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Ishijiki et al.

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(54) **POWER TRANSMISSION DEVICE**

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F16H 37/08 (2006.01)
F16H 48/40 (2012.01)
F16H 48/08 (2006.01)

(52) **U.S. Cl.**
CPC ***F16H 37/082*** (2013.01); ***F16H 48/40*** (2013.01); *F16H 2048/085* (2013.01)

(58) **Field of Classification Search**
CPC F16H 37/082; F16H 37/08; F16H 48/40; F16H 2048/085; F16H 57/082
USPC ..... 475/204, 221, 230, 331, 150; 74/606 R
See application file for complete search history.

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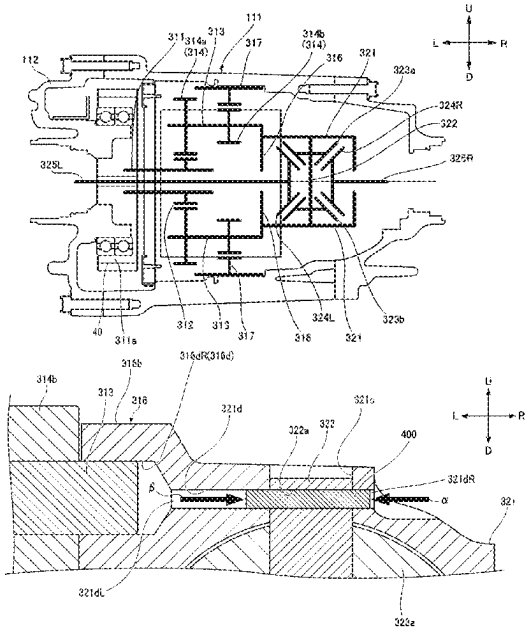
(57) **ABSTRACT**

A power transmission device includes a planetary gear mechanism and a differential gear mechanism, in which a differential case is formed in one piece with a planetary carrier in a state of being aligned with the planetary carrier in a rotation axis direction of the differential case, and is provided a fixing pin insertion hole through which a fixing pin for fixing a differential pinion shaft to the differential case is inserted, and the fixing pin insertion hole is provided at a position overlapping a pinion shaft insertion hole when the planetary carrier and the differential case are viewed from the rotation axis direction, one end of the fixing pin insertion hole communicates with the pinion shaft insertion hole, and another end thereof communicates with outside of the differential case on a side opposite to the planetary carrier.

1 Claim, 8 Drawing Sheets



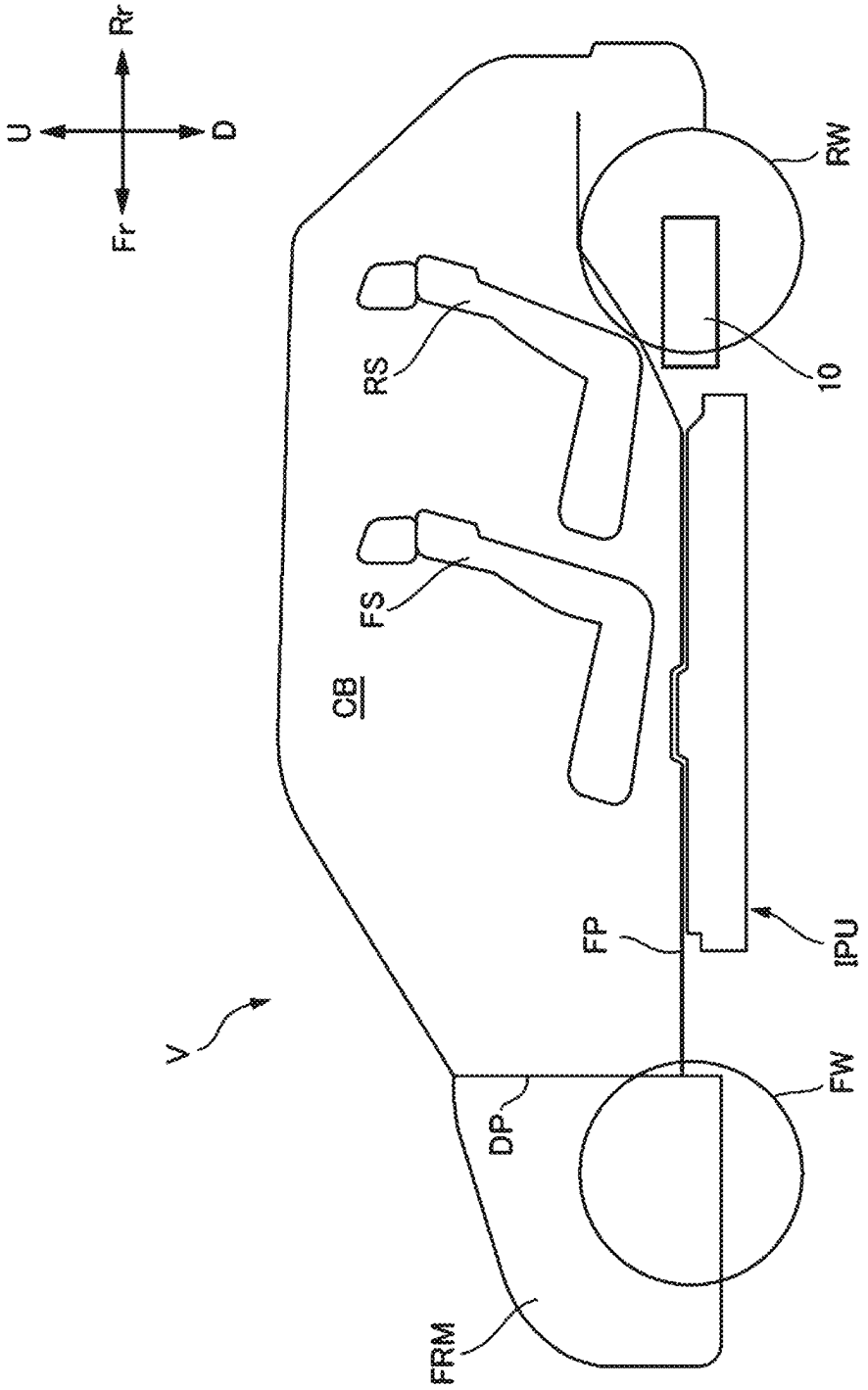
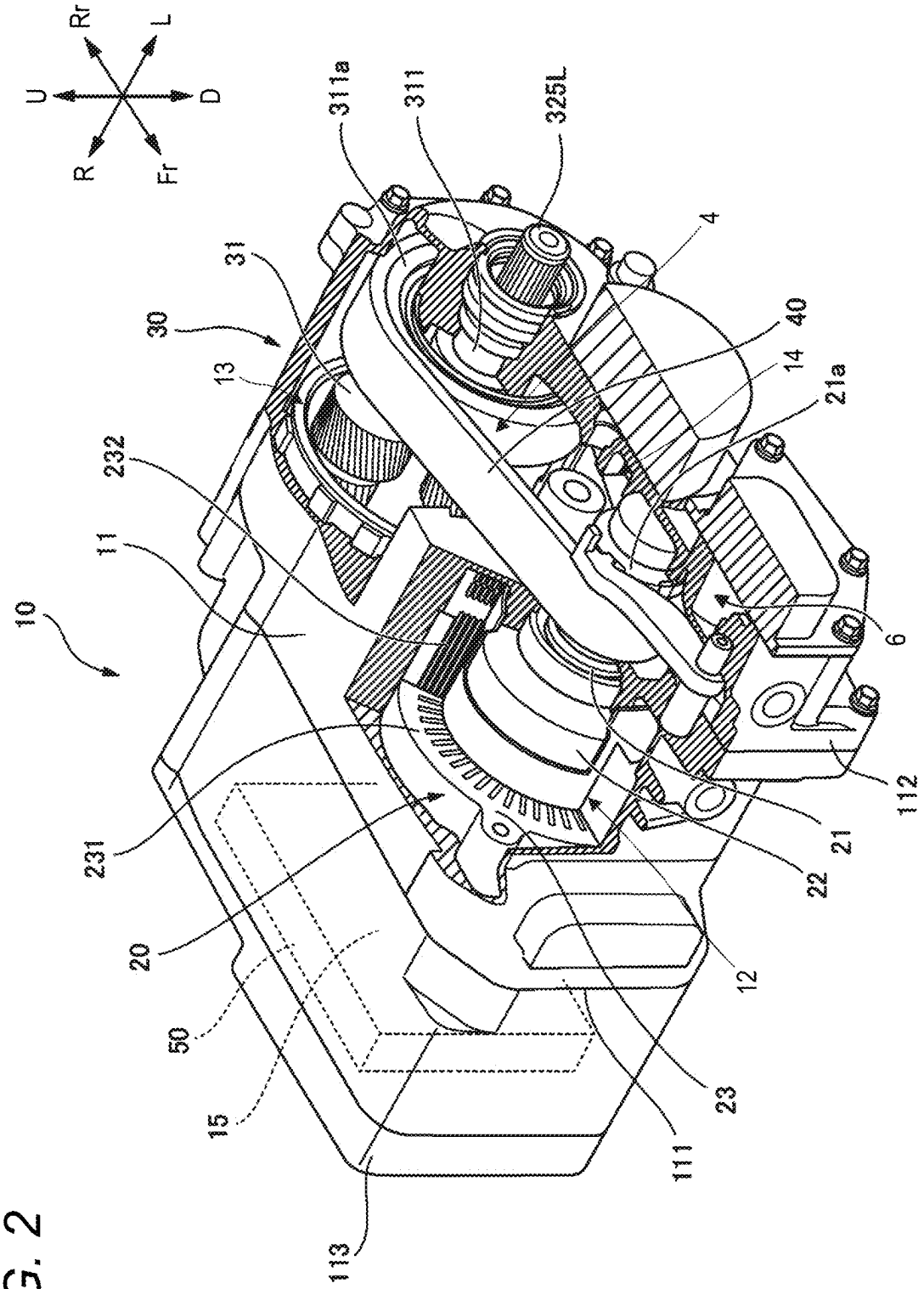


FIG. 1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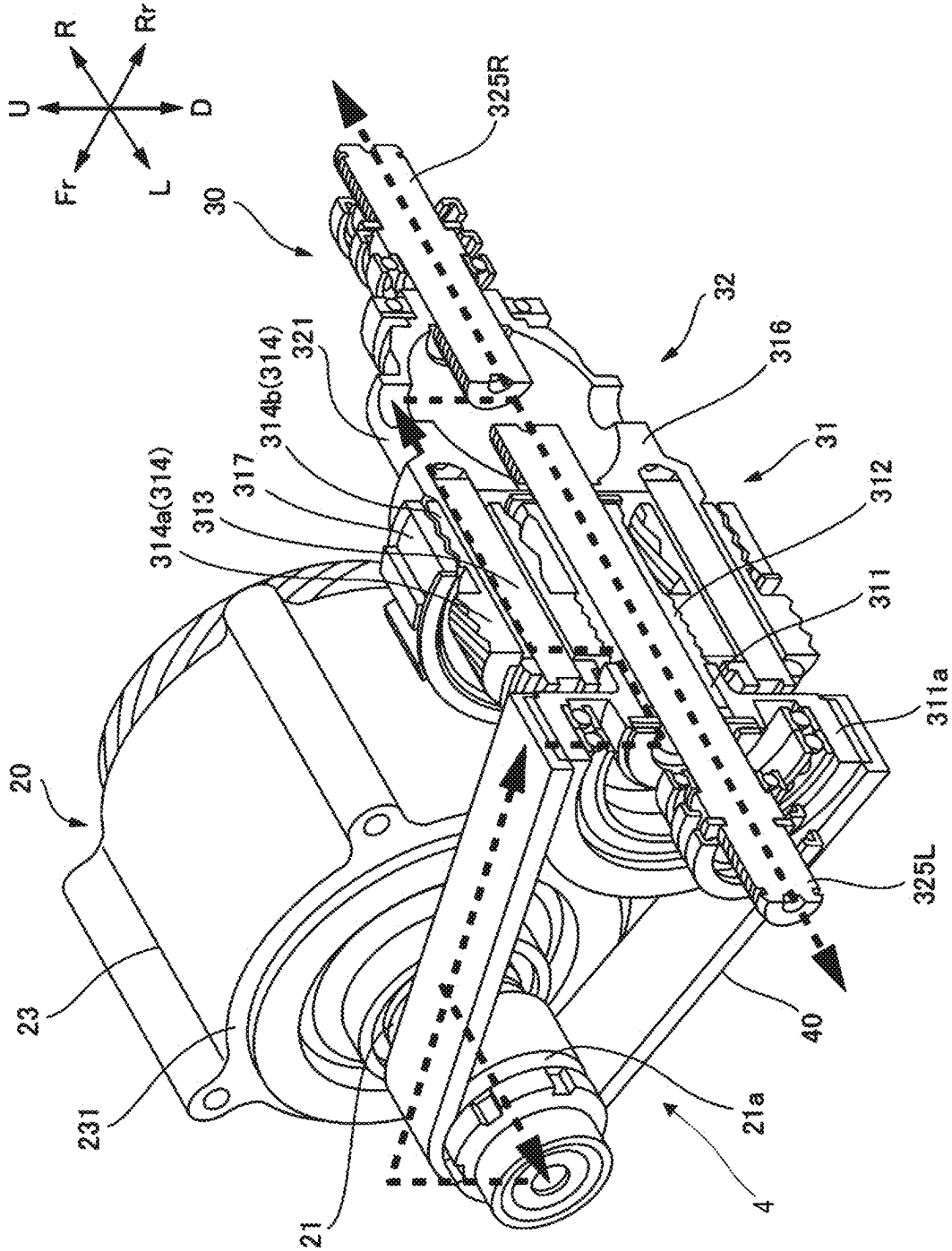
111
113

FIG. 2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31
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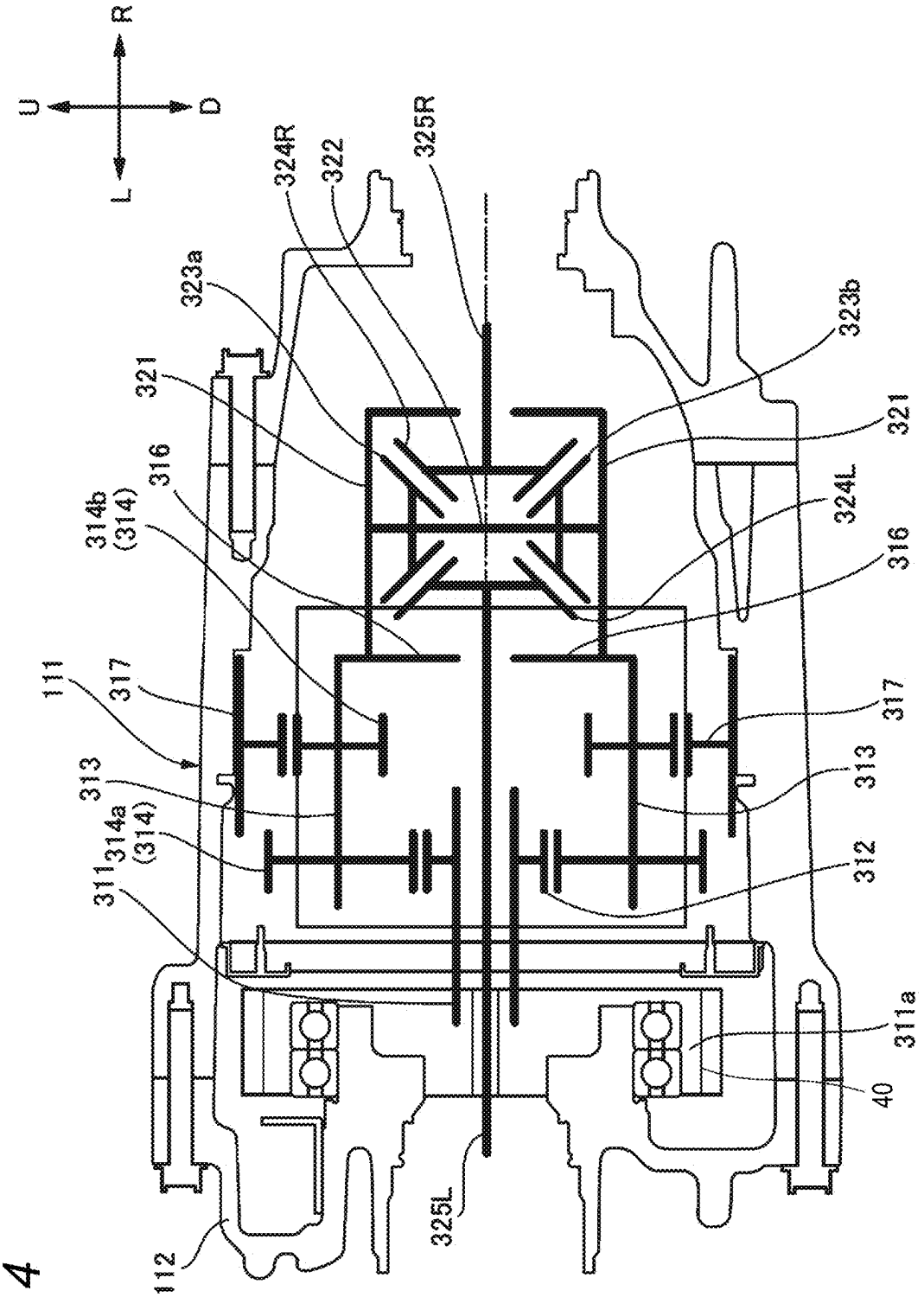
311a
325L
20
23
231
21
21a
4
40

FIG. 3


U
R
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D
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322
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323a
323b
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321
316
314b
(314)
324L
316
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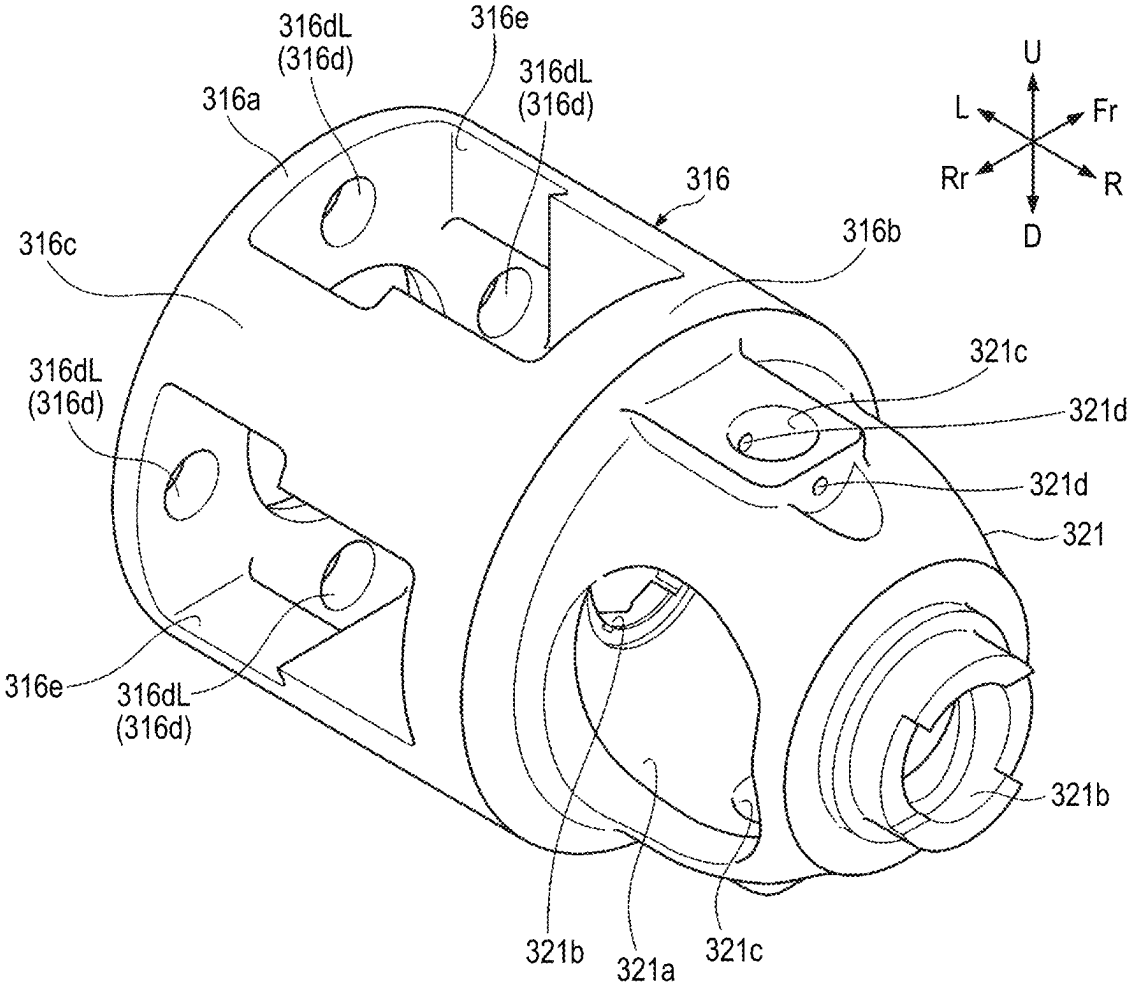
317
317
313
313
314a
(314)
311
312
311a
40
112
325L

FIG. 4

FIG. 5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(316d)
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316dL
(316d)
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316b
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(316d)
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321d
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U
L
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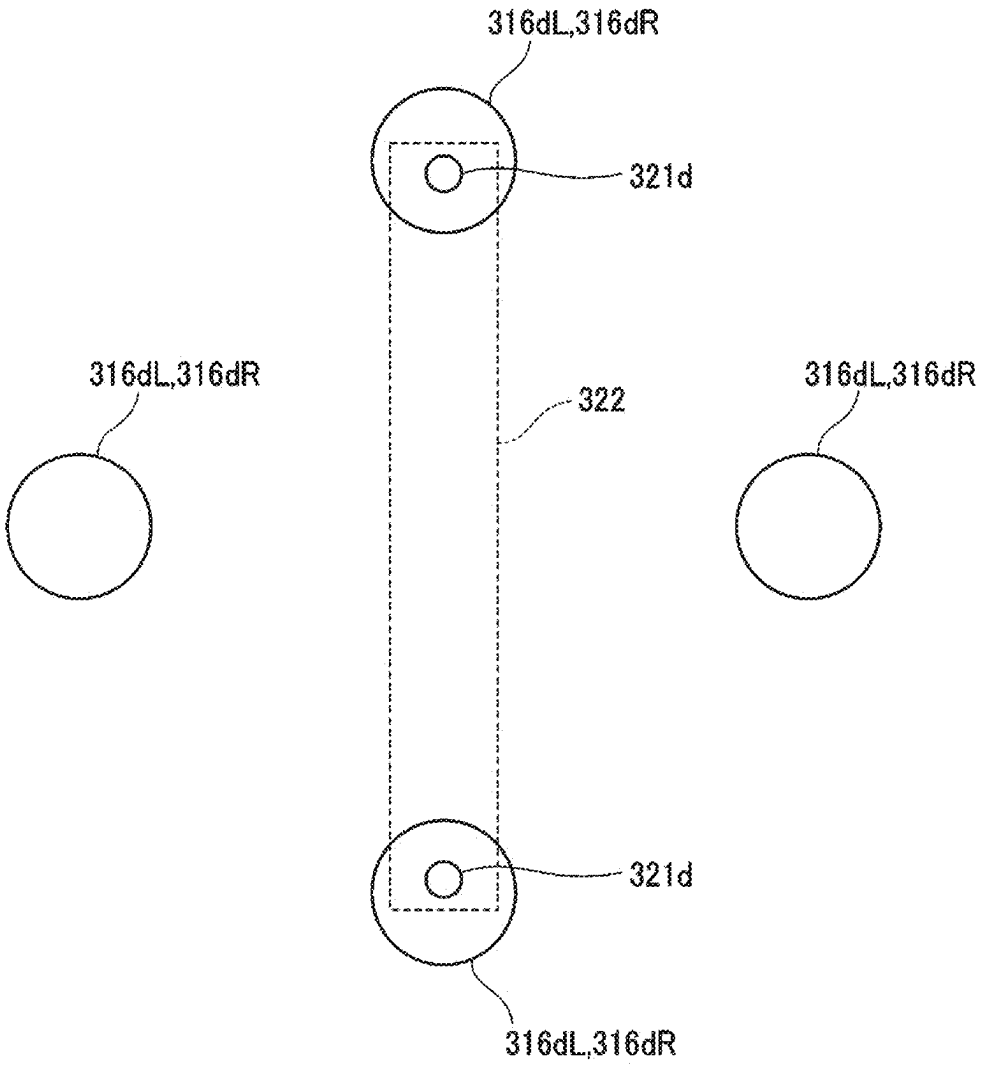
Rr
R
D

FIG. 6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322
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321d
316dL,316dR

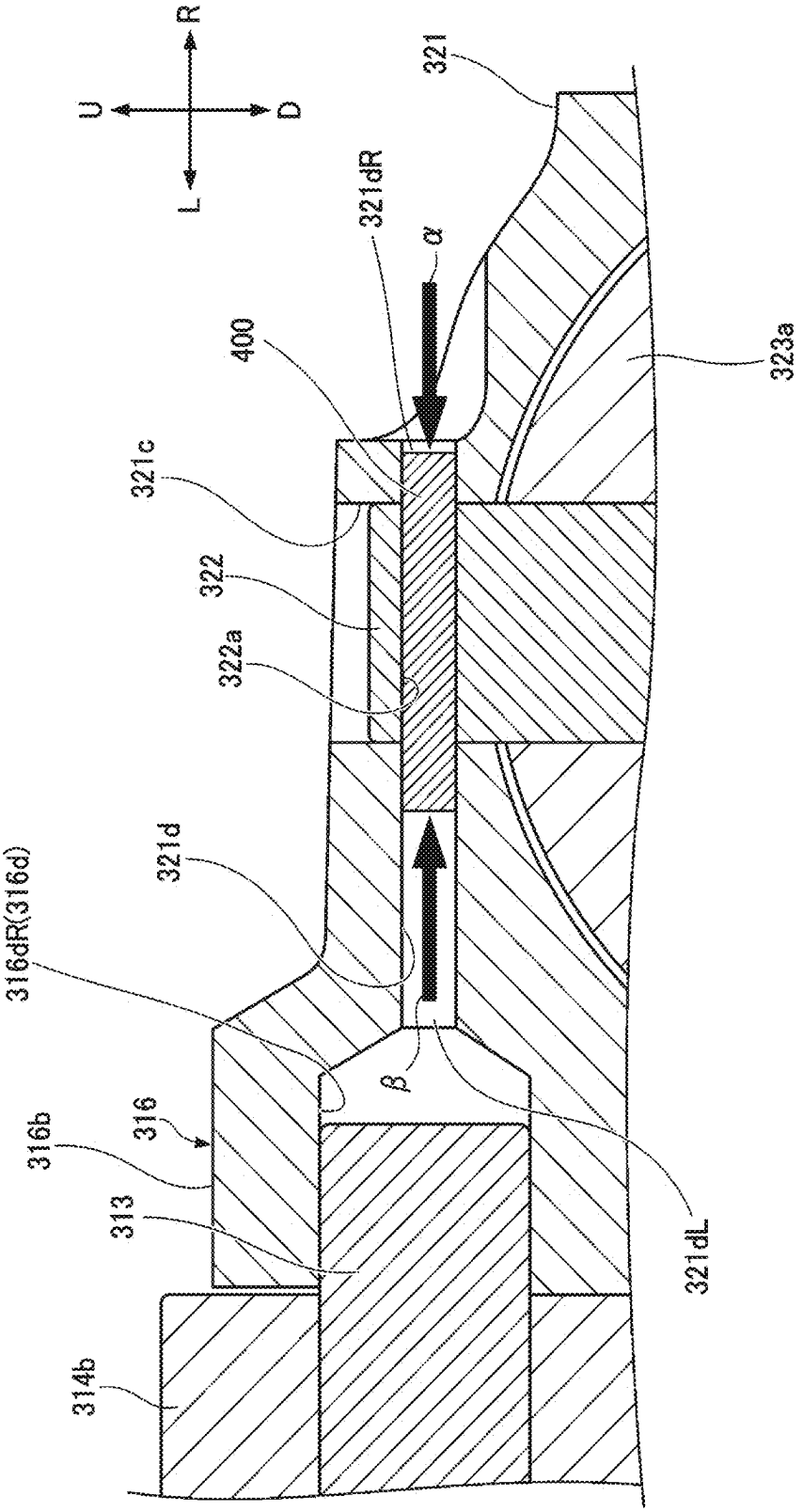
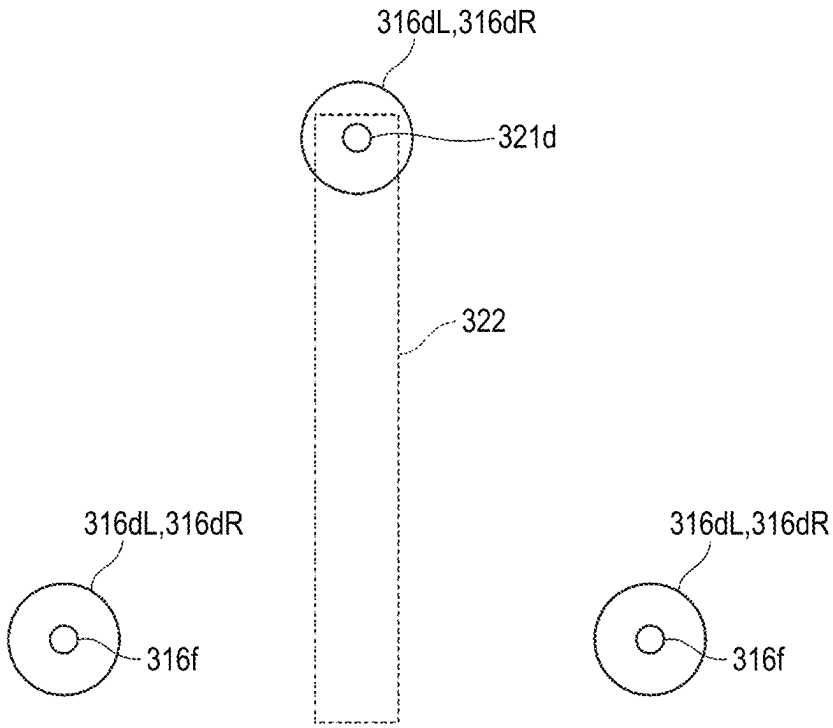

U
R
L
D
321
321dR
α
400
323a
321c
322
322a
321d
316dR(316d)
β
316b
316
313
321dL
314b

FIG. 7

FIG. 8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321d
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316dL,316dR
316f
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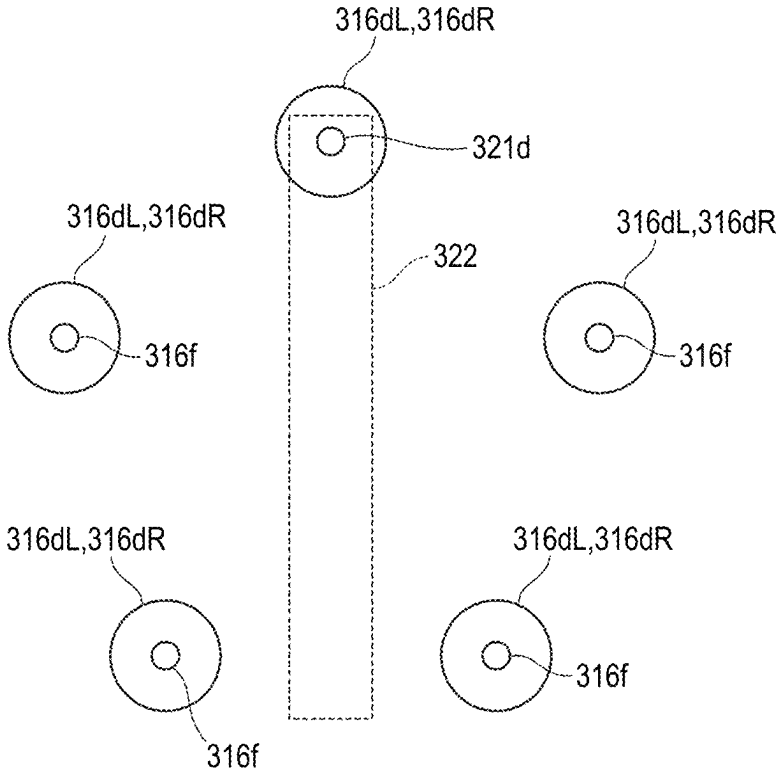
316f

FIG. 9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321d
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322
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316f
316f
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316f
316f

POWER TRANSMISSION DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on and claims priority under 35 USC 119 from Japanese Patent Application No. 2023-128786 filed on Aug. 7, 2023, the entire content of which is incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a power transmission device.

BACKGROUND ART

In recent years, as a specific countermeasure against global climate change, efforts for realizing a low-carbon society or a decarbonized society have become active. Reduction in CO_2 emission and an improvement in energy efficiency in a vehicle such as an automobile are also required, and electrification of a drive source is progressing. In addition, from the viewpoint of environmental conservation, in recent years, there has been an increasing demand for reducing the number of waste components and reusing components.

JP2013-007442A discloses a technique in which a pinion gear shaft of a rear differential is disposed in an accommodating space of a differential case on an axis orthogonal to a rotation axis of the differential case, and rotation around the axis and movement in a direction along the axis are restricted by a pin.

However, in the related art described above, there is a problem that it is difficult to detach the pin for restricting rotation and movement of the pinion gear shaft from the differential case after the pin is attached to the differential case. Therefore, for example, when the pinion gear shaft is to be detached from the differential case at the time of assembling or inspection of the rear differential, a method of breaking the differential case to detach the pinion gear shaft is generally adopted, and it is difficult to reuse the differential case or the like.

An object of the present invention is to provide a power transmission device in which a fixing pin that fixes a differential pinion shaft to a differential case can be easily detached from the differential case even after the fixing pin is attached to the differential case.

SUMMARY OF INVENTION

According to an aspect of the present invention, there is provided a power transmission device including:

a planetary gear mechanism; and

a differential gear mechanism, in which

the planetary gear mechanism includes a planetary carrier provided a pinion shaft insertion hole through which a planetary pinion shaft is inserted, the planetary pinion shaft pivotally supporting a planetary gear,

the differential gear mechanism includes a differential case supporting a differential pinion shaft,

the differential case

is formed in one piece with the planetary carrier in a state of being aligned with the planetary carrier in a rotation axis direction of the differential case, and

is provided:

a differential pinion shaft insertion hole through which the differential pinion shaft is inserted, the differential pinion shaft insertion hole being orthogonal to a rotation axis of the differential case; and

a fixing pin insertion hole through which a fixing pin is inserted, the fixing pin insertion hole being parallel to the rotation axis of the differential case and orthogonal to the differential pinion shaft insertion hole, and the fixing pin fixing the differential pinion shaft inserted in the differential pinion shaft insertion hole to the differential case, and

the fixing pin insertion hole is provided at a position overlapping the pinion shaft insertion hole when the planetary carrier and the differential case are viewed from the rotation axis direction, one end of the fixing pin insertion hole communicates with the pinion shaft insertion hole, and another end thereof communicates with outside of the differential case on a side opposite to the planetary carrier.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic view as viewed from a left side of a vehicle V on which a drive unit **10** that is an embodiment of a power transmission device of the present invention is mounted.

FIG. **2** is a cutaway perspective view of a part of the drive unit **10**.

FIG. **3** is a partial cross-sectional perspective view showing a power transmission path in the drive unit **10**.

FIG. **4** is a skeleton diagram of a deceleration device **30** in the drive unit **10**.

FIG. **5** is a perspective view as viewed from a rear side of a planetary carrier **316** of a planetary gear mechanism **31** and a differential case **321** of a differential gear mechanism **32** provided in the deceleration device **30**.

FIG. **6** is a schematic diagram showing a first example of a positional relationship between a pinion shaft insertion hole **316***d* of the planetary carrier **316** and a fixing pin insertion hole **321***d* of the differential case **321** when the planetary carrier **316** and the differential case **321** are viewed in a left-right direction.

FIG. **7** is a partial cross-sectional view of the drive unit **10** taken along a plane parallel to a differential pinion shaft **322** and a fixing pin **400** attached to the differential case **321**.

FIG. **8** is a schematic diagram showing a second example of the positional relationship between the pinion shaft insertion hole **316***d* of the planetary carrier **316** and the fixing pin insertion hole **321***d* of the differential case **321** when the planetary carrier **316** and the differential case **321** are viewed in the left-right direction.

FIG. **9** is a schematic diagram showing a third example of the positional relationship between the pinion shaft insertion hole **316***d* of the planetary carrier **316** and the fixing pin insertion hole **321***d* of the differential case **321** when the planetary carrier **316** and the differential case **321** are viewed in the left-right direction.

DESCRIPTION OF EMBODIMENTS

Hereinafter, a vehicle on which a drive unit (a drive unit **10** to be described later) that is an embodiment of a power transmission device of the present invention is mounted will be described with reference to the accompanying drawings. Hereinafter, the same or similar elements are denoted by the same or similar reference numerals, and description thereof

may be appropriately omitted or simplified. The drawings are viewed in directions of reference numerals. In the present specification and the like, in order to simplify and clarify the description, a front-rear direction, a left-right direction, and an upper-lower direction are described according to directions viewed from a driver of the vehicle, and in the drawings, a front side of the vehicle is shown as Fr, a rear side is shown as Rr, a left side is shown as L, a right side is shown as R, an upper side is shown as U, and a lower side is shown as D.

[Overall Configuration of Vehicle]

As shown in FIG. **1**, a vehicle V according to the present embodiment includes a pair of left and right front wheels FW, a pair of left and right rear wheels RW, and a floor panel FP constituting a floor of the vehicle V. The vehicle Vis partitioned, by a dash panel DP extending in the upper-lower direction above the floor panel FP, into a passenger compartment CB and a front room FRM in front of the passenger compartment CB. A front seat FS and a rear seat RS are provided in the passenger compartment CB.

The vehicle V includes the drive unit **10** serving as a drive source, and a battery pack IPU that stores electric power to be supplied to the drive unit **10**.

The drive unit **10** is disposed behind the rear seat RS and below the floor panel FP. The battery pack IPU is disposed below the floor panel FP and below a floor of the passenger compartment CB. The battery pack IPU accommodates a plurality of battery modules in which a plurality of battery cells are stacked. Each battery cell is a secondary battery that can be charged and discharged, such as a lithium ion battery or an all-solid-state battery.

[Overall Configuration of Drive Unit]

As shown in FIGS. **2** and **3**, the drive unit **10** includes a drive motor **20**, a deceleration device **30** that reduces power output from the drive motor **20** and outputs the reduced power to the outside, a chain transmission mechanism **4** that transmits the power output from the drive motor **20** to the deceleration device **30**, a control device **50** that controls the drive motor **20**, a parking mechanism **6**, and a drive unit case **11** that accommodates the above-described components.

The drive unit case **11** includes a main case **111**, a left side cover **112** covering a left side surface of the main case **111**, and a right side cover **113** covering a right side surface of the main case **111**.

The drive unit case **11** includes a motor chamber **12** that accommodates the drive motor **20**, a gear chamber **13** that accommodates the deceleration device **30**, a chain chamber **14** that accommodates the chain transmission mechanism **4** and the parking mechanism **6**, and a controller chamber **15** that accommodates the control device **50**. The motor chamber **12** and the gear chamber **13** are formed side by side in the front-rear direction such that the motor chamber **12** is located on the front side and the gear chamber **13** is located on the rear side. The chain chamber **14** is formed on the left side of the motor chamber **12** and the gear chamber **13** and is formed by the main case **111** and the left side cover **112**. The controller chamber **15** is formed on the right side of the motor chamber **12** and the gear chamber **13** and is formed by the main case **111** and the right side cover **113**.

The drive motor **20** is a so-called inner rotor motor that includes a drive shaft **21**, a rotor **22** that is attached to the drive shaft **21** and rotates integrally with the drive shaft **21**, and a stator **23** that is disposed on a radial direction outer side of the rotor **22** in a manner of facing the rotor **22** in the radial direction with a slight gap therebetween.

In the present embodiment, in the drive unit **10**, the drive motor **20** is disposed such that an axial direction (that is, the drive shaft **21**) is horizontally oriented in the left-right direction. In this way, since the drive shaft **21** is oriented in the horizontal direction, an upper-lower dimension of the drive unit **10** can be compact.

The stator **23** includes a stator core **231** and a coil **232** that is attached to the stator core **231** and includes a plurality of windings of a U-phase, a V-phase, and a W-phase.

A drive sprocket **21***a* around which a power transmission chain **40** of the chain transmission mechanism **4** is wound is attached to a left end of the drive shaft **21**. The drive sprocket **21***a* rotates integrally with the drive shaft **21**.

The chain transmission mechanism **4** includes the drive sprocket **21***a* attached to the drive shaft **21**, a driven sprocket **311***a* attached to an input shaft **311** of a planetary gear mechanism **31** to be described later on the same plane as the drive sprocket **21***a*, and the power transmission chain **40** wound around the drive sprocket **21***a* and the driven sprocket **311***a*. The driven sprocket **311***a* has a larger diameter than the drive sprocket **21***a*, and the number of teeth of the driven sprocket **311***a* is larger than the number of teeth of the drive sprocket **21***a*.

As shown in FIGS. **3** and **4**, the deceleration device **30** of the drive unit **10** includes the planetary gear mechanism **31** and a differential gear mechanism **32**.

The planetary gear mechanism **31** includes the input shaft **311**, a sun gear **312**, a plurality of planetary pinion shafts **313**, the same number of stepped pinions **314** as the planetary pinion shafts **313**, a planetary carrier **316**, and a ring gear **317**.

In the present embodiment, the planetary gear mechanism **31** is aligned behind the drive motor **20** in the front-rear direction. The planetary gear mechanism **31** is disposed such that an axial direction (that is, the input shaft **311**) is parallel to the axial direction of the drive motor **20** and is oriented in the left-right direction. The input shaft **311** of the planetary gear mechanism **31** is disposed at substantially the same height as the drive shaft **21** of the drive motor **20** in the upper-lower direction. Further, an outer diameter dimension of the planetary gear mechanism **31** is substantially the same dimension as an outer diameter dimension of the drive motor **20**, and a height of the drive unit **10** is small in the upper-lower direction.

The input shaft **311** is a hollow shaft into which a left drive shaft **325**L to be described later is inserted. The driven sprocket **311***a* around which the power transmission chain **40** of the chain transmission mechanism **4** is wound is attached to a left end of the input shaft **311**. The driven sprocket **311***a* rotates integrally with the input shaft **311**.

The sun gear **312** is an external gear provided on the input shaft **311**, and rotates integrally with the input shaft **311** about the same rotation axis.

The plurality of planetary pinion shafts **313** are disposed at equal intervals in a circumferential direction along an outer peripheral surface of the sun gear **312** in a manner of being oriented in the left-right direction parallel to the input shaft **311** on a radial direction outer side of the sun gear **312**. More specifically, in the present embodiment, four planetary pinion shafts **313** are disposed at intervals of 90 degrees in the circumferential direction along the outer peripheral surface of the sun gear **312**.

The stepped pinion **314** including a first planetary gear **314***a* and a second planetary gear **314***b* that rotate integrally is pivotally supported by each planetary pinion shaft **313** in a freely rotatable manner.

The first planetary gear **314***a* is an external gear that is disposed on the outer peripheral surface of the sun gear **312** and meshes with the sun gear **312**.

The second planetary gear **314***b* is an external gear that is disposed on an inner peripheral surface of the ring gear **317** and meshes with the ring gear **317**.

The planetary carrier **316** connects the planetary pinion shafts **313**. The planetary carrier **316** is rotatable about a rotation axis coaxial with the input shaft **311** (and the sun gear **312**) integrally with the planetary pinion shafts **313**.

Therefore, the stepped pinion **314** including the first planetary gear **314***a* and the second planetary gear **314***b* is freely rotatable about the planetary pinion shaft **313** as an axis, and is freely revolvable about the rotation axis coaxial with the input shaft **311** (and the sun gear **312**) integrally with the planetary pinion shaft **313**. The planetary carrier **316** rotates integrally with a revolutionary motion of the stepped pinion **314** on the rotation axis coaxial with the input shaft **311** (and the sun gear **312**).

The ring gear **317** is an annular internal gear whose inner peripheral surface meshes with each second planetary gear **314***b*. In the present embodiment, the ring gear **317** is fixed to the drive unit case **11**, and the ring gear **317** does not rotate.

The differential gear mechanism **32** includes a differential case **321**, a differential pinion shaft **322** supported by the differential case **321**, a first bevel gear **323***a* and a second bevel gear **323***b* pivotally supported by the differential pinion shaft **322** in a freely pivotable manner, a left side gear **324**L and a right side gear **324**R meshing with the first bevel gear **323***a* and the second bevel gear **323***b*, and the left drive shaft **325**L and a right drive shaft **325**R.

The differential case **321** is formed integrally with the planetary carrier **316** of the planetary gear mechanism **31**. Therefore, the differential case **321** rotates about the rotation axis coaxial with the input shaft **311** integrally with the planetary carrier **316** of the planetary gear mechanism **31**.

Next, a power transmission path of power output from the drive motor **20** will be described.

The power generated by the drive motor **20** is output from the drive shaft **21**, and the drive sprocket **21***a* attached to the drive shaft **21** rotates integrally with the drive shaft **21**. When the drive sprocket **21***a* rotates, the driven sprocket **311***a* rotates due to the power transmission chain **40** wound around the drive sprocket **21***a* and the driven sprocket **311***a* attached to the input shaft **311** of the planetary gear mechanism **31**. The input shaft **311** of the planetary gear mechanism **31** rotates integrally with the driven sprocket **311***a*. At this time, since the number of teeth of the driven sprocket **311***a* is larger than the number of teeth of the drive sprocket **21***a*, the rotation of the drive shaft **21** is reduced via the drive sprocket **21***a*, the power transmission chain **40**, and the driven sprocket **311***a*, and is input to the input shaft **311** of the planetary gear mechanism **31**.

In the planetary gear mechanism **31**, the power input to the input shaft **311** is transmitted to the stepped pinion **314** via the sun gear **312**. The stepped pinion **314** rotates while revolving. The planetary carrier **316** rotates integrally with the revolution of the stepped pinion **314**. In the planetary gear mechanism **31**, since the ring gear **317** is fixed, the rotation of the input shaft **311** is reduced at a predetermined reduction ratio and transmitted to the planetary carrier **316**.

In the differential gear mechanism **32**, the differential case **321** is formed integrally with the planetary carrier **316** of the planetary gear mechanism **31**, and thus rotates integrally with the rotation of the planetary carrier **316**. Therefore, the power input to the input shaft **311** of the planetary gear mechanism **31** is reduced at the predetermined reduction ratio and input to the differential case **321** via the planetary carrier **316**.

Therefore, the power output from the drive shaft **21** is input to the differential case **321** of the differential gear mechanism **32** via the power transmission chain **40** and the planetary gear mechanism **31**, and the differential pinion shaft **322** revolves about the rotation axis of the differential case **321** together with the differential case **321**.

When the vehicle V travels straight, there is no rotation difference between the left and right rear wheels RW, and thus the left side gear **324**L and the right side gear **324**R that mesh with the first bevel gear **323***a* and the second bevel gear **323***b* rotate according to rotation of the differential pinion shaft **322**. The left rear wheel RW rotates when the left drive shaft **325**L rotates integrally with the rotation of the left side gear **324**L, and the right rear wheel RW rotates when the right drive shaft **325**R rotates integrally with the rotation of the right side gear **324**R.

When the vehicle V turns, the differential pinion shaft **322** revolves, the first bevel gear **323***a* and the second bevel gear **323***b* rotate such that a rotation speed of the rear wheel RW on an inner side during turning decreases whereas a rotation speed of the rear wheel RW on an outer side during turning increases, and meanwhile, the left side gear **324**L and the right side gear **324**R that mesh with the first bevel gear **323***a* and the second bevel gear **323***b* rotate at different rotation speeds such that the rotation speed of the rear wheel RW on the inner side during turning decreases whereas the rotation speed of the rear wheel RW on the outer side during turning increases. The left rear wheel RW rotates when the left drive shaft **325**L rotates integrally with the rotation of the left side gear **324**L, and the right rear wheel RW rotates when the right drive shaft **325**R rotates integrally with the rotation of the right side gear **324**R. Therefore, when the vehicle V turns, the left drive shaft **325**L and the right drive shaft **325**R rotate such that the rotation speed of the rear wheel RW on the inner side during turning decreases whereas the rotation speed of the rear wheel RW on the outer side during turning increases.

In this way, as indicated by arrows in FIG. **3**, the power output from the drive motor **20** is reduced via the drive sprocket **21***a*, the driven sprocket **311***a*, and the power transmission chain **40**, then is input to the deceleration device **30**, is further reduced by the planetary gear mechanism **31**, and the power is appropriately distributed and transmitted to the left and right rear wheels RW by the differential gear mechanism **32**.

[Planetary Carrier and Differential Case]

Next, the planetary carrier **316** and the differential case **321** will be described in more detail.

As shown in FIG. **5**, the planetary carrier **316** is provided on the left side of the differential case **321** in a state of being aligned in the left-right direction that is the rotation axis direction of the differential case **321**. The planetary carrier **316** includes an annular left wall portion **316***a* and an annular right wall portion **316***b* facing each other in the left-right direction, and a cylindrical outer peripheral wall **316***c* connecting the annular left wall portion **316***a* and the annular right wall portion **316***b*.

Each of the left wall portion **316***a* and the right wall portion **316***b* is provided with the pinion shaft insertion hole **316***d* through which each of the plurality of planetary pinion shafts **313** is inserted. More specifically, in the present embodiment, in order to dispose the four planetary pinion shafts **313** at intervals of 90 degrees in the circumferential direction, four pinion shaft insertion holes **316***d* are provided in the left wall portion **316***a* and the right wall portion **316***b* at intervals of 90 degrees to correspond to the four planetary pinion shafts **313**, respectively. Hereinafter, the pinion shaft

insertion hole **316***d* provided in the left wall portion **316***a* is also referred to as a "pinion shaft insertion hole **316***d*L", and the pinion shaft insertion hole **316***d* provided in the right wall portion **316***b* is also referred to as a "pinion shaft insertion hole **316***d*R".

FIG. **6** shows a first example of a positional relationship between the pinion shaft insertion hole **316***d* of the planetary carrier **316** and a fixing pin insertion hole **321***d* (to be described later) of the differential case **321** when the planetary carrier **316** and the differential case **321** are viewed in the left-right direction. In FIG. **6**, a broken line denoted by reference numeral **322** indicates the differential pinion shaft **322** attached to the differential case **321**.

As shown in FIG. **6**, the pinion shaft insertion holes **316***d*L in the left wall portion **316***a* and the pinion shaft insertion holes **316***d*R in the right wall portion **316***b* face each other in the left-right direction. The four planetary pinion shafts **313** are attached to the planetary carrier **316** by being inserted into the corresponding pair of left and right pinion shaft insertion holes **316***d* (the pinion shaft insertion holes **316***d*L and the pinion shaft insertion holes **316***d*R).

As shown in FIG. **5**, the outer peripheral wall **316***c* is provided with openings **316***e* for exposing, to the outside of the planetary carrier **316**, a part of an outer peripheral surface of the stepped pinion **314** (the first planetary gear **314***a* and the second planetary gear **314***b*) pivotally supported by the respective planetary pinion shafts **313** attached to the planetary carrier **316**. The openings **316***e* are provided at positions corresponding to the stepped pinion **314** pivotally supported by the respective planetary pinion shafts **313** in a radial direction about the rotation axis of the differential case **321**.

As shown in FIG. **5**, the differential case **321** includes an accommodating portion **321***a*. The accommodating portion **321***a* accommodates the differential pinion shaft **322**, the first bevel gear **323***a*, the second bevel gear **323***b*, the left side gear **324**L, and the right side gear **324**R described above.

The differential case **321** includes a pair of left and right drive shaft insertion holes **321***b* that communicate with the accommodating portion **321***a* from the left-right direction that is the rotation axis direction of the differential case **321** and through which the left drive shaft **325**L and the right drive shaft **325**R are inserted, and a pair of differential pinion shaft insertion holes **321***c* that communicate with the accommodating portion **321***a* and through which the differential pinion shaft **322** is inserted. The pair of differential pinion shaft insertion holes **321***c* communicate with substantially a center of the accommodating portion **321***a* in the left-right direction that is the rotation axis direction of the differential case **321**, and are orthogonal to the rotation axis of the differential case **321**.

Further, the differential case **321** is provided with the fixing pin insertion hole **321***d* through which a fixing pin **400** (see FIG. **7**) for fixing the differential pinion shaft **322** to the differential case **321** is inserted. The fixing pin insertion hole **321***d* is parallel to the rotation axis of the differential case **321** and orthogonal to the pair of differential pinion shaft insertion holes **321***c*.

As shown in FIG. **7**, the fixing pin **400** is inserted through the fixing pin insertion hole **321***d* of the differential case **321** and a fixing pin insertion hole **322***a* provided in the vicinity of an end of the differential pinion shaft **322**, thereby restricting the differential pinion shaft **322** from rotating about an axis orthogonal to the rotation axis of the differential case **321** or moving along a direction of the axis.

In the present embodiment, as shown in FIG. **6**, the fixing pin insertion hole **321***d* of the differential case **321** is provided at a position overlapping any one of the pinion shaft insertion holes **316***d* provided in the planetary carrier **316** when the planetary carrier **316** and the differential case **321** are viewed in the left-right direction. As shown in FIG. **7**, a left end **321***d*L of the fixing pin insertion hole **321***d* communicates with one pinion shaft insertion hole **316***d*R provided in the right wall portion **316***b* of the planetary carrier **316**, and a right end **321***d*R of the fixing pin insertion hole **321***d* communicates with the outside of the differential case **321** on a side opposite to the planetary carrier **316**.

According to such a configuration of the present embodiment, when the fixing pin **400** that fixes the differential pinion shaft **322** to the differential case **321** is attached to the differential case **321**, the fixing pin **400** can be attached to the differential case **321** by inserting the fixing pin **400** into the fixing pin insertion hole **321***d* from the right side of the differential case **321** as indicated by an arrow denoted by reference numeral a in FIG. **7**. When the fixing pin **400** attached to the differential case **321** is to be detached, the planetary pinion shaft **313** inserted through the pinion shaft insertion hole **316***d*R communicating with the fixing pin insertion hole **321***d* is appropriately detached as indicated by an arrow denoted by reference numeral B in FIG. **7**, and then the fixing pin **400** in the fixing pin insertion hole **321***d* is pushed out to the right of the differential case **321** through the pinion shaft insertion hole **316***d*R, and thus the fixing pin **400** can be easily detached from the differential case **321**.

Therefore, according to the configuration of the present embodiment, even when the differential pinion shaft **322** is detached from the differential case **321** at the time of assembling or inspection of the differential gear mechanism **32** or the like, the differential pinion shaft **322** can be detached from the differential case **321** without breaking the differential case **321**, the fixing pin **400**, the differential pinion shaft **322**, and the like, and such components can be reused.

Further, since the pinion shaft insertion hole **316***d*R (that is, the pinion shaft insertion hole **316***d*) communicating with the fixing pin insertion hole **321***d* can be used as a hole to be used when the fixing pin **400** is pushed out from the differential case **321**, it is not necessary to provide any extra hole (a hole used only when the fixing pin **400** is pushed out from the differential case **321**) in the differential case **321**, and a decrease in strength of the differential case **321** and the planetary carrier **316** caused by providing such a hole can be avoided.

According to the configuration of the present embodiment, since the fixing pin insertion hole **321***d* of the differential case **321** and the pinion shaft insertion hole **316***d* of the planetary carrier **316** communicate with each other, for example, when the planetary pinion shaft **313** is attached to or detached from the planetary carrier **316**, the fixing pin insertion hole **321***d* communicating with the pinion shaft insertion hole **316***d* through which the planetary pinion shaft **313** is inserted functions as a so-called "air vent hole" and enables easy attachment and detachment of the planetary pinion shaft **313**. Similarly, when the fixing pin **400** is attached to or detached from the differential case **321**, the pinion shaft insertion hole **316***d* communicating with the fixing pin insertion hole **321***d* through which the fixing pin **400** is inserted functions as an air vent hole and enables easy attachment and detachment of the fixing pin **400**.

As described above, according to the present embodiment, even after the fixing pin **400** that fixes the differential pinion shaft **322** to the differential case **321** is attached to the

differential case **321**, the fixing pin **400** can be easily detached from the differential case **321**.

Although an embodiment of the present invention has been described above, it goes without saying that the present invention is not limited to the embodiment. It is apparent that those skilled in the art can conceive of various modifications and alterations within the scope described in the claims, and it is understood that such modifications and alterations naturally fall within the technical scope of the present invention. The constituent elements in the embodiment described above may be combined freely in a scope not departing from the gist of the invention.

For example, when the differential pinion shaft **322** is fixed to the differential case **321** by one fixing pin **400**, one fixing pin insertion hole **321***d* may be provided. Alternatively, even in the case where the differential pinion shaft **322** is fixed to the differential case **321** by one fixing pin **400**, a plurality of fixing pin insertion holes **321***d* may be provided as shown in FIG. **6** and the like, and actually, there may be fixing pin insertion holes **321***d* through which the fixing pin **400** is not inserted.

In the example described above, the four pinion shaft insertion holes **316***d* are provided at intervals of 90 degrees along the circumferential direction in the left wall portion **316***a* and the right wall portion **316***b*, but the configuration is not limited thereto. That is, as long as the fixing pin insertion hole **321***d* of the differential case **321** is provided at a position overlapping any one of the pinion shaft insertion holes **316***d* provided in the planetary carrier **316** when the planetary carrier **316** and the differential case **321** are viewed in the left-right direction and communicates with the pinion shaft insertion hole **316***d*, the number of pinion shaft insertion holes **316***d* is not limited to four.

As an example, as shown in FIG. **8**, three pinion shaft insertion holes **316***d* may be provided in each of the left wall portion **316***a* and the right wall portion **316***b* at intervals of 120 degrees along the circumferential direction. As another example, as shown in FIG. **9**, five pinion shaft insertion holes **316***d* may be provided in each of the left wall portion **316***a* and the right wall portion **316***b* at intervals of 72 degrees along the circumferential direction.

The number of the differential pinion shafts **322** attached to the differential case **321** is not limited to one, and may be two, for example. In this case, the fixing pin insertion hole **321***d* through which the fixing pin **400** for fixing each differential pinion shaft **322** to the differential case **321** is inserted communicates with any one of the pinion shaft insertion holes **316***d*.

For example, as shown in FIGS. **8** and **9**, a dummy hole **316***f* may be further provided at a position overlapping the pinion shaft insertion hole **316***d* other than the pinion shaft insertion hole **316***d* communicating with the fixing pin insertion hole **321***d* when the differential case **321** is viewed in the left-right direction. In this case, similarly to the fixing pin insertion hole **321***d*, one end of the dummy hole **316***f* communicates with the corresponding pinion shaft insertion hole **316***d* (pinion shaft insertion hole **316***d*R), and the other end communicates with the outside of the differential case **321** on the side opposite to the planetary carrier **316**. By providing such a dummy hole **316***f*, the dummy hole **316***f* communicating with each pinion shaft insertion hole **316***d* functions as an air vent hole and enables easy attachment and detachment of the planetary pinion shaft **313**.

In this specification, at least the following matters are described. Although corresponding constituent elements or the like in the embodiment described above are shown in parentheses, the present invention is not limited thereto.

(1) A power transmission device (drive unit **10**) including:
a planetary gear mechanism (planetary gear mechanism **31**); and
a differential gear mechanism (differential gear mechanism **32**), in which
the planetary gear mechanism includes a planetary carrier (planetary carrier **316**) provided a pinion shaft insertion hole (pinion shaft insertion hole **316***d*) through which a planetary pinion shaft (planetary pinion shaft **313**) is inserted, the planetary pinion shaft pivotally supporting a planetary gear (stepped pinion **314**, first planetary gear **314***a*, second planetary gear **314***b*),
the differential gear mechanism includes a differential case (differential case **321**) supporting a differential pinion shaft (differential pinion shaft **322**),
the differential case
is formed in one piece with the planetary carrier in a state of being aligned with the planetary carrier in a rotation axis direction of the differential case, and
is provided:
a differential pinion shaft insertion hole (differential pinion shaft insertion hole **321***c*) through which the differential pinion shaft is inserted, the differential pinion shaft insertion hole being orthogonal to a rotation axis of the differential case; and
a fixing pin insertion hole (fixing pin insertion hole **321***d*) through which a fixing pin is inserted, the fixing pin insertion hole being parallel to the rotation axis of the differential case and orthogonal to the differential pinion shaft insertion hole, and the fixing pin fixing the differential pinion shaft inserted in the differential pinion shaft insertion hole to the differential case, and
the fixing pin insertion hole is provided at a position overlapping the pinion shaft insertion hole when the planetary carrier and the differential case are viewed from the rotation axis direction, one end (left end **321***d*L) of the fixing pin insertion hole communicates with the pinion shaft insertion hole, and another end (right end **321***d*R) thereof communicates with outside of the differential case on a side opposite to the planetary carrier.

According to (1), since the one end of the fixing pin insertion hole through which the fixing pin for fixing the differential pinion shaft to the differential case is inserted communicates with the pinion shaft insertion hole of the planetary carrier and the other end communicates with outside of the differential case on a side opposite to the planetary carrier, the fixing pin in the fixing pin insertion hole is pushed out to the outside of the differential case through the pinion shaft insertion hole of the planetary carrier, and thus the fixing pin can be easily removed from the differential case.

What is claimed is:

1. A power transmission device comprising:
a planetary gear mechanism; and
a differential gear mechanism, wherein
the planetary gear mechanism includes a planetary carrier provided a pinion shaft insertion hole through which a planetary pinion shaft is inserted, the planetary pinion shaft pivotally supporting a planetary gear,
the differential gear mechanism includes a differential case supporting a differential pinion shaft,
the differential case
is formed in one piece with the planetary carrier in a state of being aligned with the planetary carrier in a rotation axis direction of the differential case, and

is provided:

a differential pinion shaft insertion hole through which the differential pinion shaft is inserted, the differential pinion shaft insertion hole being orthogonal to a rotation axis of the differential case; and

a fixing pin insertion hole through which a fixing pin is inserted, the fixing pin insertion hole being parallel to the rotation axis of the differential case and orthogonal to the differential pinion shaft insertion hole, and the fixing pin fixing the differential pinion shaft inserted in the differential pinion shaft insertion hole to the differential case, and

the fixing pin insertion hole is provided at a position overlapping the pinion shaft insertion hole when the planetary carrier and the differential case are viewed from the rotation axis direction, wherein a center point of the fixing pin is radially aligned with a center point of the planetary pinion shaft, one end of the fixing pin insertion hole communicates with the pinion shaft insertion hole, and another end thereof communicates with outside of the differential case on a side opposite to the planetary carrier.

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