

Description

Title of Invention

VEHICLE STRUCTURE FOR ELECTRIC AUTOMOBILE

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Technical Field

[0001]

The present invention relates to a vehicle structure for an electric automobile, and more particularly, to a vehicle structure for an electric automobile that is driven by four wheels.

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Background Art

[0002]

In contrast with conventional automobiles that are driven by an internal-combustion engine in which fossil fuel is burned, electric automobiles, which travel with the aid of electric motors driven by electric energy supplied from a mounted battery, are in the process of commercialization. Since the electric automobile is driven by the electric motors, it emits no carbon dioxide during traveling, and has drawn attention as an environmentally friendly automobile. Further, the electric automobiles have excellent characteristics, one of which is a low noise level, compared to conventional automobiles or hybrid vehicles.

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[0003]

Current electric automobiles have a vehicle structure similar to construction of conventional automobiles, and are usually four-wheel automobiles with two wheels each provided in the front and rear. These electric automobiles are generally constructed so that motors installed on respective front wheels disposed on the left and right are independently driven, and thereby a steering angle is given to the front wheels corresponding to the steering of a steering wheel (e.g. Patent Literature 1). This allows the electric automobiles to turn their vehicle bodies, like the conventional automobiles.

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Citation List

Patent Literature

[0004]

Patent Literature 1:

JP 1997-117016A

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Summary of Invention

Technical Problem

[0005]

However, the vehicle structures for the conventional electric automobiles
10 have problems in that the rotation radius when the vehicle body is turned is large,
and that the turnability showing easy variation in the direction of the vehicle body is
low. For this reason, a wide space is required to turn the vehicle body. For
example, when one's own automobile is parked between two automobiles that have
been parked, a space for quickly turning the vehicle body is required, and a high skill
15 level is required from a driver.

[0006]

The present invention is made in view of the above-mentioned issue, and
aims to provide a novel and improved vehicle structure for an electric automobile
capable of enhancing turnability.

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Solution to Problem

[0007]

According to an aspect, there is provided a vehicle structure for an electric
automobile that is driven by traveling wheels, in each of which a drive device driven
25 by receiving supply of electric energy is mounted, the vehicle structure comprising: a
first traveling wheel unit and a second traveling wheel unit which are provided in the
front and rear of a vehicle body and which each include an arrangement of two
traveling wheels; and a drive control unit that individually drives the four traveling
wheels depending on an amount of operation input by a driver, wherein the first
30 traveling wheel unit is constructed to be integrally rotatable about a first center of

rotation near the midpoint of a support unit, which rotatably supports the two traveling wheels forming the first traveling wheel unit at opposite ends of the first traveling wheel unit, in a plane substantially perpendicular to a direction of a height of the vehicle body, while maintaining a state in which disc surfaces of the two

5 traveling wheels are perpendicular to a straight line that passes through rotation centers of the corresponding traveling wheels and the midpoint of the support unit, and wherein the drive control unit differentially drives the traveling wheels forming the first traveling wheel unit depending on an amount of steering among the operation amount, and rotates the first traveling wheel unit about the first rotation

10 center.

[0008]

According to embodiments of the present invention, the first traveling wheel unit integrally rotates depending on the operation amount input by the driver, thereby changing the advance direction of a vehicle. Thus, it is possible to easily change the direction of the vehicle body, and provide high turnability.

[0009]

Here, an interval between the traveling wheels forming the first traveling wheel unit may be smaller than that between the traveling wheels forming the second traveling wheel unit. Thus, it is possible to reduce the rotation radius of the first traveling wheel unit and to enhance the turnability of the entire vehicle.

[0010]

Further, the drive control unit may differentially drive the four traveling wheels depending on the operation amount input by the driver, and cause the vehicle body to be turned about a predetermined position within an area where the second traveling wheel unit of the vehicle body is provided. For example, when the first traveling wheel unit rotates about the first rotation center at an angle of 90° with respect to a direction of the first traveling wheel unit when the automobile travels to the front of the vehicle body, the drive control unit may differentially drive the four traveling wheels depending on the operation amount input by the driver, and cause the vehicle body to be turned about a middle position between the two traveling wheels forming the second traveling wheel unit.

[0011]

Moreover, a radius of rotation required to turn the vehicle body may be smaller than an overall length of the vehicle body. Accordingly, the electric

automobile having the vehicle construction according to embodiments of the present invention makes it possible to turn the vehicle body in a narrow space.

[0012]

Further, the first traveling wheel unit may be a front wheel unit, whereas the second traveling wheel unit may be a rear wheel unit. Alternatively, the first traveling wheel unit may be a rear wheel unit, whereas the second traveling wheel unit may be a front wheel unit.

Advantageous Effects of Invention

[0013]

According to embodiments of the present invention as described above, it is possible to provide a vehicle structure for an electric automobile capable of enhancing turnability.

Brief Description of Drawings

[0014]

[Fig. 1] Fig. 1 is an explanatory view showing a vehicle structure for an electric automobile according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is functional block diagram explaining processing based on an electronic control device.

[Fig. 3] Fig. 3 is an explanatory view showing turnability of the electric automobile according to the same embodiment.

[Fig. 4] Fig. 4 is an explanatory view showing turnability of a conventional electric automobile.

[Fig. 5] Fig. 5 is an explanatory view showing turnability of the electric automobile according to the same embodiment.

[Fig. 6] Fig. 6 is an explanatory view showing vehicle movement when the electric automobile according to the same embodiment is parked.

[Fig. 7] Fig. 7 is an explanatory view showing a vehicle structure for an electric automobile according to a second embodiment of the present invention.

[Fig. 8] Fig. 8 is an explanatory view showing turnability of the electric automobile

according to the same embodiment.

[Fig. 9] Fig. 9 is an explanatory view showing vehicle movement when the electric automobile according to the same embodiment is parked.

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Description of Embodiments

[0015]

Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the appended drawings. Note that, in this specification and the drawings, elements that have substantially the same function and structure are denoted with the same reference signs, and repeated explanation is omitted.

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[0016]

<Summary of Vehicle Structure>

First, the summary of a vehicle structure for an electric automobile according to an embodiment of the present invention will be described. The electric automobile according the present embodiment drives a vehicle body with four traveling wheels. When the vehicle body is divided into three areas in a lengthwise direction, i.e. a front area, a middle area, and a rear area, two of the traveling wheels are installed in the front area, and the other two in the rear area.

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[0017]

A first traveling wheel unit is installed in one of the front area and the rear area, and is made up of the two traveling wheels and a support unit that supports the two traveling wheels at opposite ends thereof. The first traveling wheel unit is constructed as a swivel type of unit (swivel unit), which is rotatable about substantially the center of the support unit in a plane substantially perpendicular to a direction of the height of the vehicle body with the whole of the first traveling wheel unit formed in one body. The first traveling wheel unit rotates in proportion to an amount of steering of a steering wheel by a driver. That is, the rotation of the first traveling wheel unit is able to change an advance direction of the vehicle. Further, the traveling wheels constructing the first traveling wheel unit are driven by the electric motors that are individually provided thereto.

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[0018]

Meanwhile, a second traveling wheel unit is installed in the rear or front area in which the first traveling wheel unit is not installed, and is made up of two traveling wheels. Electric motors are installed on the respective traveling wheels constructing the second traveling wheel unit, and are able to be independently driven. However, the electric automobile according to the present embodiment may be constructed in such a manner that the center of rotation when the vehicle body is turned is present in the area where the second traveling wheel unit is installed. Thus, since the rotation center is present within the vehicle body, and because it is possible to turn the vehicle body so as to rotate on its axis, it is possible to reduce the radius of rotation of the vehicle body.

[0019]

This electric automobile has the first traveling wheel unit of the swivel type in which the two traveling wheels operate in one body, and the two traveling wheels constructing the second traveling wheel unit, that is to say, a vehicle construction similar to a three-wheel vehicle. Such an electric automobile has high turnability and allows the vehicle body to be turned even in a narrow space, compared to conventional four-wheel vehicles constructed by installing two wheels in the front and two wheels in the rear. Further, even in comparison with conventional three-wheel vehicles, the electric automobile according to the present embodiment is excellent in linear travelability, traveling stability, and driving force, because it has high turnability and is actually driven with four traveling wheels. Hereinafter, two embodiments of the electric automobile having this vehicle construction will be shown and described in detail.

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(First Embodiment)

<Vehicle Structure for Electric Automobile>

First, a vehicle structure for an electric automobile according to a first embodiment of the present invention will be described with reference to Fig. 1. Fig. 1 is an explanatory view showing a vehicle structure for an electric automobile according to the present embodiment. In Fig. 1, only functional units relevant to

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arrangement of a vehicle body 110 and traveling wheels, and a steering system are shown.

[0020]

As shown in Fig. 1, the electric automobile 100 according to the present
5 embodiment includes a front wheel unit 120 disposed in the front of an advance
direction of a vehicle body 100, and a rear wheel unit 130 disposed in the rear of the
advance direction of the vehicle body 110. The front wheel unit 120 is made up of
two traveling wheels of a right wheel 122R and a left wheel 122L. The right wheel
122R and the left wheel 122L are installed so as to be substantially parallel to each
10 other at all times. Further, disc surfaces of the right wheel 122R and the left wheel
122L are provided so as to be substantially perpendicular to a straight line connecting
the right wheel 122R and the left wheel 122L.

[0021]

The traveling wheels are provided with drive units 124R and 124L rotating
15 the travelling wheels, respectively. As the drive units 124R and 124L, in-wheel
motors may be used by way of example. The in-wheel motor is a drive device in
which a motor serving as a power source is mounted, and thus four-wheel
independent control having high power-transmission efficiency and a good response
characteristic is made possible. Further, since a drive shaft, a differential, etc. are
20 not required, a degree of freedom for vehicle body design can be improved.

[0022]

The right wheel 122R and the left wheel 122L are rotatably supported by a
support unit 126. The straight line connecting the right wheel 122R and the left
wheel 122L is adapted to pass through the center of the support unit 126. The front
25 wheel unit 120 is rotatable about the center 126c of the support unit 126 at an angle
of 360° in a plane substantially perpendicular to a direction of the height of the
vehicle body 110. The rotation angle of the front wheel unit 120 is determined by
steering a steering wheel 140 (referred to as "steering angle input unit"). That is,
the front wheel unit 120 is constructed as the swivel unit, functions as the steering
30 wheel, and rotates about the center 126c, so that it can change the advance direction
of the electric automobile 100. However, a relationship between movements of the

front wheel unit 120 and the vehicle body 110 will be described below in detail.

[0023]

The rear wheel unit 130 includes two traveling wheels including a right wheel 132R and a left wheel 132L. The right wheel 132R and the left wheel 132L of the rear wheel unit 130 are disposed at an interval that has substantially the same length as a vehicle width that is a length in a widthwise direction (a direction perpendicular to the advance direction) of the vehicle body 110. The rotation center C of the vehicle body 110 is located at a substantially middle position of a straight line connecting the right wheel 132R and the left wheel 132L. Like the front wheel unit 120, the traveling wheels are provided with drive units 134R and 134L, for instance in-wheel motors, which rotate the traveling wheels. In the present embodiment, the rear wheel unit 130 functions as a driving wheel that drives the vehicle body 110.

[0024]

As shown in Fig. 1, the electric automobile 100 according to the present embodiment is constructed so that an interval between the right wheel and the left wheel at the front wheel unit 120 is different from an interval between the right wheel and the left wheel at the rear wheel unit 130. As mentioned above, the rear wheel unit 130 is constructed so that the right wheel 134R and the left wheel 134L thereof are disposed so as to have the interval of substantially the same length W_2 as the vehicle width. Meanwhile, the interval W_1 between the right wheel 124R and the left wheel 124L of the front wheel unit 120 is smaller than the interval W_2 between the left and right wheels of the rear wheel unit 130. This is because, since the front wheel unit 120 rotates about the center 126c, the rotation radius of the front wheel unit 120 is increased when the interval W_1 between the left and right wheels of the front wheel unit 120 increases. The interval W_1 between the left and right wheels of the front wheel unit 120 may be determined by considering a magnitude of the rotation radius of the front wheel unit 120 and the stable support of the vehicle body 110.

[0025]

The electric automobile 100 having this vehicle construction is provided

with a steering angle sensor 150 that detects an amount of steering of the steering wheel 140 caused by a driver. The steering angle sensor 150 outputs the detected steering amount to an electronic control device 160. The electronic control device 160 calculates an angle of rotation of the vehicle body 110, which is to be turned, from the steering amount input from the steering angle sensor 150. Thus, the electronic control device 160 calculates an amount of drive of each of the drive units 124R, 124L, 134R and 134L which is required to rotate the vehicle body 110 by the calculated rotation angle, and drives each of the drive units 124R, 124L, 134R and 134L according to the calculated drive amount.

10 [0026]

The vehicle construction of the electric automobile 100 according to the present embodiment has been described above. In this way, the vehicle construction of the electric automobile 100 according to the present embodiment has the two traveling wheels 132R and 132L of the rear wheel unit 130 and the front wheel unit 120, and is near that of a three-wheel vehicle. However, since the electric automobile 100 according to the present embodiment is actually driven by the four wheels including the two wheels of the front wheel unit 120 and the two wheels of the rear wheel unit 130, the linear travelability and traveling stability thereof are high, compared to conventional three-wheel vehicles. That is, the conventional three-wheel vehicles are driven by two rear wheels without a drive mechanism installed on one front wheel. For this reason, a vehicle body is advanced as if it is pressed down from the rear toward the front, so that the front wheel is apt to shake from side to side, and the linear travelability is easily lowered. In contrast, the electric automobile 100 according to the present embodiment is driven by the four wheels, so that a driving force is high, and stable traveling is possible.

25 [0027]

Further, the conventional three-wheel vehicles have low turnability and cannot pull the vehicle body using the front wheel, and thus it is difficult to stably turn the vehicle body, and a wide turning space is required to stably turn the vehicle body. In the conventional three-wheel vehicles, a minimum rotation radius should

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generally have about twice of a vehicle overall length. Meanwhile, the electric automobile 100 according to the present embodiment is driven by the four wheels, so that it is possible to stably turn the vehicle body 110. The electric automobile 100 according to the present embodiment has more excellent turnability, compared to conventional four-wheel vehicles.

[0028]

<Functions of Electronic Control Device>

Here, functions of the electronic control device 160 and movement of the electric automobile 100 according to the present embodiment will be described in detail with reference to Figs. 2 to 4. Fig. 2 is functional block diagram explaining processing based on the electronic control device 160. Fig. 3 is an explanatory view showing turnability of the electric automobile 100 according to the present embodiment. Fig. 4 is an explanatory view showing turnability of a conventional electric automobile.

[0029]

The electric automobile 100 is driven according to instructions of a driver. The driver inputs a turning direction and a turning amount for turning the electric automobile using the steering angle input unit 140. As the steering angle input unit 140, the aforementioned steering wheel or a joystick may be used. The turning direction and the turning amount input from the steering angle input unit 140 are output to the electronic control device 160. Further, a vehicle speed is output from a speed sensor 170 to the electronic control device 160.

[0030]

The electronic control device 160 calculates a safe and optimal differential amount in order to drive each traveling wheel of the front wheel unit 120 and the rear wheel unit 130 on the basis of the turning direction, the turning amount, and the vehicle speed that are input. The electronic control device 160 controls each of the traveling wheels 122R, 122L, 132R and 132L so as to reduce the steering angle at the beginning of steering and increase the steering angle by a steering increment using a principle equivalent to a variable steering gear ratio, etc., which is used in power steering of a steering system. At this time, the electronic control device 160

calculates the differential amount of each of the traveling wheels 122R, 122L, 132R and 132L so as not to lead to excessive oversteering or understeering during turning, i.e. so as to lead to neutral steering in a safe and optimal state. The electronic control device 160 outputs the calculated differential amount to each of the drive units 124R, 124L, 134R and 134L in the form of a digital signal. The drive units 124R, 124L, 134R and 134L into which the digital signals are input drive the traveling wheels 122R, 122L, 132R and 132L on the basis of the digital signals, respectively.

[0031]

That is, as shown in Fig. 1, when the electric automobile is a rear wide vehicle in which the interval between the traveling wheels 132R and 132L of the rear wheel unit 130 is wider than that between the traveling wheels 122R and 122L of the front wheel unit 120, the traveling wheels 122R and 122L are differentially controlled by the drive units 124R and 124L of the front wheel unit 120 that is the swivel unit without conventional types of steering mechanisms. Thus, it is possible to turn the vehicle body. At this time, the traveling wheels 132R and 132L of the rear wheel unit 130 are optimized by adjusting the turning direction of the vehicle body turned by the front wheel unit 120 depending on a speed under the differential control of the drive unit 134R and 132L,

[0032]

The electric automobile 100 constructed in this way turns the vehicle body by differentially driving the traveling wheels 122R, 122L, 132R and 132L on the basis of the inputs from the steering angle input unit capable of turning the vehicle body using the steering wheel or the joystick without a conventional type of steering system that gives a steering angle to wheels via, for instance, a steering wheel, a steering shaft, a rack and pinion gear, a rod, a suspension link, and so on. Thus, in comparison with the conventional type of steering system, it is possible to obtain vehicle turnability about twice or more, and a space required to turn the vehicle body is reduced, so that the vehicle body has high turning efficiency.

[0033]

Further, the electric automobile 100 according to the present embodiment

has the swivel unit functioning as the steering wheel installed on the front wheel unit 120. Thereby, the electric automobile is characterized in that, when the vehicle body is turned, the front of the vehicle body is directed in the turning direction at all times. For example, the vehicle body may be turned in a right direction by the steering angle input unit 140. When the driver operates the steering angle input unit 140, the electronic control device 160 differentially drives the traveling wheels 122R, 122L, 132R and 132L. At this time, the electric automobile 100 according to the present embodiment moves so as to rotate on its axis as shown in Fig. 3, and causes the vehicle body to be turned in a right direction that is an advance direction (steering direction) by the inputs from the steering angle input unit 140. Simultaneously, the direction in which the vehicle body is directed is also changed.

[0034]

Meanwhile, in conventional vehicles, when a vehicle body is turned in a right direction by a steering wheel, a pair of front wheels are directed in an advance direction in a state in which they maintain a substantially parallel relationship, and a direction in which the vehicle body is directed is different from the advance direction. For this reason, a driver has no alternative but to empirically determine an amount of operation of the steering wheel corresponding to the advance direction of the vehicle body, and to drive the vehicle. In the electric automobile 100 according to the present embodiment, since the direction in which the front of the vehicle body is directed is matched with the turning direction, the driver can accurately recognize the advance direction of the electric automobile 100, so that the operability can be improved, and wrong operation can be also reduced.

[0035]

Here, the electric automobile 100 according to the present embodiment is constructed so that each traveling wheel is driven according to instructions from the electronic control device 160. However, at that time, among the driven traveling wheels, one or more traveling wheels may lose friction against a road surface according to conditions of the road surface, and thus run idle (i.e. slip). In this case, a slip sensor 180 is operated, and the generation of the slip is fed back to the electronic control device 160. The electronic control device 160 that is informed of

the generation of the slip of the traveling wheel calculates a new fraction of operation of each traveling wheel on the basis of an instantaneously proper driving force distribution as well as an input turning amount, and a turning direction and speed depending on a degree of the slip, and outputs the calculated results to the respective drive units 124R, 124L, 134R and 134L. The electronic control device 160 conducts drive control of each traveling wheel on the basis of the newly calculated turning direction, turning amount and vehicle speed.

[0036]

The electric automobile 100 according to the present embodiment employs the in-wheel motor as the drive unit of the traveling wheel. Since the in-wheel motor has high driving-force recoverability, it is possible to rapidly eliminate the slip state even when the slip takes place at the traveling wheel.

[0037]

<Turnability of Electric Automobile>

Hereinafter, turnability of the electric automobile 100 according to the present embodiment will be described with reference to Figs. 5 and 6, taking an operation of the electric automobile 100 by way of example. Fig. 5 is an explanatory view showing turnability of the electric automobile according to the present embodiment. Fig. 6 is an explanatory view showing vehicle movement when the electric automobile according to the present embodiment is parked.

[0038]

As shown in Fig. 5, the electric automobile 100 according to the present embodiment can rotate about the rotation center C at an angle of 360° . At this time, the rotation radius r is smaller than the vehicle overall length L of the electric automobile 100. That is, the electric automobile 100 according to the present embodiment can change the advance direction in a narrow turning space, because it can be turned so as to rotate itself on its axis.

[0039]

For example, the electric automobile 100 in which the front wheel unit 120 is in the state shown in Fig. 1 is located at position A of Fig. 5. When the vehicle body of the electric automobile 100 is turned from this state in a right direction, a

driver steers the steering wheel 140 in the right direction. The steering angle sensor 150 detects a steering amount of the steering wheel 140 and outputs the detected steering amount to the electronic control device 160. Then, the electronic control device 160 differentially drives the traveling wheels 122R and 122L of the front wheel unit 120 so as to rotate the front wheel unit 120 in the right direction at an angle of about 90°. For example, the right wheel 122R and the left wheel 122L may be driven at different rotation speeds, thereby allowing the front wheel unit 120 to rotate in the right direction. Thus, the traveling wheels 122R and 122L of the front wheel unit 120 become substantially parallel to each other in a widthwise direction of the vehicle body 110, as indicated by position_A of Fig. 5.

[0040]

In a state in which the front wheel unit 120 is indicated by position_A of Fig. 5, when the traveling wheels 122R and 122L of the front wheel unit 120 are driven by the drive units 124R and 124L, the vehicle body 110 is turned around the rotation center C in a right direction, and moves to a position of position_B. When the traveling wheels 122R and 122L of the front wheel unit 120 are further driven by the drive units 124R and 124L, the vehicle body 110 is turned around the rotation center C in the right direction, and moves to a position of position_C.

[0041]

On the other hand, when the electric automobile 100 in which the front wheel unit 120 located at position_A of Fig. 5 is in a state shown in Fig. 1 is turned in a left direction, a driver steers the steering wheel 140 in the left direction. The steering angle sensor 150 detects a steering amount of the steering wheel 140 and outputs the detected steering amount to the electronic control device 160. Then, the electronic control device 160 controls driving forces of the four traveling wheels 122R, 122L, 132R and 132L, each of which is independently driven. The electronic control device 160 differentially drives the traveling wheels 122R and 122L of the front wheel unit 120 so as to rotate the front wheel unit 120 at an angle of about 90° in the left direction. For example, the right wheel 122R and the left wheel 122L may be driven at different rotation speeds, thereby allowing the front wheel unit 120 to rotate in the left direction. Thus, the traveling wheels 122R and 122L of the front

wheel unit 120 become substantially parallel to each other in a widthwise direction of the vehicle body 110, as indicated by position_A of Fig. 5.

[0042]

In a state in which the front wheel unit 120 is indicated by position_A of Fig. 5, when the traveling wheels 122R and 122L of the front wheel unit 120 are driven by the drive units 124R and 124L, the vehicle body 110 is turned around the rotation center C in a left direction, and moves to the position of position_D. When the traveling wheels 122R and 122L of the front wheel unit 120 are further driven by the drive units 124R and 124L, the vehicle body 110 is turned around the rotation center C in the left direction, and moves to the position of position_C.

[0043]

The electric automobile 100 capable of changing the advance direction in this way has high turnability with which the advance direction of the vehicle body 110 can be easily changed in a narrow space, compared to turnability of conventional vehicles such as three-wheel vehicles or four-wheel vehicles. According to this electric automobile 100, it is possible to move the vehicle 110, which cannot be realized with vehicles having a conventional vehicle construction, and for a driver to facilitate the vehicle control.

[0044]

As an example, when the electric automobile 100A according to the present embodiment gets out of a parallel parking state, vehicle movement of the electric automobile 100A is described. As shown in Fig. 6, the electric automobile 100A according to the present embodiment is parked between two automobiles 100B and 100C. In the case of conventional automobiles, when spaces between your own automobile and two automobiles 100B and 100C in front of and behind your own automobile are narrow as in Fig. 6, a steering wheel is greatly turned to the right, thereby moving a vehicle body. Nevertheless, there is a high possibility of coming into contact with the front automobile 100B, so that your own automobile cannot easily get out.

[0045]

In contrast, the electric automobile 100A according to the present

embodiment allows the vehicle body 110 to rotate about the rotation center C adjacent to the middle between the two traveling wheels 132R and 132L constructing the rear wheel unit 130, as described above. With use of this high turnability, as shown in Fig. 6, a driver steers the steering wheel 140 to rotate the front wheel unit 120 in a right direction, thereby changing the advance direction of the vehicle body 110. The four traveling wheels 122R, 122L, 132R, and 132L are further driven under the control of the electronic control device 160, thereby moving the vehicle body 110 so as to rotate about the rotation center C. As a result, the front of the vehicle body can get out of the space between the two automobiles 100B and 100C.

10 [0046]

Thereafter, the driver steers the steering wheel 140 to rotate the front wheel unit 120 in a left direction, thereby making the traveling wheels 122R and 122L of the front wheel unit 120 substantially parallel to each other in the advance direction. The four traveling wheels 122R, 122L, 132R, and 132L are driven under the control of the electronic control device 160 to move the vehicle body 110. Thereby, the electric automobile 100A can be positioned on the right side of the automobile 100B. In this way, with the electric automobile 100 according to the present embodiment, the advance direction of the vehicle body 110 can be easily changed in a narrow space. As such, it is possible to facilitate parking and leaving of the electric automobile 100 and the parking space efficiency can also be improved. Further, the electric automobile 100 of the present embodiment has a low noise level due to characteristics of the electric automobile, and does not emit heat, gas, etc. when driven, so that it is suitable to turn the vehicle body 110 inside a building.

[0047]

25 The vehicle construction and movement of the electric automobile 100 according to the present embodiment have been described above. With the electric automobile 100 according to the present embodiment, the advance direction of the vehicle is changed by integrally rotating the front wheel unit 120 according to the steering amount of the steering wheel 140. When the front wheel unit 120 is directed perpendicular to the front-rear direction of the vehicle body, the four traveling wheels are differentially driven by the electronic control device 160, so that

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the vehicle body 110 can be turned about the rotation center C located near the middle of the rear wheel unit 130. In this way, according to the present embodiment, it is possible to realize the electric automobile 100 having high turnability. Further, when the vehicle body is turned, the front of the vehicle body is directed in a turning direction at all times, so that it is possible to improve vehicle operability and reduce wrong operation as well. Moreover, the rotating direction and torque of all the four wheels are individually controlled so as to match the advance direction and steering direction of the vehicle with each other, so that it is possible to realize high turnability and driving-force recoverability when a slip takes place.

[0048]

(Second Embodiment)

<Vehicle Structure for Electric Automobile>

Next, a vehicle structure for an electric automobile according to a second embodiment of the present invention will be described with reference to Fig. 7. Fig. 7 is an explanatory view showing a vehicle structure for an electric automobile according to the present embodiment. In Fig. 7, only functional units relevant to arrangement of a vehicle body 110 and traveling wheels, and a steering system are shown, as in Fig. 1.

[0049]

As shown in Fig. 7, the electric automobile 200 according to the present embodiment includes a front wheel unit 220 disposed in the front of an advance direction of a vehicle body 200, and a rear wheel unit 230 disposed in the rear of the advance direction of the vehicle body 210. The front wheel unit 220 includes two traveling wheels including a right wheel 222R and a left wheel 222L. The front wheel unit 220 according to the present embodiment has a construction similar to that of the rear wheel unit 130 of the first embodiment. The right wheel 222R and the left wheel 222L are disposed at an interval that has substantially the same length as a vehicle width of the vehicle body 210. The center C of rotation of the vehicle body 210 is located at a substantially middle position of a straight line connecting the right wheel 222R and the left wheel 222L. The traveling wheels are provided with

drive units 224R and 224L, such as in-wheel motors, which rotate the traveling wheels respectively.

[0050]

The rear wheel unit 230 includes two traveling wheels including a right wheel 232R and a left wheel 232L. The rear wheel unit 230 is formed as a swivel unit, similar to the front wheel unit 120 of the first embodiment. The right wheel 232R and the left wheel 232L are installed so as to be substantially parallel to each other at all times. Further, disc surfaces of the right wheel 232R and the left wheel 232L are provided so as to be substantially perpendicular to a straight line connecting the right wheel 232R and the left wheel 232L. The traveling wheels are provided with drive units 234R and 234L, such as in-wheel motors, which rotate the traveling wheels respectively.

[0051]

The right wheel 232R and the left wheel 232L are rotatably supported by a support unit 236. The straight line connecting the right wheel 232R and the left wheel 232L is adapted to pass through the center of the support unit 236. The rear wheel unit 230 is rotatable about the center 236c of the support unit 236 at an angle of 360° in a plane substantially perpendicular to a direction of the height of the vehicle body 210. An angle of rotation of the rear wheel unit 230 is determined by steering a steering wheel 140. That is, the rear wheel unit 230 rotates about the center 236c, so that it can change an advance direction of the electric automobile 200.

[0052]

As shown in Fig. 7, the electric automobile 200 according to the present embodiment is constructed so that an interval between the right wheel and the left wheel at the front wheel unit 220 is different from an interval between the right wheel and the left wheel at the rear wheel unit 230. The interval W_3 between the left and right wheels of the front wheel unit 220 is substantially the same as the vehicle width of the vehicle 210. With this regard, the interval W_4 between the left and right wheels of the rear wheel unit 230 is smaller than the interval W_3 between the left and right wheels of the front wheel unit 220. This is because a radius of rotation of the rear wheel unit 230 is reduced, like the front wheel unit 120 of the

first embodiment. The interval W_4 between the left and right wheels of the rear wheel unit 230 can be determined by considering a magnitude of the rotation radius of the rear wheel unit 230 and the stable support of the vehicle body 210. Further, the electric automobile 200 according to the present embodiment is mainly
 5 constructed so that the front wheel unit 220 functions as a driving wheel, and the rear wheel unit 230 functions as a steering wheel. Note that the front wheel unit 220 also contributes to steering by means of its differential movement, and the rear wheel unit 230 functions as the driving wheel by means of the in-wheel motor mounted in each traveling wheel.

10 [0053]

The electric automobile 200 having this vehicle construction is provided with a steering angle sensor 250 that detects an amount of steering of the steering wheel 240 caused by a driver. The steering angle sensor 250 outputs the detected steering amount to an electronic control device 260. The electronic control device
 15 260 calculates the rotation angle of the vehicle body 210 from the steering amount input from the steering angle sensor 250 when the vehicle body is turned. At this time, the electronic control device 260 performs differential control on the traveling wheels 222R and 222L and the drive unit 224R and 224L of the front wheel unit 220, and turns the vehicle body 210. Meanwhile, the traveling wheels 232R and 232L
 20 and the drive unit 234R and 234L of the rear wheel unit 230 constructed as the swivel unit are differentially controlled by the electronic control device 260 so that a turning direction of the turning vehicle is optimized according to a speed. In this way, the electronic control unit 260 calculates an amount of driving of each of the drive units 224R, 224L, 234R and 234L which is required to rotate the vehicle body
 25 210 by the calculated rotation angle, and drives each of the drive units 224R, 224L, 234R and 234L according to the calculated driving amount.

[0054]

The vehicle construction of the electric automobile 200 according to the present embodiment has been described above. In this way, the vehicle
 30 construction of the electric automobile 200 according to the present embodiment is made up of the two traveling wheels including the front wheel unit 220 and the rear

wheel unit 230, and is constructed similar to a three-wheel vehicle. However, since the electric automobile 200 according to the present embodiment is actually driven by the four wheels including the two wheels of the front wheel unit 220 and the two wheels of the rear wheel unit 230, it is characterized in that, similar to the electric automobile 100 according to the first embodiment, the linear travelability and traveling stability thereof are high, and the turnability is high, compared to conventional three-wheel vehicles.

[0055]

<Turnability of Electric Automobile>

Here, turnability of the electric automobile 200 according to the present embodiment will be described with reference to Figs. 8 and 9, taking an operation of the electric automobile 200 by way of example. Fig. 8 is an explanatory view showing turnability of the electric automobile according to the present embodiment. Fig. 9 is an explanatory view showing vehicle movement when the electric automobile according to the present embodiment is parked. As shown in Fig. 8, the electric automobile 200 according to the present embodiment can rotate about the rotation center C at an angle of 360° . At this time, the rotation radius r is smaller than the vehicle overall length L of the electric automobile 200, and can change the advance direction in a narrow turning space, similar to the electric automobile 100 according to the first embodiment.

[0056]

For example, the electric automobile 200 in which the front wheel unit 220 is in the state shown in Fig. 7 is located at position $_A$ of Fig. 8. When the vehicle body of the electric automobile 200 is turned from this state in a right direction, a driver steers the steering wheel 240 in the right direction. The steering angle sensor 250 detects a steering amount of the steering wheel 240 and outputs the detected steering amount to the electronic control device 260. Then, the electronic control device 260 differentially drives the traveling wheels 232R and 232L of the rear wheel unit 230 so as to rotate the rear wheel unit 230 in the right direction at an angle of about 90° . For example, the right wheel 232R and the left wheel 232L may be driven at different rotation speeds, thereby allowing the rear wheel unit 230 to rotate

in the right direction. Thus, the traveling wheels 232R and 232L of the rear wheel unit 230 become substantially parallel to each other in a widthwise direction of the vehicle body 210, as indicated by position_A of Fig. 8.

[0057]

5 In a state in which the rear wheel unit 230 is indicated by position_A of Fig. 8, when the traveling wheels 232R and 232L of the rear wheel unit 230 are driven by the drive units 234R and 234L, the vehicle body 210 is turned around the rotation center C in a right direction, and moves to a position of position_D. When the traveling wheels 232R and 232L of the rear wheel unit 230 are further driven by the
10 drive units 234R and 234L, the vehicle body 210 is turned around the rotation center C in the right direction, and moves to a position of position_C.

[0058]

On the other hand, when the electric automobile 200 in which the rear wheel unit 230 located at position_A of Fig. 8 is in a state shown in Fig. 7 is turned in a left
15 direction, a driver steers the steering wheel 240 in the left direction. The steering angle sensor 250 detects a steering amount of the steering wheel 240 and outputs the detected steering amount to the electronic control device 260. Then, the electronic control device 260 controls driving forces of the four traveling wheels 222R, 222L, 232R and 232L, each of which is independently driven. The electronic control
20 device 260 differentially drives the traveling wheels 232R and 232L of the rear wheel unit 230 so as to rotate the rear wheel unit 230 at an angle of about 90° in the left direction. For example, the right wheel 232R and the left wheel 232L may be driven at different rotation speeds, thereby allowing the rear wheel unit 230 to rotate in the left direction. Thus, the traveling wheels 232R and 232L of the rear wheel
25 unit 230 become substantially parallel to each other in a widthwise direction of the vehicle body 210, as indicated by position_A of Fig. 8.

[0059]

In a state in which the front wheel unit 120 is indicated by position_A of Fig. 8, when the traveling wheels 232R and 232L of the rear wheel unit 230 are driven by
30 the drive units 234R and 234L, the vehicle body 210 is turned around the rotation center C in a left direction, and moves to the position of position_B. When the

traveling wheels 232R and 232L of the rear wheel unit 230 are further driven by the drive units 234R and 234L, the vehicle body 210 is turned around the rotation center C in the left direction, and moves to the position of position_C.

[0060]

5 The electric automobile 200 capable of changing the advance direction in this way has high turnability with which the advance direction of the vehicle body 210 can be easily changed in a narrow space, compared to turnability of conventional vehicles such as three-wheel vehicles or four-wheel vehicles. According to this electric automobile 200, it is possible to move the vehicle 210, which cannot be
10 realized with vehicles having a conventional vehicle construction, and for a driver to facilitate the vehicle control.

[0061]

As an example, vehicle movement of the electric automobile 200A according to the present embodiment when the electric automobile 200A is parallel
15 parked is described. As shown in Fig. 9, the electric automobile 200A according to the present embodiment is parked between two automobiles 200B and 200C, both of which have been parallel parked. In the case of conventional automobiles, when a space between the two automobiles 200B and 200C is narrow such that it is slightly greater than the vehicle overall length, another automobile cannot be parallel parked
20 between the two automobiles 200B and 200C.

[0062]

In contrast, in the case of the electric automobile 200A according to the present embodiment, the vehicle body 210 can rotate about the rotation center C adjacent to the middle between the two traveling wheels 222R and 222L constructing
25 the front wheel unit 220, as described above. With use of this high turnability, as shown in Fig. 9, after the front of the vehicle body is put between the two automobiles 200B and 200C, a driver steers the steering wheel 240 to rotate the rear wheel unit 230 in a right direction, thereby changing the advance direction of the vehicle 210. The four traveling wheels 222R, 222L, 232R, and 232L are further
30 driven under the control of the electronic control device 260, thereby moving the vehicle body 210 between the two automobiles 200B and 200C so as to rotate about

the rotation center C. As a result, the front of the vehicle body can be parallel parked between the two automobiles 200B and 200C.

[0063]

In this way, with the electric automobile 200 according to the present embodiment, the advance direction of the vehicle body 210 can be easily changed in a narrow space. As such, it is possible to facilitate parking and leaving of the electric automobile 200 and the parking space efficiency can also be improved. Further, the electric automobile 200 of the present embodiment has a low noise level due to characteristics of the electric automobile, and does not emit heat, gas, etc. when driven, so that it is suitable to turn the vehicle body 210 inside a building.

[0064]

Further, similar to the first embodiment, the electric automobile 200 according to the second embodiment may also be provided with a slip sensor shown in Fig. 2. Thus, even when one or more traveling wheels slip, a degree of the slip is fed back to the electronic control device 260, and the driving force and direction of each of the drive units 224R, 224L, 234R and 234L (i.e. the turning direction and the turning amount of the vehicle body 210) are calculated by the electronic control device 260, so that it is possible to rapidly deal with generation of the slip, and eliminate a slip state of the traveling wheels.

[0065]

Moreover, the electric automobile 200 of the present embodiment is characterized in that, since the swivel unit is installed on the rear wheel unit 230, the front of the vehicle body is directed in a turning direction at all times when the vehicle body is turned, similar to the electric automobile 100 according to the first embodiment. A direction in which the front of the vehicle body is directed is matched with the turning direction, and thereby a driver can accurately recognize the advance direction of the electric automobile 200. As such, the operability can be improved, and wrong operation can be reduced.

[0066]

The vehicle construction and movement of the electric automobile 200 according to the present embodiment have been described above. With the electric

automobile 200 according to the present embodiment, the advance direction of the vehicle is changed by integrally rotating the front wheel unit 120 depending on the steering amount of the steering wheel 240 and the differential movement of the front wheel unit 220. When the rear wheel unit 230 is directed in a direction perpendicular to the front-rear direction of the vehicle body 210, the four traveling wheels are differentially driven by the electronic control device 260, so that the vehicle body 210 can be turned around the rotation center C located near the middle of the front wheel unit 220. In this way, according to the present embodiment, it is possible to realize the electric automobile 200 having high turnability. Further, when the vehicle body is turned, the front of the vehicle body is always directed in a turning direction, so that it is possible to improve vehicle operability and reduce wrong operation. Moreover, the rotating direction and torque of all the four wheels are individually controlled so as to match the vehicle advance direction and steering direction with each other, so that it is possible to realize high turnability and driving-force recoverability when a slip takes place.

[0067]

Further, the electric automobile 200 according to the present embodiment uses the in-wheel motor as the drive unit driving each of the traveling wheels 222R, 222L, 232R and 232L, and performs vehicle steering control using a steering method based on the operation of the in-wheel motor. The electric automobile 200 according to the present embodiment is constructed so that the front wheel unit 220 is a front wide vehicle having a large width, the traveling wheels 222R and 222L of the front wheel unit 220 function as driving wheels, and the traveling wheel itself contributing to the vehicle turning due to the differential movement is not steered. Accordingly, since there is no need to install a conventional type of steering system and machinery, the capacity of a wheel house of the front wheel or an amount of protrusion of the machinery can be significantly reduced, and a vehicle internal space can be increased.

[0068]

In the electric automobile 200 according to the present embodiment, the rear wheel unit 230 is formed as the swivel unit, and the drive units 234R and 234L are

installed on the respective traveling wheels 232R and 232L. However, the present invention is not limited to the relevant examples. For example, no drive units may be installed on the respective traveling wheels 232R and 232L. In this case, the front wheel unit 220 functions as the driving wheel that drives the vehicle, and as the steering wheel that determines the steering direction. The rear wheel unit 230 functions as a caster that supports the vehicle body 210 driven by the front wheel unit 220, and moves along with the movement of the vehicle body 210. In this way, it is possible to further simplify the construction of the electric automobile 200 and realize a vehicle having high turnability.

10 [0069]

The preferred embodiments of the present invention have been described above with reference to the accompanying drawings, whilst the present invention is not limited to the above examples, of course. A person skilled in the art may find various alternations and modifications within the scope of the appended claims, and it should be understood that they will naturally come under the technical scope of the present invention.

[0070]

For example, the construction of the vehicle body of the electric automobile of the present invention may be applied to typical passenger cars, as well as large- and small-sized cars. That is, with the construction of the vehicle body of the electric automobile of the present invention, any car is interpreted as falling within the scope of the present invention regardless of a size or a shape of the vehicle body.

Reference Signs List

25 [0071]

100, 200 Electric automobile

110, 210 Vehicle body

120, 220 Front wheel unit

130, 230 Rear wheel unit

30 140, 240 Steering wheel

150, 250 Steering angle sensor

160, 260 Electronic control device

CLAIMS

Claim 1

A vehicle structure for an electric automobile that is driven by traveling wheels, in each of which a drive device driven by receiving supply of electric energy
5 is mounted, the vehicle structure comprising:

a first traveling wheel unit and a second traveling wheel unit which are provided in the front and rear of a vehicle body and which each include an arrangement of two traveling wheels; and

a drive control unit that individually drives the four traveling wheels
10 depending on an amount of operation input by a driver,

wherein the first traveling wheel unit is constructed to be integrally rotatable about a first center of rotation near the midpoint of a support unit, which rotatably supports the two traveling wheels forming the first traveling wheel unit at opposite ends of the first traveling wheel unit, in a plane substantially perpendicular to a
15 direction of a height of the vehicle body, while maintaining a state in which disc surfaces of the two traveling wheels are perpendicular to a straight line that passes through rotation centers of the corresponding traveling wheels and the midpoint of the support unit, and

wherein the drive control unit differentially drives the traveling wheels
20 forming the first traveling wheel unit depending on an amount of steering among the operation amount, and rotates the first traveling wheel unit about the first rotation center.

Claim 2

25 The vehicle structure according to claim 1, wherein an interval between the traveling wheels forming the first traveling wheel unit is smaller than that between the traveling wheels forming the second traveling wheel unit.

Claim 3

30 The vehicle structure according to claim 1, wherein the drive control unit differentially drives the four traveling wheels depending on the operation amount

input by the driver, and causes the vehicle body to be turned about a predetermined position within an area where the second traveling wheel unit of the vehicle body is provided.

5 Claim 4

 The vehicle structure according to claim 3, wherein, when the first traveling wheel unit rotates about the first rotation center at an angle of 90° with respect to a direction of the first traveling wheel unit when traveling in front of the vehicle body, the drive control unit differentially drives the four traveling wheels depending on the
10 operation amount input by the driver, and causes the vehicle body to be turned about a middle position between the two traveling wheels forming the second traveling wheel unit.

 Claim 5

15 The vehicle structure according to claim 1, wherein a radius of rotation required to turn the vehicle body is smaller than an overall length of the vehicle body.

 Claim 6

 The vehicle structure according to claim 1, wherein the first traveling wheel
20 unit is a front wheel unit, and the second traveling wheel unit is a rear wheel unit.

 Claim 7

 The vehicle structure according to claim 1, wherein the first traveling wheel unit is a rear wheel unit, and the second traveling wheel unit is a front wheel unit.