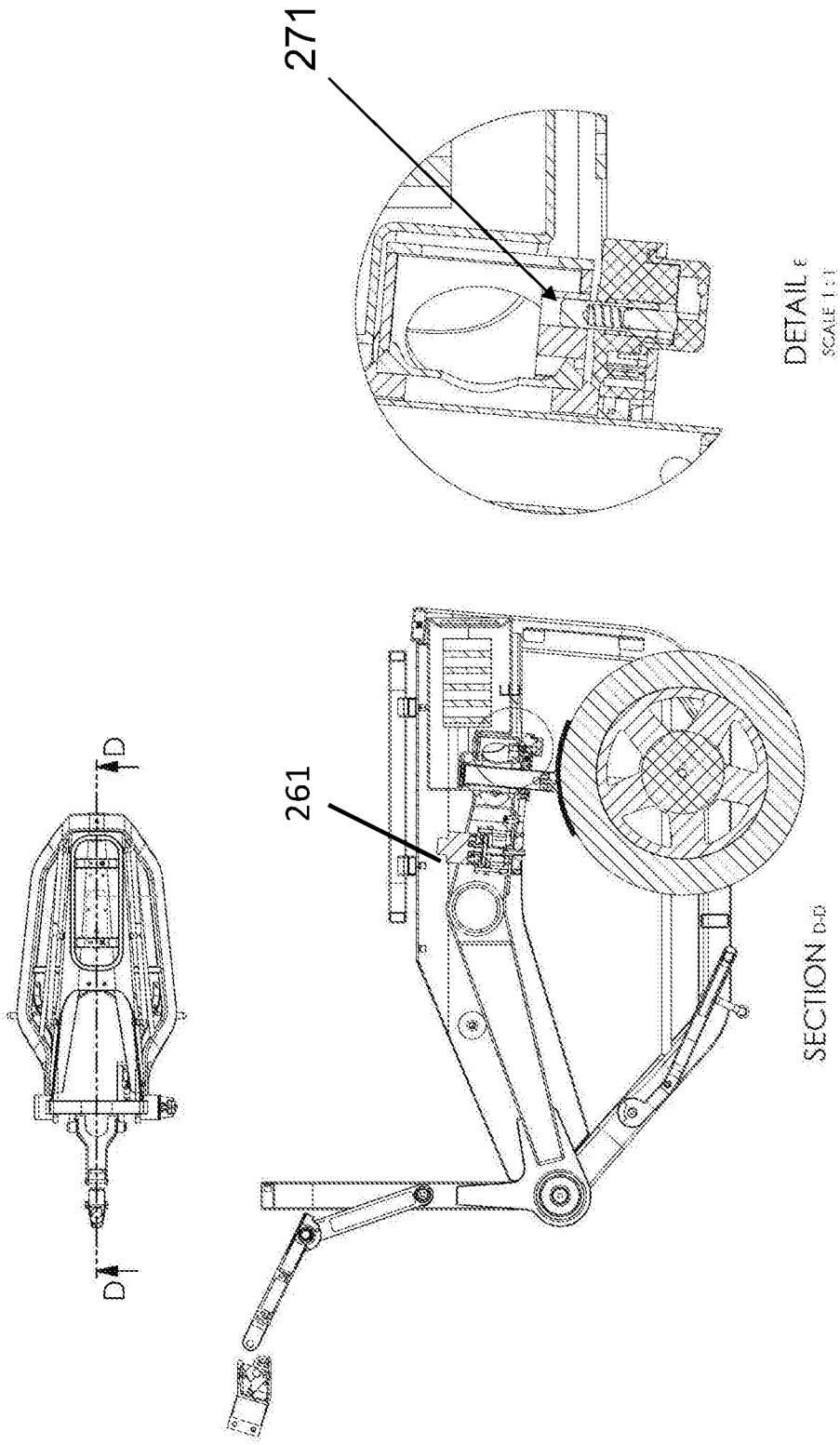


Figure 27

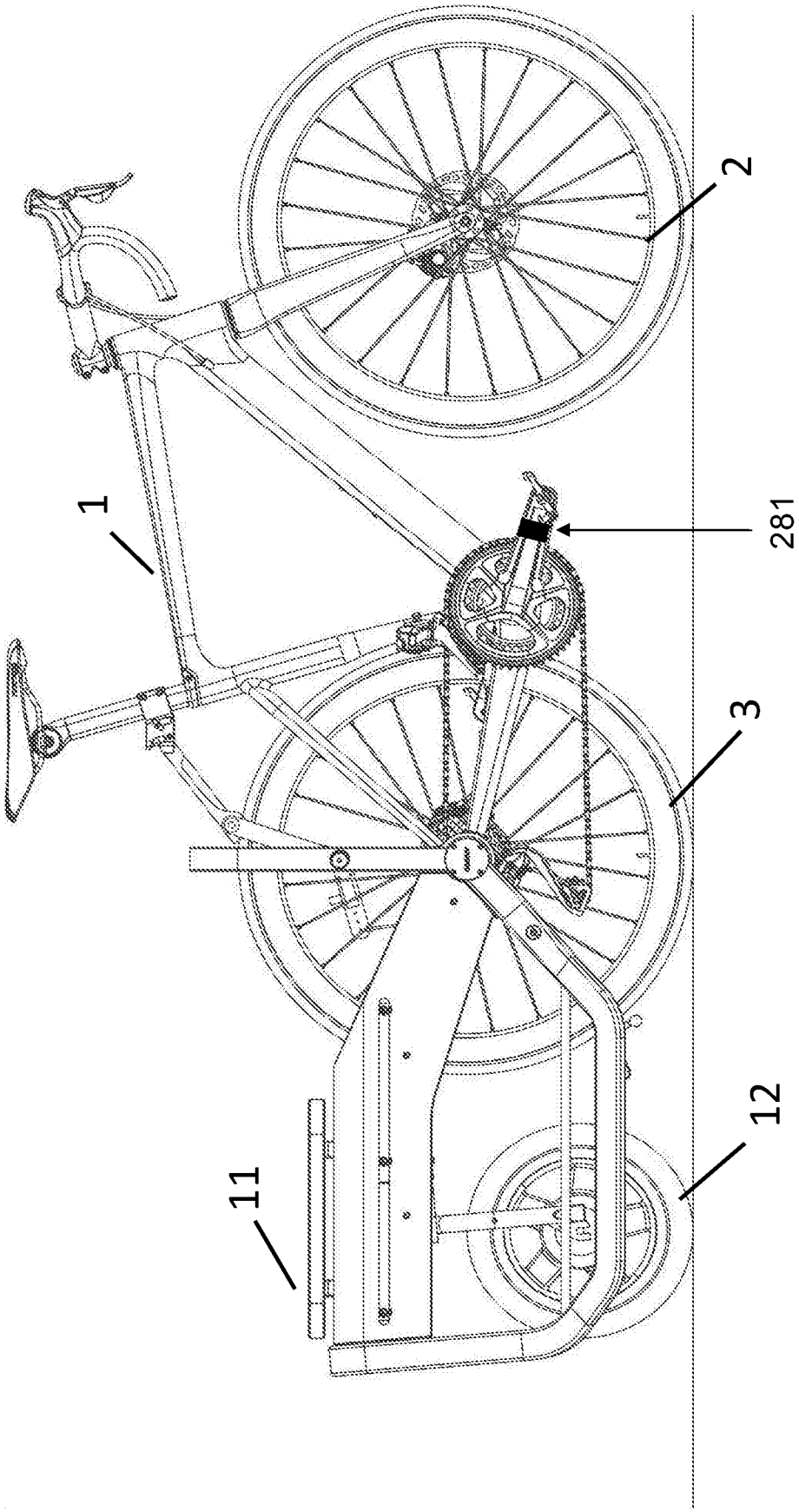
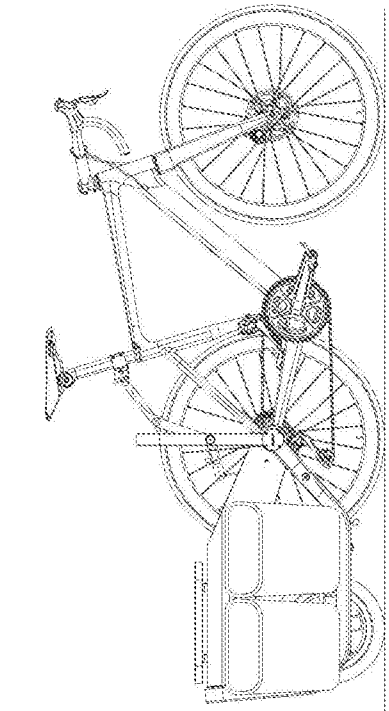
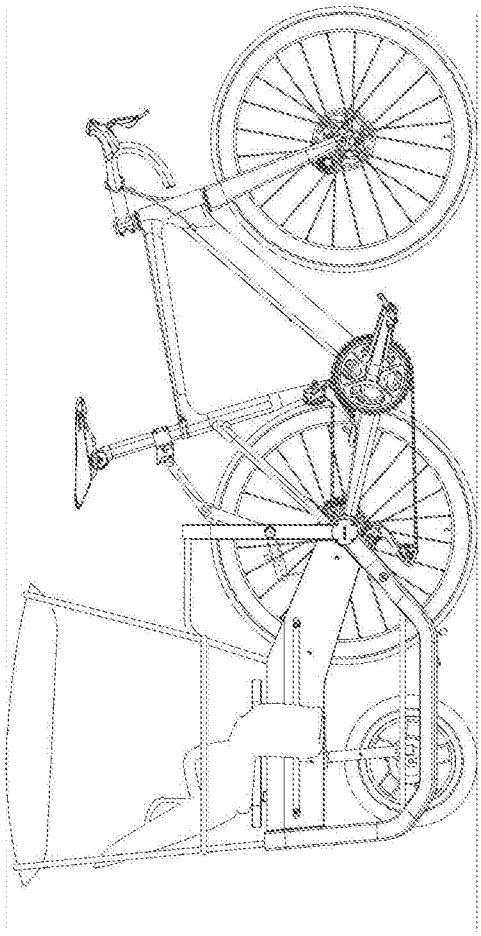


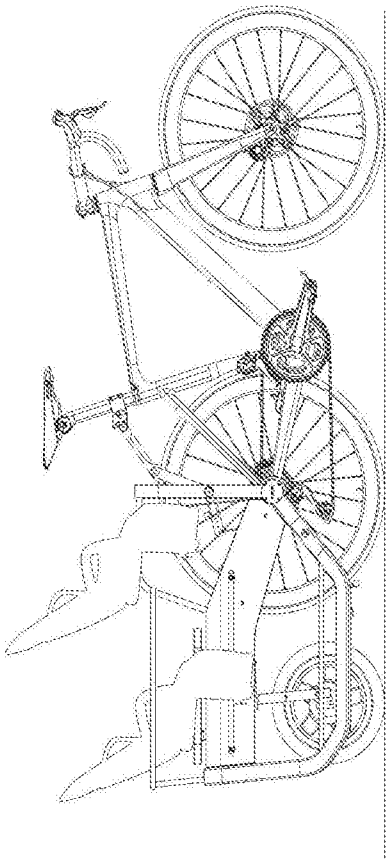
Figure 28



29B



29C



29A

Figure 29

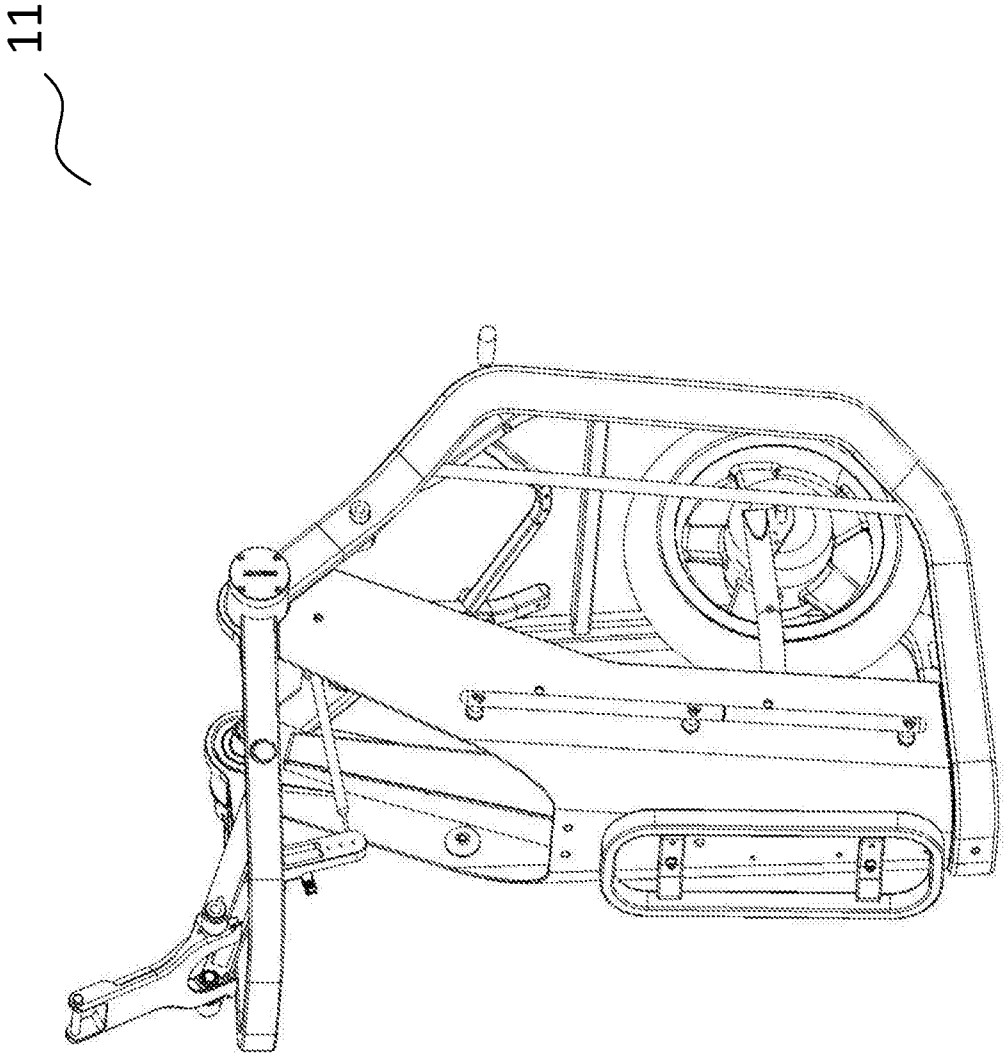


Figure 30

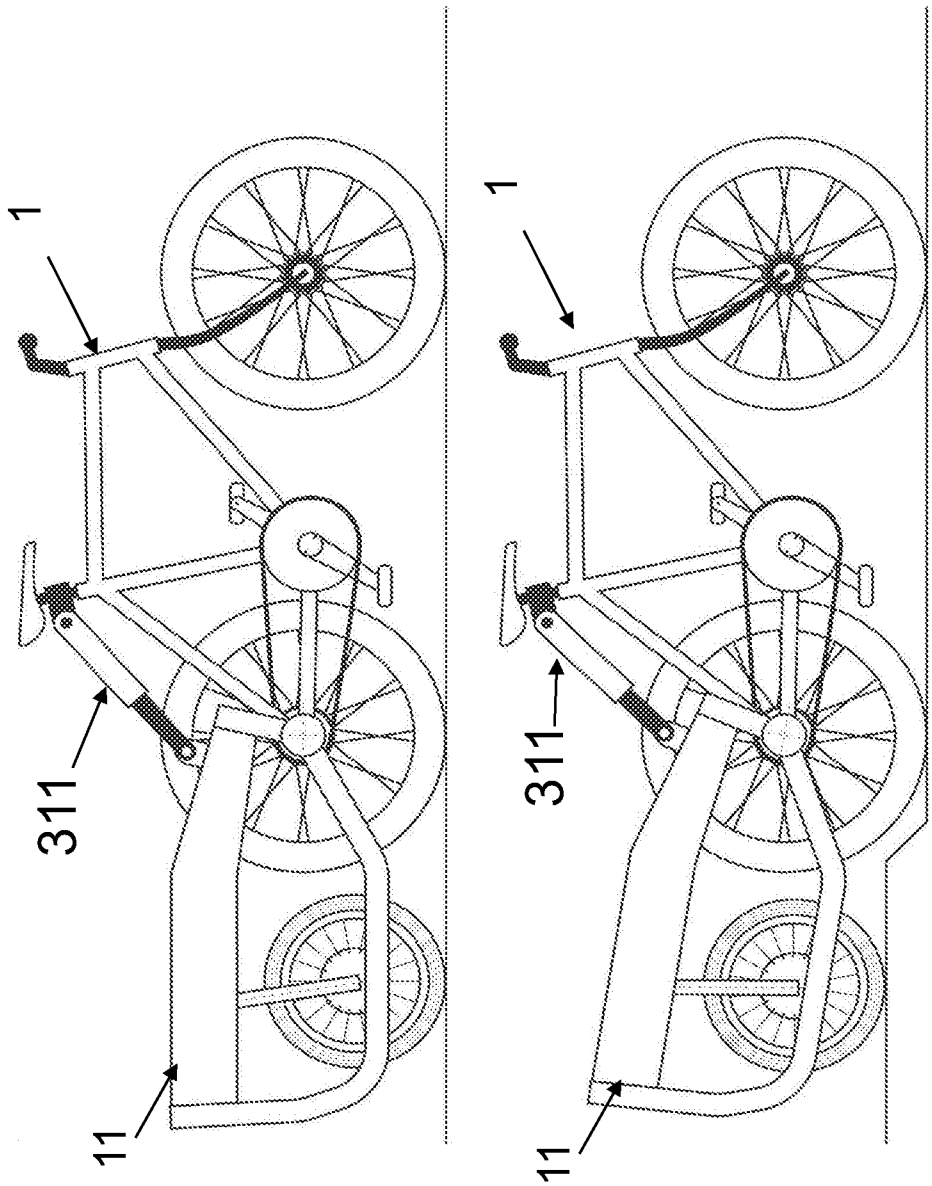


Figure 31

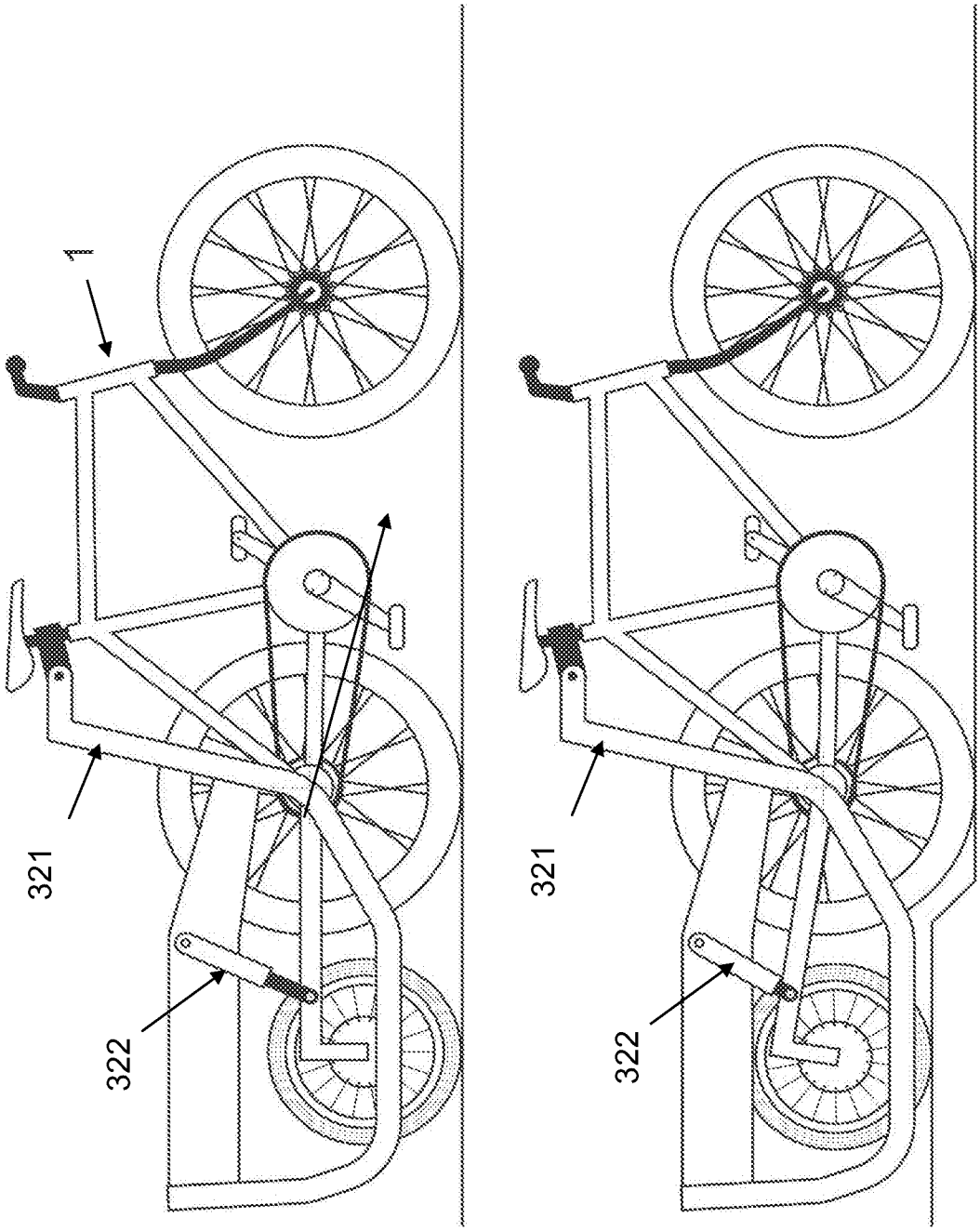


Figure 32

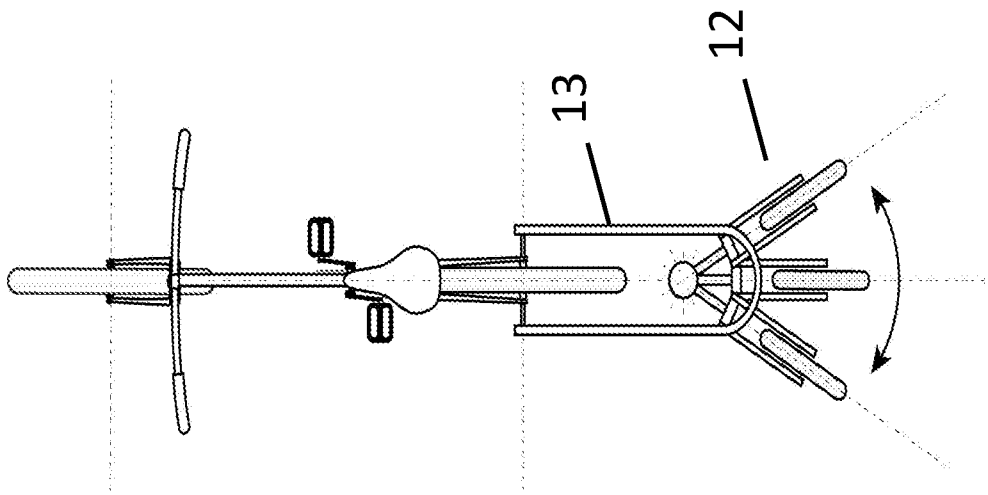


Figure 33

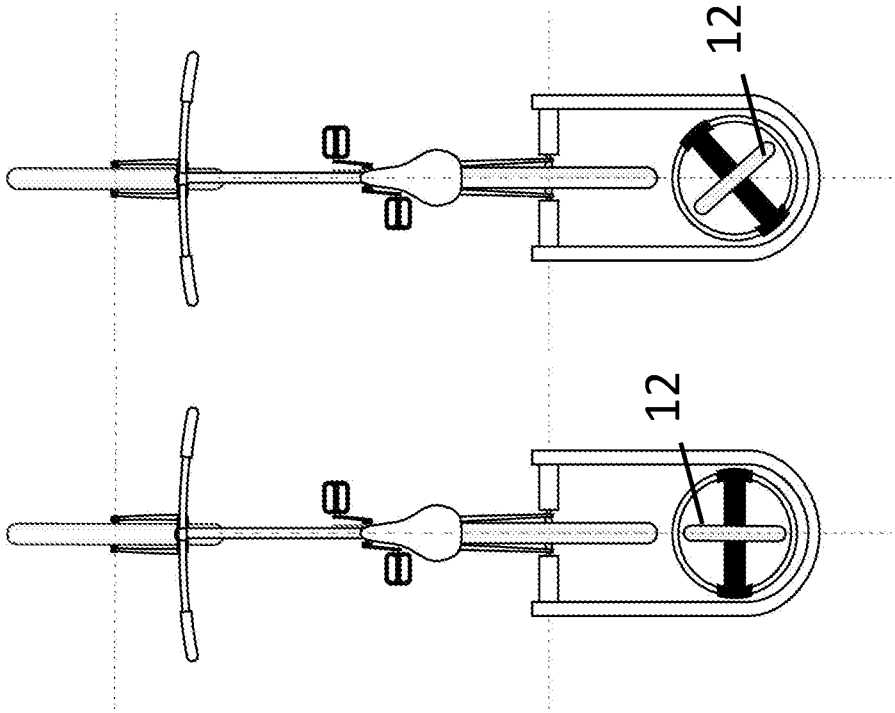


Figure 34

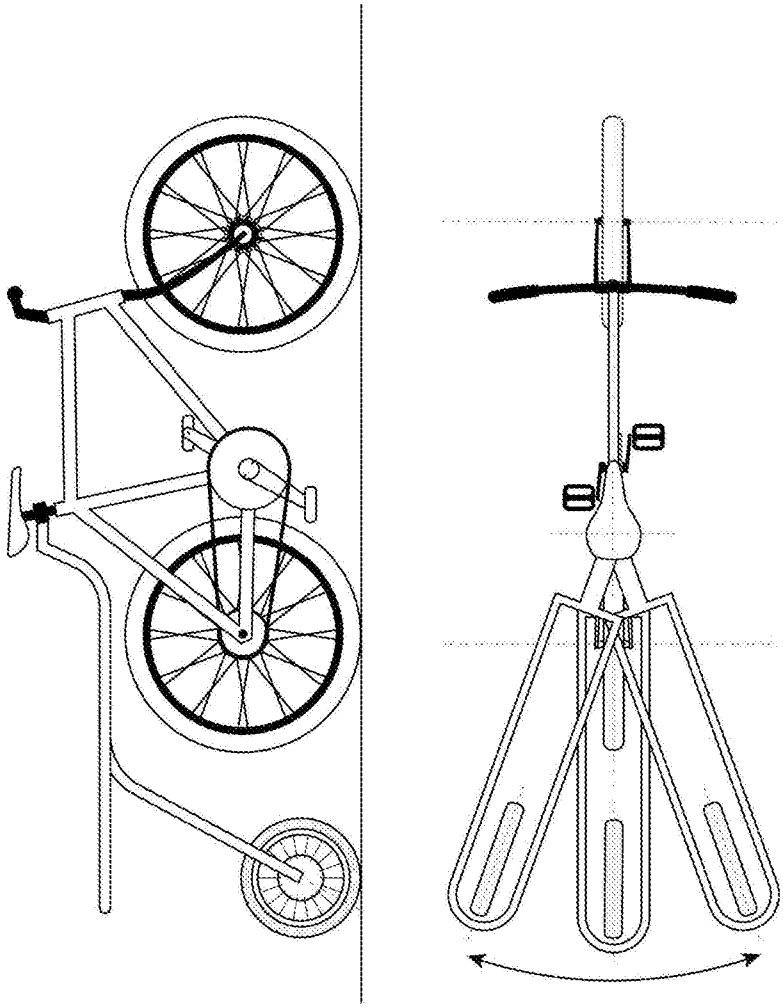


Figure 35

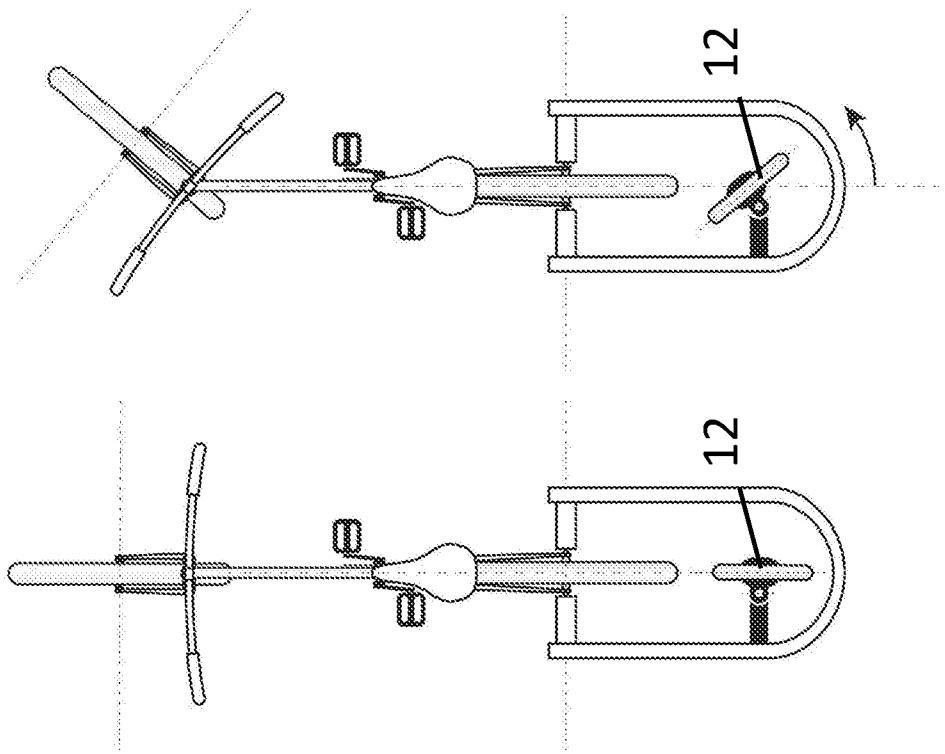


Figure 36

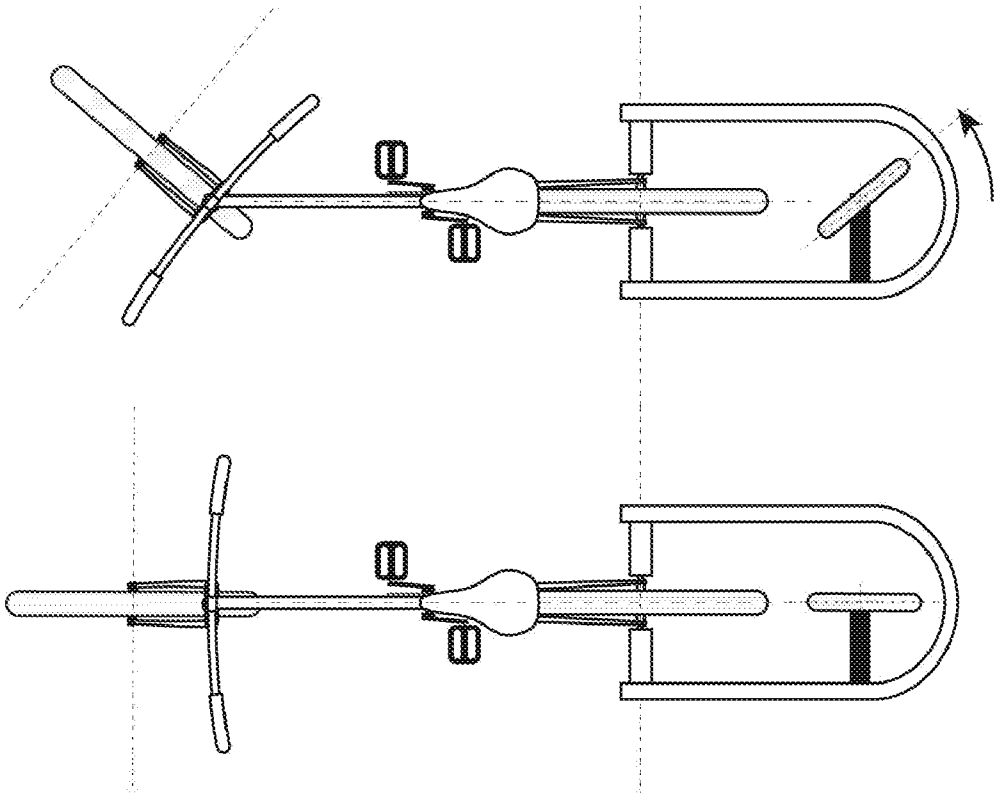


Figure 37

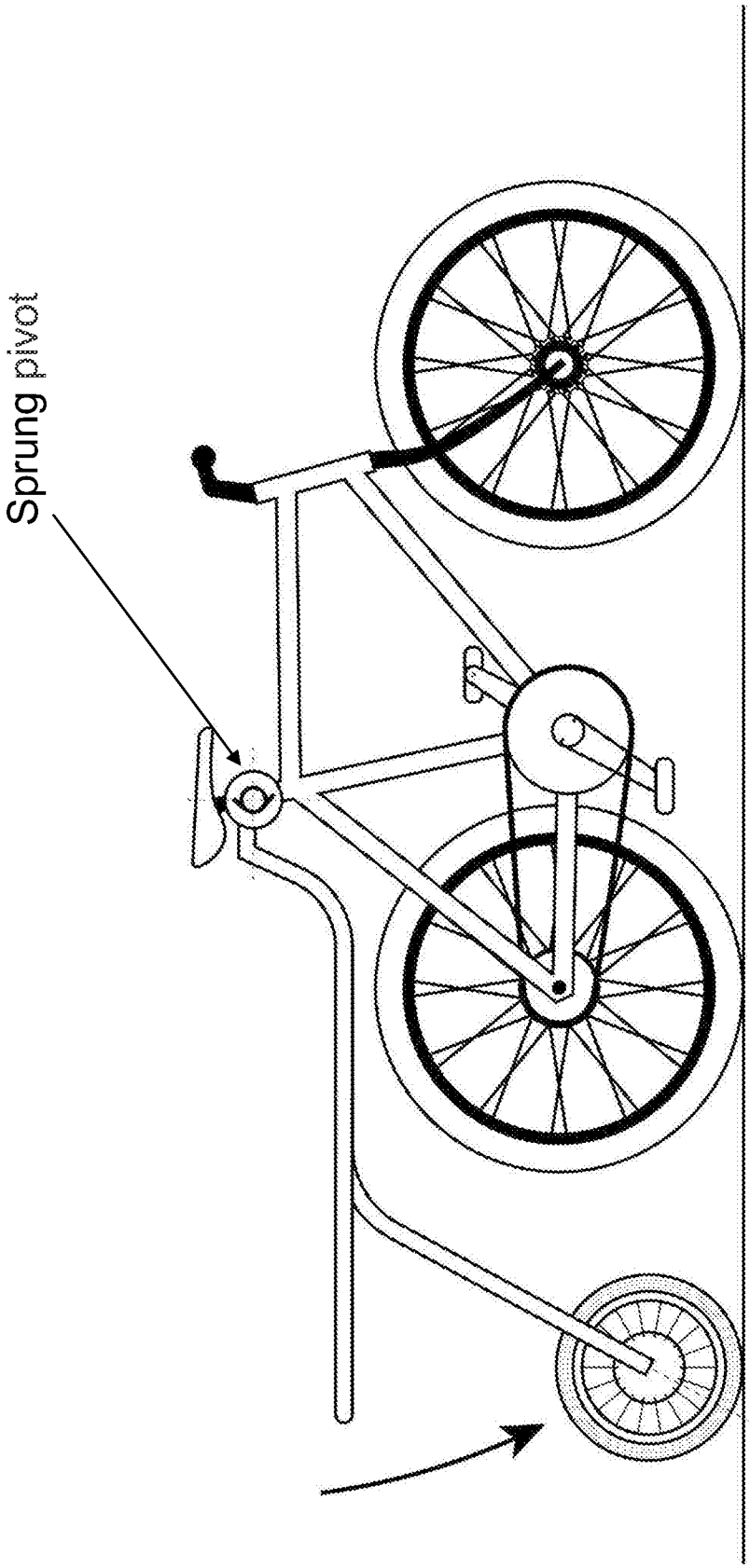


Figure 38

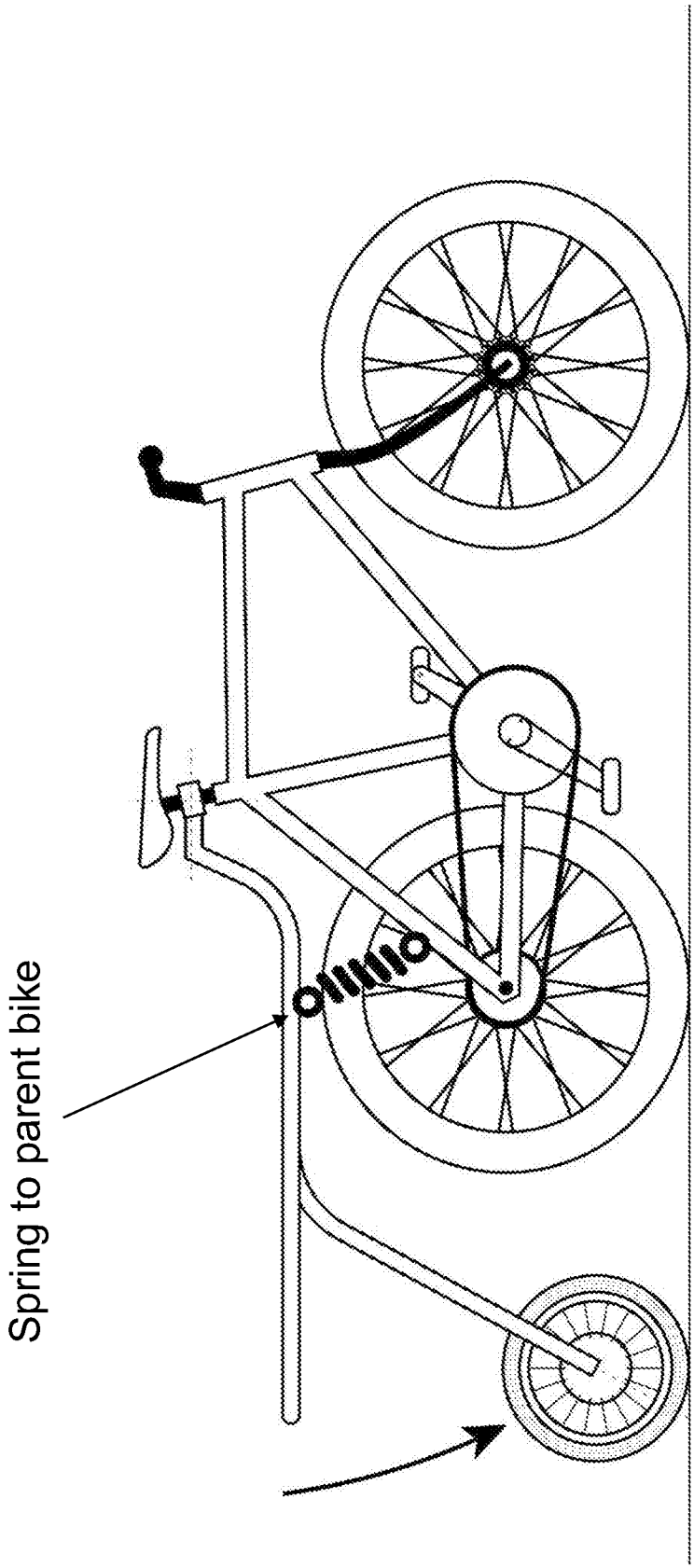


Figure 39

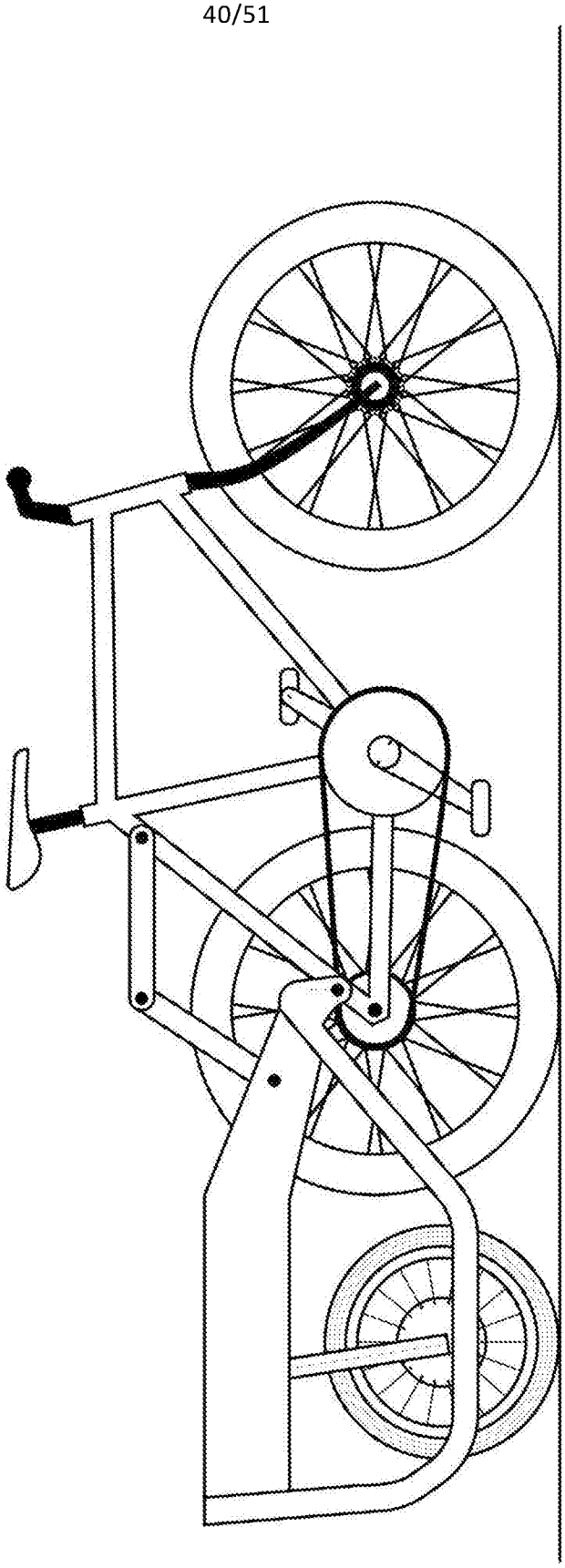


Figure 40

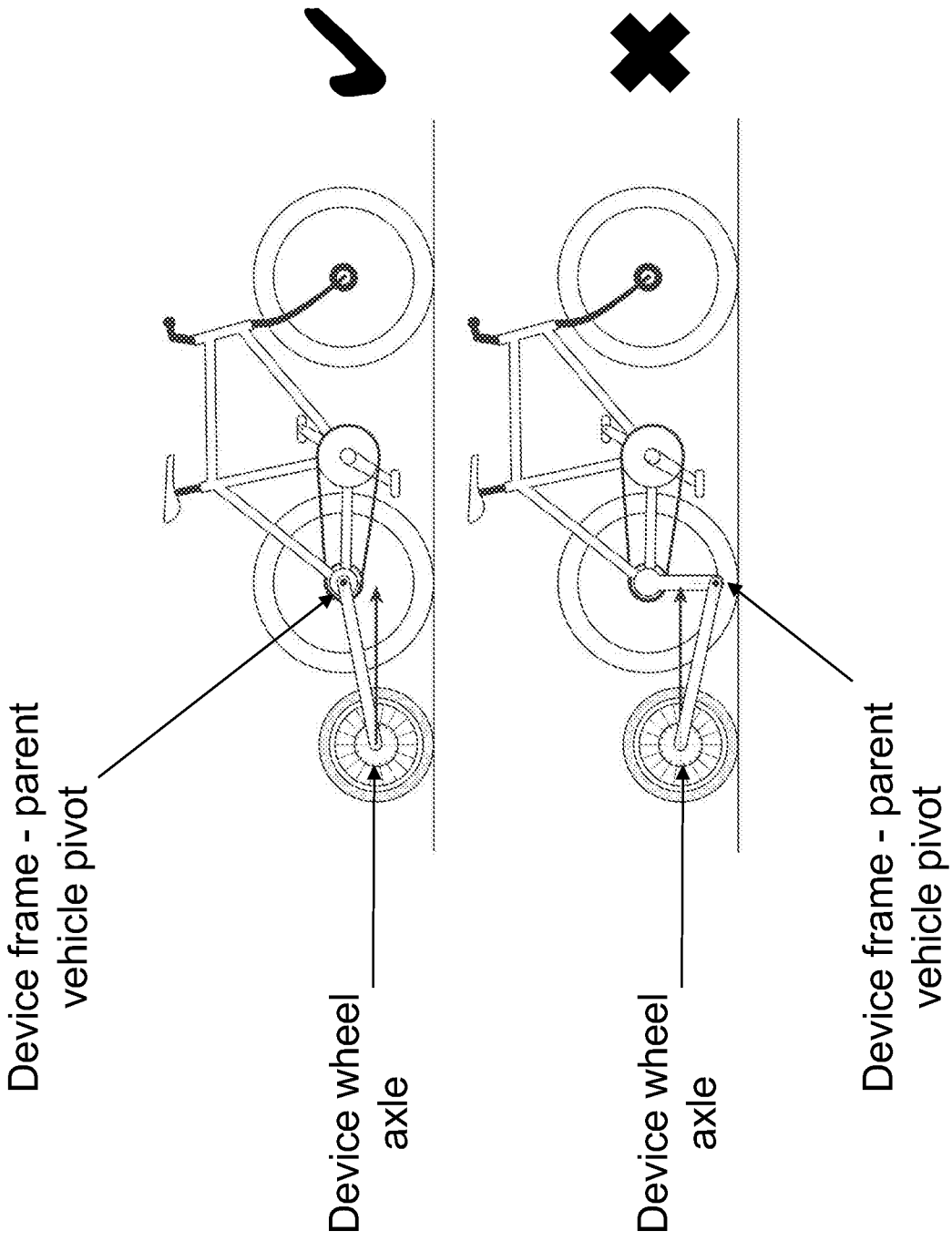

Device frame - parent vehicle pivot
Device wheel axle
Device wheel axle
Device frame - parent vehicle pivot

Figure 41

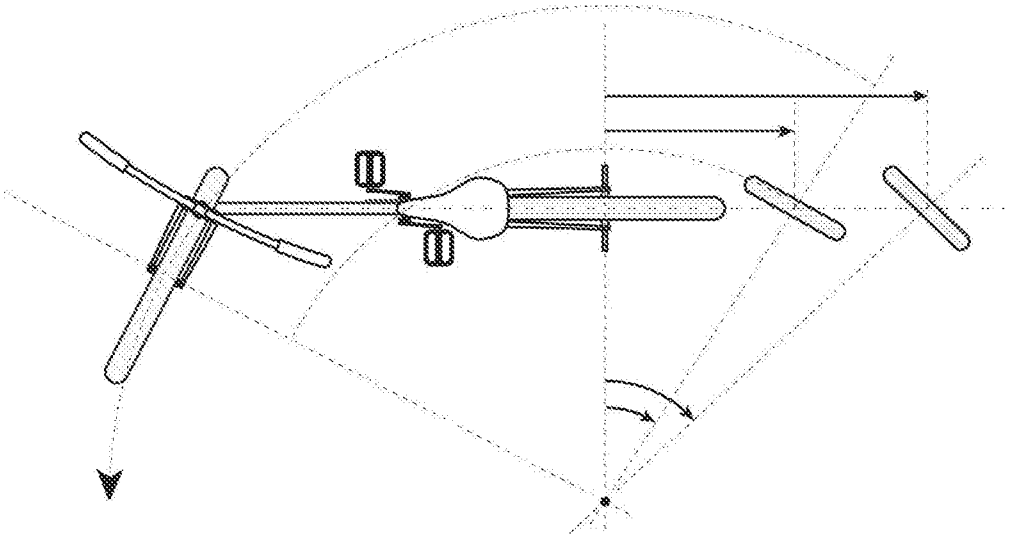


Figure 42

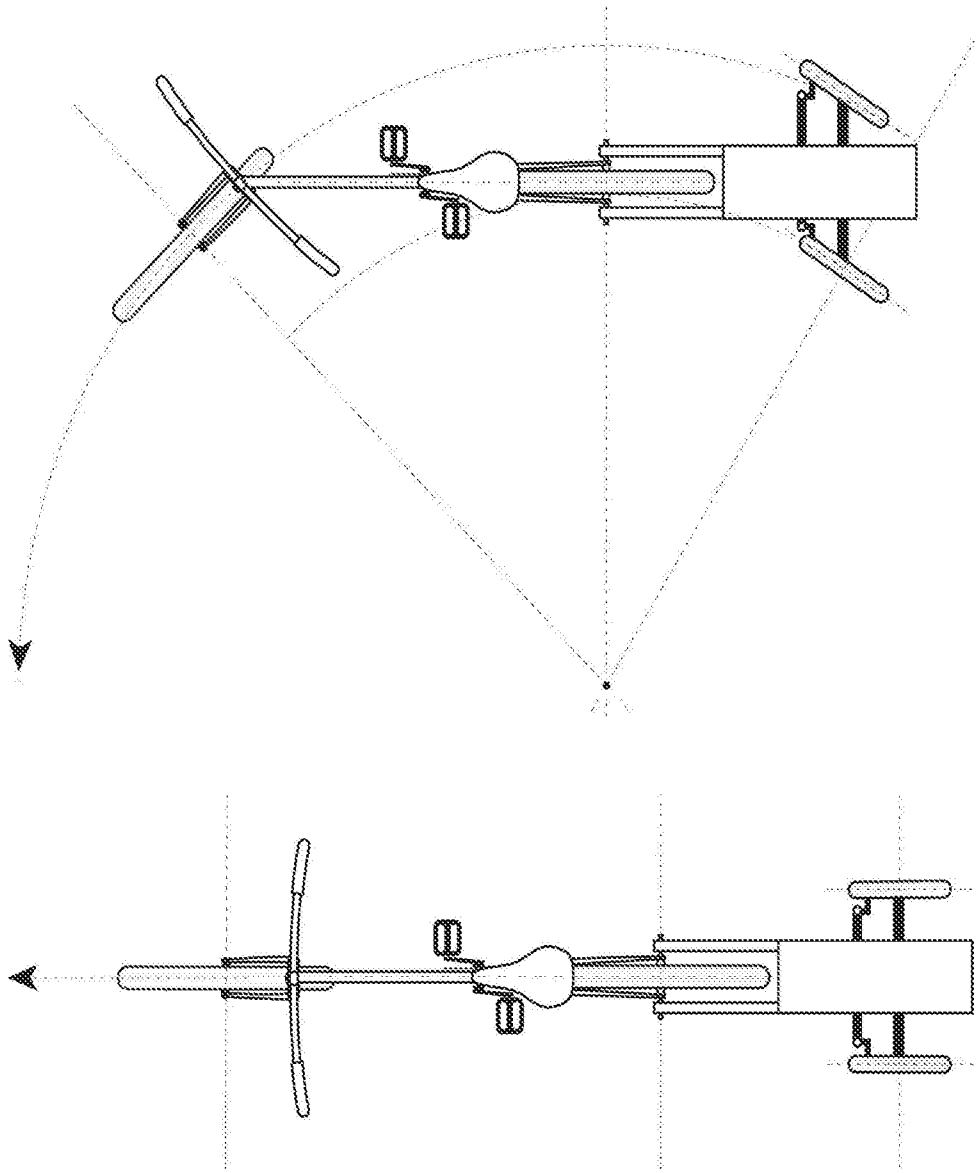


Figure 43

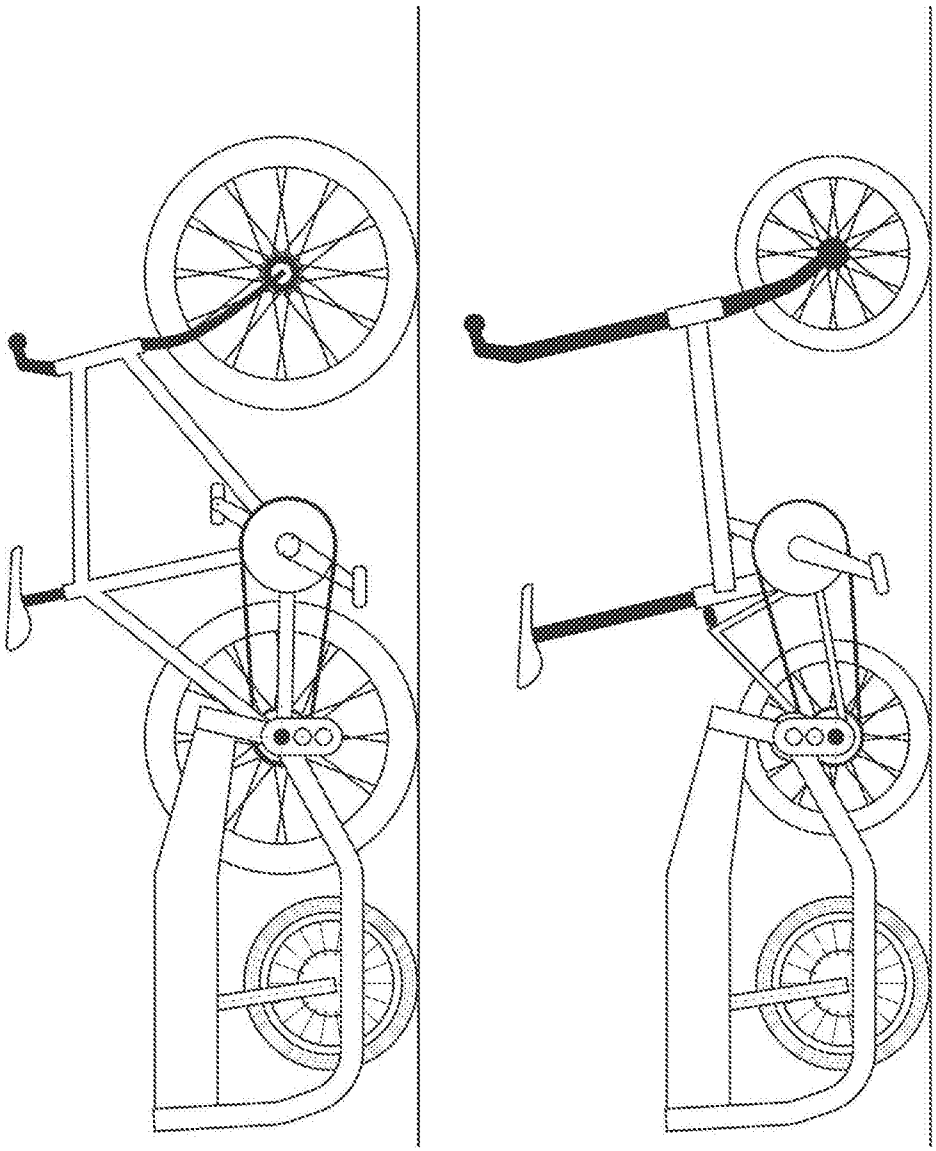


Figure 44

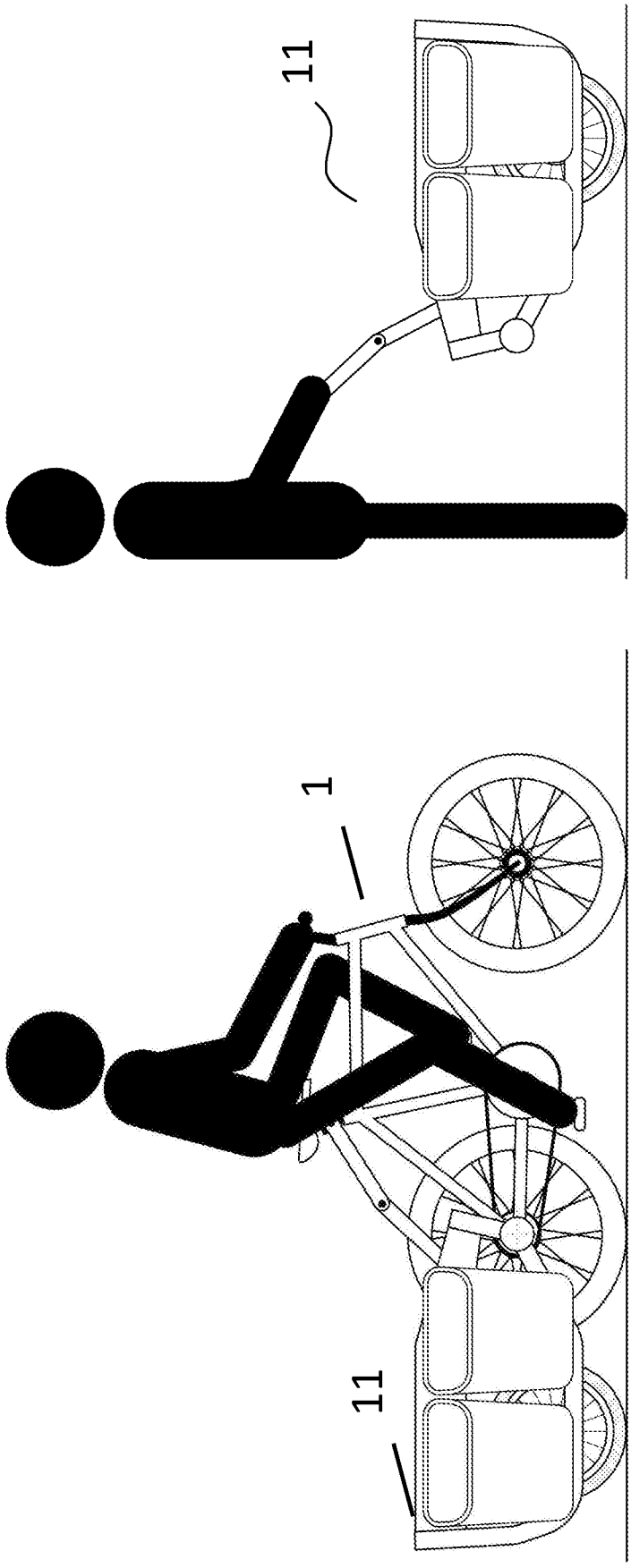


Figure 45

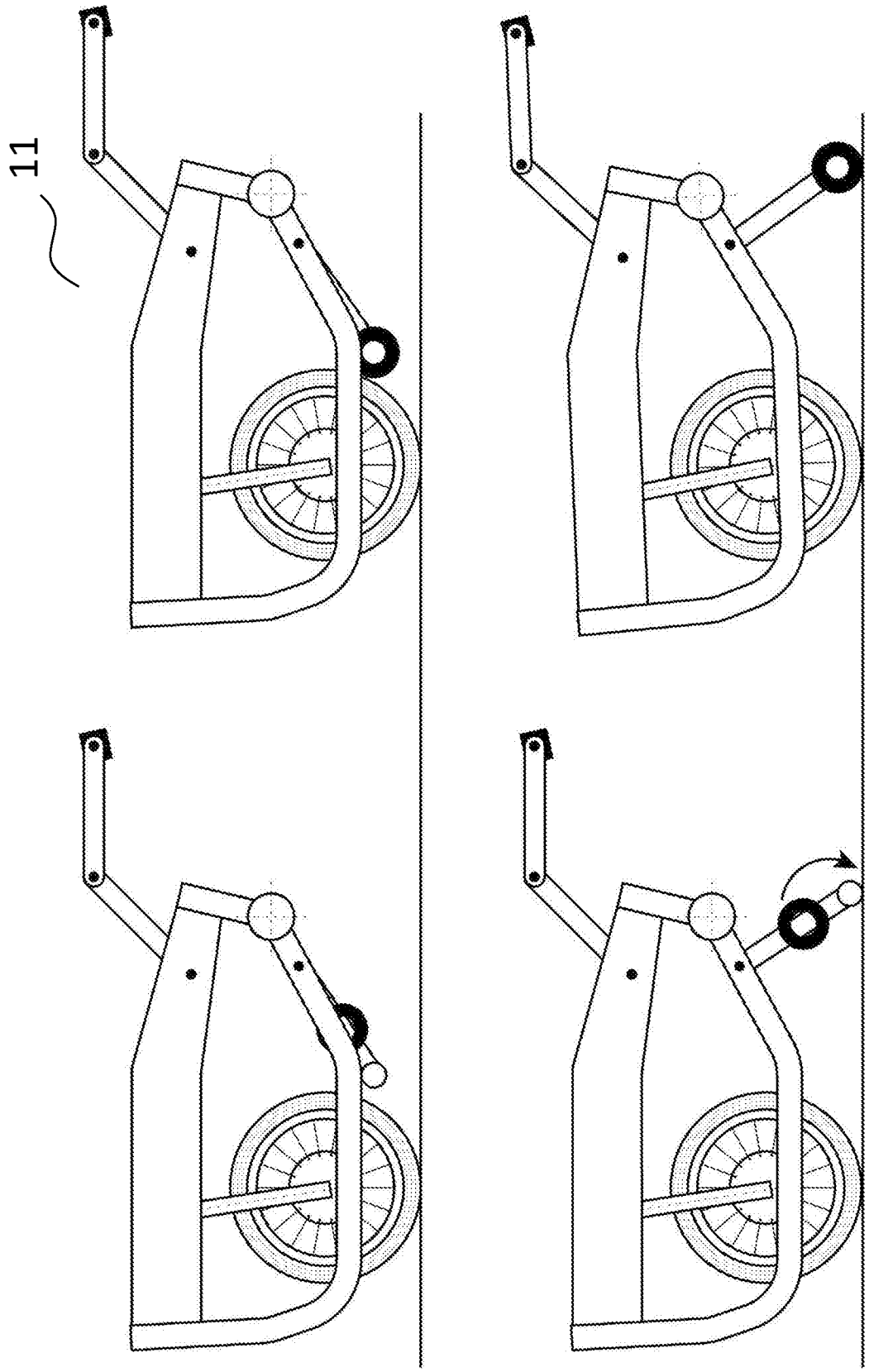


Figure 46

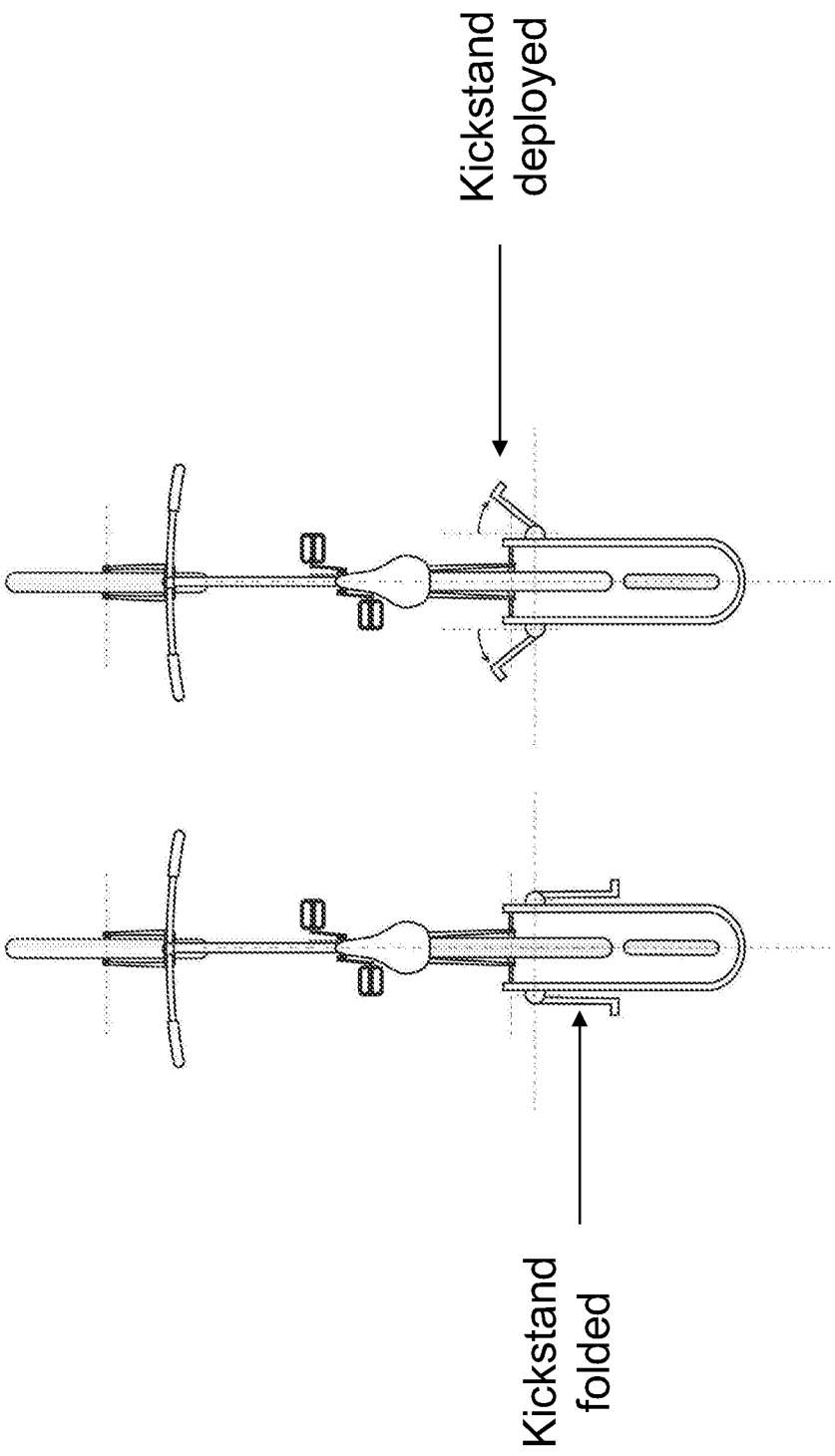


Figure 47

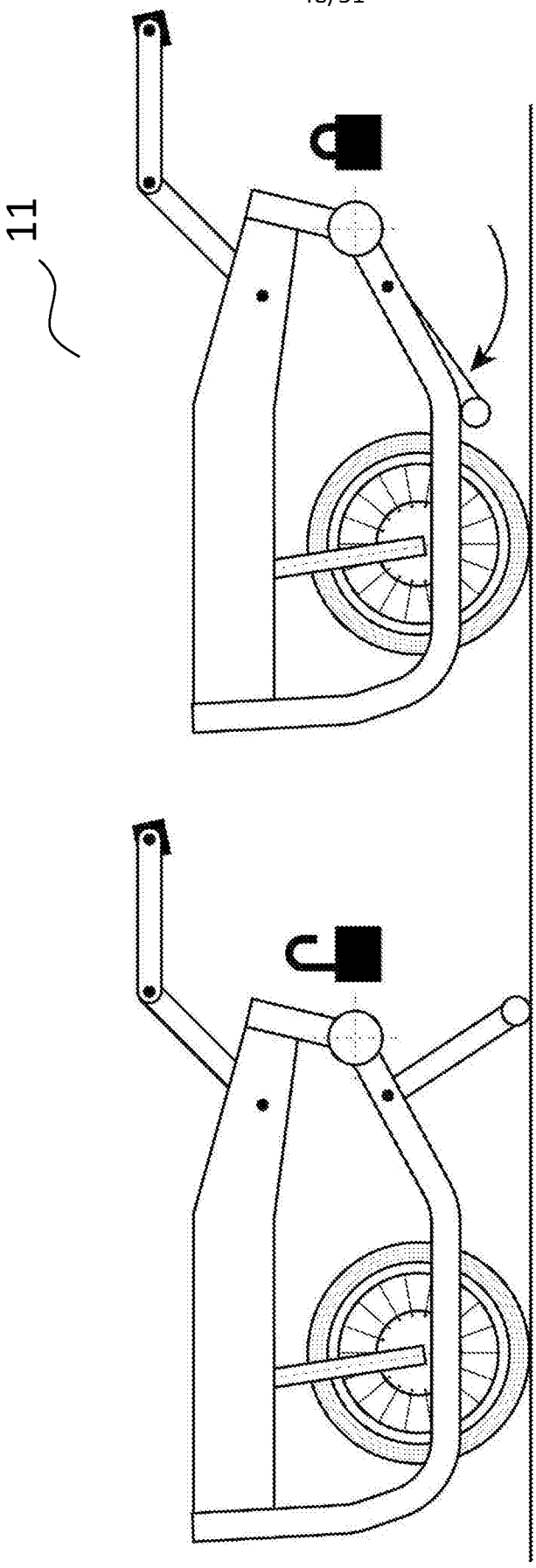


Figure 48

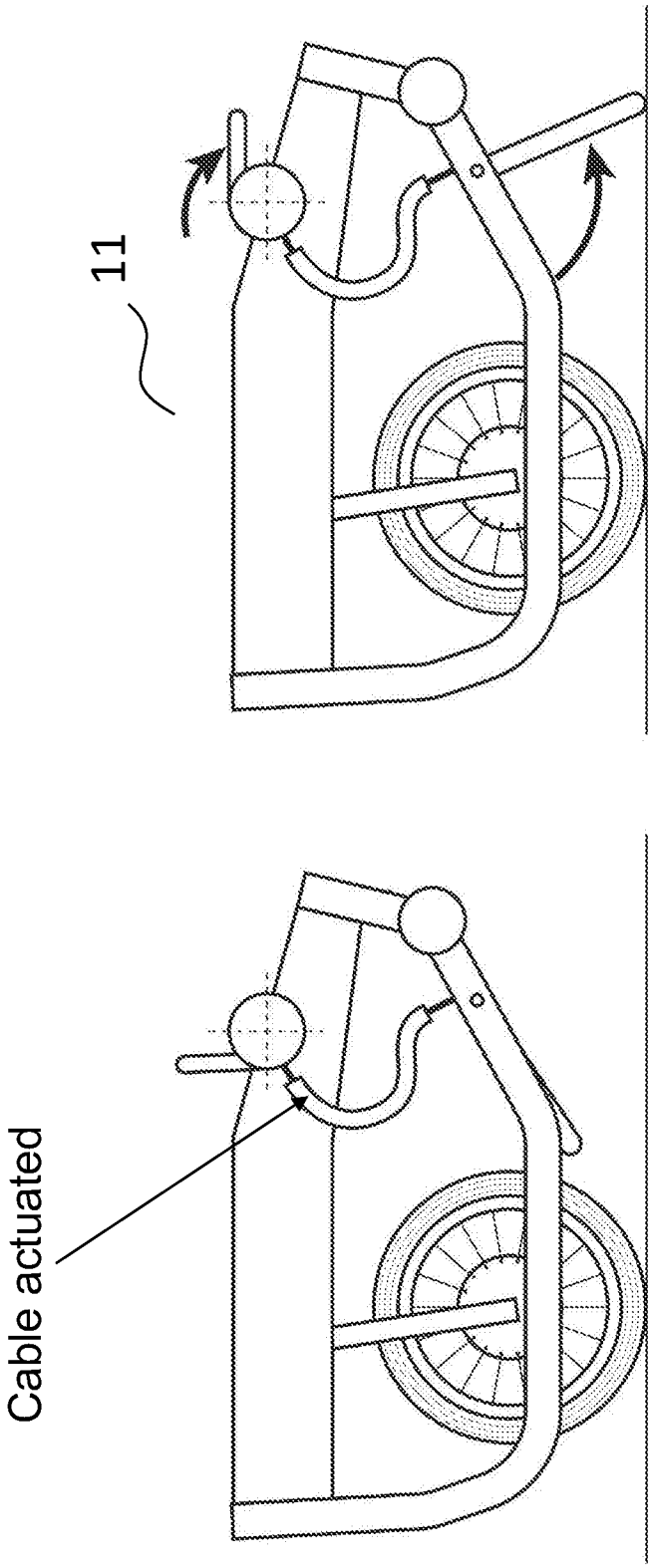


Figure 49

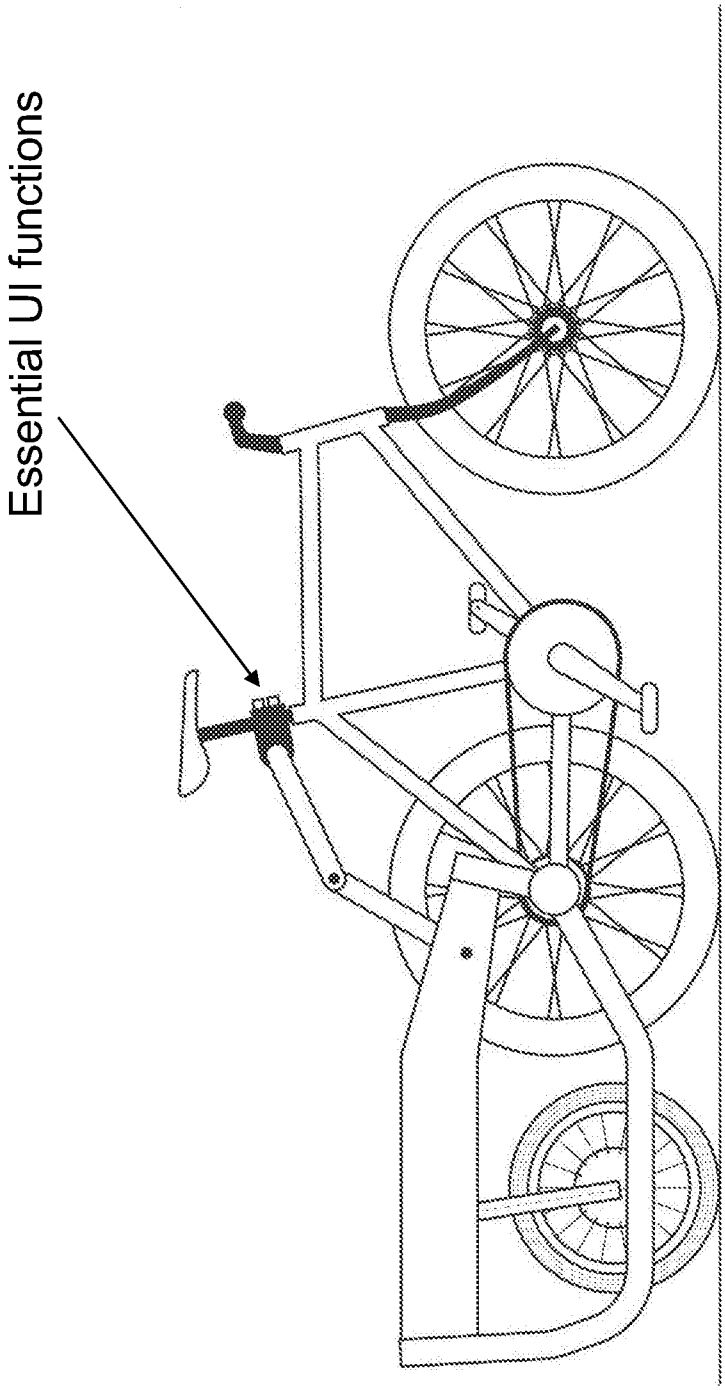


Figure 50

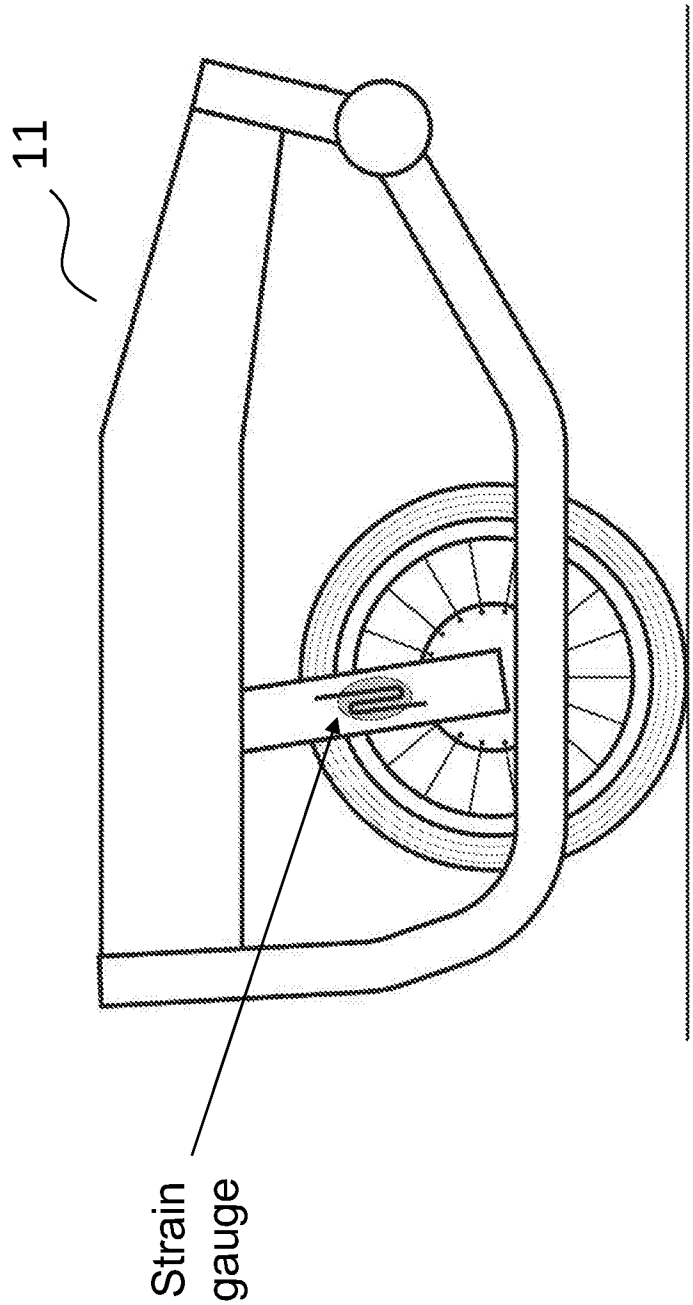


Figure 51