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Steering assembly for vehicle

Abstract

A front axle assembly includes an axle and a steering assembly. The steering assembly includes a pair of wheel hubs coupled to opposing ends of the axle, a steering gear mechanism configured to be positioned between (a) a first vertical plane defined by a first frame rail of the vehicle and (b) a second vertical plane defined by a second frame rail of the vehicle, and a linkage assembly coupling the steering gear mechanism to the pair of wheel hubs to facilitate steering the pair of wheel hubs through actuation of the steering gear mechanism. Components of linkage assembly do not extend through the first frame rail or the second frame rail.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
2225966	12/1939	Beemer	N/A	N/A
3768825	12/1972	Magnusson	N/A	N/A
6561715	12/2002	Wasylewski et al.	N/A	N/A
6719311	12/2003	Davis et al.	N/A	N/A
10836425	12/2019	Yamazaki et al.	N/A	N/A
11214305	12/2021	Maltais-Larouche et al.	N/A	N/A
11358634	12/2021	Mainville	N/A	N/A
11560198	12/2022	Doerksen et al.	N/A	N/A
12017699	12/2023	Krone et al.	N/A	N/A
12195124	12/2024	Andringa	N/A	B62D 7/08
2001/0054525	12/2000	Honzek	N/A	N/A
2015/0151651	12/2014	Stingle et al.	N/A	N/A
2019/0161115	12/2018	Yamazaki et al.	N/A	N/A
2019/0276102	12/2018	Zuleger et al.	N/A	N/A
2020/0290236	12/2019	Bjornstad et al.	N/A	N/A
2020/0290237	12/2019	Steffens et al.	N/A	N/A
2020/0290238	12/2019	Andringa et al.	N/A	N/A
2020/0291846	12/2019	Steffens et al.	N/A	N/A
2021/0171137	12/2020	Zuleger et al.	N/A	N/A
2021/0354329	12/2020	Hou et al.	N/A	N/A
2022/0072736	12/2021	Steffens et al.	N/A	N/A
2022/0118854	12/2021	Davis et al.	N/A	N/A
2022/0134372	12/2021	Andringa	N/A	N/A
2022/0134856	12/2021	Andringa et al.	N/A	N/A
2022/0144058	12/2021	Ben-Ari	N/A	N/A
2022/0266905	12/2021	Krone et al.	N/A	N/A
2022/0324285	12/2021	Wilcox et al.	N/A	N/A
2023/0052313	12/2022	Cai et al.	N/A	N/A
2024/0124058	12/2023	Jeon et al.	N/A	N/A

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
108556909	12/2017	CN	N/A
208602555	12/2018	CN	N/A
116409376	12/2022	CN	B62D 5/0421
102020125258	12/2021	DE	B62D 3/06
1 213 206	12/2001	EP	N/A
6605010	12/2018	JP	B60G 21/051

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Background/Summary

CROSS-REFERENCE TO RELATED PATENT APPLICATION (1) This application is a continuation of U.S. patent application Ser. No. 18/229,250, filed Aug. 2, 2023, which is a continuation of U.S. patent application Ser. No. 17/689,336, filed Mar. 8, 2022, which claims the benefit of and priority to U.S. Provisional Patent Application No. 63/161,236, filed Mar. 15, 2021, both of which are incorporated herein by reference in their entireties.

BACKGROUND

(1) Refuse vehicles collect a wide variety of waste, trash, and other material from residences and businesses. Operators of the refuse vehicles transport the material from various waste receptacles within a municipality to a storage or processing facility (e.g., a landfill, an incineration facility, a recycling facility, etc.).

SUMMARY

(2) One embodiment relates to a front axle assembly for a vehicle. The front axle assembly includes an axle and a steering assembly. The steering assembly includes a pair of wheel hubs coupled to opposing ends of the axle, a steering gear mechanism configured to be positioned between (a) a first vertical plane defined by a first frame rail of the vehicle and (b) a second vertical plane defined by a second frame rail of the vehicle, and a linkage assembly coupling the steering gear mechanism to the pair of wheel hubs to facilitate steering the pair of wheel hubs through actuation of the steering gear mechanism. Components of linkage assembly do not extend through the first frame rail or the second frame rail.

(3) Another embodiment relates to a vehicle. The vehicle includes a chassis and a front axle assembly. The chassis includes a left frame rail defining a first vertical plane and a right frame rail spaced from the left frame rail, the right frame rail defining a second vertical plane. The front axle assembly is coupled to a front end of the right frame rail and the left frame rail. The front axle assembly includes an axle and a steering assembly. The steering assembly includes a pair of wheel hubs coupled to opposing ends of the axle, a steering gear mechanism positioned between the first vertical plane and the second vertical plane, and a linkage assembly coupling the steering gear mechanism to the pair of wheel hubs to facilitate steering the pair of wheel hubs through actuation of the steering gear mechanism. Components of linkage assembly do not extend through the left frame rail or the right frame rail.

(4) Still another embodiment relates to a vehicle. The vehicle includes a chassis and a front axle assembly. The chassis includes a first frame rail defining a first vertical plane and a second frame

rail defining a second vertical plane. Bottom surfaces of the first frame rail and the second frame rail define a bottom plane. The front axle assembly includes an axle coupled to a front end of the first frame rail and the second frame rail, and a steering assembly. The steering assembly includes a pair of wheel hubs coupled to opposing ends of the axle, a steering gear mechanism positioned (a) between the first vertical plane and the second vertical plane and (b) above the bottom plane, and a linkage assembly coupling the steering gear mechanism to the pair of wheel hubs to facilitate steering the pair of wheel hubs through actuation of the steering gear mechanism. The linkage assembly includes (a) one or more pitman arms coupled to the steering gear mechanism, (b) a pair of steering links coupled to the one or more pitman arms, and (c) a pair of tie rod arms coupling the pair of steering links to the pair of wheel hubs. At least one of (a) the one or more pitman arms or (b) the pair of steering links is shaped such that portions of the pair of steering links proximate the first vertical plane and the second vertical plane are positioned beneath the bottom plane and pass underneath the first frame rail and the second frame rail and do not extend through the first frame rail and the second frame rail.

(5) This summary is illustrative only and is not intended to be in any way limiting. Other aspects, inventive features, and advantages of the devices or processes described herein will become apparent in the detailed description set forth herein, taken in conjunction with the accompanying figures, wherein like reference numerals refer to like elements.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. 1 is a perspective view of a refuse vehicle including an axle assembly, according to an exemplary embodiment.

(2) FIG. 2 is a top schematic diagram of the axle assembly of the refuse vehicle of FIG. 1 including an axle and a steering assembly, according to an exemplary embodiment.

(3) FIGS. 3-5 are various views of the axle assembly of FIG. 2 with the steering assembly in a plurality of orientations, according to various exemplary embodiments.

(4) FIGS. 6A-6D are various cross-sectional schematic diagrams of a portion of the axle assembly of FIG. 2, according to various exemplary embodiments.

(5) FIG. 7 is a top schematic diagram of the axle assembly of the refuse vehicle of FIG. 1, according to another exemplary embodiment.

(6) FIG. 8 is a cross-sectional schematic diagram of a portion of the axle assembly of FIG. 7, according to an exemplary embodiment.

DETAILED DESCRIPTION

(7) Before turning to the figures, which illustrate certain exemplary embodiments in detail, it should be understood that the present disclosure is not limited to the details or methodology set forth in the description or illustrated in the figures. It should also be understood that the terminology used herein is for the purpose of description only and should not be regarded as limiting.

(8) According to an exemplary embodiment, a vehicle (e.g., a refuse vehicle, etc.) of the present disclosure includes an axle assembly having an axle (e.g., a front axle, a solid axle, etc.), wheels coupled to opposing ends of the axle, and a steering assembly coupled to the axle that is configured to facilitate steering the wheels. Traditionally, vehicles have included an internal combustion engine that has an oil pan positioned along the bottom of the engine. When the engine is coupled to the frame, the oil pan extends down through the frame rails and occupies the space between and beneath the frame rails. This requires that various steering components be positioned outside of the frame rails. The vehicle of the present disclosure advantageously has the engine in a different position or the engine is replaced with an electric motor, which frees up the space between the

frame rails that was previously occupied by the engine and engine oil pan. According to an exemplary embodiment, various steering components of the vehicle including the steering gear box can, therefore, be positioned between/beneath the frame rails, as well as facilitate removing/eliminating various steering components used in traditional steering systems (e.g., a traditional steer arm, a cross link on the axle, etc.). In addition, such positioning further frees up space outside the frame rails, which can be leveraged for the packaging of other components. In some instances, the positioning of the various steering components between the frame rails facilitates narrowing the cab of the vehicle and/or enlarging the step well used for assistance when entering the cab.

(9) Overall Vehicle

(10) As shown in FIG. 1, a machine, shown as vehicle **10**, is configured as a front-loading refuse truck (e.g., a garbage truck, a waste collection truck, a sanitation truck, a recycling truck, etc.). In other embodiments, the vehicle **10** is configured as a side-loading refuse truck or a rear-loading refuse truck. In still other embodiments, the vehicle **10** is configured as another type of vehicle (e.g., a commercial truck, a cement mixer truck, a plow truck, a military vehicle, construction machinery, agriculture machinery, etc.). As shown in FIG. 1, the vehicle **10** includes a chassis, shown as frame **12**; a body assembly, shown as body **14**, coupled to the frame **12** (e.g., at a rear end thereof, etc.); and a cab, shown as cab **16**, coupled to the frame **12** (e.g., at a front end thereof, etc.). The cab **16** may include various components to facilitate operation of the vehicle **10** by an operator (e.g., a seat, a steering wheel, actuator controls, a user interface, switches, buttons, dials, etc.).

(11) As shown in FIG. 1, the vehicle **10** includes a prime mover, shown as electric motor **18**, and an energy system, shown as energy storage and/or generation system **20**. In other embodiments, the prime mover is or includes an internal combustion engine. According to the exemplary embodiment shown in FIG. 1, the electric motor **18** is coupled to the frame **12** at a position beneath the cab **16**. The electric motor **18** is configured to provide power to a plurality of tractive elements (e.g., via a drive shaft, etc.), shown as wheels **22**, supported by axle assemblies, shown as axle assemblies **100**, coupled to the frame **12** (e.g., a front end thereof, a rear end thereof, etc.). In other embodiments, the electric motor **18** is otherwise positioned and/or the vehicle **10** includes a plurality of electric motors to facilitate independently driving one or more of the wheels **22**. In still other embodiments, the electric motor **18** or a secondary electric motor is coupled to and configured to drive a hydraulic system that powers hydraulic actuators. According to the exemplary embodiment shown in FIG. 1, the energy storage and/or generation system **20** is coupled to the frame **12** beneath the body **14**. In other embodiments, the energy storage and/or generation system **20** is otherwise positioned (e.g., within a tailgate of the vehicle **10**, beneath the cab **16**, along the top of the body **14**, within the body **14**, etc.).

(12) According to an exemplary embodiment, the energy storage and/or generation system **20** is configured to (a) receive, generate, and/or store power and (b) provide electric power to (i) the electric motor **18** to drive the wheels **22** (e.g., the front wheels only, the rear wheels only, both the front wheels and the rear wheels, etc.), (ii) electric actuators of the vehicle **10** to facilitate operation thereof (e.g., lift actuators, tailgate actuators, packer actuators, grabber actuators, etc.), and/or (iii) other electrically operated accessories of the vehicle **10** (e.g., displays, lights, etc.). The energy storage and/or generation system **20** may include one or more rechargeable batteries (e.g., lithium-ion batteries, nickel-metal hydride batteries, lithium-ion polymer batteries, lead-acid batteries, nickel-cadmium batteries, etc.), capacitors, solar cells, generators, power buses, etc. In one embodiment, the vehicle **10** is a completely electric vehicle. In other embodiments, the vehicle **10** includes an internal combustion generator that utilizes one or more fuels (e.g., gasoline, diesel, propane, natural gas, hydrogen, etc.) to generate electricity to charge the energy storage and/or generation system **20**, power the electric motor **18**, power the electric actuators, and/or power the other electrically operated accessories (e.g., a hybrid vehicle, etc.). For example, the vehicle **10** may have an internal combustion engine augmented by the electric motor **18** to cooperatively

provide power to the wheels **22**. The energy storage and/or generation system **20** may thereby be charged via an on-board generator (e.g., an internal combustion generator, a solar panel system, etc.), from an external power source (e.g., overhead power lines, mains power source through a charging input, etc.), and/or via a power regenerative braking system, and provide power to the electrically operated systems of the vehicle **10**. In some embodiments, the energy storage and/or generation system **20** includes a heat management system (e.g., liquid cooling, heat exchanger, air cooling, etc.).

(13) According to an exemplary embodiment, the vehicle **10** is configured to transport refuse from various waste receptacles within a municipality to a storage and/or processing facility (e.g., a landfill, an incineration facility, a recycling facility, etc.). As shown in FIG. **1**, the body **14** includes a plurality of panels, shown as panels **32**, a tailgate **34**, and a cover **36**. The panels **32**, the tailgate **34**, and the cover **36** define a collection chamber (e.g., hopper, etc.), shown as refuse compartment **30**. Loose refuse may be placed into the refuse compartment **30** where it may thereafter be compacted (e.g., by a packer system, etc.). The refuse compartment **30** may provide temporary storage for refuse during transport to a waste disposal site and/or a recycling facility. In some embodiments, at least a portion of the body **14** and the refuse compartment **30** extend above or in front of the cab **16**. According to the embodiment shown in FIG. **1**, the body **14** and the refuse compartment **30** are positioned behind the cab **16**. In some embodiments, the refuse compartment **30** includes a hopper volume and a storage volume. Refuse may be initially loaded into the hopper volume and thereafter compacted into the storage volume. According to an exemplary embodiment, the hopper volume is positioned between the storage volume and the cab **16** (e.g., refuse is loaded into a position of the refuse compartment **30** behind the cab **16** and stored in a position further toward the rear of the refuse compartment **30**, a front-loading refuse vehicle, a side-loading refuse vehicle, etc.). In other embodiments, the storage volume is positioned between the hopper volume and the cab **16** (e.g., a rear-loading refuse vehicle, etc.).

(14) As shown in FIG. **1**, the vehicle **10** includes a lift mechanism/system (e.g., a front-loading lift assembly, etc.), shown as lift assembly **40**, coupled to the front end of the body **14**. In other embodiments, the lift assembly **40** extends rearward of the body **14** (e.g., a rear-loading refuse vehicle, etc.). In still other embodiments, the lift assembly **40** extends from a side of the body **14** (e.g., a side-loading refuse vehicle, etc.). As shown in FIG. **1**, the lift assembly **40** is configured to engage a container (e.g., a residential trash receptacle, a commercial trash receptacle, a container having a robotic grabber arm, etc.), shown as refuse container **60**. The lift assembly **40** may include various actuators (e.g., electric actuators, hydraulic actuators, pneumatic actuators, etc.) to facilitate engaging the refuse container **60**, lifting the refuse container **60**, and tipping refuse out of the refuse container **60** into the hopper volume of the refuse compartment **30** through an opening in the cover **36** or through the tailgate **34**. The lift assembly **40** may thereafter return the empty refuse container **60** to the ground. According to an exemplary embodiment, a door, shown as top door **38**, is movably coupled along the cover **36** to seal the opening, thereby preventing refuse from escaping the refuse compartment **30** (e.g., due to wind, bumps in the road, etc.).

(15) Axle Assembly

(16) According to an exemplary embodiment, the axle assemblies **100** include at least one steerable axle assembly (e.g., a front steerable axle assembly, front and rear steerable axle assemblies, etc.). According to the exemplary embodiment shown in FIGS. **2-8**, the axle assembly **100** is a front steerable axle assembly that includes (i) an axle, shown as front axle **110**, that is coupled to the frame **12** and supports a pair of the wheels **22** (i.e., front wheels) and (ii) a steering assembly, shown as steering system **200**. According to an exemplary embodiment, the front axle **110** has a solid axle structure (as opposed to an independent suspension axle design). As shown in FIGS. **2-8**, the steering system **200** includes one or more steering gear mechanisms, shown as steering gear boxes **210**; a pair of wheel hubs, shown as wheel hubs **212**, coupled to opposing ends of the front axle **110**, that facilitate coupling the wheels **22** to the axle assembly **100**; and a linkage assembly,

shown as steering linkage assembly **214**, coupling the steering gear box or boxes **210** to the wheel hubs **212**. As shown in FIGS. **2-6**, the steering system **200** includes a pair of steering gear boxes **210**. As shown in FIGS. **7** and **8**, the steering system **200** includes a single steering gear box **210**. According to an exemplary embodiment, the steering gear box or boxes **210** is/are configured to couple to a steering wheel, a steering column, etc. of the vehicle **10** to facilitate steering the wheels **22** through actuation of the steering gear box or boxes **210** and, thereby, the steering linkage assembly **214** and the wheel hubs **212** (see, e.g., FIGS. **3-5**).

(17) As shown in FIGS. **2-5**, the steering linkage assembly **214** includes a pair of connectors or connector arms, shown as pitman arms **220**, a first linkage, shown as tie link **230**, a pair of second linkages, shown as steering links **240**, and a pair of third linkages, shown as tie rod arms **250**. Each of the pitman arms **220** extends between and couples a respective one of the steering gear boxes **210** to a respective one of the steering links **240** (i.e., a left pitman arm **220** couples a left steering gear box **210** to a left steering link **240**, and a right pitman arm **220** couples a right steering gear box **210** to a right steering link **240**). The tie link **230** extends between and couples the pitman arms **220** to one another (e.g., at a position along the pitman arms **220** between the steering gear boxes **210** and a connection point to the steering links **240**, etc.). Each of the tie rod arms **250** extends between and couples a respective one of the steering links **240** to a steering arm/knuckle of a respective one of the wheel hubs **212** (i.e., a left tie rod arm **250** couples a left steering link **240** to a left steering arm/knuckle of a left wheel hub **212**, and a right tie rod arm **250** couples a right steering link **240** to a right steering arm/knuckle of a right wheel hub **212**). As shown in FIG. **7**, the steering linkage assembly **214** includes a single pitman arm **220** coupled to both of the steering links **240** and does not include the tie link **230**.

(18) As shown in FIGS. **3-6** and **8**, the frame **12** includes a first frame rail, shown as left frame rail **12a**, and a second frame rail, shown as right frame rail **12b**, spaced from the left frame rail **12a** (e.g., such that a space or gap is formed therebetween). As shown in FIGS. **6** and **8**, the left frame rail **12a** defines a first vertical plane, shown as left plane **300**, and the right frame rail **12b** defines a second vertical plane, shown as right plane **302**. A central, longitudinal plane, shown as central plane **304**, extends between the left frame rail **12a** and the right frame rail **12b** at a center point therebetween. The bottom surfaces of the left frame rail **12a** and the right frame rail **12b** extend along a bottom plane, shown as bottom plane **306**.

(19) As shown in FIG. **6**, the steering gear boxes **210** are positioned between the left plane **300** defined by the left frame rail **12a** and the right plane **302** defined by the right frame rail **12b**. More specifically, (i) a left steering gear box **210** is positioned between the left plane **300** defined by the left frame rail **12a** and the central plane **304** and (ii) a right steering gear box **210** is positioned between the right plane **302** defined by the right frame rail **12b** and the central plane **304**. According to an exemplary embodiment, the steering system **200** is centered along and symmetric about the central plane **304**.

(20) As shown in FIG. **8**, the steering gear box **210** is (i) positioned between the left plane **300** defined by the left frame rail **12a** and the right plane **302** defined by the right frame rail **12b**, and (ii) positioned along the central plane **304** such that the steering system **200** is centered along and symmetric about the central plane **304**. In another embodiment, the steering gear box **210** is (i) positioned between the left plane **300** defined by the left frame rail **12a** and the right plane **302** defined by the right frame rail **12b**, but (ii) positioned offset from the central plane **304**.

(21) As shown in FIGS. **6A** and **8**, the steering gear box or boxes **210** is/are positioned entirely beneath the bottom plane **306**. In another embodiment, as shown in FIG. **6B**, at least a portion of the steering box or boxes **210** is/are positioned along the bottom plane **306**. In still another embodiment, as shown in FIGS. **6C** and **6D**, the steering gear box or boxes **210** is/are positioned entirely above the bottom plane **306**. In such an embodiment, (i) as shown in FIG. **6C**, the steering links **240** may extend through apertures or slots **310** defined in the left frame rail **12a** and the right frame rail **12b** to connect to the tie rod arms **250**, (ii) as shown in FIG. **6D**, the steering links **240**

may be shaped to curve around/beneath the left frame rail **12a** and the right frame rail **12b** to connect to the tie rod arms **250**, and/or (iii) the pitman arm(s) **220** may drop down from the steering gear box(es) **210** such that the steering links **240** clear underneath the left frame rail **12a** and the right frame rail **12b** to connect to the tie rod arms **250**.

(22) As utilized herein, the terms “approximately,” “about,” “substantially”, and similar terms are intended to have a broad meaning in harmony with the common and accepted usage by those of ordinary skill in the art to which the subject matter of this disclosure pertains. It should be understood by those of skill in the art who review this disclosure that these terms are intended to allow a description of certain features described and claimed without restricting the scope of these features to the precise numerical ranges provided. Accordingly, these terms should be interpreted as indicating that insubstantial or inconsequential modifications or alterations of the subject matter described and claimed are considered to be within the scope of the disclosure as recited in the appended claims.

(23) It should be noted that the term “exemplary” and variations thereof, as used herein to describe various embodiments, are intended to indicate that such embodiments are possible examples, representations, or illustrations of possible embodiments (and such terms are not intended to connote that such embodiments are necessarily extraordinary or superlative examples).

(24) The term “coupled” and variations thereof, as used herein, means the joining of two members directly or indirectly to one another. Such joining may be stationary (e.g., permanent or fixed) or moveable (e.g., removable or releasable). Such joining may be achieved with the two members coupled directly to each other, with the two members coupled to each other using a separate intervening member and any additional intermediate members coupled with one another, or with the two members coupled to each other using an intervening member that is integrally formed as a single unitary body with one of the two members. If “coupled” or variations thereof are modified by an additional term (e.g., directly coupled), the generic definition of “coupled” provided above is modified by the plain language meaning of the additional term (e.g., “directly coupled” means the joining of two members without any separate intervening member), resulting in a narrower definition than the generic definition of “coupled” provided above. Such coupling may be mechanical, electrical, or fluidic.

(25) References herein to the positions of elements (e.g., “top,” “bottom,” “above,” “below”) are merely used to describe the orientation of various elements in the FIGURES. It should be noted that the orientation of various elements may differ according to other exemplary embodiments, and that such variations are intended to be encompassed by the present disclosure.

(26) It is important to note that the construction and arrangement of the vehicle **10**, the axle assembly **100**, and the steering system **200** thereof as shown in the various exemplary embodiments is illustrative only. Additionally, any element disclosed in one embodiment may be incorporated or utilized with any other embodiment disclosed herein.

Claims

1. A front axle assembly for a vehicle, the front axle assembly comprising: an axle; and a steering assembly including: a pair of wheel hubs coupled to opposing ends of the axle; a steering gear mechanism including a first gear box and a second gear box configured to be positioned between a first vertical plane defined by a first frame rail of the vehicle and a second vertical plane defined by a second frame rail of the vehicle; and a linkage assembly coupling the steering gear mechanism to the pair of wheel hubs to facilitate steering the pair of wheel hubs through actuation of the steering gear mechanism, wherein components of linkage assembly do not extend through the first frame rail or the second frame rail.

2. The front axle assembly of claim 1, wherein bottom surfaces of the first frame rail and the second frame rail define a bottom plane, and wherein the steering gear mechanism is positioned

entirely below the bottom plane.

3. The front axle assembly of claim 1, wherein bottom surfaces of the first frame rail and the second frame rail define a bottom plane, and wherein the steering gear mechanism is positioned entirely above the bottom plane.

4. The front axle assembly of claim 1, wherein the linkage assembly includes one or more pitman arms coupled to the steering gear mechanism, a pair of steering links coupled to the one or more pitman arms, and a pair of tie rod arms coupling the pair of steering links to the pair of wheel hubs.

5. The front axle assembly of claim 4, wherein bottom surfaces of the first frame rail and the second frame rail define a bottom plane, and wherein the one or more pitman arms are shaped such that portions of the pair of steering links proximate the first vertical plane and the second vertical plane are positioned beneath the bottom plane and pass underneath the first frame rail and the second frame rail and do not extend through the first frame rail and the second frame rail.

6. The front axle assembly of claim 4, wherein bottom surfaces of the first frame rail and the second frame rail define a bottom plane, wherein the pair of steering links are shaped such that portions of the pair of steering links proximate the first vertical plane and the second vertical plane are positioned beneath the bottom plane and pass underneath the first frame rail and the second frame rail and do not extend through the first frame rail and the second frame rail.

7. A front axle assembly for a vehicle, the front axle assembly comprising: an axle; and a steering assembly including: a pair of wheel hubs coupled to opposing ends of the axle; a steering gear mechanism configured to be positioned between a first vertical plane defined by a first frame rail of the vehicle and a second vertical plane defined by a second frame rail of the vehicle; and a linkage assembly coupling the steering gear mechanism to the pair of wheel hubs to facilitate steering the pair of wheel hubs through actuation of the steering gear mechanism, wherein components of linkage assembly do not extend through the first frame rail or the second frame rail, wherein bottom surfaces of the first frame rail and the second frame rail define a bottom plane, and wherein at least a portion of the steering gear mechanism is positioned along the bottom plane.

8. A vehicle comprising: a chassis including: a left frame rail defining a first vertical plane; and a right frame rail spaced from the left frame rail, the right frame rail defining a second vertical plane; and a front axle assembly coupled to a front end of the right frame rail and the left frame rail, the front axle assembly including: an axle; and a steering assembly including: a pair of wheel hubs coupled to opposing ends of the axle; a steering gear mechanism including a first gearbox and a second gearbox positioned between the first vertical plane and the second vertical plane; and a linkage assembly coupling the steering gear mechanism to the pair of wheel hubs to facilitate steering the pair of wheel hubs through actuation of the steering gear mechanism, wherein components of linkage assembly do not extend through the left frame rail or the right frame rail.

9. The vehicle of claim 8, wherein bottom surfaces of the left frame rail and the right frame rail define a bottom plane, and wherein the steering gear mechanism is positioned entirely below the bottom plane.

10. The vehicle of claim 8, wherein bottom surfaces of the left frame rail and the right frame rail define a bottom plane, and wherein the steering gear mechanism is positioned entirely above the bottom plane.

11. The vehicle of claim 8, wherein the linkage assembly includes one or more pitman arms coupled to the steering gear mechanism, a pair of steering links coupled to the one or more pitman arms, and a pair of tie rod arms coupling the pair of steering links to the pair of wheel hubs.

12. The vehicle of claim 11, wherein bottom surfaces of the left frame rail and the right frame rail define a bottom plane, and wherein at least one of the one or more pitman arms or the pair of steering links is shaped such that portions of the pair of steering links proximate the first vertical plane and the second vertical plane are positioned beneath the bottom plane and pass underneath the left frame rail and the right frame rail and do not extend through the left frame rail and the right frame rail.

13. The vehicle of claim 12, wherein the one or more pitman arms are shaped such that the portions of the pair of steering links proximate the first vertical plane and the second vertical plane are positioned beneath the bottom plane and pass underneath the left frame rail and the right frame rail and do not extend through the left frame rail and the right frame rail.
14. The vehicle of claim 12, wherein the pair of steering links are shaped such that the portions of the pair of steering links proximate the first vertical plane and the second vertical plane are positioned beneath the bottom plane and pass underneath the left frame rail and the right frame rail and do not extend through the left frame rail and the right frame rail.
15. A vehicle comprising: a chassis including: a left frame rail defining a first vertical plane; and a right frame rail spaced from the left frame rail, the right frame rail defining a second vertical plane; and a front axle assembly coupled to a front end of the right frame rail and the left frame rail, the front axle assembly including: an axle; and a steering assembly including: a pair of wheel hubs coupled to opposing ends of the axle; a steering gear mechanism positioned between the first vertical plane and the second vertical plane; and a linkage assembly coupling the steering gear mechanism to the pair of wheel hubs to facilitate steering the pair of wheel hubs through actuation of the steering gear mechanism, wherein components of linkage assembly do not extend through the left frame rail or the right frame rail, wherein bottom surfaces of the left frame rail and the right frame rail define a bottom plane, and wherein at least a portion of the steering gear mechanism is positioned along the bottom plane.
16. A vehicle comprising: a chassis including: a first frame rail defining a first vertical plane; and a second frame rail defining a second vertical plane; wherein bottom surfaces of the first frame rail and the second frame rail define a bottom plane; and a front axle assembly including: an axle coupled to a front end of the first frame rail and the second frame rail; and a steering assembly including: a pair of wheel hubs coupled to opposing ends of the axle; a steering gear mechanism positioned between the first vertical plane and the second vertical plane and above the bottom plane; and a linkage assembly coupling the steering gear mechanism to the pair of wheel hubs to facilitate steering the pair of wheel hubs through actuation of the steering gear mechanism, the linkage assembly including one or more pitman arms coupled to the steering gear mechanism, a pair of steering links coupled to the one or more pitman arms, and a pair of tie rod arms coupling the pair of steering links to the pair of wheel hubs; and wherein at least one of the one or more pitman arms or the pair of steering links is shaped such that portions of the pair of steering links proximate the first vertical plane and the second vertical plane are positioned beneath the bottom plane and pass underneath the first frame rail and the second frame rail and do not extend through the first frame rail and the second frame rail.
17. The vehicle of claim 16, wherein the one or more pitman arms are shaped such that the portions of the pair of steering links proximate the first vertical plane and the second vertical plane are positioned beneath the bottom plane and pass underneath the first frame rail and the second frame rail and do not extend through the first frame rail and the second frame rail.
18. The vehicle of claim 16, wherein the pair of steering links are shaped such that the portions of the pair of steering links proximate the first vertical plane and the second vertical plane are positioned beneath the bottom plane and pass underneath the first frame rail and the second frame rail and do not extend through the first frame rail and the second frame rail.
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