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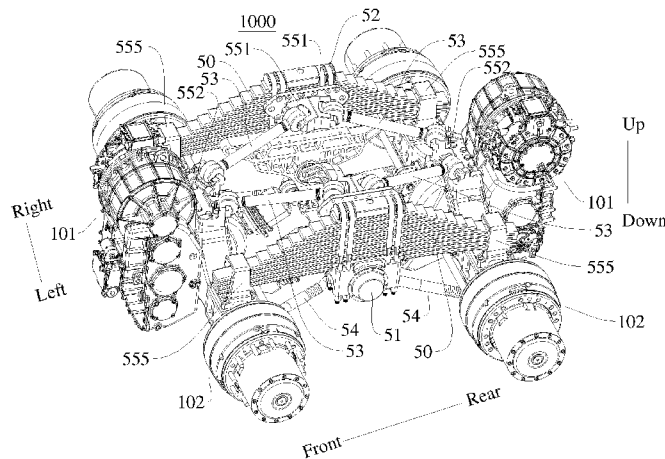
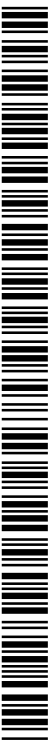


FIG. 3

(57) Abstract: A vehicle (100000) and a drive axle unit (10000) for the vehicle (100000) are provided. The drive axle unit (10000) includes a drive axle assembly (1000), the drive axle assembly (1000) including two vehicle axle assemblies, each vehicle axle assembly including an axle case assembly (102), and the axle case assembly (102) including an axle case component (21) and two half axles (22); at least one of the two vehicle axle assemblies is an electric drive axle assembly (100), the electric drive axle assembly (100) further including an electric power assembly (101) and a suspension apparatus, the electric power assembly (101) including a power motor (11), a transmission (12), and a differential (13), the transmission (12) having a transmission housing (121), the power motor (11) being fixed to the transmission housing (121), the differential (13) being supported on the transmission housing (121), the transmission housing (121) being fixed to the axle case component (21), the transmission (12) including a plurality of transmission shafts (I, II, III, IV), the plurality of transmission shafts (I, II, III, IV) being sequentially disposed from top to bottom, and the suspension apparatus being connected between the electric power assembly (101) and a frame (400) of the vehicle (100000); and a suspension system (500), each vehicle axle assembly being connected to the frame (400) of the vehicle (100000) by using the suspension system (500).



**DESCRIPTION****VEHICLE AND DRIVE AXLE UNIT FOR VEHICLE****5 CROSS-REFERENCE TO RELATED APPLICATIONS**

This application claims priority to and benefits of Chinese Patent Application Nos. 201511028995.3 and 201521137775.X, both filed with the State Intellectual Property Office of P. R. China on December 31, 2015. The entire contents of the above-identified applications are incorporated herein by reference.

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**FIELD**

Embodiments of the present disclosure relate to the field of vehicle technologies, and specifically, to an electric drive axle assembly and a vehicle having the electric drive axle assembly.

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**BACKGROUND**

In the prior art, a drive axle has many transmission stages, a long transmission chain, low transmission efficiency, a large volume and large noise, is difficult to perform arrangement and not environmentally friendly, and may cause severe air pollution, so that there is a space for  
20 improvement.

**SUMMARY**

The present disclosure is to resolve one of the technical problems in the prior art at least to a certain degree. For this, the present disclosure provides a drive axle unit for a vehicle that has a  
25 compact structure, energy conservation and a high integration degree, and is green and environmentally friendly.

The present disclosure further provides a vehicle.

A drive axle unit for a vehicle according to a first aspect of the present disclosure includes: a  
30 drive axle assembly, the drive axle assembly including two vehicle axle assemblies disposed at an interval in a front-rear direction, each vehicle axle assembly including an axle case assembly, the axle case assembly including an axle case component and two half axles, the two half axles being

located inside the axle case component; at least one of the two vehicle axle assemblies being an electric drive axle assembly, the electric drive axle assembly further including an electric power assembly and a suspension apparatus, the electric power assembly including a power motor, a transmission, and a differential, the transmission having a transmission housing, the power motor  
5 being fixed to the transmission housing, the differential being supported on the transmission housing, the differential being located inside the axle case component, the transmission housing being fixed to the axle case component, the transmission including a plurality of transmission shafts, the plurality of transmission shafts being sequentially disposed from top to bottom, the suspension apparatus being connected between the electric power assembly and a frame of the  
10 vehicle; and a suspension system, each vehicle axle assembly being connected to the frame of the vehicle by using the suspension system.

For the drive axle unit for a vehicle according to the present disclosure, at least one of two vehicle axle assemblies in a drive axle assembly is configured to be an electric drive axle assembly that has a compact structure, a short transmission chain, high transmission efficiency and easy  
15 arrangement, so that a vehicle implements a smooth driving process, is green and environmentally friendly, and has zero emission, zero pollution, and low noise. A suspension system connects a frame and each vehicle axle assembly, to make the vehicle more comfortable.

A vehicle according to a second aspect of the present disclosure includes the drive axle unit of the first aspect, and therefore has advantages such as a smooth driving process, zero emission, zero  
20 pollution, low noise, and high comfort and an advantage of being green and environmentally friendly.

## **BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a schematic structural view of a drive axle assembly and a frame according to an  
25 embodiment of the present disclosure;

FIG. 2 is a top view of FIG. 1;

FIG. 3 is a schematic structural view of a drive axle assembly according to an embodiment of the present disclosure;

FIG. 4 is a top view of FIG. 3;

30 FIG. 5 is a schematic structural view of FIG. 3 from a bottom view point;

FIG. 6 is a schematic structural view of an electric drive axle assembly according to an

embodiment of the present disclosure;

FIG. 7 is a sectional view of FIG. 6;

FIG. 8 is an enlarged view of part E in FIG. 7;

FIG. 9 is a schematic structural view of an axle case assembly according to an embodiment of  
5 the present disclosure;

FIG. 10 is a schematic structural view of an electric power assembly according to an  
embodiment of the present disclosure;

FIG. 11 is a schematic structural view of an internal structure of a transmission according to  
an embodiment of the present disclosure;

10 FIG. 12 is a side view of FIG. 11;

FIG. 13 is a schematic structural view of a power takeoff according to an embodiment of the  
present disclosure;

FIG. 14 is a schematic structural view of a transmission of a vehicle according to the present  
disclosure; and

15 FIG. 15 is a schematic view of a vehicle according to an embodiment of the present  
disclosure.

## **DETAILED DESCRIPTION**

The embodiments of the present disclosure are described below in detail, and examples of the  
20 embodiments are shown in the accompanying drawings. The following embodiments that are  
described with reference to the accompanying drawings are exemplary, and are intended to explain  
the present disclosure rather than to be construed as a limitation to the present disclosure.

A vehicle 100000 according to an embodiment of the present disclosure is described below  
with reference to FIG. 1 to FIG. 15. As shown in FIG. 1 to FIG. 15, the vehicle 100000 according to  
25 this embodiment of the present disclosure includes a frame 400, a first axle assembly 300, and a  
drive axle unit 10000 for a vehicle, where the drive axle unit 10000 includes a drive axle assembly  
1000 and a suspension system 500. The drive axle assembly 1000 is a second vehicle axle  
assembly 1000.

The first axle assembly 300 and the second axle assembly 1000 are disposed at an interval in  
30 a front-rear direction of the vehicle 100000. As shown in FIG. 15, the first axle assembly 300 is a  
front vehicle axle assembly of the vehicle 100000, and the second axle assembly 1000 is a rear

vehicle axle assembly of the vehicle 100000.

As shown in FIG. 15, the second axle assembly 1000 includes two vehicle axle assemblies disposed at an interval in a front-rear direction of the vehicle 100000. As shown in FIG. 1 to FIG. 7, each vehicle axle assembly includes an axle case assembly 102, the axle case assembly 102  
5 includes an axle case component 21 and two half axles 22, and the two half axles 22 are located inside the axle case component 21.

At least one of the two vehicle axle assemblies is an electric drive axle assembly 100, that is, one of the two vehicle axle assemblies may be the electric drive axle assembly 100, and the other one is a driven axle; or the two vehicle axle assemblies are both electric drive axle assemblies 100.

10 In an embodiment in which the two vehicle axle assemblies are both electric drive axle assemblies 100, each vehicle axle assembly may drive the vehicle 100000 to run, so that the second axle assembly 1000 is a drive axle and has strong power, and the vehicle 100000 can adapt to even roads and slopes, and has desirable comprehensive economic efficiency.

In an embodiment, the two electric drive axle assemblies 100 are disposed to be that a first  
15 electric drive axle assembly 100 is formed after a second electric drive axle assembly 100 rotates about an axis in an up-down direction perpendicular to the front-rear direction by 180°. That is, the first electric drive axle assembly 100 is a rear drive axle, and the second electric drive axle assembly 100 is a middle drive axle. The second electric drive axle assembly 100 is formed after the electric drive axle assembly 100 rotates about an axis in the up-down direction perpendicular to  
20 the front-rear direction by 180°. Accordingly, the structure of the second axle assembly 1000 is more compact, arrangement is facilitated, space utilization rate is high, and load distribution is even.

In an embodiment, the two electric drive axle assemblies 100 may be completely the same. In this way, the middle drive axle and the rear drive axle may be in common use, so as to reduce a  
25 manufacturing cost. Certainly, in some other embodiments of the present disclosure, the two electric drive axle assemblies 100 may be slightly different.

In an embodiment, in an embodiment in which the two vehicle axle assemblies are electric drive axle assemblies 100, the drive axle unit 10000 for a vehicle may further include two motor controllers. The two motor controllers correspond to the two electric drive axle assemblies 100 one  
30 to one, and each motor controller separately controls a power motor 11 of a corresponding electric drive axle assembly 100. Accordingly, the two electric drive axle assemblies 100 work separately

without mutual interference and respectively controlled by the two motor controllers. A precise control unit is used to adjust a rotational speed of the power motor 11, so as to implement real-time synchronization. In addition, because the two electric drive axle assemblies 100 may work separately, even if one electric drive axle assembly 100 cannot work, the other the electric drive axle assembly 100 can still drive the entire vehicle to run. Moreover, two independent power sources, that is, two independent power motors 11, are provided, so that the power of the entire vehicle is stronger.

In an embodiment in which one of the two vehicle axle assemblies is the electric drive axle assembly 100, and the other one of the two vehicle axle assemblies is a driven axle, the electric drive axle assembly 100 actuates the driven axle, so as to make the vehicle 100000 to run, so that the structure is simple and arrangement is easy.

As shown in FIG. 6 to FIG. 14, the electric drive axle assembly 100 includes an electric power assembly 101 and the axle case assembly 102. The electric power assembly 101 includes the power motor 11, a transmission 12, and a differential 13. As shown in FIG. 6 to FIG. 9, the axle case assembly 102 includes the axle case component 21 and the two half axles 22. The two half axles 22 and the differential 13 are both located inside the axle case component 21.

It may be understood that, after speed changing and torque adjusting performed by the transmission 12, power output by the power motor 11 is transferred to the differential 13, two output ends of the differential 13 output the power to the two half axles 22, and the two half axles 22 transfers the power to wheels connected to the half axles 22, so as to drive the vehicle 100000 to run.

As shown in FIG. 6 and FIG. 7, in the electric drive axle assembly 100 in this embodiment of the present disclosure, the transmission 12 has a transmission housing 121. The power motor 11 is fixed to the transmission housing 121, the differential 13 is supported on the transmission housing 121, and the transmission housing 121 is fixed to the axle case component 21. For example, in some embodiments of the present disclosure, the power motor 11 may be fixed to the transmission housing 121 by using a threaded connecting piece, the transmission housing 121 may be fixed to the axle case component 21 by using a threaded connecting piece, and the differential 13 is supported on the transmission housing 121 by using a bearing.

That is, in the electric drive axle assembly 100, the transmission housing 121 may be used as a mounting carrier for the power motor 11, and the transmission housing 121 is a member for

connecting the electric power assembly 101 and the axle case assembly 102, so that the power motor 11, the transmission 12, the differential 13 and the axle case assembly 102 are integrated.

For the electric drive axle assembly 100 according to this embodiment of the present disclosure, the power motor 11, the transmission 12, the differential 13, and the axle case assembly 102 are integrated, so that the structure is compact, assembly is simple, the mass is small, a small volume is occupied, a small space is occupied, arrangement on the vehicle 100000 is facilitated, a transmission chain is shortened, a transmission loss is small, and transmission efficiency is high.

The transmission 12 includes a plurality of transmission shafts. The plurality of transmission shafts is sequentially disposed from top to bottom. Accordingly, a distance from the center of mass of the electric power assembly 101 to the center of the axle case assembly 102 is greatly shortened, so that relative torque from the electric power assembly 101 to the axle case assembly 102 is reduced, connection is reliable, and transmission is smoother.

In an embodiment, the electric drive axle assembly 100 may further include a suspension apparatus, where the suspension apparatus is connected between the electric power assembly 101 and the frame 400. That is, the electric power assembly 101 is not completely supported by the axle case assembly 102, and the electric power assembly 101 is further connected to the frame 400 by using the suspension apparatus. In this way, torque to the axle case assembly 102 generated by a center of mass offset of the electric power assembly 101 can be effectively balanced. The suspension apparatus is disposed, so that impact can be effectively reduced, so as to achieve hopping synchronization between the electric power assembly 101 and the axle case assembly 102 as much as possible, and the torque between the electric power assembly 101 and the axle case assembly 102 is nearly reduced to zero, thereby ensuring the reliability of connection between the electric power assembly 101 and the axle case assembly 102, thereby ensuring stability of power transmission, and ensuring the use safety of the entire electric drive axle assembly 100.

Such an arrangement manner of the electric drive axle assembly 100 is more suitable for the vehicle 100000 in which the electric power assembly 101 has a large volume and the power motor 11 has large power, so as to meet running requirements of a heavy-load vehicle 100000 very desirably.

The suspension apparatus may be connected between an end, far away from the axle case assembly 102, of the transmission housing 121 and the frame 400, so as to better balance torque for the axle case assembly 102 generated by centroid shift of the electric power assembly 101 to

the axle case assembly 102, so that mounting of the electric power assembly 101 and the axle case assembly 102 is more stable.

In an embodiment, the suspension apparatus may include two shock absorbers, and the two shock absorbers may be symmetrically disposed on a left side and a right side of the transmission housing 121. Accordingly, the electric power assembly 101 is subject to more balanced forces. The  
5 frame 400 may include a beam, an end of the shock absorber is mounted on the beam, and the other end of the shock absorber is mounted on the transmission housing 121.

For the electric drive axle assembly 100 according to this embodiment of the present disclosure, the suspension apparatus is disposed between the electric power assembly 101 and the  
10 frame 400, so that impact can be effectively reduced, so as to achieve hopping synchronization between the electric power assembly 101 and the axle case assembly 102 as much as possible, and the torque between the electric power assembly 101 and the axle case assembly 102 is nearly reduced to zero, thereby ensuring the reliability of connection between the electric power assembly  
15 101 and the axle case assembly 102, and ensuring stability of power transmission, making use of the entire electric drive axle assembly 100 more reliable and safer.

Each vehicle axle assembly is connected to the frame 400 by using the suspension system 500. That is, the suspension system 500 is a connecting member between the frame 400 and each vehicle axle assembly, so that influence on the whole vehicle caused by vibrations of the driving system of the vehicle 100000 is greatly reduced, thereby improving the comfort of the entire  
20 vehicle.

For the drive axle unit 10000 for a vehicle according to this embodiment of the present disclosure, at least one of two vehicle axle assemblies in a second axle assembly 1000 is configured to be an electric drive axle assembly 100 that has a compact structure, a short transmission chain, high transmission efficiency, and easy arrangement, so that the vehicle 100000  
25 implements a smooth driving process, is green and environmentally friendly, and has zero emission, zero pollution, and low noise. The suspension system 500 connects the frame 400 and each vehicle axle assembly, making the vehicle 100000 more comfortable. A plurality of transmission shafts are sequentially disposed from top to bottom, and a distance from the center of mass of the electric power assembly 101 to the center of the axle case assembly 102 is greatly  
30 shortened, so that relative torque from the electric power assembly 101 to the axle case assembly 102 is reduced, connection is reliable, and transmission is smoother.

For the vehicle 100000 according to this embodiment of the present disclosure, the foregoing drive axle unit 10000 is used, so that the vehicle 100000 has advantages such as a smooth driving process, smoother transmission, reliable connection, zero emission, zero pollution, low noise, and high comfort and an advantage of being green and environmentally friendly.

5 The vehicle 100000 according to this embodiment of the present disclosure is described below in detail with reference to FIG. 1 to FIG. 15. As shown in FIG. 15, the vehicle 100000 includes the frame 400, the first axle assembly 300, and the drive axle unit 10000. The drive axle unit 10000 includes the second axle assembly 1000 and the suspension system 500.

10 The first axle assembly 300 and the second axle assembly 1000 are disposed at an interval in a front-rear direction of the vehicle 100000. The second axle assembly 1000 includes two vehicle axle assemblies. At least one of the two vehicle axle assemblies is the electric drive axle assembly 100, and each vehicle axle assembly is connected to the frame 400 by using the suspension system 500.

15 The suspension system 500 according to this embodiment of the present disclosure is described in detail below with reference to FIG. 1 to FIG. 5. As shown in FIG. 1 to FIG. 5, the suspension system 500 includes two elastic members disposed at an interval in a left-right direction 50, a balance shaft assembly 51, and a first thrust rod group and a second thrust rod group disposed at an interval in an up-down direction.

20 The two elastic members 50 are disposed at an interval in a left-right direction, where a first elastic member is located on a left side of the vehicle 100000, and a second elastic member is located on the right side of the vehicle 100000. Two ends (that is, a front end and a rear end) of each elastic member 50 are respectively connected to the two axle case components 21, and each elastic member 50 is located above the two axle case components 21. In an embodiment, the elastic member 50 includes at least one plate spring. In an embodiment, the elastic member 50  
25 includes a plurality of plate springs, and the plurality of plate springs is stacked from the top to bottom.

In other words, a front end of the first elastic member 50 on the left side is connected to a left end of the axle case component 21 of the vehicle axle assembly that is located in front. A rear end of the first elastic member 50 on the left side is connected to a left end of the axle case component  
30 21 of the vehicle axle assembly that is located rear. The elastic member 50 on the left side is located above the two axle case components 21. A front end of the second elastic member 50 on

the right side is connected to a right end of the axle case component 21 of the vehicle axle assembly that is located in front. A rear end of the second elastic member 50 on the right side is connected to a right end of the axle case component 21 of the vehicle axle assembly that is located rear. The second elastic member 50 on the right side is located above the two axle case components 21.

That is, for the drive axle unit 10000 for a vehicle according to the present disclosure, because the axle case component 21 is completely placed below the elastic member 50, that is, the axle case assembly 102 and the electric power assembly 101 are both located below the elastic member 50 (a plate spring), influence on the whole vehicle caused by vibrations of the electric power assembly 101 is greatly reduced, the comfort of the entire vehicle is improved, a driving process is smooth, and the vehicle is green and environmentally friendly and has zero emission, zero pollution, and low noise.

The balance shaft assembly 51 is fixed to the frame 400, and the balance shaft assembly 51 is located between the two vehicle axle assemblies in a front-rear direction, that is, the two vehicle axle assemblies are respectively located on two sides of the balance shaft assembly 51. A middle portion of each elastic member 50 is fixed to the balance shaft assembly 51, that is, the balance shaft assembly 51 may be used as a connecting member between the elastic member 50 and the frame 400. The middle portion of the first elastic member 50 on the left side is fixed at the left end of the balance shaft assembly 51, and the middle portion of the second elastic member 50 on the right side is fixed at the right end of the balance shaft assembly 51. Accordingly, fixing of each elastic member 50 is more secure, that is, two ends of each elastic member 50 are respectively fixed to an end portion of a same side of the two axle case components 21, and the middle portion of each elastic member 50 is fixed at a corresponding end of the balance shaft assembly 51.

An example in which the elastic member 50 includes at least one plate spring is used. The middle portion of each elastic member 50 is fixed to the balance shaft assembly 51 by using a U-bolt 52, that is, at least one plate spring is fixed to a corresponding end of the balance shaft assembly 51 by using the U-bolt 52.

In an embodiment, each elastic member 50 is fixed to a corresponding end of a balance shaft assembly by using two U-bolts 52 that are disposed at an interval in a front-rear direction.

As shown in FIG. 1 to FIG. 5, the first thrust rod group includes two first subgroups that are symmetrically disposed in a front-rear direction. The two first subgroups correspond to the two

axle case components 21 one to one, that is, each first subgroup includes a plurality of first thrust rods 53, and each first thrust rod 53 is connected between the frame 400 and a corresponding axle case component 21.

5 The second thrust rod group includes two second subgroups that are symmetrically disposed in a front-rear direction. The two second subgroups correspond to the two axle case components 21 one to one. Each second subgroup includes a plurality of second thrust rods 54, and each second thrust rod 54 is connected between the balance shaft assembly 51 and a corresponding axle case component 21.

10 In other words, any first thrust rod 53 in the first thrust rod group is connected between the frame 400 and a corresponding axle case component 21. Any second thrust rod 54 in the second thrust rod group is connected between the balance shaft assembly 51 and a corresponding axle case component 21. By means of the connections between the foregoing two thrust rod groups and the balance shaft assembly 51 and the frame 400, so that locations of the two vehicle axle assemblies relative to the frame 400 are fixed, and when the second axle assembly generates power, the  
15 vehicle body is pushed to move forward.

In an embodiment of the present disclosure, the first thrust rod group is located above the second thrust rod group, and a first end of each first thrust rod 53 is connected to a middle portion of a corresponding axle case component 21. For example, the first end of each first thrust rod 53 is connected to a middle portion of a corresponding axle case component 21 by using a first thrust  
20 rod axle case mounting seat 552. The first thrust rod axle case mounting seat 552 is fixed to the middle portion of the axle case component 21, and the first thrust rod axle case mounting seat 552 is located above the axle case component 21.

A second end of each first thrust rod 53 is connected to the frame 400 by using a first thrust rod frame mounting seat 551, the first thrust rod frame mounting seat 551 is fixed to the frame 400,  
25 and the first thrust rod frame mounting seat 551 is located between the two axle case components 21.

In other words, each first thrust rod 53 corresponds to one first thrust rod axle case mounting seat 552 and one first thrust rod frame mounting seat 551. A front end of the first thrust rod 53 in the first subgroup located in front is connected to the middle portion of the axle case component  
30 21 in the front by using the first thrust rod axle case mounting seat 552. A rear end of the first thrust rod 53 in the first subgroup located in front is connected to the frame 400 by using the first

thrust rod frame mounting seat 551. A rear end of the first thrust rod 53 in the first subgroup located rear is connected to the middle portion of the axle case component 21 in the rear by using the first thrust rod axle case mounting seat 552. A front end of the first thrust rod 53 in the first subgroup located rear is connected to the frame 400 by using the first thrust rod frame mounting seat 551.

In an embodiment, the first end of each first thrust rod 53 is located on an inner side at the second end of the same first thrust rod 53. That is, each first thrust rod 53 is disposed obliquely, the first thrust rod 53 in the first subgroup located in front extends outwardly from front to rear, and the first thrust rod 53 in the first subgroup located in the rear extends inwardly from front to rear.

In an embodiment, the first thrust rod frame mounting seat 551 is fixed to an inner side of the frame 400. Accordingly, the structure of the suspension system 500 is more compact, and connection and assembling are more convenient. It should be understood that, the frame 400 may include two girders that are disposed at an interval in a left-right direction, the first thrust rod frame mounting seat 551 on the left side is located on an inner side of the girder on the left side, and the first thrust rod frame mounting seat 551 on the right side is mounted and located on an inner side of the girder on the right side.

In some embodiments of the present disclosure, each first subgroup includes two first thrust rods 53. Each first subgroup corresponds to two first thrust rod axle case mounting seats 552, and the two first thrust rods 53 are one-to-one correspondingly connected to the two first thrust rod axle case mounting seats 552. Each first subgroup corresponds to two first thrust rod frame mounting seats 551, and second ends of the two first thrust rods 53 correspond to two first thrust rod frame mounting seats 551 one to one.

In other words, the two first thrust rod axle case mounting seats 552 corresponding to the two first thrust rods 53 in each first subgroup are integrated into a first thrust rod V-shaped axle case mounting seat 556.

In an embodiment, one first thrust rod frame mounting seat 551 connected to a rear end of the first thrust rod 53 on the left side in the first subgroup located on the front side and one first thrust rod frame mounting seat 551 connected to a front end of the first thrust rod 53 on the left side in the first subgroup located on the rear side may be integrated, and one first thrust rod frame mounting seat 551 connected to a rear end of the first thrust rod 53 on the right side in the first

subgroup located on the front side and one first thrust rod frame mounting seat 551 connected to a front end of the first thrust rod 53 on the right side in the first subgroup located on the rear side may be integrated. In this way, the two first thrust rod frame mounting seats 551 are integrated, so that the structural strength is high, and assembling with the frame 400 is simpler. In an embodiment, the integrated first thrust rod frame mounting seat 551 may be fixed to the frame 400 by using a threaded connecting piece.

In an embodiment of the present disclosure, the first thrust rod group is located above the second thrust rod group. A first end of each second thrust rod 54 is connected to an end portion of a corresponding axle case component 21. For example, a first end of each second thrust rod 54 is connected to the end portion of the corresponding axle case component 21 by using a second thrust rod axle case mounting seat 554. The second thrust rod axle case mounting seat 554 is fixed to an end portion of the axle case component 21, and the second thrust rod axle case mounting seat 554 is located below the corresponding axle case component 21.

A second end of each second thrust rod 54 is connected to the balance shaft assembly 51 by using a second thrust rod balance shaft mounting seat 553, the second thrust rod balance shaft mounting seat 553 is fixed to an end portion of the balance shaft assembly 51, and an end portion of an axle case component 21 and an end portion of the balance shaft assembly 51 which correspond to the same second thrust rod 54 are located on a same side of the drive axle assembly 1000.

In other words, each second thrust rod 54 corresponds to one second thrust rod axle case mounting seat 554 and one second thrust rod balance shaft mounting seat 553. A front end of the second thrust rod 54 on the left side in the second subgroup located in front is connected to a left end portion of the axle case component 21 in front by using the second thrust rod axle case mounting seat 554. A front end of the second thrust rod 54 on the right side in the second subgroup located in the front is connected to the right end portion of the axle case component 21 in front by using the second thrust rod axle case mounting seat 554. A rear end of the second thrust rod 54 on the left side in the second subgroup located in front is connected to a left side end portion of the balance shaft assembly 51 by using the second thrust rod balance shaft mounting seat 553. A rear end of the second thrust rod 54 on the right side in the second subgroup located in the front is connected to a right side end portion of the balance shaft assembly 51 by using the second thrust rod balance shaft mounting seat 553.

A rear end of the second thrust rod 54 on the left side in the second subgroup located in the rear is connected to a left end portion of the axle case component 21 in the rear by using the second thrust rod axle case mounting seat 554. A rear end of the second thrust rod 54 on the right side in the second subgroup located in the rear is connected to a right end portion of the axle case component 21 by using the second thrust rod axle case mounting seat 554. A front end of the second thrust rod 54 on the left side in the second subgroup located in the rear is connected to a left side end portion of the balance shaft assembly 51 by using the second thrust rod balance shaft mounting seat 553. A front end of the second thrust rod 54 on the right side in the second subgroup located in the rear is connected to a right side end portion of the balance shaft assembly 51 by using the second thrust rod balance shaft mounting seat 553.

In an embodiment, the second end of each second thrust rod 54 is located on an inner side of the first end of the same second thrust rod 54, that is, each second thrust rod 54 is disposed obliquely, the second thrust rod 54 in the second subgroup located in front extends inwardly from front to rear, and the second thrust rod 54 in the second subgroup located in the rear extends outwardly from front to rear.

In some embodiments of the present disclosure, each second subgroup includes two second thrust rods 54, and the second subgroup corresponds to two second thrust rod axle case mounting seats 554. In an embodiment, as shown in FIG. 5, two elastic member mounting seats 555 disposed at an interval in a left-right direction are respectively fixed to the two ends of the axle case component 21 corresponding to the second subgroup, the two elastic member mounting seats 555 correspond to the two second thrust rod axle case mounting seats 554 one to one, each second thrust rod axle case mounting seat 554 is fixed below a corresponding elastic member mounting seat 555, and each second thrust rod balance shaft mounting seat 553 is fixed below the balance shaft assembly 51.

In other words, an elastic member mounting seat 555 is fixed at a left end of the axle case component 21 corresponding to the second subgroup, the second thrust rod axle case mounting seat 554 at a corresponding left end is fixed below the elastic member mounting seat 555 at the left end, and a second thrust rod balance shaft mounting seat 553 is fixed below at a left end of the balance shaft assembly 51 corresponding to the second subgroup. An elastic member mounting seat 555 is fixed at the right end of the axle case component 21 corresponding to the second subgroup, and the second thrust rod axle case mounting seat 554 at a corresponding right end is

fixed below the elastic member mounting seat 555 at the right end, and a second thrust rod balance shaft mounting seat 553 is fixed below a right end of the balance shaft assembly 51 corresponding to the second subgroup. In this way, the second thrust rod group is completely disposed below the first thrust rod group, to make an upper portion and a lower portion of the vehicle axle assembly  
5 fixed with the frame 400, so that locations of the frame 400 and the vehicle axle assembly may be relatively fixed, the frame 400 and the vehicle axle assembly are subject to more balanced applied forces, load distribution is more even, and overall arrangement of the vehicle 100000 is optimized.

In an embodiment, two ends of each first thrust rod 53 and two ends of each second thrust rod 54 have rubber ball hinge structures, so that the connection between each first thrust rod 53 and the  
10 frame 400, between each first thrust rod 53 and the vehicle axle assembly, between each second thrust rod 54 and the balance shaft assembly 51, and between each second thrust rod 54 and the vehicle axle assembly have flexibility to some extent, a vibration absorption effect is desirable, and connection is convenient.

In an embodiment, as shown in FIG. 1 to FIG. 5, the two vehicle axle assemblies are both  
15 electric drive axle assemblies 100, and one electric drive axle assembly 100 is formed after another electric drive axle assembly 100 rotates by 180 degrees, so that the middle drive axle and the rear drive axle may share one electric drive axle assembly 100. Only one vehicle axle assembly needs to be developed. For four first thrust rods 53 of the first thrust rod group and four second thrust rods 54 of the second thrust rod group, only one mould needs to be developed for each thrust rod  
20 group, so that a development cost is greatly reduced.

In short, for the drive axle unit 10000 for a vehicle according to this embodiment of the present disclosure, the electric drive axle assembly 100 integrates the power motor 11, the transmission 12, and the axle case assembly 102, so that the structure is compact and transmission efficiency is high. Moreover, a sole electric drive manner is used in the second axle assembly 1000  
25 of the drive axle unit 10000 for a vehicle, so that an energy utilization rate is high, a response speed is fast, and power performance is stronger. In addition, the entire power part of the vehicle 100000 is located below the elastic members 50, that is, a vibration source of the entire vehicle is placed under the elastic members 50. By means of the vibration absorption of the suspension system 500, the vibration is dampened, the comfort of the entire vehicle is greatly improved, and a  
30 plurality of members (for example, the vehicle axle assembly, the first thrust rod 53, and the second thrust rod 54) may be in common use, so that a development cost is low. In an embodiment,

when the two vehicle axle assemblies are both electric drive axle assemblies 100, the two electric drive axle assemblies 100 may work synchronously, or may work separately, so that even if one electric drive axle assembly 100 cannot work, the other electric drive axle assembly 100 can also drive the entire vehicle to run. Two independent power sources make the power of the entire vehicle stronger.

The electric drive axle assembly 100 according to this embodiment of the present disclosure is described below in detail with reference to FIG. 6 to FIG. 15. The electric drive axle assembly 100 shown in FIG. 6 to FIG. 15 includes the electric power assembly 101, the axle case assembly 102, and the suspension apparatus. In an embodiment, the electric power assembly 101 may be fixed to the axle case assembly 102 by using a plurality of bolts, so that the electric power assembly 101 and the axle case assembly 102 are integrated into the electric drive axle assembly 100.

As shown in FIG. 6, FIG. 7, and FIG. 10 to FIG. 14, the electric power assembly 101 includes the power motor 11, the transmission 12, the differential 13, and an electrohydraulic gear shift actuating module 15, where the transmission 12 has the transmission housing 121.

As shown in FIG. 6, the power motor 11 may be fixed to the transmission housing 121 by using the plurality of bolts, where the plurality of bolts is disposed at an interval in a circumferential direction of the power motor 11. The power motor 11 may be a permanent-magnet synchronous motor. The power motor 11 is connected to an external power supply by using a three-phase wire, thereby implementing driving of the power motor 11.

As shown in FIG. 10, the power motor 11 includes an active cooling structure. The active cooling structure configured to actively cool the power motor 11. In some embodiments, the active cooling structure includes a coolant circulation passage 111 for cooling the power motor 11. Circulation of coolant inside the coolant circulation passage 111 is used to cool the power motor 11. As shown in FIG. 10, the coolant circulation passage 111 has an inlet A and an outlet B, the coolant may enter the coolant circulation passage 111 from an inlet A, and after performing heat exchange with the power motor 11, the coolant is output from the outlet B.

Accordingly, the power motor 11 is provided with the active cooling structure, so that the power motor 11 may be prevented from being overheated, efficiency is indirectly improved, the power motor 11 is prevented from being burnt up, and high-power, high-rotational-speed, and long-time running requirements can be met, operating conditions of a vehicle are fit more desirably,

and this can be used in full-series models from a light type to a heavy type.

In an embodiment, the active cooling structure may further include a coolant driving member, the coolant driving member is disposed to the coolant circulation passage 111 to drive coolant to flow inside the coolant circulation passage 111. In an embodiment, the coolant driving member  
5 may be a cooling oil pump. Accordingly, the active cooling structure is provided with the coolant driving member, so that an integration degree is high, and assembling is simple.

Certainly, in some embodiments of the present disclosure, the coolant circulation passage 111 may also be connected to coolant located outside the electric drive axle assembly 100, that is, the coolant may be introduced from outside, that is, the coolant circulation passage 111 of the active  
10 cooling structure may share the coolant driving member with a coolant circulation passage of another member on the vehicle.

The transmission housing 121 may be fixed to the axle case component 21 of the axle case assembly 102 by using bolts. The axle case component 21 includes the axle case 210 and a case cover 213. A differential receiving space whose two side end surfaces are both open is provided at  
15 a middle portion of the axle case 210. The case cover 213 is detachably mounted on the axle case 210 to close a first open side end surface of the middle portion of the axle case 210, and the transmission housing 121 is fixed to a second open side end surface of the middle portion of the axle case 210.

In an embodiment, the case cover 213 may be detachably mounted on the axle case 210 by  
20 using a threaded connecting piece. Specifically, as shown in FIG. 6, FIG. 7, and FIG. 9, the threaded connecting piece is a bolt 403. The case cover 213 may be connected in a threaded manner on the first open side end surface of the middle portion of the axle case 210 by using the plurality of bolts 403 that are disposed at an interval in a circumferential direction of the case cover 213. In this way, the case cover 213 is detachably mounted on the axle case 210, so that  
25 mounting of the electric power assembly 101 can be more convenient, a fixing structure is simple, and operations are convenient. Specifically, the case cover 213 on the first side end surface of the middle portion of the axle case 210 is made to be an assembly type, so that the difficulty of assembling the electric power assembly 101 and the two half axles 22 can be effectively reduced, and repair of the differential 13 is further facilitated.

30 In an embodiment, the electric drive axle assembly 100 further includes a plurality of bolts. A plurality of threaded holes is provided on the transmission housing 121. The plurality of through

holes one-to-one corresponding to the plurality of threaded holes is provided on the axle case 210. The plurality of bolts corresponds to the plurality of through holes one to one. Each bolt passes through a corresponding through hole and is fixed inside a corresponding threaded hole to fix the transmission housing 121 on the second open side end surface of the middle portion of the axle case 210.

That is, for the electric drive axle assembly 100 according to this embodiment of the present disclosure, the plurality of threaded holes is provided in the transmission housing 121, and the plurality of through holes is provided in the axle case 210. In this way, in a case in which the strength of connection is ensured, the volume of the transmission 12 may further be as small as possible, and the structure is more compact.

In an embodiment, as shown in FIG. 7, two half axle sleeves 23 may be respectively fixed to the two ends (that is, the left end and the right end) of the axle case component 21 through welding.

The axle case assembly 102 may further include two wheel reducers 20, two hub assemblies 24, two brakes 25, and two brake mounting plates 214. Each hub assembly 24 is rotatably mounted to a corresponding half axle sleeve 23. The two half axle sleeves 23 are fitted over the two half axles 22 one to one, the two wheel reducers 20 correspond to the two hub assemblies 24 one to one, an input end of each wheel reducer 20 is connected to a corresponding half axle 22, and an output end of each wheel reducer 20 is connected to a corresponding hub assembly 24.

In some embodiments of the present disclosure, as shown in FIG. 8, the wheel reducer 20 is a planetary gear reducer. The planetary gear reducer includes a sun gear 202, a planetary gear 203, and an inner gear ring 204, and the sun gear 202 is fixed to the half axle 22, to rotate synchronously with the half axle 22. The planetary gear 203 is engaged with the sun gear 202 and the inner gear ring 204, and the inner gear ring 204 is fixed to a corresponding half axle sleeve 23 by using an inner gear ring support 205. Accordingly, a small volume is occupied, transmission efficiency is high, and a speed reduction range is broad.

In an embodiment, as shown in FIG. 8, the wheel reducer 20 includes a wheel reducer housing 201. The wheel reducer housing 201 may be fixed to the hub assembly 24. Accordingly, the volume of the axle case assembly 102 is further reduced, the structure is compact, and a space is saved.

In an embodiment, the inner gear ring support 205 is engaged with the inner gear ring 204,

the planetary gear reducer may further include a retainer ring 206, and the retainer ring 206 is sandwiched between the inner gear ring support 205 and the inner gear ring 204 in a radial direction, so as to stop the inner gear ring 204 in a radial direction, so that assembly precision of the wheel reducer 20 and the hub assembly 24 is ensured relatively desirably.

5           The two brakes 25 correspond to the two hub assemblies 24 one to one, that is, one brake 25 corresponds to one hub assembly 24 to brake the hub assembly 24. The two brake mounting plates 214 are respectively fixed to the two ends of the axle case component 21 through welding (and specifically, the two brake mounting plates 214 may be respectively fixed onto the two half axle sleeves 23 in a welding manner, the two half axle sleeves 23 may be respectively fixed onto the  
10 two ends of the axle case component 21 in a welding manner), the two brakes 25 are fixed to the two brake mounting plates by using threaded connecting pieces 214 one to one, and brake drums 251 of the two brakes 25 are one-to-one correspondingly fixed to the two hub assemblies 24.

          The axle case assembly 102 may further include two axial stopper sets 27, and the two axial stopper sets 27 correspond to the two hub assemblies 24 one to one, that is, one axial stopper set  
15 27 correspond to one hub assembly 24 to stop the hub assembly 24 in an axial direction. Each inner gear ring support 205 is fitted over a corresponding half axle sleeve 23 by using a spline structure, and each axial stopper set 27 includes a stop nut 271 and a locking sheet 272. The stop nut 271 and the locking sheet 272 are both fitted over the corresponding half axle sleeve 23, and the stop nut 271 is connected to the corresponding half axle sleeve 23 in a threaded manner to  
20 tighten a corresponding inner gear ring support 205 and a corresponding hub assembly 24 between the locking sheet 272 and a brake drum 251 of a corresponding brake 25.

          It should be understood that, the two wheel reducers 20, the two hub assemblies 24, the two half axle sleeves 23, the two brakes 25, the two brake mounting plates 214, the two axial stopper sets 27, and the two half axles 22 all correspond one to one, and in a width direction of the vehicle,  
25 are respectively symmetrically located at the left end and the right end of the axle case component 21.

          The left end is used as an example below to describe connection relationships and location relationships of the wheel reducer 20, the hub assembly 24, the half axle sleeve 23, the brake 25, the brake mounting plate 214, and the axial stopper set 27.

30           Specifically, as shown in FIG. 8, one half axle sleeve 23 is welded at the left end of the axle case component 21, the hub assembly 24 at the left end is rotatably mounted to the half axle sleeve

23 at the left end, and the half axle sleeve 23 at the left end is fitted over the half axle 22 on the left side. The hub assembly 24 is a part of a wheel, and the rotation of the hub assembly 24 can implement the rotation of the wheel. More specifically, as shown in FIG. 8, a left end of the half axle 22 at the left end pass through the half axle sleeve 23 at the left end and is connected to the sun gear 202, an end cover is fixed with the wheel reducer 20 (for example, the wheel reducer housing 201) at the left end by using a threaded connecting piece (a bolt 406 shown in FIG. 8). A right end of the half axle 22 at the left end is connected to the differential 13 by using a spline. The half axle 22 at the left end transfers power output by the differential 13 to an input end of the wheel reducer 20 at the left end. After speed reduction by the wheel reducer 20 at the left end, the power is transferred through an output end of the wheel reducer 20 at the left end to the hub assembly 24 at the left end, to actuate the wheels to rotate.

The brake 25 at the left end corresponding to the hub assembly 24 at the left end is mounted to the brake mounting plate 214 at the left end. The brake mounting plate 214 at the left end is fixed to the left end of the axle case component 21. The brake drum 251 of the brake 25 at the left end is further fixed to the hub assembly 24 at the left end to rotate together with the hub assembly 24. For example, the brake mounting plate 214 may be fitted over and fixedly welded to the axle case 210 of the axle case component 21, the brake 25 at the left end is fixed to the brake mounting plate 214 at the left end by using a threaded connecting piece, and the brake drum 251 of the brake 25 at the left end may be fixed to the hub assembly 24 at the left end by using a bolt 405, where there are a plurality of threaded connecting pieces and a plurality of bolts 405. In an axial direction, that is, a left-right direction of the vehicle, the brake 25 at the corresponding end is located between the brake mounting plate 214 at the corresponding end and the hub assembly 24 at the corresponding end.

The axial stopper set 27 corresponding to the hub assembly 24 at the left end are a left end set, and the stop nut 271 in the left end set and the locking sheet 272 in the left end set are both fitted over the half axle sleeve 23 at the left end. The stop nut 271 in the left end set is connected to the half axle sleeve 23 at the left end in a threaded manner to tighten the inner gear ring support 205 at the left end and the hub assembly 24 at the left end between the locking sheet 272 at the left end set and the brake drum 251 of the brake 25 at the left end. Accordingly, the hub assembly 24 may perform locking in an axial direction by using fitting between the stop nut 271 and the brake drum 251 of the brake 25. Similarly, the wheel reducer 20 may also perform locking in an axial direction

by using fitting between the stop nut 271 and the brake drum 251 of the brake 25. Specifically, the wheel reducer housing 201, the brake drum 251 of the brake 25, and a part of the hub assembly 24 are fixed together by using the bolt 405.

The locking sheet 272 may prevent the stop nut 271 from loosening. Specifically, each hub assembly 24 is rotatably fitted over a corresponding half axle sleeve 23 by using the hub bearing 241, and the axial stopper set 27 may adjust a clearance of the hub bearing 241.

By means of the foregoing description, a person skilled in the art may derive connection relationships and location relationships of the wheel reducer 20, the hub assembly 24, the half axle sleeve 23, the brake 25, the brake mounting plate 214, and the axial stopper set 27 at the right end, and details are no longer described herein.

In an embodiment, the axle case assembly 102 may further include two ABS sensor components, the two ABS sensor components may be fixed to the two brake mounting plates one to one by using threaded connecting pieces 214, that is, an ABS sensor component at the left end is fixed to the brake mounting plate 214 at the left end, and an ABS sensor component at the right end is fixed to the brake mounting plate 214 at the right end. In an embodiment, the threaded connecting piece may be a screw.

Specifically, a sensor head of the ABS sensor component and an induction gear ring of the hub assembly 24 rotate to form an induction voltage signal, the induction voltage signal is output to a control system (for example, an ECU in the vehicle), and the control system controls the brake 25 to lock during braking.

In an embodiment, as shown in FIG. 10, the electric power assembly 101 may further include the electrohydraulic gear shift actuating module 15. The electrohydraulic gear shift actuating module 15 is configured to control the transmission 12, and the electrohydraulic gear shift actuating module 15 is mounted on the transmission housing 121. A sensor and a precise flow valve matching the electrohydraulic gear shift actuating module 15 are mounted to the electrohydraulic gear shift actuating module 15, and an external electronic control unit may make a response by using a collected signal, so that a shifting speed and a shifting time point of the transmission 12 can be precisely controlled, so that the transmission 12 has smooth shifting, a fast response speed, and desirable operability, and may relieve driving fatigue.

A differential lock mechanism is mounted on the transmission 12, and the differential lock mechanism is configured to selectively to lock one of the two half axles 22 and a differential

housing of the differential 13 that integrates with an electric drive axle.

A working principle of the differential lock mechanism is that when a driving wheel slips, the differential housing and the half axle 22 are locked together, making the differential 13 lose a differential function, so that all torque can be transferred to a driving wheel on another side, which is particularly important for a construction vehicle that slips easily when running on a muddy road.

For the axle case assembly 102 according to this embodiment of the present disclosure, the differential lock mechanism is disposed, so that according to a different running condition of the vehicle, the differential 13 implements a differential function or disables the differential function, which is particular suitable for an agitator truck that runs in a severe working condition, so that the agitator truck has strong power. Moreover, the differential lock mechanism is integrated with the transmission 12, so that the structure is compact, mounting is secure, working is stable, reliability is high, thereby providing the electric drive axle assembly 100 with higher reliability and more complete functions.

The transmission includes a transmission power input portion and a transmission power output portion. The transmission power input portion is directly connected to a motor output shaft of the power motor, the transmission power output portion is constructed to be suitable for outputting power that is from the transmission power input portion to the differential, and the power is output to the wheels of the vehicle by using the differential to drive the vehicle to travel. In an embodiment, as shown in FIG. 5, the differential 13 may be supported on the transmission housing 121 by using a differential bearing.

The electric power assembly 101 may further include a power takeoff 14. The power takeoff 14 includes a power takeoff input end and a power takeoff output end. The power takeoff input end is configured to move in cooperation with at least one of the transmission power input portion and the transmission power output portion. That is, the power takeoff input end may be configured to move in cooperation with the transmission power input portion. The power takeoff input end may also be configured to move in cooperation with the transmission power output portion. The power takeoff input end may further be configured to move in cooperation with the transmission power input portion and simultaneously move in cooperation with the transmission power output portion. The wording "move in cooperation" refers to that actions of two members have a driving and driven relationship, the action of one member actuates the action of the other member.

The power takeoff output end is configured to be selectively joined to the power takeoff input

end to output power from the power takeoff input end. That is, when the power takeoff device output end is joined to the power takeoff input end, the power takeoff output end may output, to an apparatus 16 to be driven, power from the power takeoff input end.

In an embodiment, the power takeoff 14 is fixed to the transmission housing 121, that is, the power takeoff 14 is integrated on the transmission housing 121. Accordingly, the structure of the electric power assembly 101 is more compact. Specifically, the power takeoff 14 may include the power takeoff housing 141, and the power takeoff housing 141 is connected to the transmission housing 121 or the power takeoff housing 141 and the transmission housing 121 are integrated.

When the transmission 12 is only used to drive the vehicle, power of the power motor 11 is output to the wheels of the vehicle by sequentially using the transmission power input portion, the transmission power output portion and the differential 13, so as to drive vehicle to run.

When the apparatus 16 to be driven needs to be driven, a part of the power of the power motor 11 is output to the wheels of the vehicle by sequentially using the transmission power input portion, the transmission power output portion and the differential 13. Another part of power of the power motor 11 is output to the apparatus 16 to be driven by sequentially using at least one of the transmission power input portion and the transmission power output portion, the power takeoff input end and the power takeoff output end.

In an embodiment of the present disclosure, the apparatus 16 to be driven is an oil pump. When being driven by the power takeoff 14, the oil pump can generate high-pressure hydraulic oil to provide a power source for a bed lifting mechanism of a dump truck and the like, to meet other power requirement of the entire vehicle.

That is, for the electric drive axle assembly 100 for a vehicle according to this embodiment of the present disclosure, the power takeoff 14 is provided, so that power can be output to a mechanism that has a need, so that more market requirements can be met, and the electric drive axle assembly 100 is more practical. In addition, because the power takeoff input end moves in cooperation with to at least one of the transmission power input portion and the transmission power output portion, a quantity of transmission members is small, transmission efficiency is high, a failure rate can be reduced, and a manufacturing cost is reduced.

The power takeoff input end may include a power takeoff gear k3. The power takeoff output end may include a power takeoff shaft V. As shown in FIG. 13, the power takeoff shaft V may be supported by the power takeoff housing 141 by using a power takeoff bearing 142. The power

takeoff gear k3 is freely fitted over the power takeoff shaft V, that is, the power takeoff gear k3 may rotate relative to the power takeoff shaft V, that is, when the power takeoff gear k3 rotate, the power takeoff shaft V may not rotate.

The power takeoff 14 may further include a power takeoff a synchronizer S3. The power  
5 takeoff synchronizer S3 is configured to selectively synchronize the power takeoff gear k3 with the power takeoff shaft V. That is, when the apparatus 16 to be driven needs power, the power takeoff synchronizer S3 synchronizes the power takeoff gear k3 with the power takeoff shaft V, so that the power takeoff shaft V outputs power output by the power takeoff gear k3 to the apparatus 16 to be driven. When the apparatus 16 to be driven does not need power, the power takeoff gear k3 and the  
10 power takeoff shaft V are separated, and the power takeoff gear k3 may idle about the power takeoff shaft V.

In an embodiment of the present disclosure, as shown in FIG. 11 to FIG. 14, a plurality of transmission shafts may include a first shaft I, a second shaft II, a third shaft III, and a fourth shaft IV. The first shaft I, the second shaft II, the third shaft III, and the fourth shaft IV are all supported  
15 on the transmission housing 121 by using a bearing. Specifically, as shown in FIG. 11, FIG. 12, and FIG. 14, the first shaft I, the second shaft II, the third shaft III, and the fourth shaft IV all extend in a width direction of the vehicle. The width direction of the vehicle is a left-direction of the vehicle, and the power motor 11 may be arranged on the right side of the transmission housing 121.

The first shaft I is connected to the motor output shaft VI of the power motor 11. As shown in  
20 FIG. 11, the first shaft I may be connected to the motor output shaft VI by using a spline structure. Specifically, the first shaft I has an inner spline, and the motor output shaft VI has an outer spline fitting with the inner spline. Certainly, the first shaft I may also be connected to the motor output shaft VI by using a coupling. For the electric power assembly 101 according to this embodiment of the present disclosure, the motor output shaft VI of the power motor 11 is directly connected to the  
25 first shaft I, so that a transmission chain is short, and the structure is simple.

As shown in FIG. 11 and FIG. 14, an input gear q is fixed to the first shaft I, that is, the input gear q may rotate synchronously with the first shaft I, an idler gear q' is fixed to the second shaft II, that is, the idler gear q' may rotate synchronously with the second shaft II, and the idler gear q' is engaged with the input gear q.

30 As shown in FIG. 14, the third shaft III includes a first shaft segment III-1 and a second shaft segment III-2 that are coaxially disposed, and the second shaft segment III-2 is configured to be

selectively joined to the first shaft segment III-1, that is, the second shaft segment III-2 may be joined to the first shaft segment III-1 to rotate synchronously with the first shaft segment III-1, and the second shaft segment III-2 and the first shaft segment III-1 may also rotate separately.

As shown in FIG. 14, one end of the first shaft segment III-1 is fitted over the second shaft segment III-2, that is, one end, near the first shaft segment III-1, of the second shaft segment III-2 is supported by the first shaft segment III-1. The first shaft segment III-1 is further supported by the transmission housing 121. Specifically, the first shaft segment III-1 is a hollow shaft, and the first shaft segment III-1 has a bearing hole. The end, near the first shaft segment III-1, of the second shaft segment III-2 is supported inside the bearing hole of the first shaft segment III-1 (that is, an inner circumferential wall of the first shaft segment III-1) by using a bearing B1. The first shaft segment III-1 (that is, an outer circumferential wall of the first shaft segment III-1) is further supported by the transmission housing 121 by using a bearing B2. The bearing B1 includes a pair of tapered roller bearings that are located at one end of the second shaft segment III-2. The bearing B2 includes two cylindrical roller bearings that are respectively located at two ends of the first shaft segment III-1. Different types of bearings are disposed inside and outside, so that the third shaft III is subject to more reasonable forces, thereby indirectly prolonging the service life of the transmission 12.

A first gear k1 is fixed to the first shaft segment III-1, that is, the first gear k1 may rotate synchronously with the first shaft segment III-1. When the first shaft segment III-1 is not joined to the second shaft segment III-2, the first gear k1 may rotate freely relative to the second shaft segment III-2. When the first shaft segment III-1 is joined to the second shaft segment III-2, the first gear k1 may further rotate synchronously together with the second shaft segment III-2. The first gear k1 is engaged with the idler gear q'. A plurality of gear position driven gears is freely fitted over the second shaft segment III-2, that is, the plurality of gear position driven gears may rotate relative to the second shaft segment III-2. That is, when the gear position driven gears rotate, the second shaft segment III-2 may not rotate.

A second gear k2 and a plurality of gear position driving gears are fixed to the fourth shaft IV, that is, the second gear k2 may rotate synchronously with the fourth shaft IV, and each of the plurality of gear position driving gears may rotate synchronously with the fourth shaft IV. The second gear k2 is engaged with the first gear k1, and the plurality of gear position driving gears is engaged with the plurality of gear position driven gears one to one.

In an embodiment, the third shaft III and the fourth shaft IV have various lengths and structures, and on the third shaft III and the fourth shaft IV, there may be different numbers of pairs of engaged gears, so that the transmission 12 has outputs of more gears.

5 The first shaft I, the input gear q, the second shaft II, and the idler gear q' form the transmission power input portion. The third shaft III, the first gear k1, the fourth shaft IV, the second gear k2, the plurality of gear position driving gears, and the plurality of gear position driven gears form the transmission power output portion.

10 In an embodiment, as shown in FIG. 14, an output gear z is further fixed to the second shaft segment III-2, that is, the output gear z may rotate synchronously with the second shaft segment III-2, and the output gear z may be engaged with a differential driven gear z' of the differential 13, so that power output by the power motor 11 is transferred to the differential 13 through the transmission 12 and actuates the half axle 22 and the wheels by using the differential 13, so as to make the vehicle run.

15 In an embodiment preferably, the input gear q, the idler gear q', the first gear k1, the second gear k2, the plurality of gear position driving gears, and the plurality of gear position driven gears are all helical gears. The output gear z is also a helical gear. Accordingly, transmission gears of the electric power assembly 101 are all helical gears, so that the entire transmission 12 has smooth transmission, low noise, high transmission efficiency, and large transmission torque.

20 In an embodiment of the present disclosure, the plurality of gear position driven gears include a first-gear driven gear 1', a second-gear driven gear 2', and a third-gear driven gear 3'. The plurality of gear position driving gears includes a first-gear driving gear 1, a second-gear driving gear 2 and a third-gear driving gear 3. The first-gear driven gear 1' is engaged with the first-gear driving gear 1, the second-gear driven gear 2' is engaged with the second-gear driving gear 2, and the third-gear driven gear 3' is engaged with the third-gear driving gear 3.

25 The transmission power output portion may further include a first-fourth gear synchronizer S1 and a second-third gear synchronizer S2. The first-fourth gear synchronizer S1 is configured to selectively join one of the first shaft segment III-1 and the first-gear driven gear 1' to the second shaft segment III-2. That is, the second shaft segment III-2 may be joined to the first shaft segment III-1 by using the first-fourth gear synchronizer S1 to rotate synchronously with the first shaft segment III-1, or the second shaft segment III-2 may be joined to the first-gear driven gear 1' by using the first-fourth gear synchronizer S1, so that the second shaft segment III-2 and the first-gear  
30

driven gear 1' rotate synchronously, or the second shaft segment III-2 may also be located at an intermediate location where the second shaft segment III-2 is neither joined to the first shaft segment III-1 nor joined to the first-gear driven gear 1'.

The second-third gear synchronizer S2 is configured to selectively join one of the second-gear driven gear 2' and the third-gear driven gear 3' to the second shaft segment III-2. That is, the second shaft segment III-2 may be joined to the second-gear driven gear 2' by using the second-third gear synchronizer S2, so that the second shaft segment III-2 and the second-gear driven gear 2' rotate synchronously, or the second shaft segment III-2 may be joined to the third-gear driven gear 3' by using the second-third gear synchronizer S2, so that the second shaft segment III-2 and the third-gear driven gear 3' rotate synchronously, or the second shaft segment III-2 may also be located at an intermediate location where the second shaft segment III-2 is neither joined to the second-gear driven gear 2' nor joined to the third-gear driven gear 3'.

As shown in FIG. 14, the output gear z is located between the first-gear driven gear 1' and the second-gear driven gear 2'. Accordingly, the structure of the transmission 12 is more compact.

In the four-gear transmission 12, two ends of the first shaft I are supported by the transmission housing 121 by using tapered roller bearings in pairs. The idler gear q' is connected to the second shaft II by fitting of an inner and outer spline structure. The second shaft II is supported by the transmission housing 121 by using tapered roller bearings in pairs at two ends. The third-gear driven gear 3', the second-gear driven gear 2', and the first-gear driven gear 1' are linked on the second shaft segment III-2 by fitting of bearings. The second-third gear synchronizer S2, the first-fourth gear synchronizer S1, and the output gear z are linked on the second shaft segment III-2 by fitting of the spline structures. The second gear k2 is connected on the fourth shaft IV by fitting of the spline structures, and the third-gear driving gear 3, the second-gear driving gear 2, and the first-gear driving gear 1 all fit and are connected on the fourth shaft IV by fitting of the spline structures. The differential driven gear z' may be fixedly mounted on the differential 13 by using a threaded connecting piece or in a welding form, so as to actuate the differential 13 to rotate.

As may be seen from the foregoing description, the present disclosure provides a four-gear transmission 12 that has a large speed ratio, large torque, relatively strong power performance, relatively desirable operability, and can meet use requirements of a vehicle, especially, a heavy-load vehicle.

In the description of the present disclosure, it needs to be understood that, direction or location relationships represented by the terms such as "center", "longitudinal", "horizontal", "length", "width", "thickness", "up", "down", "front", "rear", "left", "right", "vertical", "horizontal", "top", "bottom", "inside", "outside", "clockwise", "counterclockwise", "axial direction", "radial direction", and "circumferential direction" are based on the direction or location relationships shown in the accompanying drawings, and are only used to facilitate description of the present disclosure and simplify description, rather than to represent or imply that the discussed apparatuses or elements must have specific directions or must be constructed and operated in specific directions. Therefore, the direction or location relationships cannot be understood as a limitation to the present disclosure.

In addition, the terms "first" and "second" are only used for the purpose of description, and should not be can understood to represent or imply relative importance or implicitly represent a quantity of indicated technical features. Accordingly, features that are defined by "first" and "second" may explicitly or implicitly include at least one of the features. In the description of the present disclosure, "a plurality of" means at least two, for example, two or three, unless otherwise clearly and specifically defined.

In the present disclosure, unless otherwise clearly specified and defined, the terms such as "mount", "connected", "connect", and "fix" should be understood in a broad sense. For example, the terms may represent fixed connection, or may represent detachable connection, or may represent a whole; or may represent mechanical connection, or may represent electric connection or may represent communication; may represent direct connection, or may represent indirect connection by using an intermediate medium, or may represent internal connection between two elements or a mutual effect relationship between two elements, unless otherwise clearly defined. For a person of ordinary skill in the art, specific meanings of the foregoing terms in the present disclosure may be understood according to a specific case.

In the present disclosure, unless otherwise clearly specified and defined, when a first feature is "on" or "under" a second feature, the first feature and the second feature may be in direct contact, or the first feature and the second feature are in indirect contact by using an intermediate medium. Moreover, when the first feature is "on" and "above" the second feature, the first feature may be right above or obliquely above the second feature, or only means that the first feature has a horizontal height greater than that of the second feature. When the first feature is "under" and

"below" the second feature, the first feature may be right below the second feature or obliquely below the second feature, or only means that the first feature has a horizontal height less than that of the second feature.

In the description of this specification, the description of reference terms such as "one  
5 embodiment", "some embodiments", "example", "embodiment", or "some examples" refer to that specific features, structures, materials or characteristics that are described with reference to the embodiments or examples are included in at least one embodiment or example of the present disclosure. In this specification, schematic description of the foregoing terms does not necessarily  
10 involve the same embodiment or example. Moreover, the described specific features, structures, materials or characteristics may be combined in a suitable manner in any one or more embodiments or examples. In addition, without causing any contradictions, a person skilled in the art may combine and group different embodiments or examples and features in different embodiments or examples described in this specification.

Although the embodiments of the present disclosure are shown and described above, it may  
15 be understood that the foregoing embodiments are exemplary and cannot be construed as a limitation to the present disclosure. A person of ordinary skill in the art may make changes, modifications, replacements, and variations to the foregoing embodiments within the scope of the present disclosure.

20

## CLAIMS

1. A drive axle unit for a vehicle, comprising:

a drive axle assembly, the drive axle assembly comprising two vehicle axle assemblies disposed at an interval in a front-rear direction, each vehicle axle assembly comprising an axle case assembly, the axle case assembly comprising an axle case component and two half axles, and  
5 the two half axles being located inside the axle case component;

at least one of the two vehicle axle assemblies being an electric drive axle assembly, the electric drive axle assembly further comprising an electric power assembly and a suspension apparatus, the electric power assembly comprising a power motor, a transmission, and a  
10 differential, the transmission having a transmission housing, the power motor being fixed to the transmission housing, the differential being supported by the transmission housing, the differential being located inside the axle case component, the transmission housing being fixed to the axle case component, the transmission comprising a plurality of transmission shafts, the plurality of transmission shafts being sequentially disposed from top to bottom, and the suspension apparatus  
15 being connected between the electric power assembly and a frame of the vehicle; and

a suspension system, each vehicle axle assembly being connected to the frame of the vehicle by using the suspension system.

2. The drive axle unit according to claim 1, wherein the suspension system comprises two elastic members disposed at an interval in a left-right direction, two ends of each elastic member  
20 being respectively connected to two axle case components, and each elastic member being located above the two axle case components.

3. The drive axle unit according to claim 2, wherein the suspension system further comprises: a balance shaft assembly, the balance shaft assembly being fixed to the frame and being located between the two vehicle axle assemblies in a front-rear direction, a middle portion of each elastic  
25 member being fixed to the balance shaft assembly.

4. The drive axle unit according to claim 3, wherein each elastic member comprises at least one plate spring.

5. The drive axle unit according to claim 4, wherein the middle portion of each elastic member is fixed to the balance shaft assembly by using a U-bolt.

30 6. The drive axle unit according to claim 3, wherein the suspension system further comprises a first thrust rod group and a second thrust rod group that are disposed at an interval in an up-down

direction,

the first thrust rod group comprises two first subgroups that are symmetrically disposed in a front-rear direction, the two first subgroups correspond to the two axle case components one to one, each first subgroup comprises a plurality of first thrust rods, and each first thrust rod is connected  
5 between the frame and a corresponding axle case component, and

the second thrust rod group comprises two second subgroups that are symmetrically disposed in a front-rear direction, the two second subgroups correspond to the two axle case components one to one, each second subgroup comprises a plurality of second thrust rods, and each second thrust rod is connected between the balance shaft assembly and a corresponding axle case  
10 component.

7. The drive axle unit according to claim 6, wherein a first end of each first thrust rod is connected to a middle portion of a corresponding axle case component, a second end of each first thrust rod is connected to the frame by using a first thrust rod frame mounting seat, and the first thrust rod frame mounting seat is fixed to the frame and is located in the middle between the two  
15 axle case components.

8. The drive axle unit according to claim 7, wherein the first end of each first thrust rod is located on an inner side of the second end of the same first thrust rod.

9. The drive axle unit according to claim 7, wherein a first end of each first thrust rod is connected to the middle portion of the corresponding axle case component by using a first thrust rod axle case mounting seat, and the first thrust rod axle case mounting seat is fixed to the middle  
20 portion of the axle case component and is located above the axle case component.

10. The drive axle unit according to claim 9, wherein each first subgroup comprises two first thrust rods, the first subgroups correspond to two first thrust rod axle case mounting seats, and the two first thrust rod axle case mounting seats are integrally formed; and

25 the first subgroups correspond to two first thrust rod frame mounting seats, and second ends of the two first thrust rods correspond to the two first thrust rod frame mounting seats one to one.

11. The drive axle unit according to claim 7, wherein the first thrust rod frame mounting seat is fixed to an inner side of the frame.

12. The drive axle unit according to claim 6, wherein  
30 a first end of each second thrust rod is connected to an end portion of a corresponding axle case component, a second end of each second thrust rod is connected to the balance shaft assembly

by using a second thrust rod balance shaft mounting seat, the second thrust rod balance shaft mounting seat is fixed to an end portion of the balance shaft assembly, and the end portion of the axle case component and the end portion of the balance shaft assembly corresponding to the same second thrust rod are located on a same side of the drive axle assembly.

5           13. The drive axle unit according to claim 12, wherein the second end of each second thrust rod is located on an inner side of the first end of the same second thrust rod.

          14. The drive axle unit according to claim 12, wherein a first end of each second thrust rod is connected to the end portion of the corresponding axle case component by using a second thrust rod axle case mounting seat, and the second thrust rod axle case mounting seat is fixed to the end  
10           portion of the corresponding axle case component and is located below the corresponding axle case component.

          15. The drive axle unit according to claim 14, wherein each second subgroup comprises two second thrust rods, and the second subgroups correspond to two second thrust rod axle case mounting seats;

15           two elastic member mounting seats disposed at an interval in a left-right direction are respectively fixed to two ends of the axle case component corresponding to the second subgroup, the two elastic member mounting seats correspond to the two second thrust rod axle case mounting seats one to one, and each second thrust rod axle case mounting seat is fixed below a corresponding elastic member mounting seat; and

20           each second thrust rod balance shaft mounting seat is fixed below the balance shaft assembly.

          16. The drive axle unit according to claim 6, wherein a rubber ball hinge structure is provided at two ends of each first thrust rod and two ends of each second thrust rod.

          17. The drive axle unit according to claim 1, wherein the plurality of transmission shafts comprises:

25           a first shaft, an input gear being fixed to the first shaft, and the first shaft being connected to a motor output shaft;

          a second shaft, an idler gear being fixed to the second shaft, and the idler gear being engaged with the input gear;

          a third shaft, the third shaft comprising a first shaft segment and a second shaft segment that  
30           are coaxially disposed, the second shaft segment being configured to be selectively joined to the first shaft segment, a first gear being fixed to the first shaft segment, the first gear being engaged

with the idler gear, and a plurality of gear position driven gears being fitted over the second shaft segment; and

a fourth shaft, a second gear and a plurality of gear position driving gears being fixed to the fourth shaft, the second gear being engaged with the first gear, and the plurality of gear position driving gears being engaged with the plurality of gear position driven gears one to one.

18. The drive axle unit according to claim 17, wherein the plurality of gear position driven gears comprise a first-gear driven gear, a second-gear driven gear, and a third-gear driven gear,

the plurality of gear position driving gears comprise a first-gear driving gear engaged with the first-gear driven gear, a second-gear driving gear engaged with the second-gear driven gear, and a third-gear driving gear engaged with the third-gear driven gear; and

the transmission further comprises:

a first-fourth gear synchronizer, the first-fourth gear synchronizer being configured to selectively join one of the first shaft segment and the first-gear driven gear to the second shaft segment; and

a second-third gear synchronizer, the second-third gear synchronizer being configured to selectively join one of the second-gear driven gear and the third-gear driven gear to the second shaft segment.

19. The drive axle unit according to any one of claims 1 to 18, wherein the two vehicle axle assemblies are both electric drive axle assemblies, and the two electric drive axle assemblies are configured to be that one electric drive axle assembly is formed after the other electric drive axle assembly rotates about an axis in an up-down direction perpendicular to a front-rear direction by 180°.

20. The drive axle unit according to claim 19, further comprising: two motor controllers, the two motor controllers corresponding to the two electric drive axle assemblies one to one, and each motor controller separately controlling a power motor corresponding to an electric drive axle assembly.

21. The drive axle unit according to any one of claims 1 to 19, wherein one of the two vehicle axle assemblies is an electric drive axle assembly, and the other one of the two vehicle axle assemblies is a driven axle.

22. A vehicle, comprising: the drive axle unit according to any one of claims 1 to 21.

DRAWINGS

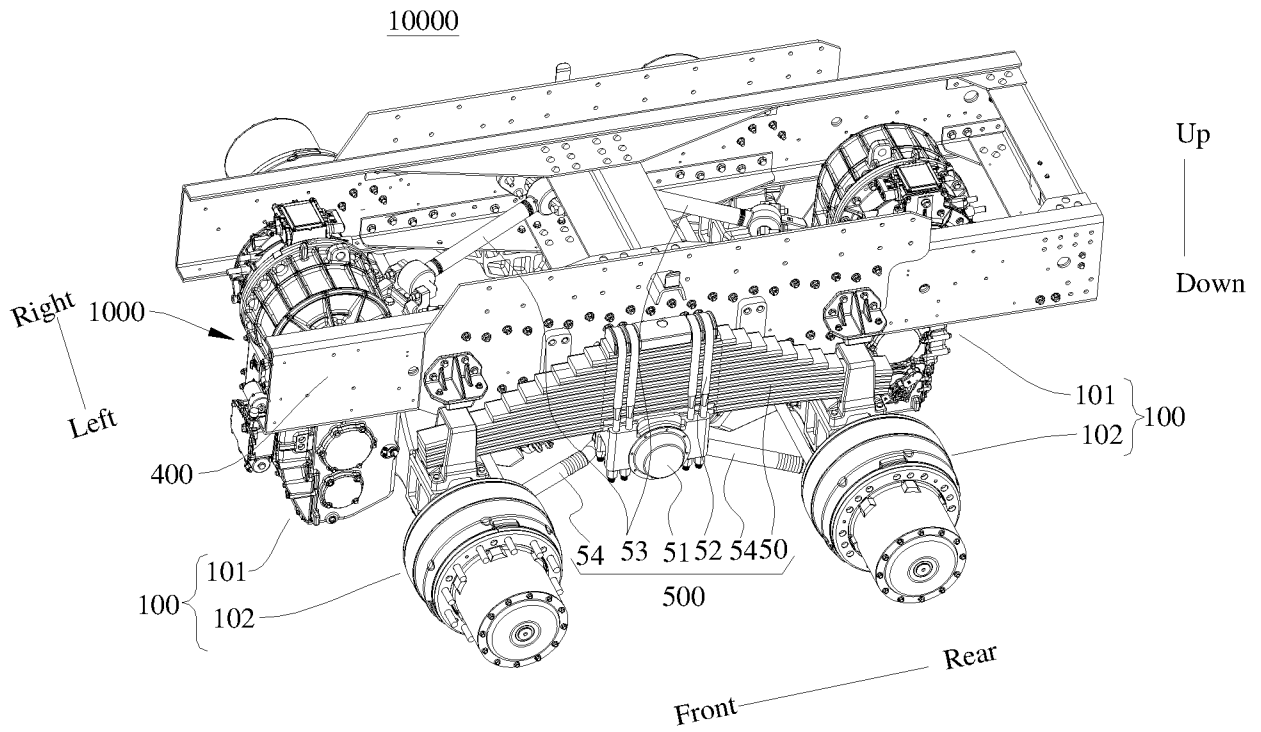


FIG. 1

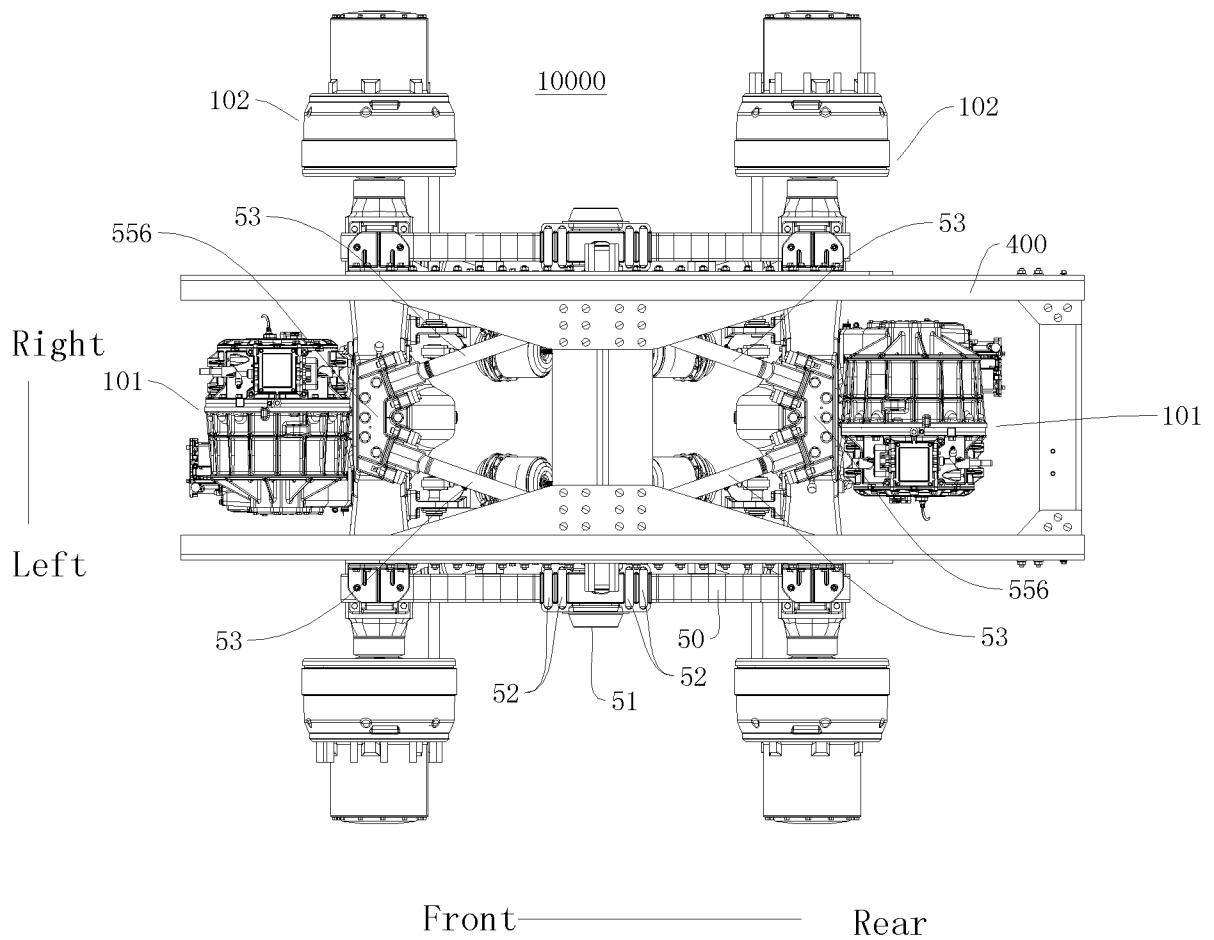


FIG. 2

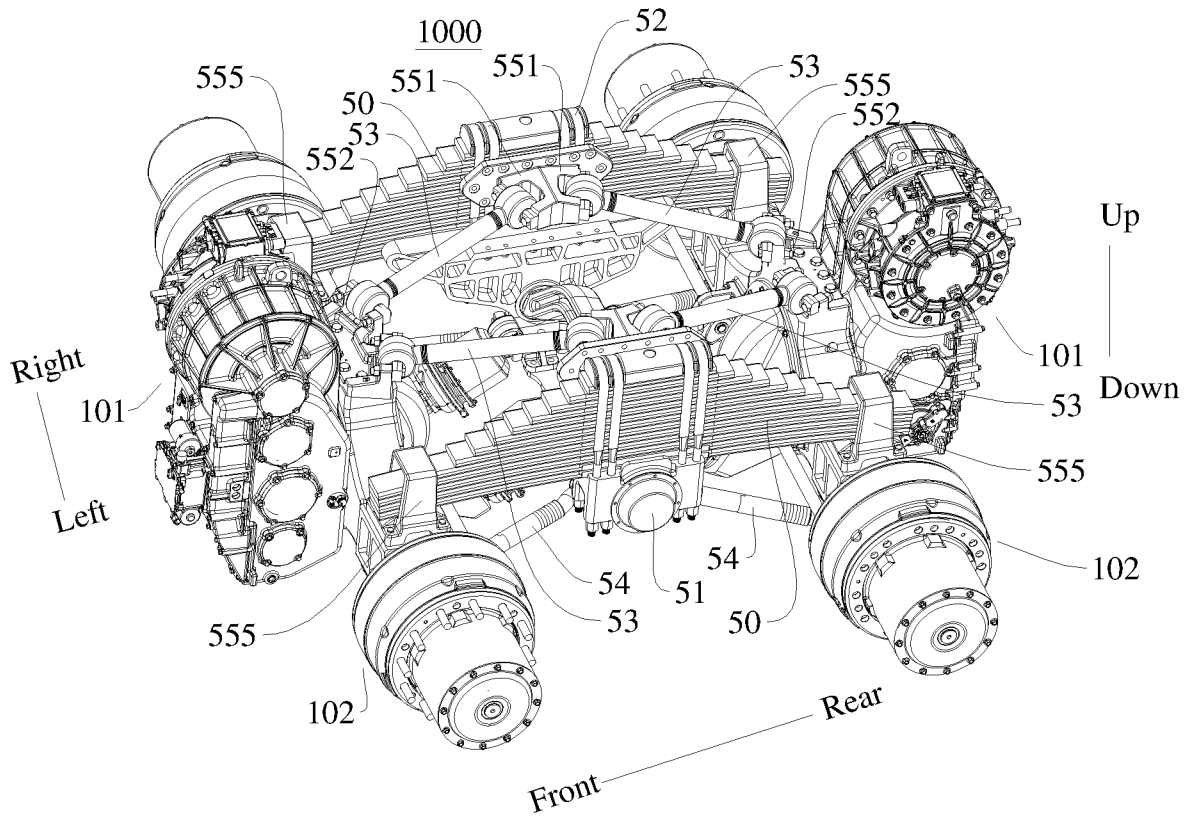


FIG. 3

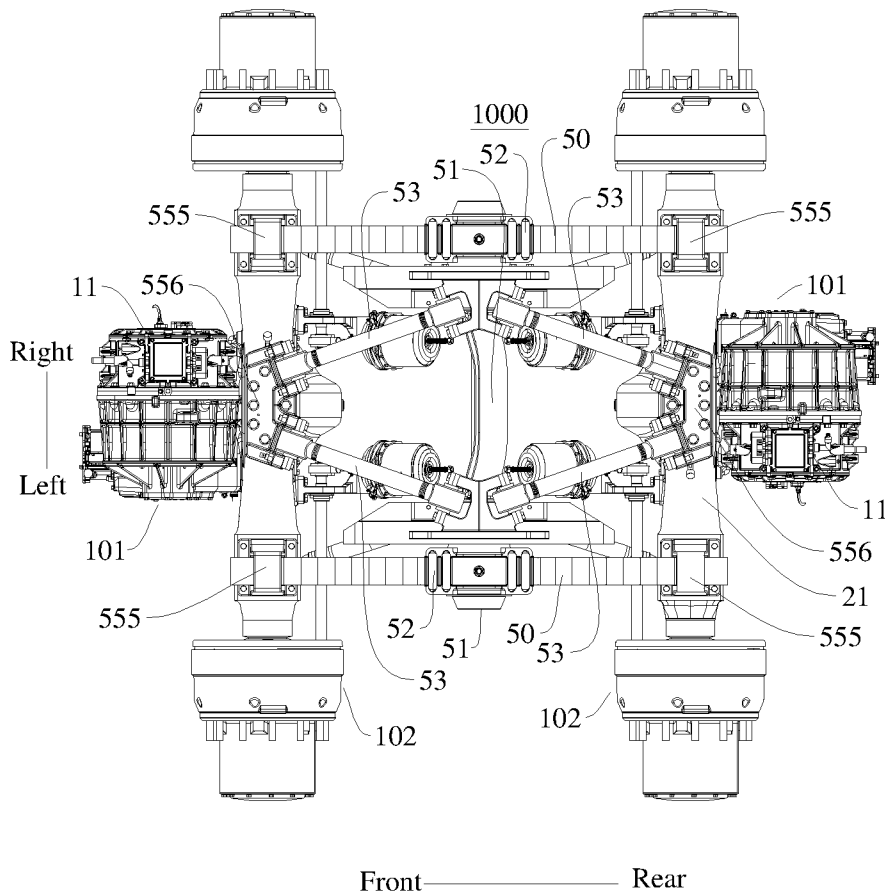


FIG. 4

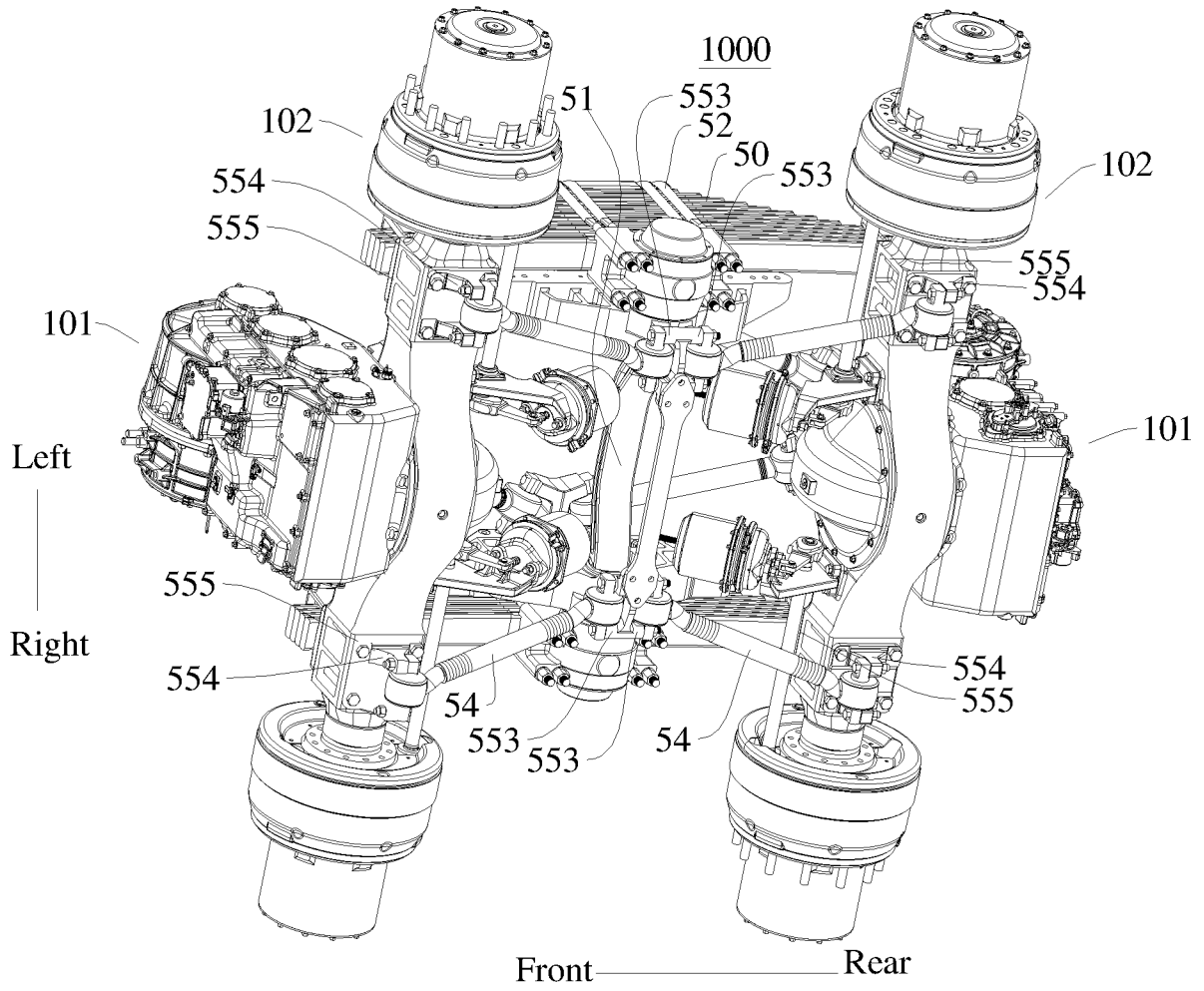


FIG. 5

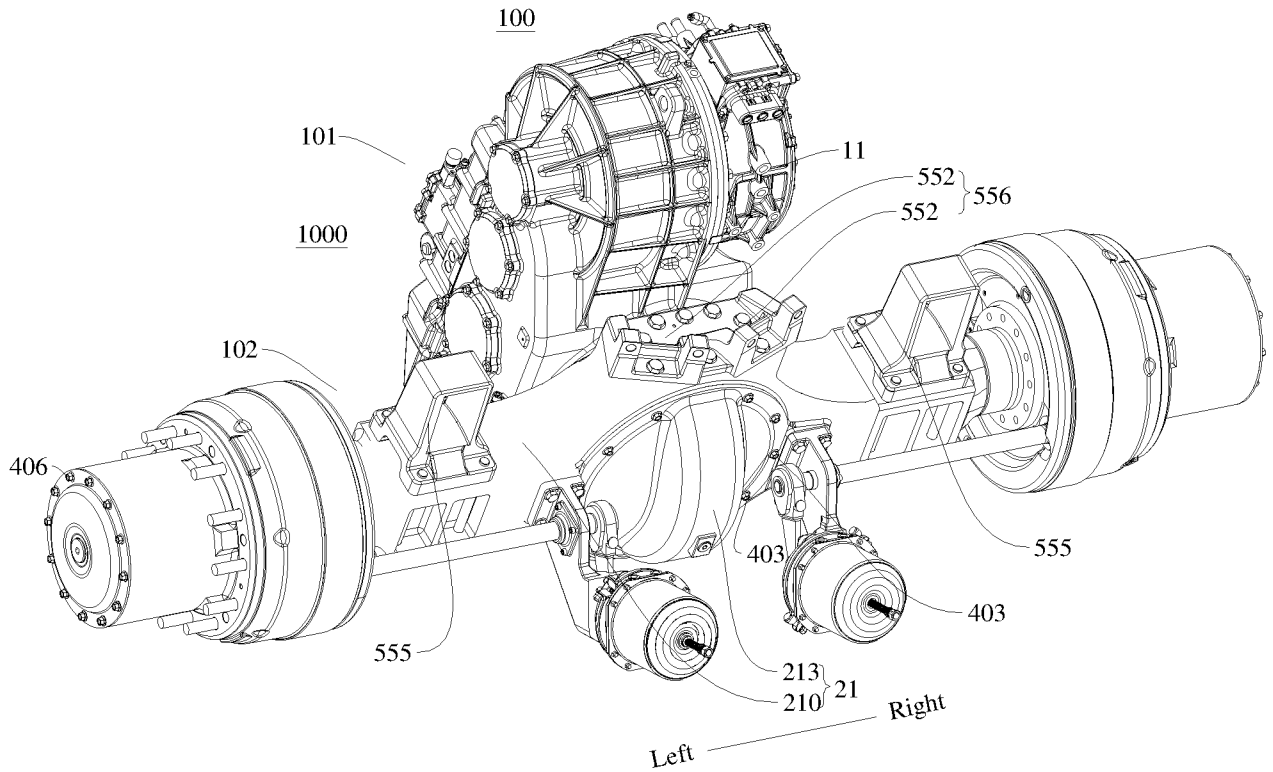


FIG. 6

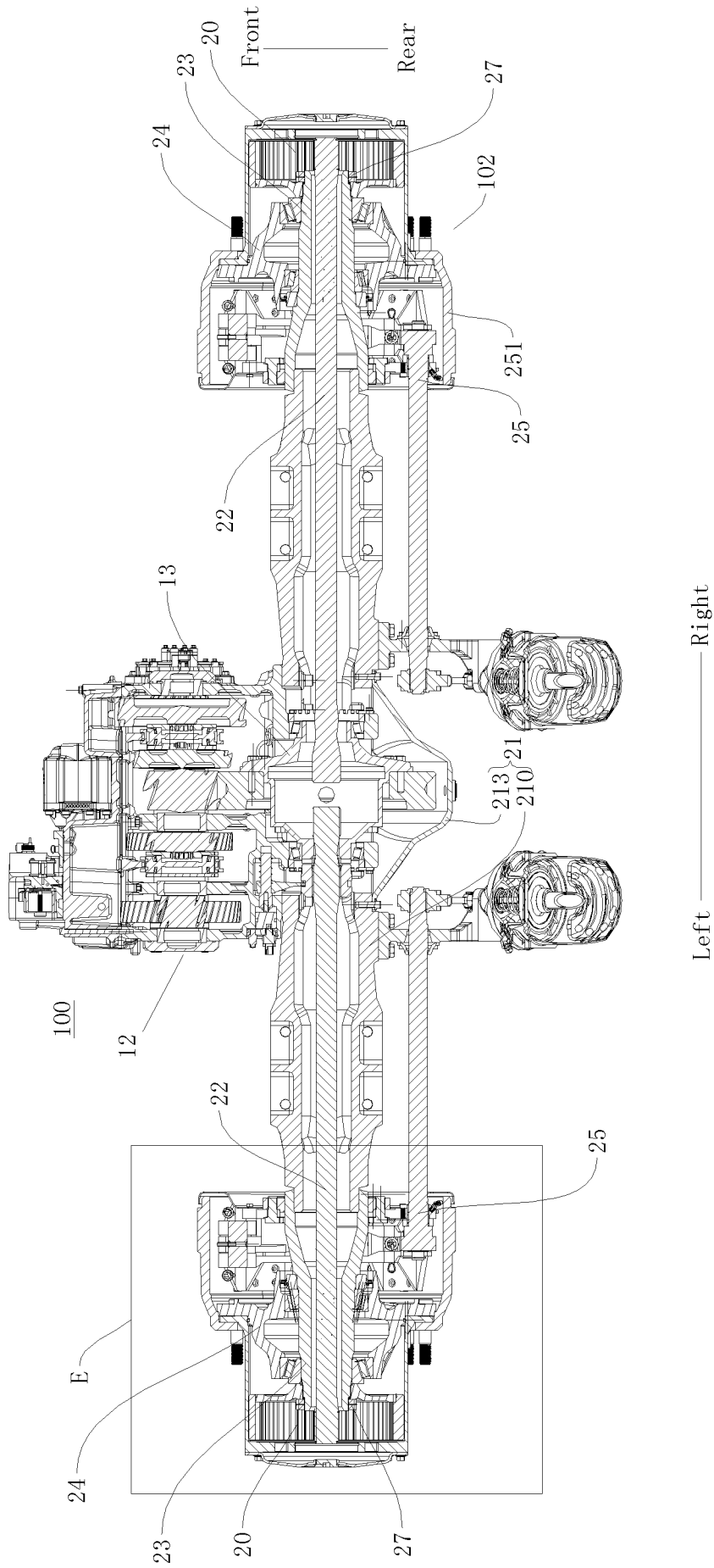


FIG. 7

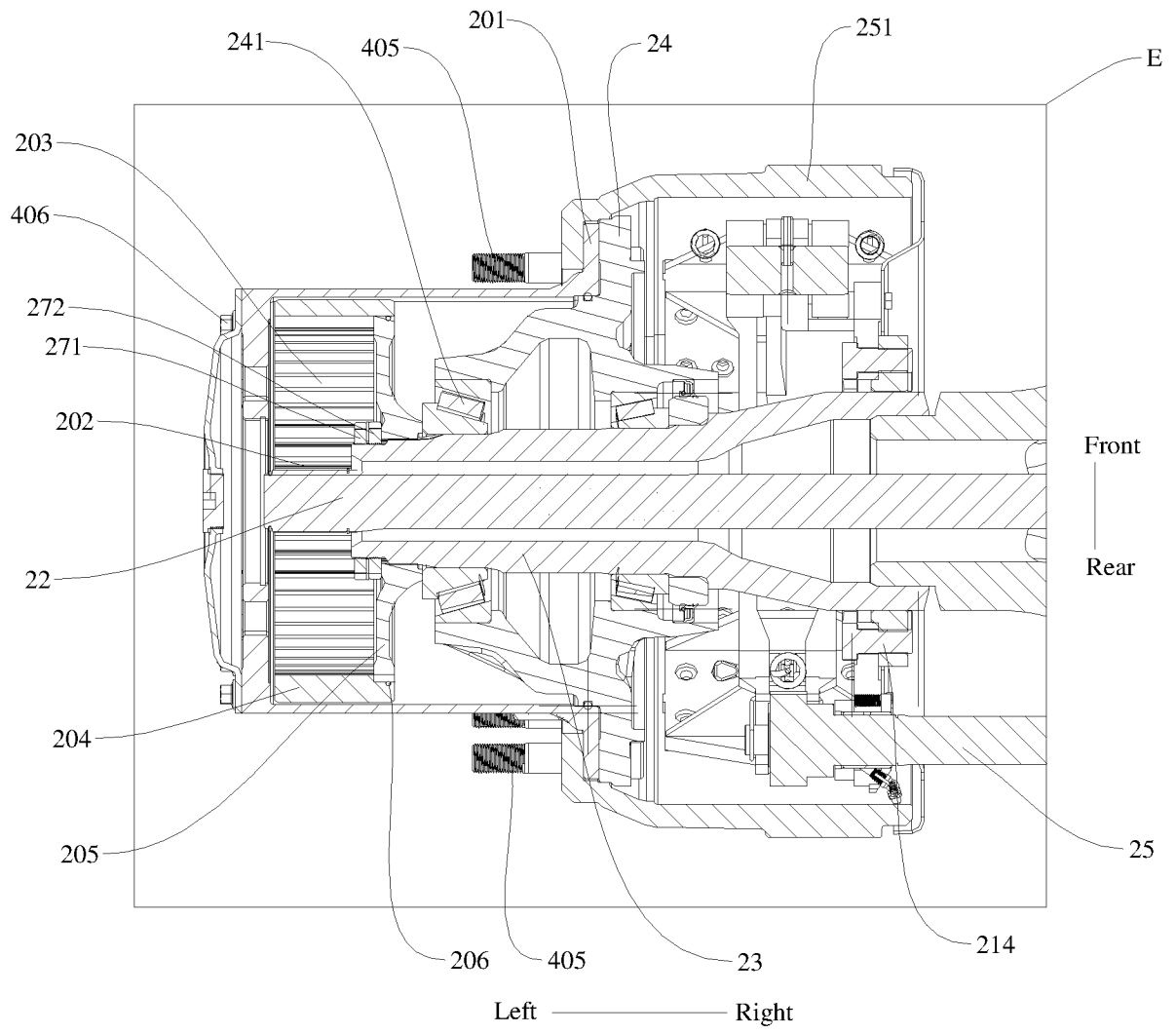


FIG. 8

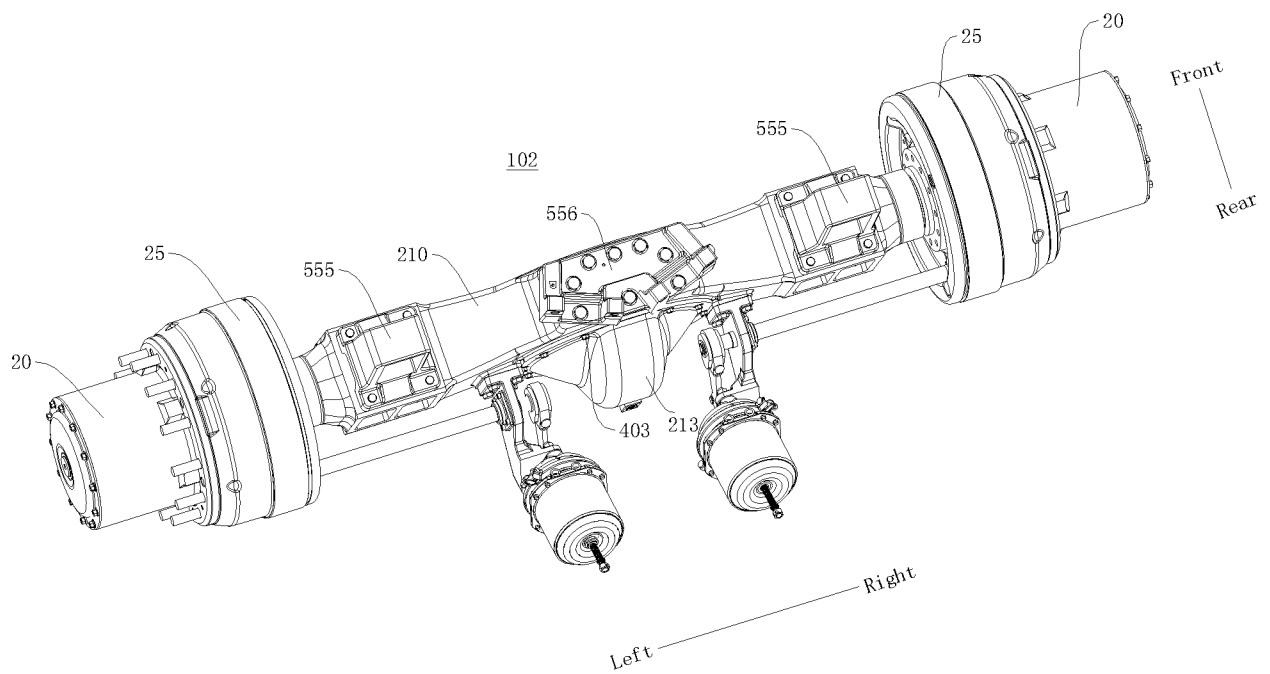


FIG. 9

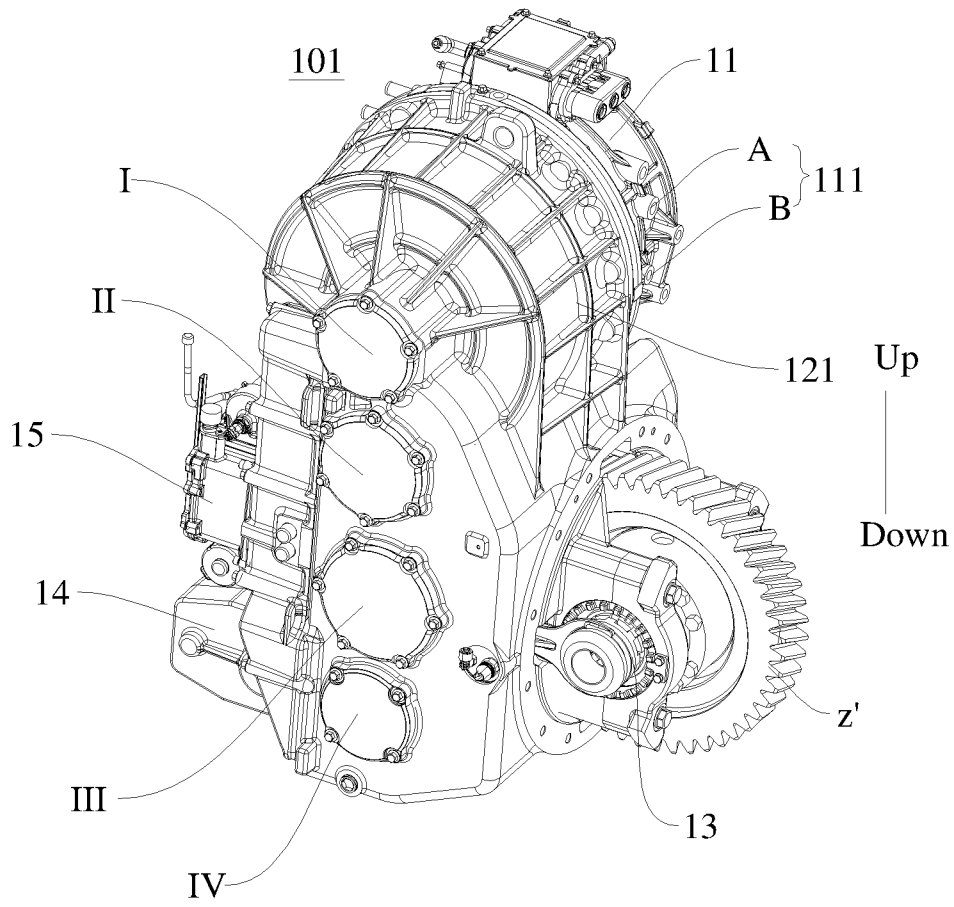


FIG. 10

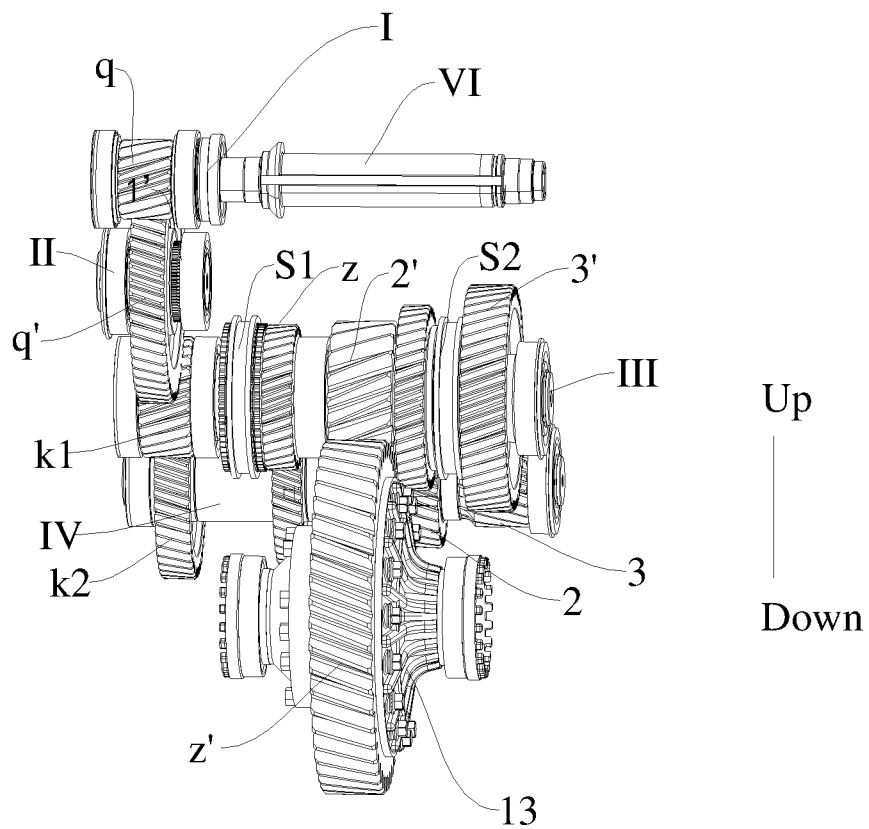


FIG. 11

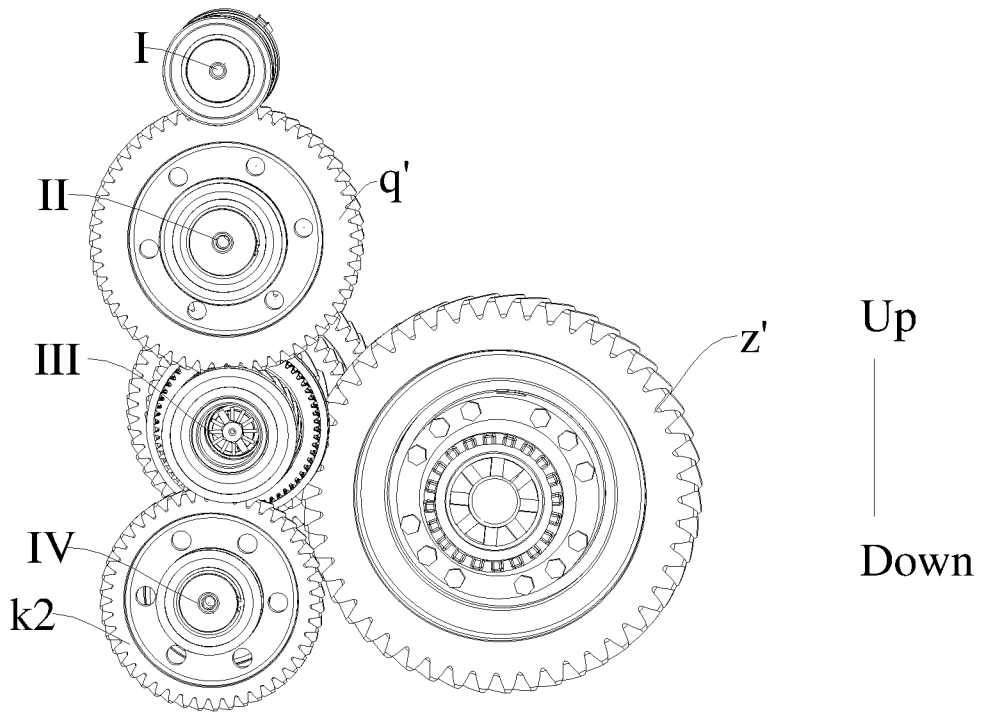


FIG. 12

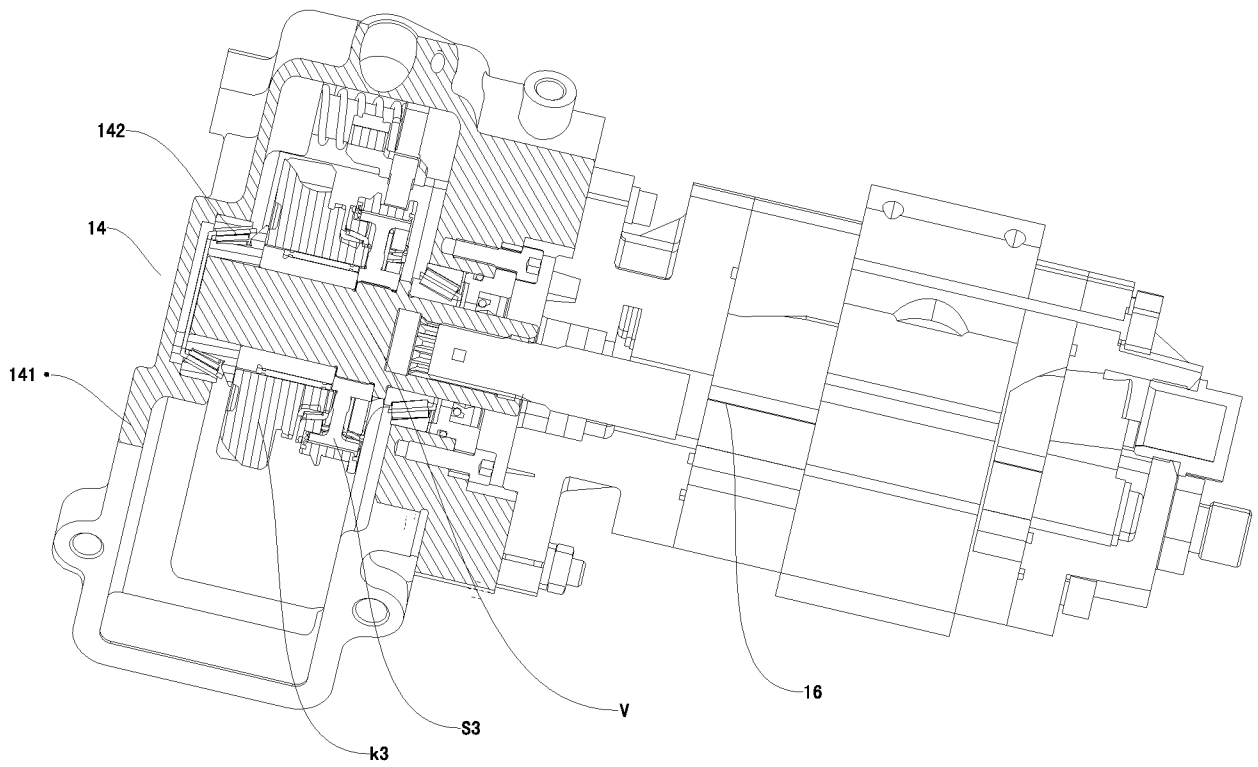


FIG. 13

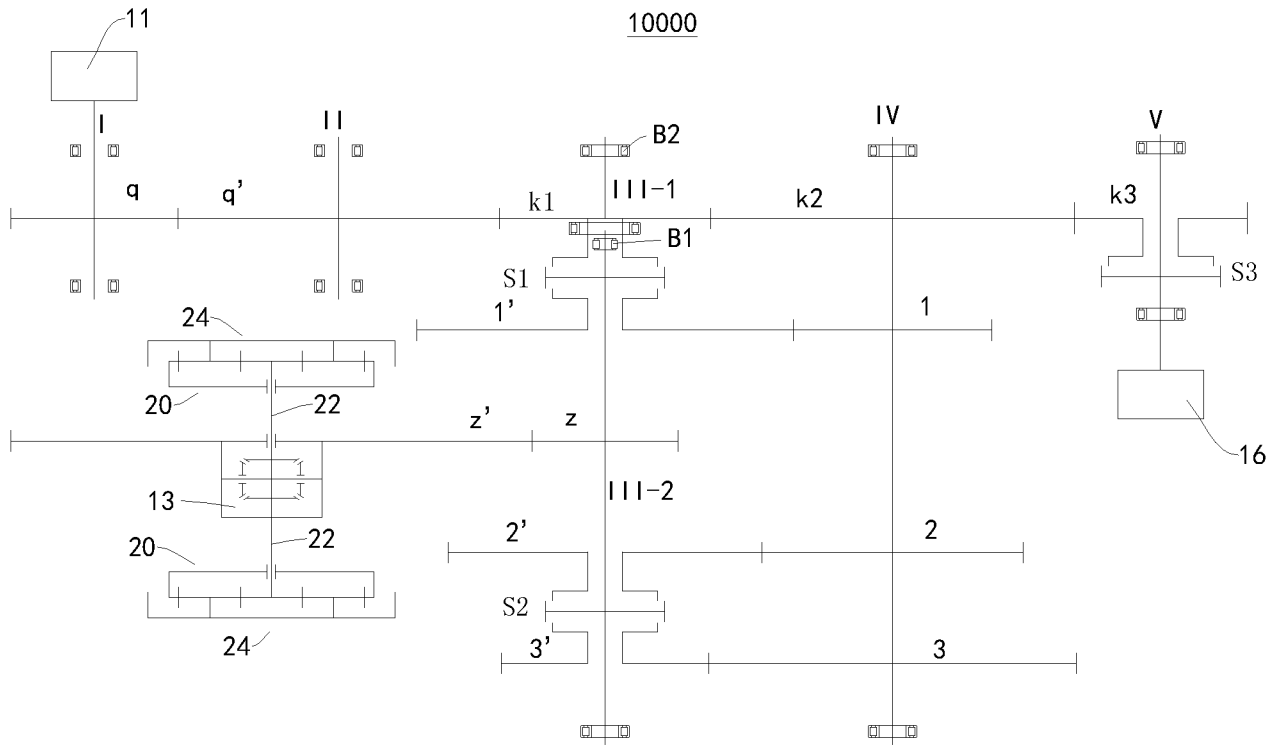


FIG. 14

100000

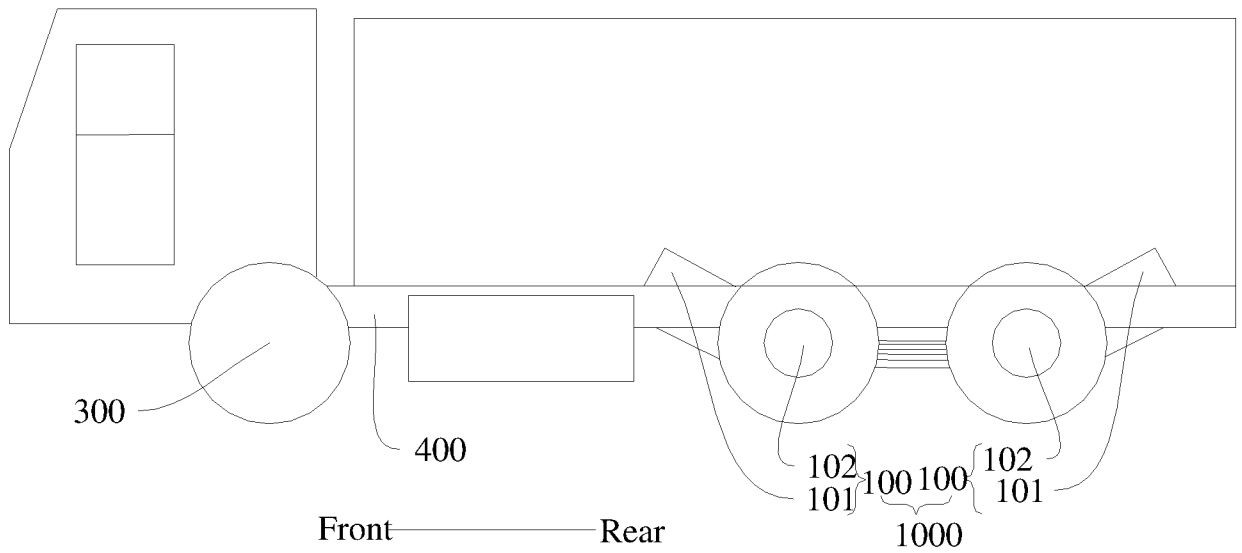


FIG. 15

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2016/112657

**A. CLASSIFICATION OF SUBJECT MATTER**

B60K 1/02(2006.01)i; B60G 11/06(2006.01)i; B60K 17/16(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

B60K B60G B60B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, VEN, CNTXT, CNKI, EPODOC: vehicle, axle, assembly, case, electric, motor, transmission, suspension, balance, rod, thrust, seat

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 105966221 A (BYD COMPANY LIMITED) 28 September 2016 (2016-09-28) detailed description	1-22
PX	CN 205468492 U (BYD COMPANY LIMITED) 17 August 2016 (2016-08-17) detailed description	1-22
PX	CN 105984278 A (BYD COMPANY LIMITED) 05 October 2016 (2016-10-05) detailed description	1-22
PX	CN 205468311 U (BYD COMPANY LIMITED) 17 August 2016 (2016-08-17) detailed description	1-22
PX	CN 105966237 A (BYD COMPANY LIMITED) 28 September 2016 (2016-09-28) detailed description	1-16, 19-22
PX	CN 205326780 U (BYD COMPANY LIMITED) 22 June 2016 (2016-06-22) detailed description	1-16, 19-22
PX	CN 105984335 A (BYD COMPANY LIMITED) 05 October 2016 (2016-10-05) detailed description	1-16, 19-22

 Further documents are listed in the continuation of Box C. See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

28 February 2017

Date of mailing of the international search report

07 March 2017

Name and mailing address of the ISA/CN

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Telephone No. (86-10)62089484

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2016/112657

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	CN 202368295 U (BEIQI FOTON MOTOR CO LTD) 08 August 2012 (2012-08-08) description, paragraphs [0049] to [0053]; figures 3 and 4	1-22
Y	CN 201881893 U (LI XIANG) 29 June 2011 (2011-06-29) description, paragraphs [0013] to [0016]; figure 1	1-22
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**INTERNATIONAL SEARCH REPORT**  
**Information on patent family members**

International application No.

**PCT/CN2016/112657**

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CN	205468492	U	17 August 2016	None	
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CN	2925948	Y	25 July 2007	None	
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				WO	2008033204 A2 20 March 2008
				EP	2069156 A2 17 June 2009
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				AT	531540 T 15 November 2011