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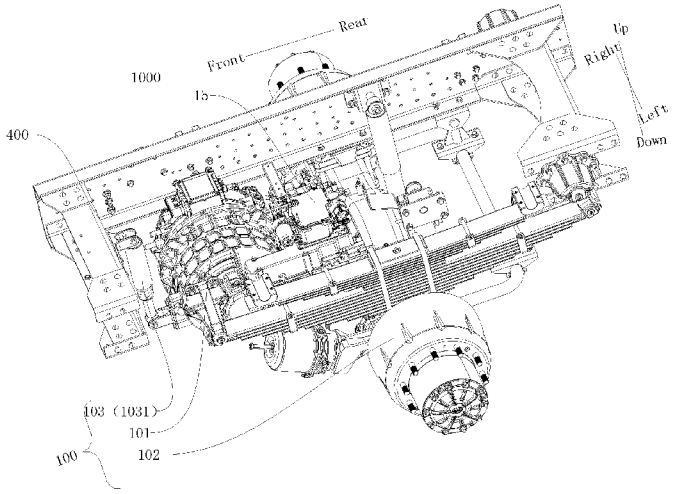


FIG. 1

(57) Abstract: An electric drive axle assembly for a vehicle includes: an electric power assembly (101) including a power motor (11) being fixed to the transmission housing (121), a transmission (12) having a transmission housing (121), a differential (13) being supported by the transmission housing (121), an axle case assembly including an axle case component (21) and two half axles (22). The two half axles (22) and the differential (13) are both located inside the axle case component (21). The transmission housing (121) is fixed to the axle case component (21); and a suspension apparatus (103) is connected between the electric power assembly (101) and a frame (400) of the vehicle (1000). A vehicle is also provided. The electric drive axle assembly for a vehicle has a compact structure, a small volume, high reliability and high safety.

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DESCRIPTION

VEHICLE AND ELECTRIC DRIVE AXLE ASSEMBLY FOR VEHICLE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to and benefits of Chinese Patent Application Nos. 201511031160.3 and 201521139104.7, 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.

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.

BACKGROUND

In the prior art, a power motor, a transmission, a transmission shaft, and a vehicle axle are all separately arranged, power is transferred stage by stage, resulting in many transmission stages, long transmission chain, low transmission efficiency, a large volume and hard arrangement. Moreover, to meet a high power requirement, volumes of the power motor and the transmission are usually relatively large, so that the vehicle axle bears large torque, it is difficult to ensure connection strength between the vehicle axle and the transmission, and there is a space for improvement.

SUMMARY

The present disclosure is to solve at least one of the technical problems in the prior art at least to a certain degree. For this, the present disclosure provides an electric drive axle assembly for a vehicle that has a small volume and a high integration degree.

An electric drive axle assembly for a vehicle according to a first aspect of the present disclosure includes: an electric power assembly, the electric power assembly including a power motor, a transmission, and a differential, the transmission having a transmission housing, the

power motor being fixed to the transmission housing, and the differential being supported by the transmission housing; an axle case assembly, the axle case assembly including an axle case component and two half axles, the two half axles and the differential being both located inside the axle case component, and the transmission housing being fixed to the axle case component; and a suspension apparatus, and the suspension apparatus being connected between the electric power assembly and a frame of the vehicle.

The electric drive axle assembly for a vehicle according to the embodiment of the present disclosure has a simple structure, a small volume, high working reliability, and smooth power transfer.

According to some embodiments of the present disclosure, the power motor includes an active cooling structure, the active cooling structure including a coolant circulation passage configured to cool the power motor.

According to some embodiments of the present disclosure, the active cooling structure further includes a coolant driving member, the coolant driving member being disposed to the coolant circulation passage to drive a coolant to flow inside the coolant circulation passage.

According to some embodiments of the present disclosure, the axle case component includes: an axle case, a differential receiving space whose two side end surfaces are both open being provided at a middle portion of the axle case; and a case cover, the case cover being detachably mounted on the axle case to close a first open side end surface of the middle portion of the axle case, and the transmission housing being fixed on a second open side end surface of the middle portion of the axle case.

In an embodiment, the case cover is detachably mounted on the axle case by using a threaded connecting piece.

According to some embodiments of the present disclosure, the electric drive axle assembly for a vehicle further includes a plurality of bolts, a plurality of threaded holes being provided in the transmission housing, a plurality of through holes corresponding to the plurality of threaded holes being disposed on the axle case one to one, the plurality of bolts corresponding to the plurality of through holes one to one, and each bolt passing through a corresponding through hole and to be fixed inside a corresponding threaded hole to fix the transmission housing fixed on the second open side end surface of the middle portion of the axle case.

According to some embodiments of the present disclosure, two half axle sleeves are

respectively fixed at two ends of the axle case component through welding, and the axle case assembly further includes two hub assemblies, each hub assembly is rotatably mounted to a corresponding half axle sleeve, and the two half axle sleeves are fitted over the two half axles one to one.

According to some embodiments of the present disclosure, the electric drive axle assembly for a vehicle further includes two wheel reducers, the two wheel reducers corresponding to the two hub assemblies one to one, an input end of each wheel reducer being connected to a corresponding half axle, and an output end of each wheel reducer being connected to a corresponding hub assembly.

According to some embodiments of the present disclosure, the wheel reducer is a planetary gear reducer, and the planetary gear reducer includes a sun gear, a planetary gear and an inner gear ring, the sun gear is fixed to the half axle, the planetary gear is engaged with the sun gear and the inner gear ring, and the inner gear ring is fixed to a corresponding half axle sleeve by using an inner gear ring support.

According to some embodiments of the present disclosure, the inner gear ring support is engaged with the inner gear ring, and the planetary gear reducer further includes a retainer ring, at least one part of the inner gear ring support is sandwiched between the retainer ring and the inner gear ring in an axial direction.

According to some embodiments of the present disclosure, the axle case assembly further includes two brakes and two brake mounting plates, the two brakes correspond to the two hub assemblies one to one, the two brake mounting plates are respectively fixed at two ends of the axle case component through welding, the two brakes are both fixed to the two brake mounting plates one to one by using a threaded connecting piece, and brake drums of the two brakes are fixed to the two hub assemblies one to one.

According to some embodiments of the present disclosure, the electric drive axle assembly for a vehicle further includes two axial stopper sets corresponding to the two hub assemblies one to one, each inner gear ring support is fitted over a corresponding half axle sleeve by using a spline structure, each axial stopper set includes a stop nut and a locking sheet, and the stop nut and the locking sheet are both fitted over the corresponding half axle sleeve, the stop nut is connected to the corresponding half axle sleeve in a threaded manner to tighten a corresponding inner gear ring support and a corresponding hub assembly between the locking sheet and a brake drum of a

corresponding brake.

According to some embodiments of the present disclosure, the axle case assembly further includes a differential lock mechanism, the differential lock mechanism is mounted to the axle case component and configured to selectively lock one of the two half axles and a differential housing of the differential.

According to some embodiments of the present disclosure, the differential lock mechanism includes: a drive cylinder, an end of the drive cylinder being fixed to the axle case component; a transmission component; and a sliding sleeve, the sliding sleeve being fitted over the half axle and being rotatably synchronous with the half axle, and the drive cylinder driving the sliding sleeve by using the transmission component, so that the sliding sleeve moves in an axial direction of the half axle between an unlocking location of being unlocked from the differential housing and a locking location of being locked to the differential housing.

According to some embodiments of the present disclosure, the transmission component includes: a connecting rod, an end of the connecting rod being rotatably connected to the drive cylinder; a shifting yoke bar, the shifting yoke bar being fixedly connected to the other end of the connecting rod, and the shifting yoke bar being rotatably supported by the axle case component; and a shifting yoke, the shifting yoke being fitted over the shifting yoke bar by using a spline structure, where a sliding groove is disposed in the sliding sleeve, and the shifting yoke is located inside the sliding groove.

According to some embodiments of the present disclosure, the differential lock mechanism further includes a differential lock sensor component, the differential lock sensor component including: a sensor, the sensor being disposed to the axle case component; a moving rod, the moving rod being movably disposed to the axle case component; and a fixed piece, the fixed piece being fixed to the shifting yoke, and being configured to drive the moving rod to abut against the sensor so that the sensor sends a locking signal, t when the shifting yoke swing to make the sliding sleeve moves to the locking location.

According to some embodiments of the present disclosure, 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, and the transmission power output portion is configured to be suitable for outputting power that is from the transmission power input portion to the differential.

According to some embodiments of the present disclosure, the electric power assembly further includes a power takeoff, the power takeoff 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, the power takeoff output end is configured to be selectively joined to the power takeoff input end to output power that is from the power takeoff input end, and the power takeoff is fixed to the transmission housing.

According to some embodiments of the present disclosure, the power takeoff input end includes a power takeoff gear, the power takeoff output end includes a power takeoff shaft, the power takeoff gear is freely fitted over the power takeoff shaft, and the power takeoff further includes a power takeoff synchronizer, the power takeoff synchronizer is configured selectively synchronize the power takeoff gear with the power takeoff shaft.

According to some embodiments of the present disclosure, the transmission includes a first shaft, an input gear being fixed on the first shaft, and the first shaft being connected to the motor output shaft; a second shaft, an idler gear being fixed on the second shaft, and the idler gear being engaged with the input gear; a third shaft, the third shaft including a first shaft segment and a second shaft segment that are coaxially disposed, the second shaft segment being configured to be selectively joined to the first shaft segment, a first gear being fixed on 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 on 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, where the first shaft, the input gear, the second shaft, and the idler gear form the transmission power input portion, and the third shaft, the first gear, the fourth shaft, the second gear, the plurality of gear position driving gears, and the plurality of gear position driven gears form the transmission power output portion.

According to some embodiments of the present disclosure, the plurality of gear position driven gears includes a first-gear driven gear, a second-gear driven gear, and a third-gear driven gear; the plurality of gear position driving gears includes 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 power output

portion further includes: 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.

According to some embodiments of the present disclosure, an output gear is further fixed on the second shaft segment, the output gear is located between the first-gear driven gear and the second-gear driven gear, and the output gear is suitable for being engaged with a differential driven gear of the differential.

According to some embodiments of the present disclosure, the power takeoff gear and the second gear are directly engaged for transmission.

According to some embodiments of the present disclosure, the first shaft segment is supported on the transmission housing, and an end, near the first shaft segment, of the second shaft segment is supported on the first shaft segment.

According to some embodiments of the present disclosure, the input gear, the idler gear, the first gear, the second gear, the plurality of gear position driving gears, and the plurality of gear position driven gears are all helical gears.

According to some embodiments of the present disclosure, the first shaft is connected to the motor output shaft of the power motor by using a spline structure or a coupling.

According to some embodiments of the present disclosure, the electric power assembly further includes an electrohydraulic gear shift actuating module, the electrohydraulic gear shift actuating module being configured to control the transmission and being mounted on the transmission housing.

According to some embodiments of the present disclosure, the suspension apparatus is connected between an end, far away from the axle case assembly, of the transmission housing and the frame of the vehicle.

According to some embodiments of the present disclosure, the suspension apparatus includes two shock absorbers, the two shock absorbers are symmetrically disposed on a left side and a right side of the transmission housing.

A vehicle according to an embodiment of a second aspect of the present disclosure includes the electric drive axle assembly for a vehicle of the first aspect.

The vehicle according to the embodiment of the present disclosure has a compact structure, high working reliability, and smooth power transfer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial schematic structural view of a vehicle according to an embodiment of the present disclosure;

FIG. 2 is a schematic structural view of an electric drive axle assembly for a vehicle according to an embodiment of the present disclosure;

FIG. 3 is a sectional view of an electric drive axle assembly for a vehicle according to an embodiment of the present disclosure;

FIG. 4 is an enlarged view of part E in FIG. 3;

FIG. 5 is an enlarged view of part F in FIG. 3;

FIG. 6 is a schematic structural view of an axle case assembly of an electric drive axle assembly for a vehicle according to an embodiment of the present disclosure;

FIG. 7 is a schematic structural view of a differential lock mechanism of an electric drive axle assembly for a vehicle according to an embodiment of the present disclosure;

FIG. 8 is a schematic structural view of an electric power assembly according to an embodiment of the present disclosure;

FIG. 9 is a schematic structural view of the inside of a transmission according to an embodiment of the present disclosure;

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

FIG. 11 is a schematic view of a transmission structure of a vehicle according to the present disclosure; and

FIG. 12 is a main 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 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.

An electric drive axle assembly 100 for a vehicle 1000 according to an embodiment of the present disclosure is described below with reference to FIG. 1 to FIG. 12. As shown in FIG. 1 to FIG. 12, the electric drive axle assembly 100 for the vehicle 1000 according to the embodiment of the present disclosure includes an electric power assembly 101, an axle case assembly 102 and a suspension apparatus 103.

As shown in FIG. 1 to FIG. 3, FIG. 5, and FIG. 8 to FIG. 11, the electric power assembly 101 includes a power motor 11, a transmission 12 and a differential 13. As shown in FIG. 1 to FIG. 3, FIG. 4, FIG. 6, and FIG. 7, the axle case assembly 102 includes an axle case component 21 and two half axles 22. The two half axles 22 and the differential 13 are all located inside the axle case component 21.

It should be understood that, in some embodiments, lengths of the two half axles 22 may be the same. In some other embodiments, lengths of the two half axles 22 may be different. For example, when a bump of the axle case component 21 has an eccentric structure, as shown in FIG. 2, the lengths of the two half axles 22 may be unequal, that is, one half axle 22 is long, and the other half axle 22 is short.

It should be understood that, through speed changing and torque adjusting 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 half axles 22 transfer the power to wheels connected to the half axles 22, so as to drive the vehicle 1000 to run.

As shown in FIG. 1 to FIG. 3, in the electric drive axle assembly 100 for the vehicle 1000 according to this embodiment of the present disclosure, the transmission 12 has a transmission housing 121, the power motor 11 is fixed on the transmission housing 121, the differential 13 is supported by the transmission housing 121, and the transmission housing 121 is fixed on the axle case component 21. For example, in some embodiments of the present disclosure, the power motor 11 may be fixed on the transmission housing 121 by using a threaded connecting piece, the transmission housing 121 may be fixed on the axle case component 21 by using a threaded connecting piece, and the differential 13 is supported by the transmission housing 121 by using a bearing.

That is, in the electric drive axle assembly 100 for the vehicle 1000, 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.

In some embodiments, a suspension apparatus 103 is connected between the electric power assembly 101 and a frame 400 of the vehicle 1000. 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 103. 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 103 is provided, 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, 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, ensuring the stability of power transmission, and ensuring the use safety of the entire electric drive axle assembly 100.

Such an arrangement of the electric drive axle assembly 100 is more suitable for the vehicle 1000 in which the electric power assembly 101 occupies a large volume and the power motor 11 has high power, so as to meet running requirements of a heavy-load vehicle 1000 very desirably.

It should be understood that, according to a vehicle body form for the vehicle 1000, specific meaning of the frame 400 is different. When a bearing vehicle body is used, the frame 400 is a part of the vehicle body. When a non-bearing vehicle body is used, the frame 400 may be a mounting carrier for the vehicle body.

As shown in FIG. 1, the suspension apparatus 103 may be connected between an end, far away from the axle case assembly 102, of the transmission housing 121 and the frame 400 of the vehicle 1000, making it easier to balance torque to the axle case assembly 102 generated by a center of mass offset of the electric power assembly 101, so that mounting of the electric power assembly 101 and the axle case assembly 102 is more stable.

In an embodiment, the suspension apparatus 103 may include two shock absorbers 1031. The two shock absorbers 1031 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. As shown in FIG. 1, the frame 400 may include a beam, an end of the shock absorber 1031 is mounted on the beam, and the other end of the shock absorber 1031 is mounted

on the transmission housing 121.

For the electric drive axle assembly 100 for the vehicle 1000 according to the 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, assembling is simple, the mass is reduced, a small volume is occupied, a small space is occupied, arrangement on the vehicle 1000 is convenient, a transmission chain is shortened, a transmission loss is small, and transmission efficiency is high. The suspension apparatus 103 is disposed between the electric power assembly 101 and the 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 101 and the axle case assembly 102, ensuring stability of power transmission, and making use of the entire electric drive axle assembly 100 more reliable and safer.

The electric drive axle assembly 100 for the vehicle 1000 according to the embodiment of the present disclosure is described below in detail with reference to FIG. 1 to FIG. 12. As shown in FIG. 1 to FIG. 12, the electric drive axle assembly 100 for the vehicle 1000 according to the embodiment of the present disclosure includes the electric power assembly 101, the axle case assembly 102 and the suspension apparatus 103. In an embodiment, as shown in FIG. 5, the electric power assembly 101 may be fixed on the axle case assembly 102 by using a plurality of bolts 401, so that the electric power assembly 101 and the axle case assembly 102 are integrated into the electric drive axle assembly 100 for the vehicle 1000.

As shown in FIG. 1 to FIG. 3, FIG. 5, and FIG. 8 to FIG. 11, the electric power assembly 101 includes the power motor 11, the transmission 12, the differential 13, an electrohydraulic gear shift actuating module 15, and a power takeoff 14, in which the transmission 12 has the transmission housing 121.

As shown in FIG. 5, the power motor 11 may be fixed on the transmission housing 121 by using a plurality of bolts 402, and the plurality of bolts 402 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. 8, the power motor 11 includes an active cooling structure. The active

cooling structure is 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. 8, the coolant circulation passage 111 has an inlet A and an outlet B, the coolant may enter the coolant circulation passage 111 from the 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, 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, so that the power motor can match operating conditions of the vehicle 1000 more desirably, and 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 the coolant to flow inside the coolant circulation passage 111. In an embodiment, the coolant driving member may be a cooling oil pump. Accordingly, the active cooling structure is provided with the coolant driving member, so an integration degree is high, assembling is easy, the structure is more compact, and efficiency is higher.

Certainly, in some embodiments of the present disclosure, the coolant circulation passage 111 may also be connected to a coolant located outside the electric drive axle assembly 100 for the vehicle 1000, that is, the coolant may be introduced from outside, that is, the coolant circulation passage 111 of the active cooling structure may share the coolant driving member with a coolant circulation passage of other members on the vehicle 1000.

The transmission housing 121 may be fixed on the axle case component 21 of the axle case assembly 102 by using a bolt 401. In an embodiment, the transmission housing 121 may include at least two parts that are detachably connected. The transmission housing 121 is configured to have detachable connection, which may facilitate mounting of parts and components such as gears and shafts inside the transmission 12, so that collision of teeth does not occur during assembly, assembling manufacturability is desirable, and integration with the power motor 11 and the axle case component 21 is facilitated; moreover, mounting of the differential 13 inside the axle case component 21 may further become convenient.

The transmission 12 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 VI of the power motor 11, and the transmission power output portion is configured to be suitable for outputting power that is from the transmission power input portion to the differential 13, and the power is output to wheels of the vehicle 1000 by using the differential 13 to drive the vehicle 1000 to run. In an embodiment, as shown in FIG. 5, the differential 13 may be supported by the transmission housing 121 by using a differential bearing.

The electric power assembly 101 may further include the 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, that is, 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 output end and the power takeoff input end are joined, the power takeoff output end may output power from the power takeoff input end to an apparatus 16 to be driven.

In an embodiment, the power takeoff 14 is fixed to the transmission housing 121, that is, the power takeoff 14 is integrated with the transmission housing 121, and accordingly, the structure of the electric power assembly 101 is more compact. In an embodiment, the power takeoff 14 may include a power takeoff housing 141, 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 1000, power of the power motor 11 is output to the wheels of the vehicle 1000 by sequentially using the transmission power input portion, the transmission power output portion and the differential 13, so as to drive the vehicle

1000 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 1000 by sequentially using the transmission power input portion, the transmission power output portion and the differential 13. Another part of the 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 bed lifting mechanism of the vehicle 1000 and the like with a power source, thereby meeting other power requirements of the entire vehicle.

That is, for the electric drive axle assembly 100 for the vehicle 1000 according to the 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 as to meet more market requirements, and make the electric drive axle assembly 100 more applicable. In addition, because the power takeoff input end moves in cooperation with at least one of the transmission power input portion and the transmission power output portion, so that the number 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. 10 and FIG. 11, 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 rotates, the power takeoff shaft V may not rotate.

The power takeoff 14 may further include a power takeoff a synchronizer S3. The power 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 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. 9 and FIG. 11, the transmission 12 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 by the transmission housing 121 by using a bearing. In an embodiment, as shown in FIG. 9 and FIG. 11, 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 1000, in which the width direction of the vehicle 1000 is a left-right direction of the vehicle 1000, 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 FIG. 5, the first shaft I may be connected to the motor output shaft VI by using a spline structure. In an embodiment, 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 first shaft I, so that a transmission chain is short, and the structure is simple.

As shown in FIG. 9 and FIG. 11, an input gear q is fixed on the first shaft I, that is, the input gear q may rotate synchronously with the first shaft I. An idler gear q' is fixed on the second shaft II, that is, the idler gear q' may rotate synchronously with the second shaft II. The idler gear q' is engaged with the input gear q.

As shown in FIG. 5 and FIG. 11, 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. The second shaft segment III-2 and the first shaft segment III-1 may also rotate separately.

As shown in FIG. 5, an end of the first shaft segment III-1 is fitted over the second shaft segment III-2, that is, an end, near the first shaft segment III-1, of the second shaft segment III-2 is supported by the first shaft segment III-1, and the first shaft segment III-1 is further supported by the transmission housing 121. In an embodiment, the first shaft segment III-1 is a hollow shaft. 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 an 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 on 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 plurality of 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 on 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 different numbers of pairs of gears may also be engaged on the third shaft III and the fourth shaft IV, so that the transmission 12 has outputs of more gear positions.

The first shaft I, the input gear q, the second shaft II and the idler gear q' form the transmission power input portion, and 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.

In some embodiments, as shown in FIG. 5 and FIG. 11, an output gear z is further fixed on 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 the half axles 22 and the wheels are driven by using the differential 13, thereby implementing running of the vehicle 1000.

In some embodiments 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.

In an embodiment of the present disclosure, the plurality of gear position driven gears includes 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.

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 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. 5 and FIG. 11, 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 using 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 to the second shaft segment III-2 by using a bearing. The second-third gear synchronizer S2, the first-fourth gear synchronizer S1 and the output gear z are linked to the second shaft segment III-2 by using fitting of a spline structure. The second gear k2 is connected on the fourth shaft IV by using fitting of a spline structure. The third-gear driving gear 3, the second-gear driving gear 2, and the first-gear driving gear 1 are all connected on the fourth shaft IV by using fitting of a spline structure. The differential driven gear z' may be fixedly mounted to 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, so that a speed ratio is large, torque is large, power performance is relatively strong, operability is relatively desirable, and a use requirement of a heavy-load vehicle can be met.

A working process of the electric drive axle assembly 100 according to this embodiment of the present disclosure is described below with reference to FIG. 11.

Power output by the power motor 11 is output to the first shaft I by using the motor output shaft VI. The input gear q on the first shaft I transmits power to the idler gear q' on the second shaft II. The idler gear q' transfers the power to the first gear k1 on the first shaft segment III-1. The first gear k1 actuates the first shaft segment III-1 to rotate synchronously. The first gear k1 transfers the power to the second gear k2, and the second gear k2 actuates the fourth shaft IV to rotate synchronously.

The first-fourth gear synchronizer S1 joins the first-gear driven gear 1' to the second shaft segment III-2, the second-third gear synchronizer S2 is located at an intermediate location, and the transmission 12 is at a first gear. The second-third gear synchronizer S2 joins the second-gear driven gear 2' to the second shaft segment III-2, the first-fourth gear synchronizer S1 is located at an intermediate location, and the transmission 12 is at a second gear. The second-third gear synchronizer S2 joins the third-gear driven gear 3' to the second shaft segment III-2, the first-fourth gear synchronizer S1 is located at an intermediate location, and the transmission 12 is at a third gear. The first-fourth gear synchronizer S1 joins the first shaft segment III-1 to the second shaft segment III-2, the second-third gear synchronizer S2 is located at an intermediate location, and the transmission 12 is at a fourth gear. At a neutral gear, the first-fourth gear synchronizer S1 and the second-third gear synchronizer S2 are located at intermediate locations. At the reversing gear, the first-fourth gear synchronizer S1 joins the first-gear driven gear 1' to the second shaft segment III-2, and the power motor 11 rotates in the opposite direction (that is, in a rotating direction opposite that at the forward gear).

When a corresponding gear position driven gear is joined to the second shaft segment III-2, the power is transferred to the second shaft segment III-2 through the first shaft I, the input gear q, the idler gear q', the first gear k1, the second gear k2, and the gear position driving gears correspondingly engaged to the gear position driven gear. The second shaft segment III-2 outputs the power to the output gear z, and the output gear z is engaged with the differential driven gear z', so as to actuate the differential 13 to rotate. When the first shaft segment III-1 is joined to the second shaft segment III-2, the power is directly transferred to the second shaft segment III-2 through the first shaft I, the input gear q, the idler gear q', the first gear k1, and the first shaft segment III-1, so as to actuate the output gear z, and the output gear z is engaged with the differential driven gear z', so as to actuate the differential 13 to rotate.

In an embodiment, the power takeoff gear k3 and the second gear k2 are directly engaged for transmission, so that a transmission chain is short, the structure is compact, and driving of the apparatus 16 to be driven is further facilitated.

In an embodiment, as shown in FIG. 1, FIG. 2, and FIG. 8, 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 to 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 and a fast response speed, implements stepless speed changing, has desirable operability, and may relieve driving fatigue.

The axle case assembly 102 of the electric drive axle assembly 100 according to this embodiment of the present disclosure is described below in detail with reference to FIG. 1 to FIG. 7. As shown in FIG. 1 to FIG. 7, 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 for the electric drive axle assembly 100 for the vehicle 1000 may both be located inside a receiving space defined by the axle case component 21.

For the electric drive axle assembly 100 for the vehicle 1000 according to the embodiment of the present disclosure, the electric power assembly 101 and the axle case assembly 102 are integrated, that is, the electric drive axle assembly 100 for the vehicle 1000 is the integrated electric drive axle assembly 100. The axle case component 21 is suitable to be fixed with the transmission housing 121 of the integrated electric drive axle assembly 100.

The axle case component 21 includes an axle case 210 and a case cover 213. A differential receiving space whose two side end surfaces are both open is provided at 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. The transmission housing 121 is fixed on 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 using a threaded connecting piece. In an embodiment, as shown in FIG. 2 and FIG. 5, the threaded connecting piece is a bolt 403. The case cover 213 may be connected on the first open side end surface of the middle portion of the axle case 210 in a threaded manner by using a plurality of bolts 403 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 mounting of the electric power assembly 101 is more convenient, and a fixing structure is simple, and operations are convenient. In an embodiment, the case cover 213 on the first side end surface of the middle portion of the axle case 210 is assembled, 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.

In an embodiment, the axle case 210 may include a first half axle case 211 and a second half axle case 212. The first half axle case 211 is a stamping piece, and the second half axle case 212 is also a stamping piece. The second half axle case 212 and the first half axle case 211 are fixed to form the axle case 210 in a welded manner. The axle case 210 defines a space for receiving the two half axles 22. The axle case 210 is formed by welding two half axle cases that are both stamping pieces, so that the structure is simple, the mass is low, processing is easy, and a manufacturing cost is low.

In an embodiment, the electric drive axle assembly 100 further includes a plurality of bolts 401. A plurality of threaded holes is provided in the transmission housing 121. A plurality of through holes corresponding to the plurality of threaded holes one to on is provided in the axle case 210. The plurality of bolts 401 corresponds to the plurality of through holes one by one. Each bolt 401 passes through a corresponding through hole to be 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, so that the structure is more compact.

In some embodiments, as shown in FIG. 3 and FIG. 4, 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 respectively (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. 4, 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. The sun gear 202 is fixed on the half axle 22, so as 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. 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 wide.

In an embodiment, as shown in FIG. 4, the wheel reducer 20 includes a wheel reducer housing 201, the wheel reducer housing 201 may be fixed to the hub assembly 24, and accordingly, the volume of the axle case assembly 102 is further reduced, the structure is compact, and a space is saved.

In some embodiments, 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 at least part of the inner gear ring support 205 is sandwiched between the retainer ring 206 and the inner gear ring 204 in an axial direction, so as to stop the inner gear ring 204 in an axial direction, so that assembling precision of the wheel reducer 20 and the hub assembly 24 is ensured relatively desirably.

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, the two brakes 25 fixed to the two brake mounting plates 214 one to one by using a threaded connecting piece, and brake drums 251 of the two brakes 25 are fixed to the two hub assemblies 24 one to one.

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 27 corresponds 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 structures. 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 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 are respectively symmetrically located at the left end and the right end of the axle case component 21 in a width direction of the vehicle 1000.

The right 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 at the end.

In an embodiment, as shown in FIG. 4, one half axle sleeve 23 is welded at the right end of the axle case component 21, the hub assembly 24 at the right end is rotatably mounted to the half axle sleeve 23 at the right end, and the half axle sleeve 23 at the right end is fitted over the half axle 22 on the right 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. 4, the right end of the half axle 22 at the right end passes through the half axle sleeve 23 at the right end to be connected to the sun gear 202. An end cover is fixed with the wheel reducer 20 at the right end (for example, the wheel reducer housing 201) by using a threaded connecting piece (for example, a bolt 406 shown in FIG. 4). The left end of the half axle 22 at the right end is connected to the differential 13 by using a spline. The half axle 22 at the right end transfers power output by the differential 13 to an input end of the wheel reducer 20 at the right end. After speed reduction by the wheel reducer 20 at the right end, the power is transferred to the hub assembly 24 at the right end through an output end of the wheel reducer 20 at the right end, and then actuates the wheels to rotate.

The brake 25 at the right end corresponding to the hub assembly 24 at the right end is mounted to the brake mounting plate 214 at the right end. The brake mounting plate 214 at the right end is fixed to the right end of the axle case component 21. The brake drum 251 of the brake 25 at the right end is further fixed to the hub assembly 24 at the right 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 right end is fixed to the brake mounting plate 214 at the right end by using a threaded connecting piece, and the brake drum 251 of the brake 25 at the right end may be fixed to the hub assembly 24 at the right end by using a bolt 405, and there are a plurality of threaded connecting pieces and a plurality of

bolts 405. In an axial direction, that is, in a left-right direction of the vehicle 1000, the brake 25 at a 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 right end is a right end set, the stop nut 271 of the right end set and the locking sheet 272 of the right end set are both fitted over the half axle sleeve 23 at the right end, and the stop nut 271 of the right end set is connected to the half axle sleeve 23 at the right end in a threaded manner to tighten the inner gear ring support 205 at the right end and the hub assembly 24 at the right end between the locking sheet 272 of the right end set and the brake drum 251 of the brake 25 at the right 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. In an embodiment, 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. In an embodiment, each hub assembly 24 is rotatably fitted over a corresponding half axle sleeve 23 by using the hub bearing 241, and the axial stoppers 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 left end, and details are no longer described herein.

In an embodiment, the axle case assembly 102 may further include two ABS sensor components 26. The two ABS sensor components 26 may be fixed to the two brake mounting plates 214 one to one by using a threaded connecting piece, that is, an ABS sensor component 26 at the left end is fixed to the brake mounting plate 214 at the left end, and an ABS sensor component 26 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.

In an embodiment, when a sensor head of the ABS sensor component 26 and the induction gear ring 242 of the hub assembly 24 rotate to form an induction voltage signal, the signal is output to a control system (for example, an ECU of the vehicle 1000), and the control system controls the brake 25 to lock during braking.

A differential lock mechanism 28 is mounted to the axle case component 21, and the differential lock mechanism 28 is configured to selectively lock one of the two half axles 22 and a differential housing of the integrated differential 13 of the electric drive axle assembly 100.

A working principle of the differential lock mechanism 28 is that when one driving wheel slips, the differential housing and the half axles 22 are locked together, making the differential 13 lose an 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.

In some embodiments of the present disclosure, as shown in FIG. 7, the differential lock mechanism 28 includes a drive cylinder 281, a transmission component 282 and a sliding sleeve 283. An end of the drive cylinder 281 is fixed to the axle case component 21. As shown in FIG. 7, an end of the drive cylinder 281 is connected to the axle case component 21 in a threaded manner by using a screw rod 285. The other end of the drive cylinder 281 is connected to the sliding sleeve 283 by using the transmission component 282.

The sliding sleeve 283 is fitted over the half axle 22, the sliding sleeve 283 may rotate synchronously with the half axle 22, and the drive cylinder 281 drives the sliding sleeve 283 by using the transmission component 282, so that the sliding sleeve 283 moves between an unlocking location and a locking location in an axial direction of the half axle 22. When the sliding sleeve 283 is located at the unlocking location, the sliding sleeve 283 and the differential housing are unlocked. In this case, the differential 13 normally implements a differential function. When the sliding sleeve 283 is located at the locking location, the sliding sleeve 283 and the differential housing are locked together, and the differential 13 loses the differential function.

In an embodiment, the sliding sleeve 283 may be connected to the half axle 22 by using a spline structure. A side of the sliding sleeve 283 may be provided a sliding sleeve tooth-shaped end surface, a differential tooth-shaped end surface is disposed on the differential housing, the sliding sleeve tooth-shaped end surface and the differential tooth-shaped end surface are opposite, and the sliding sleeve tooth-shaped end surface and the differential tooth-shaped end surface selectively fit to lock the sliding sleeve 283 and the differential housing.

In an embodiment, as shown in FIG. 7, the transmission component 282 may include a connecting rod 2821, a shifting yoke bar 2822 and a shifting yoke 2833. An end of the connecting rod 2821 is rotatably connected to the drive cylinder 281, the other end of the connecting rod 2821

is fixedly connected to the shifting yoke bar 2822, and the shifting yoke bar 2822 is rotatably supported by the axle case component 21. The shifting yoke 2833 is fitted over the shifting yoke bar 2822 by using a spline structure, a sliding groove 2831 is disposed in the sliding sleeve 283, and the shifting yoke 2833 is located inside the sliding groove 2831. Accordingly, the transmission component 282 has a simple structure and easy arrangement.

In some embodiments, the differential lock mechanism 28 may further include a differential lock sensor component 284. The differential lock sensor component 284 may include a sensor 2841, a moving rod 2842 and a fixed piece 2843. The sensor 2841 is disposed on the axle case component 21, and the moving rod 2842 is movably disposed to the axle case component 21. That is, the moving rod 2842 may move relative to the axle case component 21. The fixed piece 2843 is fixed to the shifting yoke 2833, and the fixed piece 2843 is configured to that when the shifting yoke 2833 swings to make the sliding sleeve 283 move to the locking location, the fixed piece 2843 drive the moving rod 2842 to abut against the sensor 2841 so that the sensor 2841 makes a locking signal. In an embodiment, the fixed piece 2843 may be a sheet metal piece, and the sheet metal piece may be fastened to the shifting yoke 2833 in a threaded manner by using a bolt 404.

The differential lock mechanism 28 shown in FIG. 7 is used as an example. When the drive cylinder 281 ventilates or expires, the connecting rod 2821 is driven by the drive cylinder 281 to rotate about an axis of the shifting yoke bar 2822, and actuates the shifting yoke bar 2822 to rotate. Because the shifting yoke bar 2822 is rotatably supported by the axle case component 21, and the shifting yoke bar 2822 is connected to the shifting yoke 2833 by using a spline structure, the shifting yoke bar 2822 may actuate the shifting yoke 2833 to swing. By using fitting between the shifting yoke 2833 and the sliding groove 2831, the shifting yoke 2833 pushes the sliding sleeve 283 to move in an axial direction of the half axle 22, so as to control a tooth on the sliding sleeve tooth-shaped end surface of the sliding sleeve 283 to be engaged with or disengaged from a tooth on the differential tooth-shaped end surface of the differential 13, thereby eventually implementing locking or differential of the left half axle 22 and the right half axle 22.

For the axle case assembly 102 according to this embodiment of the present disclosure, the differential lock mechanism 28 is disposed, so that according to a different running working condition of the vehicle 1000, the differential 13 may implement a differential function of the differential 13 or disable the differential function of the differential 13. Especially, when the vehicle 1000 is running in a terrible working condition, the vehicle 1000 has strong power.

Moreover, the differential lock mechanism 28 is integrated with the axle case component 21, so that the structure is compact, mounting is secure, working is stable, reliability is high, and the electric drive axle assembly 100 has higher reliability and more complete functions.

In short, for the electric drive axle assembly 100 for the vehicle 1000 according to the embodiment of the present disclosure, the transmission housing 121 connects the power motor 11 and the axle case assembly 102, to implement integrated arrangement of the electric power assembly 101 that includes the power motor 11, the transmission 12 and the differential 13 and the axle case assembly 102 that includes the axle case component 21 and the two half axles 22, so that transmission efficiency is improved, the mass is reduced, and a space is saved. Moreover, the suspension apparatus 103 is disposed between the frame 400 and the electric power assembly 101, torque to the axle case assembly 102 generated by a center of mass offset of the electric power assembly 101 is effectively balanced, so that the connection between the electric power assembly 101 and the axle case assembly 102 is more reliable, and power transmission is smoother, making the entire electric drive axle assembly 100 safer.

In some embodiments, for the power motor 11, the power motor 11 including the active cooling structure is used. Active cooling is performed by using a build-in internal cooling oil pump or external coolant, to make the power motor 11 more suitable for long-time, high-rotational-speed, and high-power running. For the transmission 12, the four-gear automatic transmission 12 is used, so that the structure is simple, the mass is small, a speed ratio is large, torque is large, power performance is relatively strong, operability is relatively desirable, and a use requirement of a heavy-load vehicle can be met. Moreover, gears of the transmission 12 are all helical gears, so that transmission is smooth, transmission torque is large, efficiency is high, and noise is low.

The vehicle 1000 according to the present disclosure is briefly described below with reference to FIG. 12. The vehicle 1000 according to this embodiment of the present disclosure includes any electric drive axle assembly 100 for the vehicle 1000 in the foregoing embodiment. In some embodiments, the vehicle 1000 may include a front vehicle axle 300 and a rear vehicle axle that are disposed at an interval in a front-rear direction of the vehicle 1000. For the rear vehicle axle, the electric drive axle assembly 100 for the vehicle 1000 according to the embodiment of the present disclosure may be used, so that a transmission chain is short, a small space is occupied, and overall arrangement of the vehicle 1000 is facilitated. Especially, mounting of a battery system of a pure electric vehicle is facilitated, and a space is saved to mount the battery system, thereby

improving battery endurance.

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 embodiment", "some embodiments", "example", "specific example", 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 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 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.

CLAIMS

1. An electric drive axle assembly for a vehicle, comprising:

an electric power assembly comprising a power motor, a transmission and a differential, the transmission having a transmission housing, the power motor being fixed to the transmission housing, and the differential being supported by the transmission housing;

an axle case assembly comprising an axle case component and two half axles, the two half axles and the differential being both located inside the axle case component, and the transmission housing being fixed to the axle case component; and

a suspension apparatus connected between the electric power assembly and a frame of the vehicle.

2. The electric drive axle assembly according to claim 1, wherein the power motor comprises an active cooling structure that comprises a coolant circulation passage configured to cool the power motor.

3. The electric drive axle assembly according to claim 2, wherein the active cooling structure further comprises a coolant driving member disposed to the coolant circulation passage to drive a coolant to flow inside the coolant circulation passage.

4. The electric drive axle assembly according to claim 1, wherein the axle case component comprises:

an axle case, a differential receiving space whose two side end surfaces are both open being provided at a middle portion of the axle case; and

a case cover detachably mounted on the axle case to close a first open side end surface of the middle portion of the axle case, and the transmission housing being fixed to a second open side end surface of the middle portion of the axle case.

5. The electric drive axle assembly according to claim 4, wherein the case cover is detachably mounted on the axle case by using a threaded connecting piece.

6. The electric drive axle assembly according to claim 5, further comprising a plurality of bolts, a plurality of threaded holes being provided in the transmission housing, a plurality of through holes corresponding to the plurality of threaded holes one to one being disposed in the axle case, the plurality of bolts corresponding to the plurality of through holes one to one, and each bolt passing through a corresponding through hole and to be fixed inside a corresponding threaded

hole to fix the transmission housing on the second open side end surface of the middle portion of the axle case.

7. The electric drive axle assembly according to claim 1, wherein two half axle sleeves are respectively fixed at two ends of the axle case component through welding, and the axle case assembly further comprises two hub assemblies, each hub assembly is rotatably mounted to a corresponding half axle sleeve, and the two half axle sleeves are fitted over the two half axles one to one.

8. The electric drive axle assembly according to claim 7, further comprising two wheel reducers, the two wheel reducers corresponding to the two hub assemblies one to one, an input end of each wheel reducer being connected to a corresponding half axle, and an output end of each wheel reducer being connected to a corresponding hub assembly.

9. The electric drive axle assembly according to claim 8, wherein the wheel reducer is a planetary gear reducer, the planetary gear reducer comprises a sun gear, a planetary gear and an inner gear ring, the sun gear is fixed to the half axle, the planetary gear is engaged with the sun gear and the inner gear ring, and the inner gear ring is fixed to a corresponding half axle sleeve by using an inner gear ring support.

10. The electric drive axle assembly according to claim 9, wherein the inner gear ring support is engaged with the inner gear ring, and the planetary gear reducer further comprises a retainer ring, at least part of the inner gear ring support is sandwiched between the retainer ring and the inner gear ring in an axial direction.

11. The electric drive axle assembly according to claim 10, wherein the axle case assembly further comprises two brakes and two brake mounting plates, the two brakes correspond to the two hub assemblies one to one, the two brake mounting plates are respectively fixed at two ends of the axle case component through welding, the two brakes are both fixed to the two brake mounting plates one to one by using a threaded connecting piece, and brake drums of the two brakes are fixed to the two hub assemblies one to one.

12. The electric drive axle assembly according to claim 11, further comprising two axial stopper sets corresponding to the two hub assemblies one to one, each inner gear ring support being fitted over a corresponding half axle sleeve by using a spline structure, each axial stopper set comprising a stop nut and a locking sheet, and the stop nut and the locking sheet being both fitted over the corresponding half axle sleeve, the stop nut being connected to the corresponding half

axle sleeve in a threaded manner to tightly press a corresponding inner gear ring support and a corresponding hub assembly between the locking sheet and a brake drum of a corresponding brake.

13. The electric drive axle assembly according to claim 1, wherein the axle case assembly further comprises a differential lock mechanism, the differential lock mechanism is mounted to the axle case component and configured to selectively lock one of the two half axles and a differential housing of the differential.

14. The electric drive axle assembly according to claim 13, wherein the differential lock mechanism comprises:

a drive cylinder, an end of the drive cylinder being fixed to the axle case component;

a transmission component; and

a sliding sleeve, the sliding sleeve being fitted over the half axle and being rotatably synchronous with the half axle, and the drive cylinder driving the sliding sleeve by using the transmission component, so that the sliding sleeve moves in an axial direction of the half axle between an unlocking location of being unlocked from the differential housing and a locking location of being locked to the differential housing.

15. The electric drive axle assembly according to claim 14, wherein the transmission component comprises:

a connecting rod, an end of the connecting rod being rotatably connected to the drive cylinder;

a shifting yoke bar, the shifting yoke bar being fixedly connected to the other end of the connecting rod, and the shifting yoke bar being rotatably supported by the axle case component; and

a shifting yoke, the shifting yoke being fitted over the shifting yoke bar by using a spline structure, wherein a sliding groove is disposed in the sliding sleeve, and the shifting yoke is located inside the sliding groove.

16. The electric drive axle assembly according to claim 15, wherein the differential lock mechanism further comprises a differential lock sensor component, the differential lock sensor component comprises:

a sensor, the sensor being disposed to the axle case component;

a moving rod, the moving rod being movably disposed to the axle case component; and

a fixed piece, the fixed piece being fixed to the shifting yoke, and being configured to drive the moving rod to abut against the sensor so that the sensor sends a locking signal, when the shifting yoke swing to make the sliding sleeve moves to the locking location.

17. The electric drive axle assembly according to claim 1, wherein the transmission comprises 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, and the transmission power output portion is configured to be suitable for outputting power that is from the transmission power input portion to the differential.

18. The electric drive axle assembly according to claim 17, wherein the electric power assembly further comprises a power takeoff, the power takeoff comprises 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, the power takeoff output end is configured to be selectively joined to the power takeoff input end to output power that is from the power takeoff input end, and the power takeoff is fixed to the transmission housing.

19. The electric drive axle assembly according to claim 18, wherein the power takeoff input end comprises a power takeoff gear, the power takeoff output end comprises a power takeoff shaft, the power takeoff gear is freely fitted over the power takeoff shaft, and the power takeoff further comprises a power takeoff synchronizer, the power takeoff synchronizer is configured to selectively synchronize the power takeoff gear with the power takeoff shaft.

20. The electric drive axle assembly according to claim 19, wherein the transmission comprises:

a first shaft, an input gear being fixed to the first shaft, and the first shaft being connected to the 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 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,

wherein the first shaft, the input gear, the second shaft and the idler gear form the transmission power input portion, and the third shaft, the first gear, the fourth shaft, the second gear, the plurality of gear position driving gears and the plurality of gear position driven gears form the transmission power output portion.

21. The electric drive axle assembly according to claim 20, wherein the plurality of gear position driven gears comprises a first-gear driven gear, a second-gear driven gear and a third-gear driven gear;

the plurality of gear position driving gears comprises 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 power output portion 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.

22. The electric drive axle assembly according to claim 21, wherein an output gear is further fixed to the second shaft segment, the output gear is located between the first-gear driven gear and the second-gear driven gear, and the output gear is suitable for being engaged with a differential driven gear of the differential.

23. The electric drive axle assembly according to claim 20, wherein the power takeoff gear and the second gear are directly engaged for transmission.

24. The electric drive axle assembly according to claim 20, wherein the first shaft segment is supported by the transmission housing, and an end, near the first shaft segment, of the second shaft segment is supported by the first shaft segment.

25. The electric drive axle assembly according to claim 20, wherein the input gear, the idler gear, the first gear, the second gear, the plurality of gear position driving gears, and the plurality of

gear position driven gears are all helical gears.

26. The electric drive axle assembly according to claim 20, wherein the first shaft is connected to the motor output shaft of the power motor by using a spline structure or a coupling.

27. The electric drive axle assembly according to claim 1, wherein the electric power assembly further comprises an electrohydraulic gear shift actuating module, the electrohydraulic gear shift actuating module is configured to control the transmission and is mounted to the transmission housing.

28. The electric drive axle assembly according to any one of claims 1 to 27, wherein the suspension apparatus is connected between an end, far away from the axle case assembly, of the transmission housing and the frame of the vehicle.

29. The electric drive axle assembly according to claim 28, wherein the suspension apparatus comprises two shock absorbers, the two shock absorbers are symmetrically disposed on a left side and a right side of the transmission housing.

30. A vehicle, comprising the electric drive axle assembly according to any one of claims 1 to 29.

DRAWINGS

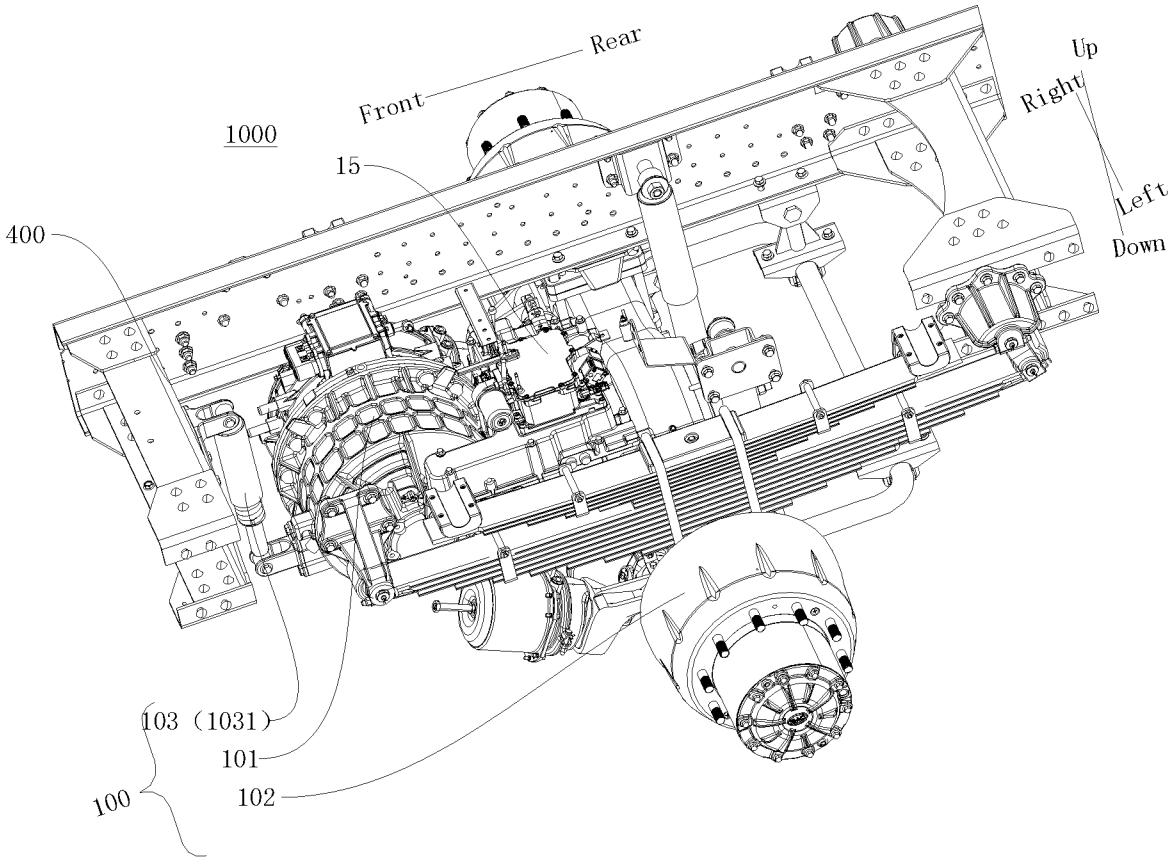


FIG. 1

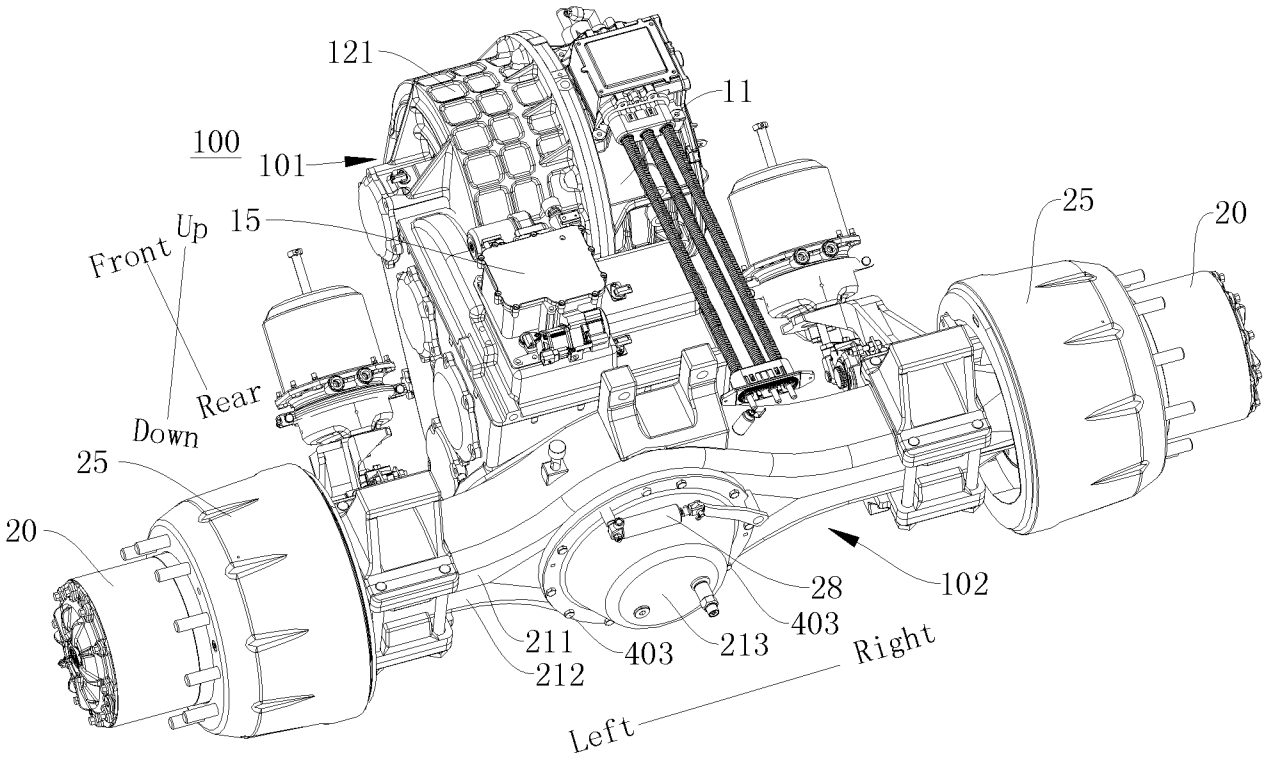


FIG. 2

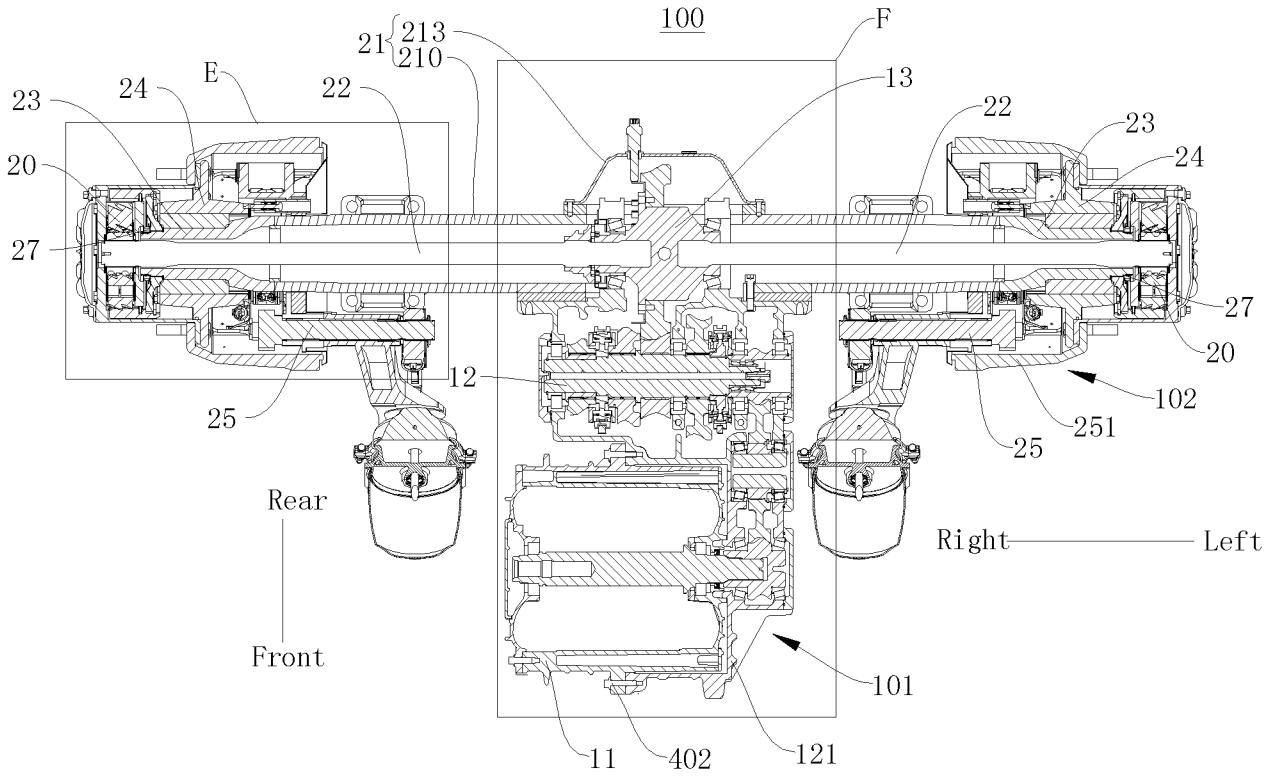

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FIG. 3

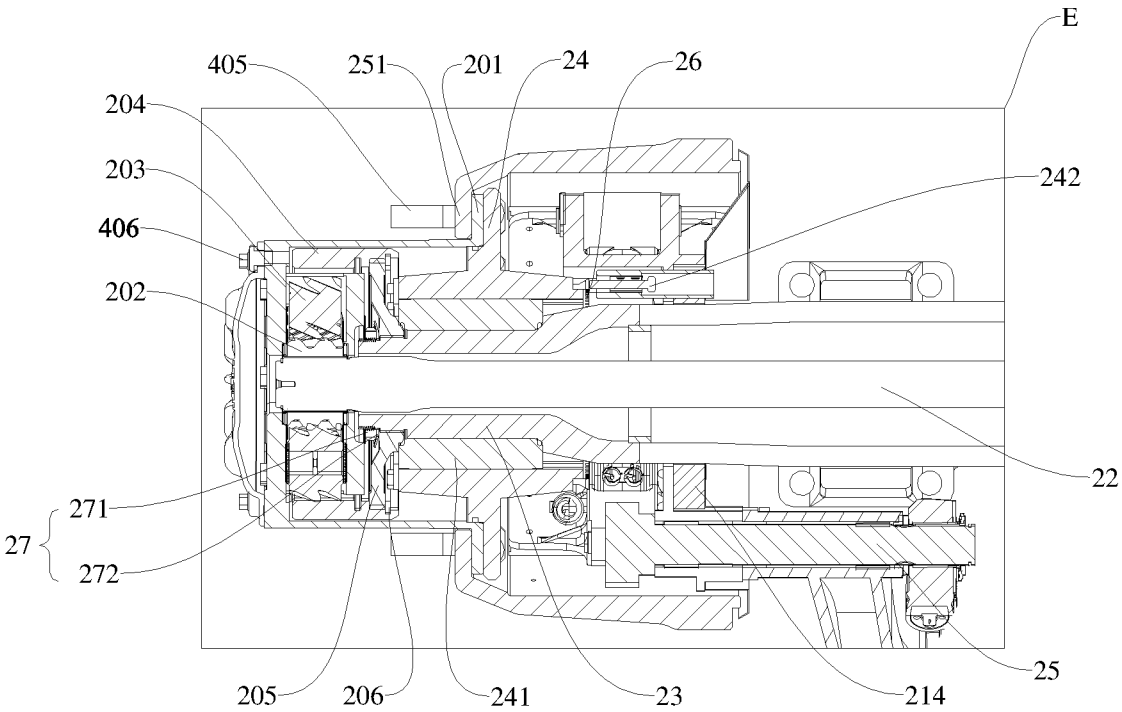

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FIG. 4

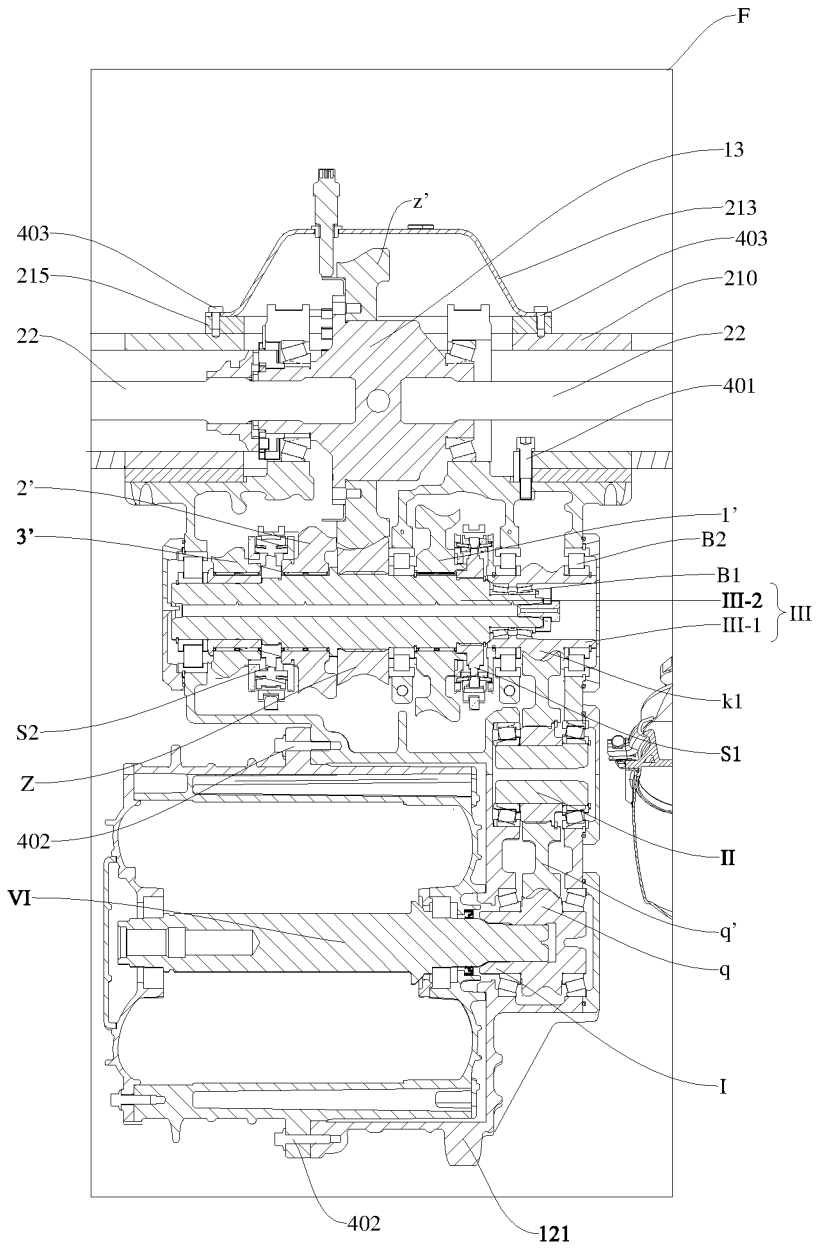

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FIG.5

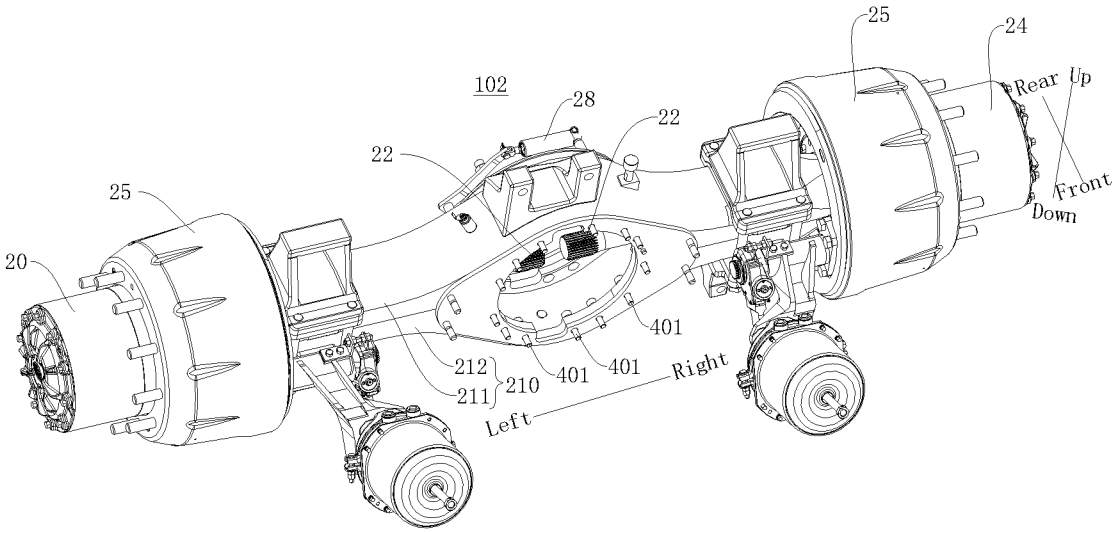

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FIG. 6

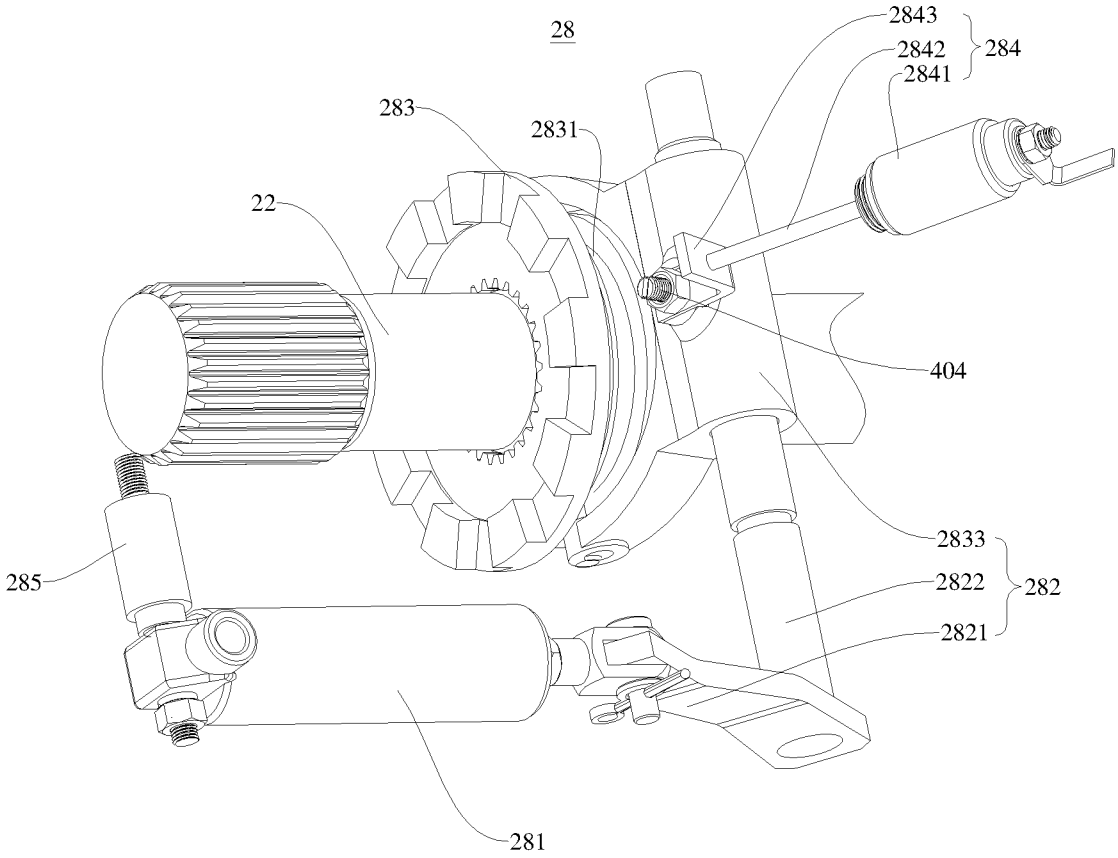

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FIG. 7

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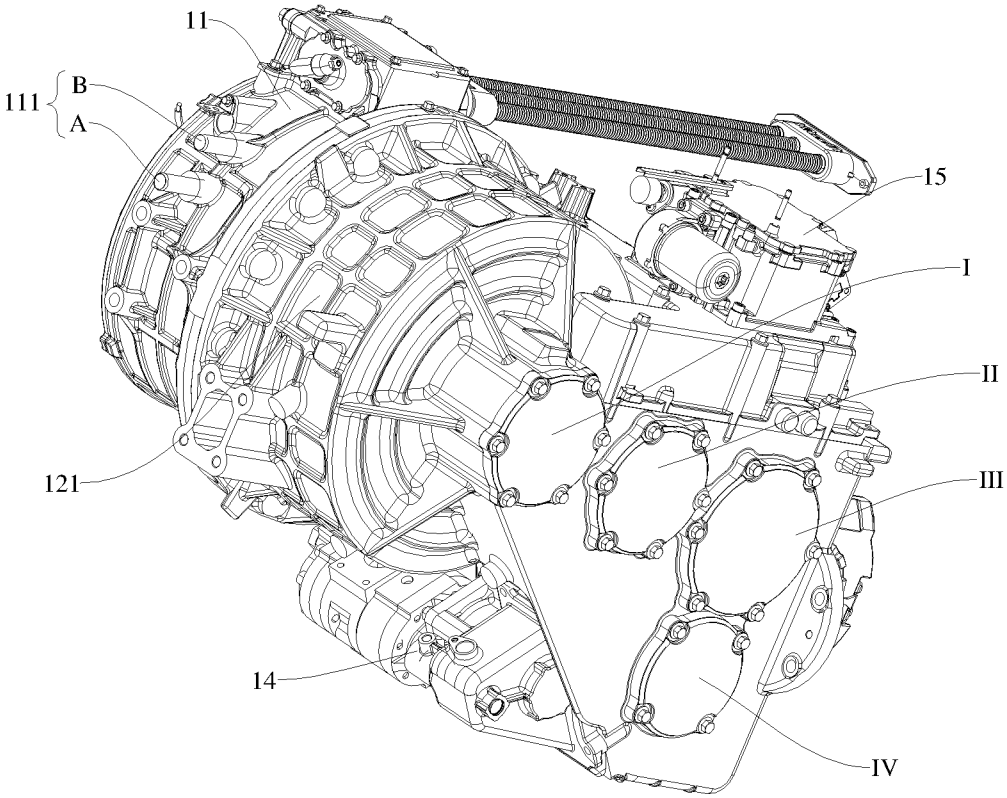


FIG. 8

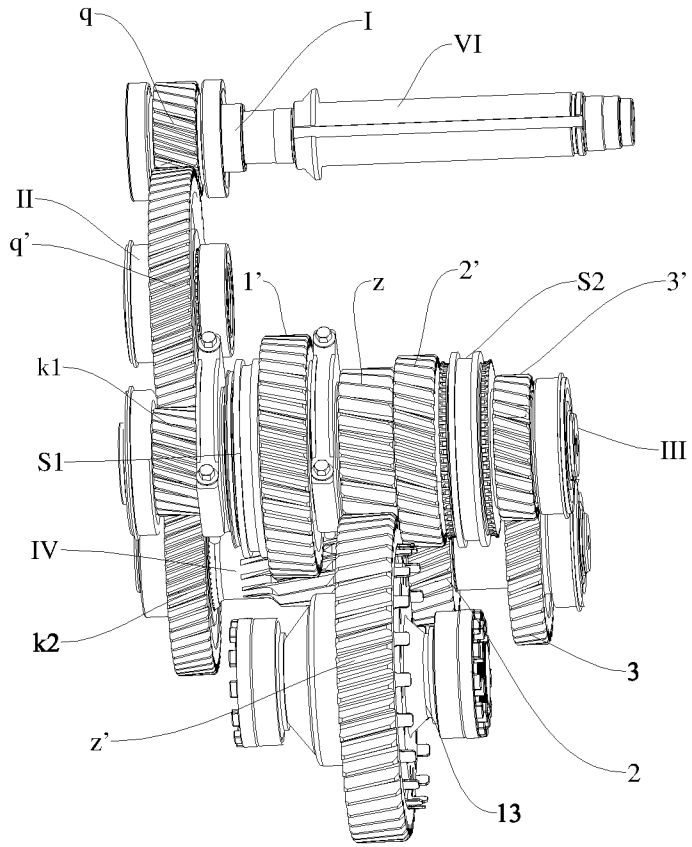


FIG. 9

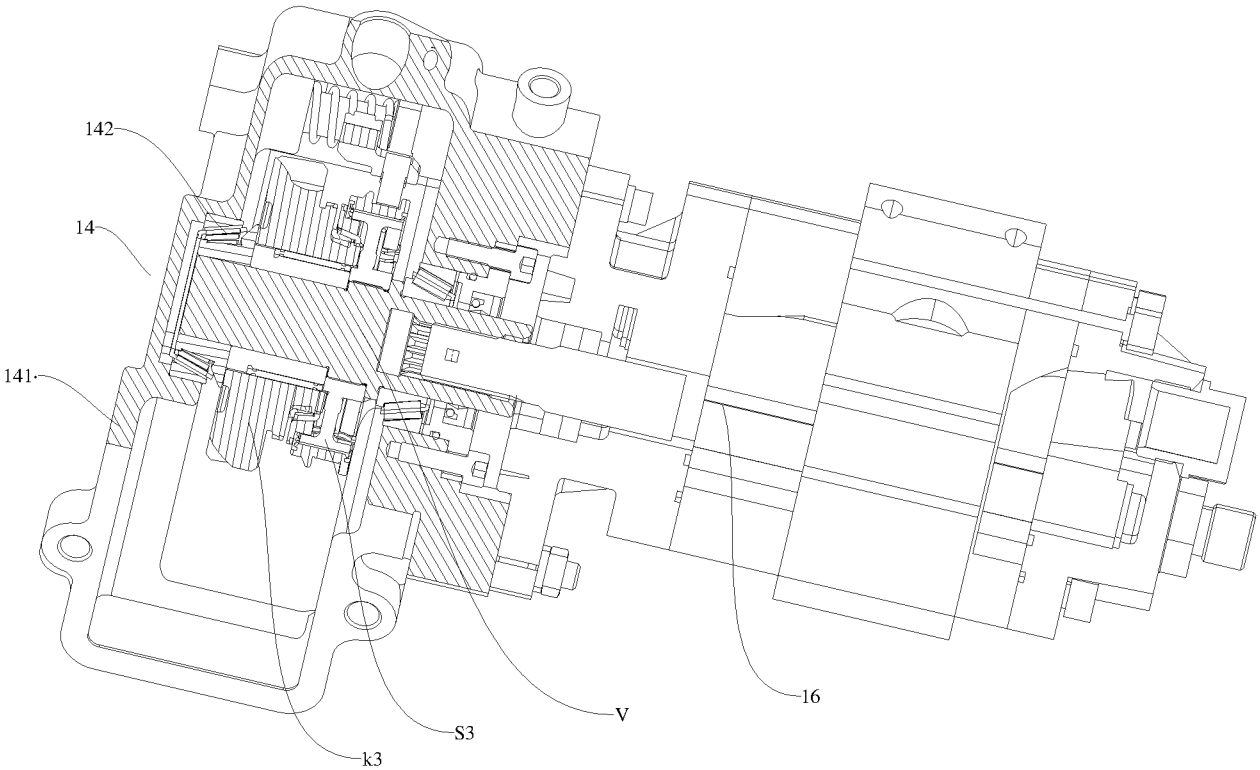

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FIG. 10

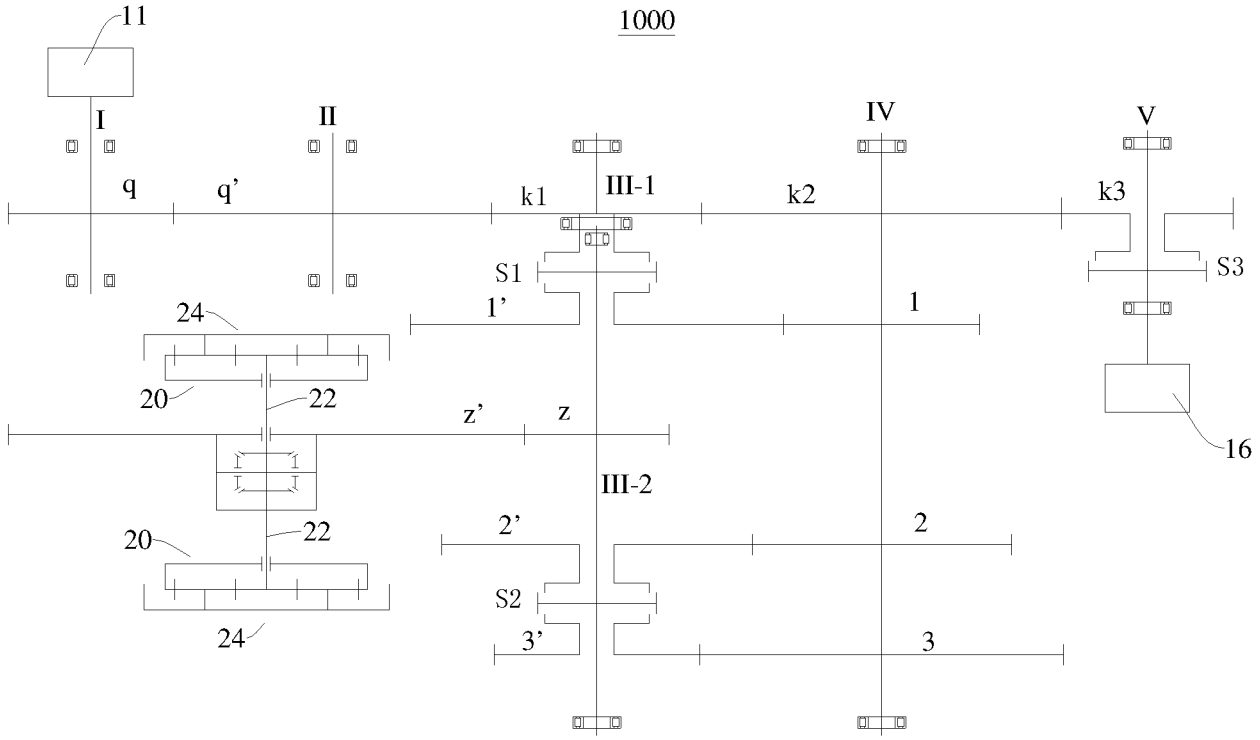

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FIG. 11

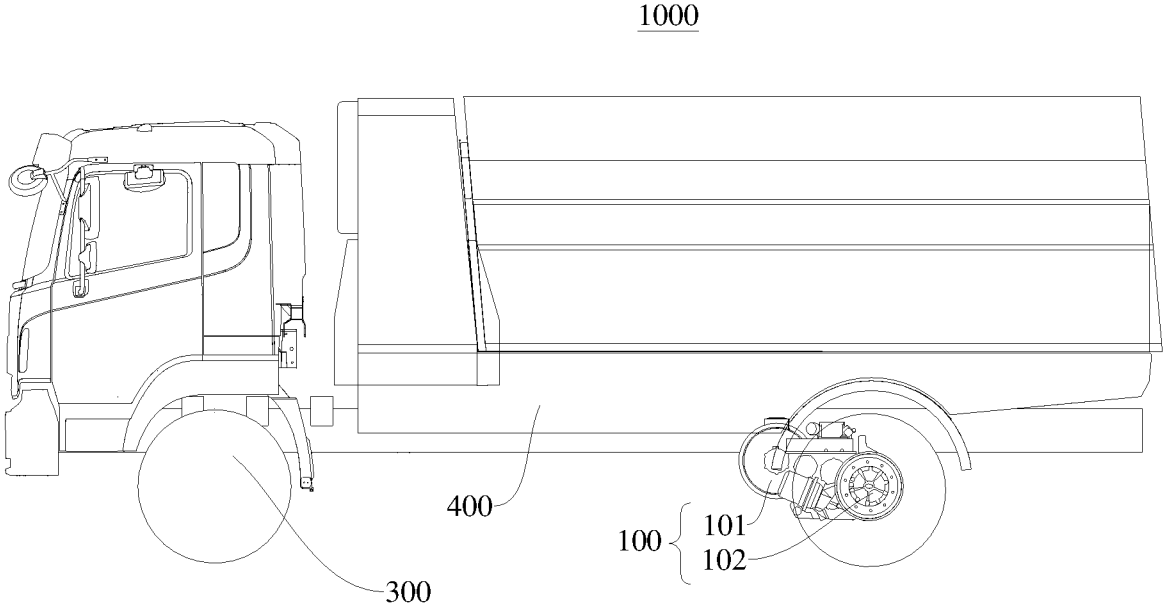


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/112659

A. CLASSIFICATION OF SUBJECT MATTER

B60K 1/00(2006.01)i; B60K 17/04(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

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, CNKI, VEN: motor,transmission,differential,housing,case,axle,suspension

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 201881893 U (XIANG LI) 29 June 2011 (2011-06-29) See description, paragraphs [0014] to [0016] and figure 1	1-30
Y	CN 204567292 U (SUZHOU DAFANG SPECIAL VEHICLE) 19 August 2015 (2015-08-19) See description, paragraphs [0021] to [0034] and figures 1 to 2	1-30
PX	CN 105966219 A (BYD CO LTD) 28 September 2016 (2016-09-28) See the whole document	1-30
PX	CN 205326778 U (BYD CO LTD) 22 June 2016 (2016-06-22) See the whole document	1-30
PX	CN 105984335 A (BYD CO LTD) 05 October 2016 (2016-10-05) See the whole document	1-14, 30
PX	CN 205468492 U (BYD CO LTD) 17 August 2016 (2016-08-17) See the whole document	1-9, 17-30
PX	CN 205365231 U (BYD CO LTD) 06 July 2016 (2016-07-06) See the whole document	1-14, 30

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

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"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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 January 2017	**09 March 2017**

Name and mailing address of the ISA/CN	Authorized officer
STATE INTELLECTUAL PROPERTY OFFICE OF THE P.R.CHINA **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China**	**SUN,Jinfeng**
Facsimile No. **(86-10)62019451**	Telephone No. **(86-10)62085285**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/112659

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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PX	CN 105984278 A (BYD CO LTD) 05 October 2016 (2016-10-05) See the whole document	1-9, 17-30
PX	CN 205468311 U (BYD CO LTD) 17 August 2016 (2016-08-17) See the whole document	1-9, 17-30
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A	WO 0110663 A1 (EGS INCET ET AL) 15 February 2001 (2001-02-15) See the whole document	1-30

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/112659

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CN	205326778	U	22 June 2016	None			
CN	105984335	A	05 October 2016	None			
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				DE	3135490	A1	15 July 1982
CN	103921674	A	16 July 2014	None			
WO	0110663	A1	15 February 2001	None			