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(54) **DRIVER OF ELECTRIC AUTOMOBILE**

TREIBER FÜR ELEKTROKRAFTFAHRZEUG

ORGANE MOTEUR D'UNE AUTOMOBILE ELECTRIQUE

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(56) References cited:
GB-A- 2 334 496
JP-A- 5 076 106
JP-A- 7 298 418
JP-A- 10 295 004
JP-A- 2001 158 254
US-A- 5 294 191
US-A- 6 033 041

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Description

Technical Field

[0001] The present invention relates to an electric car equipped with driving motors, and more particularly, it relates to a driving device capable of selecting drive wheels or regenerative brake wheels in accordance with traveling circumstances of the electric car.

Background Art

[0002] As a driving device of an electric car, it is most preferable that all wheels have the driving motors placed therein so as to control the respective drive forces in accordance with respective loads exerted thereon. In other words, by applying a drive force on each wheel in proportion to a load exerted on the wheel, making use of the frictional force between the tire of the wheel and the road surface can be maximized and a spin phenomenon of the wheel under acceleration can be minimized.

[0003] Unfortunately, with respect to an all-wheel drive electric car, since a necessary drive force of the car is shared by all wheels, an output of the motor of each wheel is relatively small, and in particular, in normal driving constituting the majority of driving of the car, an output of the motor is merely a fraction of the maximum output, thereby causing a problem that the motor is obliged to be used in a poor efficient region.

[0004] GB-A-2334496 describes a hybrid vehicle with controlled downhill electrodynamic braking, with the tecnical features in the preamble of claim 1.

[0005] The present invention seeks to provide an improved driving device of an electric car having four or more wheels, exactly selecting drive wheels according road circumstances.

[0006] The present invention is defined by a driving device as defined in claim 1 hereinafter.

Brief Description of the Drawings

[0007]

Fig. 1 is a structural diagram of a drive system of an electric car according an embodiment of the present invention.

Fig. 2 is a diagrammatic view of a drive mechanism of the electric car according the embodiment of the present invention.

Fig. 3 is an efficiency characteristic diagram of a driving motor of the electric car.

Fig. 4 is a diagrammatic view of a load exerted on the electric car.

[0008] An embodiment of the present invention will be described in detail.

[0009] Fig. 1 is a structural diagram of a drive system of an electric car according the embodiment of the present invention, and Fig. 2 is a diagrammatic view of a drive mechanism of the same.

[0010] With respect to reference numbers appearing in Fig. 1, 1 denotes a right front wheel, 2 denotes a left front wheel, 3 denotes a right rear wheel, 4 denotes a left rear wheel, 5 denotes a right front wheel driving motor, 6 denotes a left front wheel driving motor, 7 denotes a right rear wheel driving motor, 8 denotes a left rear wheel driving motor, 9 denotes an inverter connected to the right front wheel driving motor 5, 10 denotes an inverter connected to the left front wheel driving motor 6, 11 denotes an inverter connected to the right rear wheel driving motor 7, 12 denotes an inverter connected to the left rear wheel driving motor 8, 13 denotes a battery connected to the respective inverters 9 to 12, 14 denotes a right front wheel stroke sensor, 15 denote a left front wheel stroke sensor, 16 denotes a right rear wheel stroke sensor, 17 denotes a left rear wheel stroke sensor, 18 denotes a steering angle sensor, 19 denotes a longitudinal deceleration sensor, and 20 denotes a controller receiving information from each of the sensors 14 to 19 and controlling each or the inverters 9 to 12.

[0011] With respect to reference numbers appearing in Fig. 2, 21 denotes each wheel, 22 denotes a brake mechanism 22 disposed in each wheel 21, 23 denotes a motor connected to each wheel 21, 24 denotes an upper arm, 25 denotes a lower arm, 26 denotes a part of the car body (car body side), and 27 denotes a stroke sensor disposed between the lower arm 25 and the part of the car body (car body side) 26.

[0012] The efficiency characteristic of the driving motor of the electric car will be described.

[0013] Fig. 3 is an efficiency characteristic diagram of the driving motor of the electric car.

[0014] As is obvious from Fig. 3, the overall efficiency of the electric car including the motors, a reduction gear, and

the inverters is highest in the region of 30 to 40% of the maximum torque and decreases as the torque is reduced; especially, it decreases sharply in a low torque region.

[0015] Accordingly, in order to use the motor in an excellently efficient region, its use in a very low torque region must be avoided.

[0016] To this object, in the driving device of an electric car according to the present invention, in order to use the driving motor in an excellently efficient region, front wheel drive or rear wheel drive is selected in accordance with loads exerted on the wheels so as to halve the number of the drive wheels. In other words, by doubling a drive torque of the motor, the motor torque is kept at a relatively high value even in normal driving constituting the majority of traveling; thus, the motor is used in a higher efficient region.

[0017] Also, at the same time, in order to prevent reduction in utilization rate of the road frictional force, which is a drawback of two wheel (or half-the-number-of-wheel) drive, of the front wheels or the rear wheels, the wheels (or a group of the wheels) having greater loads exerted thereon are selected so as to serve as the drive wheels.

[0018] Its embodiment will be described in detail below.

[0019] Fig. 4 is a diagrammatic view of a load exerted on the electric car.

[0020] As shown in Fig. 4, when the gross weight of the car, a front wheel load, a rear wheel load, a coefficient of friction between the tire and the road surface are respectively defined by Wt, Wf, Wr, and μ, and when rear wheel drive is considered, the maximum drive force is limited by $Wr \times \mu$. Also, the utilization rate of the frictional force of the road surface is given by Wr/Wt. Accordingly, in order to effectively use the frictional force of the road surface, it is desirable to select the wheels of all wheels, having a greater load exerted thereon.

[0021] Then, detection of a wheel load of the electric car will be described.

[0022] The front and rear wheel loads are not always constant but vary in accordance with the gradient of the road surface, acceleration, and deceleration. Table 1 shows the varying tendency.

[Table 1]

	Upslope	Downslope	Acceleration	Deceleration
Front wheel load	decrease	increase	decrease	increase
Rear wheel load	increase	decrease	increase	decrease

[0023] Although a variety of sensors such as a speed sensor are available as means for detecting the gradient of the road surface or acceleration and deceleration, serving as variable factors of the foregoing wheel loads, in order to accurately detect a load and a change in loads exerted on each wheel, a vertical change of a suspension of the wheel is most preferably detected by the stroke sensor 27 disposed between the lower arm 25 and the part of the car body (car body side) 26 as shown in Fig. 2. Since the deformation of the suspension spring changes in proportion to the wheel load, the wheel load can be accurately detected by measuring the vertical change of the suspension with the stroke sensor 27. More particularly, by measuring the vertical changes of the respective wheels with the right front wheel stroke sensor 14, the left front wheel stroke sensor 15, the right rear wheel stroke sensor 16, and the left rear wheel stroke sensor 17 shown in Fig. 1, the respective wheel loads are accurately detected; the detected values are sent to the controller 20; the inverters 9 to 12 are controlled in accordance with output signals of the controller 20; and the driving motors 5 to 8 placed in the respective wheels 1 to 4 are appropriately driven.

[0024] As a result, the motors can be effectively driven in accordance with the loads of the corresponding wheels.

[0025] Subsequently, regenerative brake of the electric car will be described.

[0026] The regenerative brake puts on brakes such that the driving motors 5 to 8 works as generators and the battery 13 works as a load by sending generated electricity into the battery 13.

[0027] Accordingly, whether or not the regenerative brake is sufficiently effective depends on an amount of electric discharge of the battery 13; hence, when the battery 13 is nearly in a state of being fully charged, the battery 13 is difficult to charge electricity further, whereby the regenerative brake does not work sufficiently.

[0028] When the battery 13 is divided into two systems, the discharging state of the battery 13 varies in accordance with the respective systems; hence, from the viewpoint of recovering energy, all drive wheels are most preferably subject to the regenerative brake so as to recover energy in accordance with the respective charging states.

[0029] Thus, in the driving device of an electric car according to the present invention, either the front or rear wheels are selected so as to serve as the drive wheels in accordance with the gradient of the road surface, whereby the road surface friction is effectively made use of, and also the motors are used in the excellently efficient middle torque range.

[0030] Although there is a problem that the magnitude of the regenerative brake force is limited to a large extent, depending on the depth of discharge of the source battery, all wheels can serve as the regenerative brake wheels according to the present invention, thereby more effectively recovering energy.

[0031] Also in the driving device of an electric car according to the present invention, upon turning, by selecting the

radially outer and inner wheels so as to serve as the drive and regenerative brake wheels, respectively, on the basis of the output of the steering angle sensor 18, the turning is smoothly carried out.

[0032] Further, by applying regenerative brake on the radially inner wheels upon turning, the turning can be more sharply carried out.

[0033] As described above, in an electric car having four or more wheels, driving motors capable of driving and regenerative braking are disposed in all wheels and also, of these wheels, the drive wheels and the regenerative brake wheels are selected in accordance with traveling circumstances. More particularly, either the front or rear wheels are selected so as to serve as the drive wheels in accordance with the gradient of the road surface.

[0034] That is, a system is presented in which the drive wheels or the regenerative brake wheels are selected in accordance with the gradient of the road surface and offers advantages in utilization efficiency of the road surface friction and traveling stability.

[0035] As described above in detail, the driving device of an electric car according to the present invention offers the following advantages.

(A) Upon traveling on an upslope or a level road, by selecting the rear wheels, having greater loads exerted thereon due to the gradient of the road surface or the acceleration, so as to serve as the drive wheels, and also, upon traveling on a downslope, by selecting the front wheels having greater loads exerted thereon due to the gradient of the road surface, the motors can be used in an excellently efficient region, thereby providing sufficient drives;
(B) Also, by making use of all wheels as the regenerative brake wheels, energy is effectively recovered.

Industrial Applicability

[0036] The driving device of an electric car according to the present invention seek to provide a drive mechanism in which a sufficient drive force is obtained by using motors in an excellently efficient region and which is therefore suitable for a driving device of an electric car.

Claims

1. A driving device of an electric car having four or more wheels (1, 2, 3, 4), all wheels (1, 2, 3, 4) having driving motors (5, 6, 7, 8), capable of driving and regenerative braking, placed therein, wherein it is adapted to select **characterised in that** a plurality of the wheels (1 ,2, 3, 4) so as to serve as drive wheels or regenerative brake wheels in accordance with traveling circumstances of the car, it is further adapted to select the rear wheels (3, 4) or a group of the rear wheels so as to serve as the drive wheels upon traveling on a level road and an upslope, and the front wheels (1, 2) or a group of the front wheels so as to serve as the drive wheels upon traveling on a downslope.

2. The driving device of an electric car according to Claim 1, wherein it is further adapted to select the radially outer wheels so as to serve as the drive wheels upon turning.

3. The driving device of an electric car according to Claim 1, wherein it is further adapted to select all wheels (1, 2, 3, 4) so as to serve as the regenerative brake wheels upon braking.

Patentansprüche

1. Antriebsvorrichtung eines Elektrofahrzeugs, das vier oder mehr Räder (1, 2, 3, 4) aufweist, wobei alle Räder (1, 2, 3, 4) Antriebsmotoren (5, 6, 7, 8) aufweisen, die antreiben und regenerativ bremsen können und darin angeordnet sind, wobei die Vorrichtung dafür ausgelegt ist, eine Vielzahl der Räder (1, 2, 3, 4) auszuwählen, so dass diese gemäß den Fahrbedingungen des Fahrzeugs als Antriebsräder oder Räder mit regenerativer Bremse dienen, und wobei die Vorrichtung des Weiteren dafür ausgelegt ist, die Hinterräder (3, 4) oder eine Gruppe der Hinterräder auszuwählen, so dass diese als Antriebsräder dienen, wenn eine ebene Straße oder eine Steigung befahren wird, und die Vorderräder (1, 2) oder eine Gruppe der Vorderräder auszuwählen, so dass diese als Antriebsräder dienen, wenn ein Gefälle befahren wird.

2. Antriebsvorrichtung eines Elektrofahrzeugs nach Anspruch 1, wobei sie des Weiteren dafür ausgelegt ist, die radial äußeren Räder auszuwählen, so dass diese bei Kurvenfahrt als Antriebsräder dienen.

3. Antriebsvorrichtung eines Elektrofahrzeugs nach Anspruch 1, wobei sie des Weiteren dafür ausgelegt ist, alle Räder

(1, 2, 3, 4) auszuwählen, so dass diese beim Bremsen als Räder mit regenerativer Bremse dienen.

Revendications

1. Dispositif d'entraînement d'une voiture électrique présentant quatre roues ou plus (1, 2, 3, 4), toutes les roues (1, 2, 3, 4) intégrant des moteurs d'entraînement (5, 6, 7, 8) assurant l'entraînement et le freinage par récupération, dans lequel le dispositif peut sélectionner une pluralité de roues (1, 2, 3, 4) comme roues d'entraînement ou roues de freinage par récupération en fonction des conditions de conduite de la voiture, **caractérisé en ce que** le dispositif peut, par ailleurs, sélectionner les roues arrière (3, 4) ou un groupe des roues arrière comme roues d'entraînement lors d'une conduite sur une route plane et en montée, et les roues avant (1, 2) ou un groupe de roues avant comme roues d'entraînement lors d'une conduite en descente.

2. Dispositif d'entraînement d'une voiture électrique selon la revendication 1, dans lequel le dispositif peut sélectionner les roues radiales extérieures comme roues d'entraînement lors d'un virage.

3. Dispositif d'entraînement d'une voiture électrique selon la revendication 1, dans lequel le dispositif peut sélectionner toutes les roues (1, 2, 3, 4) comme roues de freinage par récupération lors du freinage.

FIG. 1

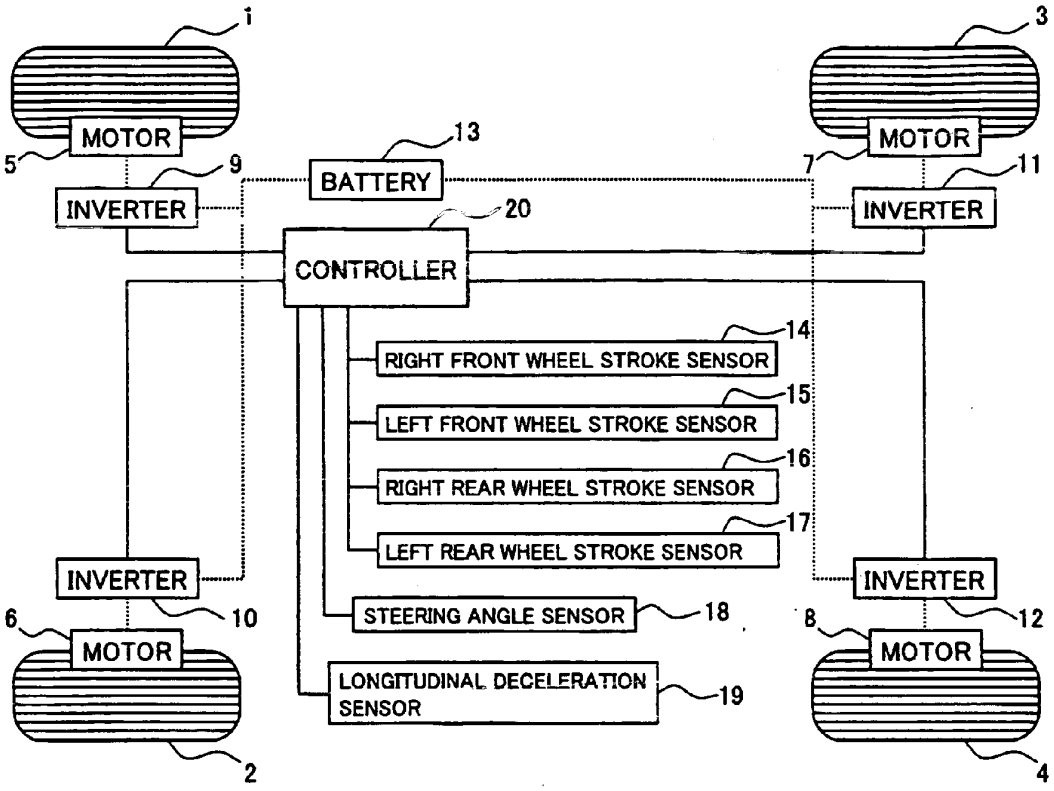

1
3
MOTOR
MOTOR
5
9
13
7
11
INVERTER
BATTERY
INVERTER
20
CONTROLLER
14
RIGHT FRONT WHEEL STROKE SENSOR
15
LEFT FRONT WHEEL STROKE SENSOR
16
RIGHT REAR WHEEL STROKE SENSOR
17
LEFT REAR WHEEL STROKE SENSOR
INVERTER
INVERTER
6
10
STEERING ANGLE SENSOR
18
8
12
MOTOR
MOTOR
LONGITUDINAL DECELERATION SENSOR
19
2
4

FIG. 2

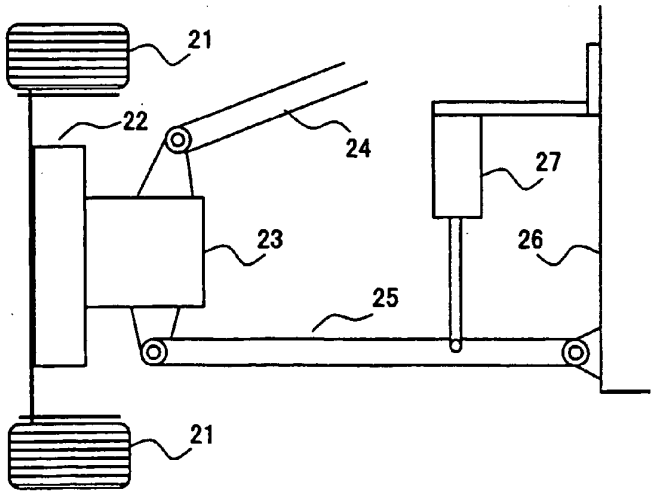

21
22
24
27
23
26
25
21

FIG. 3

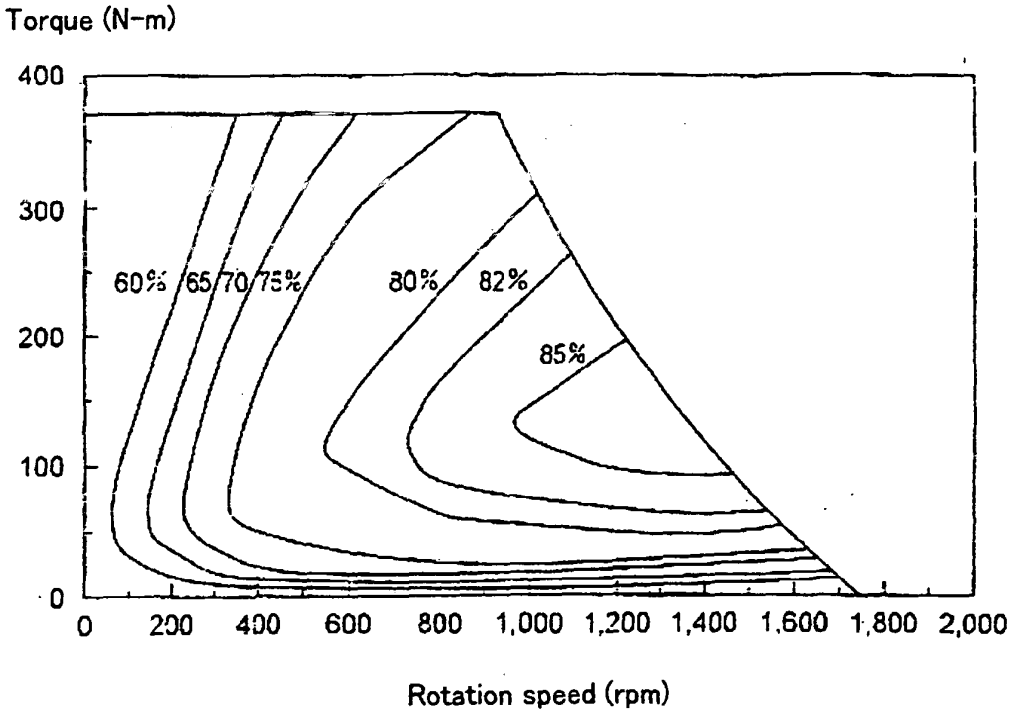
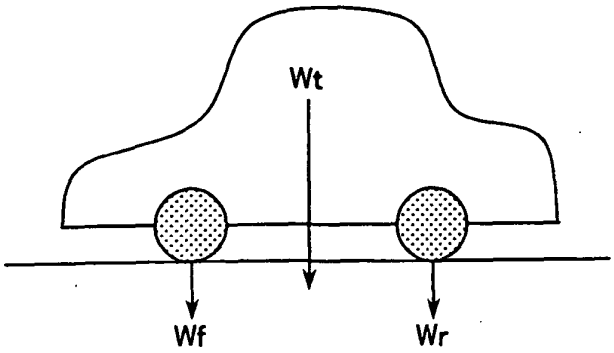

Torque (N-m)
400
300
200
100
0
60%
65
70
75%
80%
82%
85%
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
Rotation speed (rpm)

FIG. 4


Wt
Wf
Wr

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 2334496 A **[0004]**