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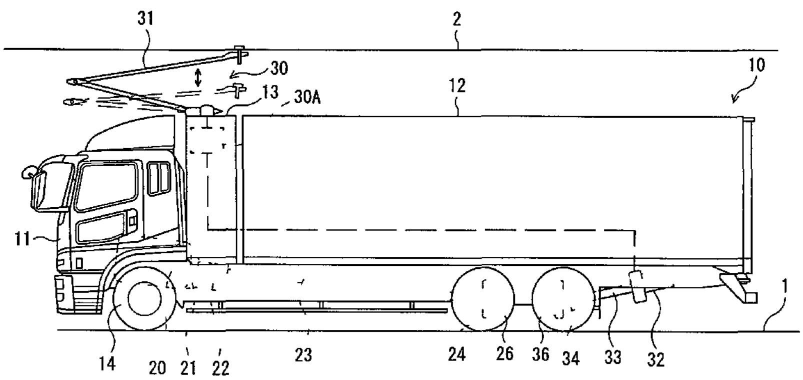
(54) Title HYBRID VEHICLE WITH POWER COLLECTOR AND OPERATION SYSTEM THEREFOR

Fig 1



(57) Abstract To provide a hybrid vehicle with a power collector and an operation system therefor which can reduce the cost of manufacturing the vehicle as a whole and spread the use of the vehicle A hybrid vehicle with a power collector is comprised of a first drive system comprising a driving engine (20), which drives drive wheels (26), and a first driving force transmission system that transmits rotational driving force of the engine (20) to the drive wheels (26), a second drive system comprising a motor (32) for driving, which rotates on electrical power received by the power collector (30) and drives drive wheels, and a second driving force transmission system that is different from the first driving force transmission system and transmits rotational drive force of the motor (32) to the drive wheels (36), and an integrated control meant, (40) for carrying out integrated control of the first drive system and the second drive system

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Hybrid Vehicle with Power Collector and Operation System Therefor

The present invention relates to a hybrid vehicle with a power collector that receives electrical power from overhead wires, and an operation system therefor.

In recent years, with attention focused on global environments, development and commercialization of so-called electric vehicles and hybrid vehicles that are effective in reducing fuel consumption and exhaust gases such as CO_2 have been pursued. However, in the case of electric vehicles unequipped with an engine (an internal combustion engine or a prime motor) and driven by only a motor (an electric motor), electric energy depends only on a battery mounted in the vehicle, and the cruising ranges of the vehicles are limited because there are limits to the capacities of batteries capable of being mounted in the vehicles. Thus, under the present circumstances, hybrid vehicles that use an engine and a motor in combination to secure a long cruising range is being predominantly commercialized.

On the other hand, the cruising ranges of railroad vehicles (electric trains) using electric energy are not limited because they run on electrical power received from overhead wires, but it is necessary to lay tracks and manage them, which requires high construction cost and high maintenance cost. Thus, they are not suitable for meticulous transportation between arbitrary sections of track, although they are suitable for mass transportation between specific sections of track. Moreover, when there is an obstacle on a track, the vehicle must be halted for many hours while recovery efforts such as removal of the obstacle are performed.

On the other hand, in the case of vehicles running on electrical power received from overhead wires such as "trolley buses" that became widespread to a certain extent in the past (hereinafter referred to as power-collecting electric vehicles), no tracks are needed unlike electric trains, and hence construction cost and maintenance cost can be reduced, and obstacles of certain sizes can be avoided. However, they need overhead wires, and they cannot run on roads unequipped with overhead wires. Thus, they do not have flexibility which general vehicles have, and hence under the present circumstances, they are not in widespread use in our country.

As a technology to enable such power-collecting electric vehicles to run even on roads unequipped with overhead wires, a vehicle equipped with not only a driving motor (a drive motor) driven by electrical power received from overhead wires but also an internal combustion engine for generating electrical power to run the drive motor or supplying mechanical power directly to a drive unit of the vehicle, that is, a vehicle developed by applying hybrid technology to the power-collecting electric vehicle has been proposed in Patent Literature 1. According to this technology, electrical power from the internal combustion engine is inputted to a transmission constituting the drive unit of the vehicle. Also, in Patent Literature 2, a vehicle equipped with a driving motor (a drive motor) running on electrical power received from overhead wires but also a driving internal combustion engine (an engine) for generating electrical power to run the drive motor, that is, a vehicle developed by applying so-called series type hybrid car technology to the power-collecting electric vehicle has been proposed in relation to both electric trains and vehicles.

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As described above, when equipped with an internal combustion engine and constructed as a so-called hybrid car, the power-collecting electric vehicle is able to run even on a road unequipped with overhead wires with its cruising range being not limited by battery capacity. Moreover, when constructed as a vehicle that needs no tracks, the power-collecting electric vehicle is able to run using a motor without emitting exhaust gas from an internal combustion engine as long as overhead wires are installed above or in a road.
On the other hand, the power-collecting electric vehicle is not suitable for application to general passenger vehicles driven by general drivers, considering that, for example, cost is considerably increased because a power collector equipped with trolley poles or pantographs is needed, maintenance of the power collector must be performed, and there is no advantage unless the vehicle frequently runs on roads equipped with overhead wires.
However, in the case of a large commercial vehicle such as a truck or a bus, the cost of installing the power collector can be substantially reduced by increasing its usage frequency because in many cases, the vehicle drives over a long distance on main roads such as expressways that can be easily equipped with overhead wires. Moreover, because a travel business or a transport business owns the vehicle, proper maintenance of the power collector exposed outside can be performed. Therefore, the hybrid vehicle with the power collector is suitably applied to large commercial vehicles in terms of spreading the use of the hybrid vehicle with the power collector.
However, to spread the use of the hybrid vehicle with the power collector, in the case of

using an existing vehicle without making the vehicle itself a dedicated vehicle, it is generally necessary to not only add the power collector but also make extensive modifications on the vehicle, which requires high manufacturing cost. Moreover, unless the hybrid vehicle with the power collector becomes widespread up to a certain point, it is difficult to reduce vehicle cost by volume efficiency. Thus, the challenge to the widespread use of the hybrid vehicle with the power collector is to reduce the cost of manufacturing the vehicle as a whole.

The present invention has been made to solve the above described problem, and an object of the present invention is to provide a hybrid vehicle with a power collector and an operation system therefor that can reduce the cost of manufacturing the vehicle as a whole and spread the use of the vehicle.

To attain the above object, the hybrid vehicle with the power collector according to the present invention has a first drive system that is comprised of a driving internal combustion engine which drives drive wheels, and a first driving force transmission system that transmits rotational driving force of the driving internal combustion engine to the drive wheels; a second drive system that is comprised of a power collector that receives electrical power from overhead wires, a driving motor which rotates on electrical power received by the power collector, and a second driving force transmission system that is different from the first driving force transmission system and transmits rotational driving force of the driving motor; and an integrated control means for carrying out integrated control of the first drive system and the second drive system (claim 1).

It is preferred that first drive wheels driven by the first driving force transmission system and second drive wheels driven by the second driving force transmission system are separate drive wheels (claim 2).

First drive wheels driven by the first driving force transmission system and second drive wheels driven by the second driving force transmission system may be common drive wheels, the first driving force transmission system being connected to a first input shaft of a final reduction gear for the common drive wheels, and the second driving force transmission system being connected to a second input shaft of the final reduction gear for the common drive wheels (claim 3).

It is preferred that the hybrid vehicle with the power collector has an internal combustion engine control means for controlling the driving internal combustion engine, a power collector control means for controlling the power collector, and a motor control means for controlling the driving motor, wherein the integrated control means carries out integrated control of the internal combustion engine control means, the power collector control means, and the motor control means (claim 4).

In this case, it is preferred that at least a motor driving mode in which the vehicle is driven by only rotational driving force of the driving motor, and an internal combustion engine driving mode in which the vehicle is driven by only rotational driving force of the driving internal combustion engine are provided as vehicle driving modes, the vehicle has driving mode selection means for selecting any of the driving modes, and when the driving mode selection means switches from the driving mode using the driving internal combustion engine to the motor driving mode, the integrated control means stops the driving internal combustion engine being in operation on condition that an RPM of the driving motor becomes equal to or greater than a predetermined RPM set in advance (claim 5).

Moreover, it is preferred that the hybrid vehicle with the power collector is further comprised of an overhead wire determination means for determining whether or not the overhead wires are installed in front of the road on which the vehicle is running, wherein when the overhead wire determination means determines that the overhead wires are not installed in front of the road during driving in the driving mode using the driving motor, the integrated control means automatically switches to the internal combustion engine driving mode irrespective of which driving mode is selected by the driving mode selection means before the vehicle enters the area unequipped with the overhead wires (claim 6).

In this case, it is preferred that the hybrid vehicle with the power collector is further comprised of a vehicle position determination means adapted to be movable between an operating position at which electrical power is received from the overhead wires and a retracted position at which electrical power is not received from the overhead wires, for determining whether or not the power collector is at such a position as to be able to receive electrical power from the overhead wires, wherein when the vehicle position determination means determines that the power collector is at such a position as to be able to receive electrical power from the overhead wires in a case where the driving mode selection means selects the driving mode using the driving motor, the power collector control means sets the power collector at the operating position so as to collect power, and in a case where the driving mode selection means selects the internal combustion engine driving mode, sets the power collector at the retracted position so as not to collect power (claim 7).

It is also preferred that the hybrid vehicle with the power collector is comprised of a storage unit (a battery) that, even in a case where electrical power is not received from the overhead wires, temporarily supplies electrical power to the driving motor even to enable the driving motor to run, and an energy recovery unit that recovers braking energy of the vehicle and stores the same as electric energy in the storage unit, and also collects surplus electric energy that is not used for driving in electrical power received from the

overhead wires and stores the same in the storage unit (claim 8). .
An operation system for operating the hybrid vehicle with the power collector is comprised of an overhead wire-equipped road having a driving lane equipped with the overhead wires, an overhead wire-unequipped connecting road unequipped with the overhead wires and connecting to the overhead wire-equipped road, a road-to-vehicle communication means for carrying out communication between both the overhead wire-equipped road and the overhead wire-unequipped road and the hybrid vehicle with the power collector and vehicles capable of using the overhead wires which are running on any of the roads, and a power feed control means for acquiring information on a request for use of the overhead wires from each of the vehicles using the road-to-vehicle communication means, and controlling the state of power feeding to the overhead wires based on the information (claim 9).

According to the hybrid vehicle with the power collector of the present invention (claim 1), because the first driving force transmission system that transmits rotational driving force of the driving internal combustion engine to the drive wheels, and the second driving force transmission system that transmits rotational driving force of the driving motor to the drive wheels are provided as separate systems, the hybrid vehicle with the power collector can be constructed by simply adding the second drive system comprised of the power collector, the driving motor, and the second driving force transmission system to a general vehicle that drives drive wheels by only rotational driving force of the driving internal combustion engine, and with almost no need to make modifications on the first drive system of the general vehicle. Thus, the hybrid vehicle with the power collector can be manufactured at low cost by using many parts of the general vehicle.
Moreover, because the first drive wheels driven by the first drive system and the second drive wheels driven by the second drive system are constructed as separate drive wheels, the hybrid vehicle with the power collector can be constructed by simply adding the second drive system for the drive wheels to a general existing vehicle that drives the first drive wheels by only rotational driving force of the driving internal combustion engine, and without the need to make modifications on the first drive system of the general existing vehicle, and thus can be manufactured at low cost by using many parts of the general vehicle (claim 2).
Also, in the case where the first drive wheels driven by the first driving force transmission system and the second drive wheels driven by the second driving force transmission system are common drive wheels, because the first driving force transmission system is connected to the first input shaft of the final reduction gear for the common drive wheels, and the second driving force transmission system is connected to the second input shaft

of the final reduction gear for the common drive wheels, the hybrid vehicle with the power collector can be constructed by simply connecting the first driving force transmission system to the first input shaft of the final reduction gear for the common driving wheels of a general existing vehicle, and with almost no need to make modifications on the first drive system of a general existing vehicle, and thus can be manufactured at low cost by using many parts of the general existing vehicle (claim 3).

Also, because the internal combustion engine control means controls the driving internal combustion engine, the power collector control means controls the power collector, the motor control means controls the driving motor, and the integrated control means carries out integrated control of the internal combustion engine control means, the power collector control means, and the motor control means, the driving internal combustion engine and the driving motor can be appropriately and smoothly used as the situation demands, and an existing computer unit or existing computer software can be used as the internal combustion engine control means.

Further, because the driving mode selection means can select either of the motor driving mode in which the vehicle is driven by only rotational driving force of the driving motor, and the internal combustion engine driving mode in which the vehicle is driven by only rotational driving force of the internal combustion engine as the vehicle driving mode, and when the driving mode selection means switches from the driving mode from the driving mode using the driving internal combustion engine to the motor driving mode, the integrated control means stops the driving internal combustion engine being in operation on condition that an RPM of the driving motor becomes equal to or greater than a predetermined RPM set in advance, rotational driving force of the driving motor can be secured when the driving internal combustion engine is stopped, and therefore, interruption of driving force for the vehicle can be prevented (claim 5).

Moreover, because when it is determined that the overhead wires are not installed in front of the road where the vehicle is actually running during driving in the driving mode using the driving motor, the integrated control means automatically switches to the internal combustion engine driving mode irrespective of which driving mode is selected by the driving mode selection means before the vehicle enters the area unequipped with the overhead wires, rotational driving force of the driving motor can be secured when the driving internal combustion engine is stopped, and therefore, interruption of driving force for the vehicle can be prevented (claim 6).

Moreover, because when the vehicle position determination means determines that the power collector is at such a position as to be able to receive electrical power from the overhead wires in a case where the driving mode selection means selects the driving mode using the driving motor, the power collector control means sets the power collector at the operating position so as to collect power, and in a case where the driving mode selection means selects the internal combustion engine driving mode, sets the power collector at the retracted position so as not to collect power, the power collector can be selectively operated when needed and retracted when not needed (claim 7).

Further, because the electric energy recovery unit that recovers and stores braking energy of the vehicle and stores the same as electric energy in the storage unit, and also collects surplus electric energy that is not used for driving in electrical power received from the overhead wires and stores the same in the storage unit, energy can be effectively used (claim 8).

Also, according to the operation system for operating the hybrid vehicle with the power collector (claim 9), because the power feed control means acquires information on a request for use of the overhead wires from each vehicle via the road-to-vehicle communication means carrying out communication between both an overhead wire-equipped road and an overhead wire-unequipped road and vehicles capable of using the overhead wires which are running on any of the roads, and controls the state of power feeding to the overhead wires based on the information electrical power can be fed to the overhead wires in an appropriate manner, and the vehicles capable of using the overhead wires can run while reliably receiving electrical power form the overhead wires. The hybrid vehicle with the power collector can be driven by the motor while operating the power collector on the overhead-equipped road and reliably using electrical power received from the overhead wires, the emission of exhaust gas, noise, and so on resulting from driving by the internal combustion engine can be reduced.

FIG. 1 is a side view showing a hybrid vehicle with a power collector according to a first embodiment of the present invention.

FIG. 2 is a diagram showing a construction of a drive system of the hybrid vehicle with the power collector according to the first embodiment of the present invention.

FIG. 3 is a schematic diagram useful in explaining an operation system for the hybrid vehicle with the power collector according to the first embodiment and a second embodiment of the present invention.

FIG. 4 is a flowchart useful in explaining how the drive system of the hybrid vehicle with the power collector according to the first embodiment of the present invention is controlled.

FIGS. 5A and 5B are skeleton diagrams showing a construction of a drive system of a hybrid vehicle with a power collector according to the second embodiment of the present invention, in which FIG. 5A shows an overall construction thereof and FIG. 5B shows a construction of a final reduction gear thereof.

The present invention will now be described in detail with reference to the drawings showing embodiments thereof.

First, a description will be given of a first embodiment of the present invention with reference to FIGS. 1 to 4.

FIG. 1 is a side view showing a hybrid vehicle with a power collector according to the present embodiment, and FIG. 2 is a diagram showing a construction of a drive system thereof.

As shown in FIGS. 1 and 2, in the present embodiment, the hybrid vehicle with the power collector is applied to a heavy truck (hereinafter also referred to merely as "the vehicle") 10. The heavy truck 10 is constructed as a rear two-axle vehicle, in which wheels 26 and 36 of respective rear two axles 25 and 35 are drive wheels. Note that in the case of making a distinction between right and left with regard to the rear two axles and the rear wheels, "R" is added to reference numerals 25, 35, 26, and 36 to indicate the right ones, and "L" is added to reference numerals 25, 35, 26, and 36 to indicate the left ones.

In the vehicle 10, an engine (a driving internal combustion engine) 20 and front wheels 14 are mounted below a vehicle interior 11. A cargo 12 is provided behind the vehicle interior 11. Below the cargo 12, the rear first axle 25 and the rear first drive wheels 26 are provided on the front side, and the rear second axle 35 and the rear second drive wheels 36 are provided on the rear side. The rear first axle 25 is connected to the engine 20 via a clutch 21, a transmission 22, a propeller shaft 23, and a first final reduction gear 24, so that driving force from the engine 20 is transmitted to the first drive wheels 26 mounted on the rear first axle 25.

The clutch 21, the transmission 22, the propeller shaft 23, and the first final reduction gear 24 constitute a first driving force transmission system that transmits rotational driving force of the engine 20 to the drive wheels 26, and the first driving force transmission system and the engine 20 constitute a first drive system.

An electric motor (a driving motor, hereinafter also referred to merely as the motor) 32 is provided below the cargo 12 and behind the rear second axle 35, and the rear second axle 35 is connected to the motor 32 via a propeller shaft 33 and a second final reduction gear 34, so that driving force is transmitted from the motor 32 to the second drive wheels 36 mounted on the rear second axle 35.

The propeller shaft 33 and the second final reduction gear 34 constitute a second driving force transmission system that transmits rotational driving force of the motor 32 to the drive wheels 36, and the second driving force transmission system, a power collector 30, and the motor 32 constitute a second drive system.

To supply electrical power to the motor 32, pantographs (or trolley poles) 31 are provided as power recovery units of the power collector 30 in an upper part of the vehicle 10, and it is arranged such that electrical power is supplied via the pantographs 31 to the motor 32 from overhead wires 2 disposed above a road. The overhead wires 2 are comprised of a pair of overhead wires 2a and 2b, and the pantographs 31 are also comprised of a pair of pantographs 31a and 31b. The pantographs 31a and 31b are connected to the overhead wires 2a and 2b, respectively.

Here, it is assumed that direct current is supplied to the overhead wires 2, and one of the two overhead wires 2a and 2b is a power supply line to which direct current is supplied, and the other one acts as an electricity return line. Note that in the case of making no distinction between the two pantographs and between the two overhead wires, they are designated by reference numerals 2 and 31, respectively. Note that alternating current may be supplied to the two overhead wires 2a and 2b.

The power collector 30 has the pantographs 31 and an actuator 3OA raising and lowering the pantographs 31, and the pantographs 31 are adapted to be driven between an operating position at which they receive electrical power from the overhead wires 2 as indicated by solid lines in FIG. 1 and a retracted position at which they receive no electrical power as indicated by two-dot chain lines in FIG. 1.

Also, there are provided also an ENG-ECU (an engine electronic control unit) 41 as an internal combustion engine control means for controlling the engine 20, the clutch 21, and the transmission 22, an M-ECU (a motor electronic control unit) 42 as a motor control means for controlling the motor 32, and an R-ECU (a power collector electronic control unit) 43 as a power collector control means for controlling the power collector 30. Further, there is provided an ECU (an electronic control unit) 40 as an integrated control means for carrying out integrated control of the ENG-ECU 41, the M-ECU 42, and the R-ECU 43.

The engine 20 is a diesel engine, and its fuel injection quantity is electronically controlled by the ENG-ECU 41 in response to an output request. The clutch 21 is adapted to be engaged and disengaged by a clutch actuator, not shown, and the transmission 22 is adapted to be a mechanical automatic transmission that is activated by a gear shift actuator, not shown, to select a shift gear to be used. These actuators are electronically controlled by the ENG-ECU 41 in response to a gear shift request, so that the clutch 21 is engaged and disengaged, and shift gears are changed.

A three-phase alternating current motor is used here as the motor 32, and its rotation state is electronically controlled by the M-ECU 42 in response to an output request. It should be noted that the motor 32 carries out regenerative operation as well as normal powering operation, and the M-ECU 42 has a function (a regeneration control means) 46 of carrying out regenerative control of the motor 32 so that regenerative energy is stored as electric energy in a battery (a power storage means) 47 when the vehicle is braked. It should be noted that electrical power stored in the battery 47 is emergently used for operation of the motor 32, for example, when a trouble occurs while the power collector 30 is collecting power.

The power collector 30 is capable of supplying electrical power to the motor 32 via a charge control circuit 44 and an inverter 45. Because the three-phase alternating current motor is used here as the motor 32, direct current collected by the power collector 30 is converted into alternating current by the inverter 45 and supplied to the motor 32. The charge control circuit 44 provides control to store in the battery 47 surplus electrical power that is not used by the motor 32 in electrical power collected by the power collector 30. It should be noted that the electrical power stored in the battery 47 can also be converted into alternating current by the inverter 45 and supplied to the motor 32.

It should be noted that the charge control circuit 44, the regeneration control means 46 of the M-ECU 42, and the motor 32 constitute an electric energy collector.

The ECU 40 as the integrated control means sets a vehicle driving mode and carries out integrated control of the ENG-ECU 41, the M-ECU 42, and the R-ECU 43 based on information from roads, GPS information, and so on received via a transmitting and receiving unit 48, output requests (including braking requests) from an accelerator pedal and a brake pedal, not shown, and selection information from a selection switch (a driving mode selection means) 50 that allows selection of a driving mode.

As vehicle driving modes, there are provided a motor driving mode (also called a trolley driving mode or a power collector driving mode) in which the vehicle is driven by only rotational driving force from the motor 32, and an internal combustion engine driving mode in which the vehicle is driven by only rotational driving force from the engine 20. The selection switch 50 allows a driver to select either of these driving modes, and also allows selection of an automatic selection mode in which a driving mode is automatically selected by the ECU 40.

When the automatic selection mode is selected using the selection switch 50, the ECU 40 as well acts as a driving mode selection means. In a situation where the road 1 is equipped with the overhead wires 2, and the vehicle 10 is running on a driving lane equipped with the overhead wires 2 and can collect power from the overhead wires 2, the motor driving mode is primarily selected. In a case where electrical power is especially needed in a situation where electrical power can be collected from the overhead wires 2, a combined driving mode is automatically selected. In a situation where electrical power cannot be collected from the overhead wires 2, the internal combustion engine driving mode is primarily selected. It should be noted that the ECU 40 can also select the combined driving mode (this is also included in the trolley driving mode or the power collector driving mode) in which the vehicle is driven by a combination of rotational driving force from the motor 32 and rotational driving force from the engine 20.

Whether or not electrical power is collectable from the overhead wires 2 can be determined using a sensor 49 such as a camera which is disposed in the vicinity of the pantographs 31 (here, just below the pantographs 31) and detects the presence of the overhead wires 2. When detection information is obtained form the sensor 49, it is determined that electrical power can be collected from the overhead wires 2, and when detection information is not obtained form the sensor 49, it is determined that electrical power cannot be collected from the overhead wires 2. The ECU 40 has a vehicle position determination means for determining whether or not the pantographs 31 are at positions where they can receive electrical power from the overhead wires 2.

The ECU 40 also has an overhead wire determination means for determining whether or not the overhead wires 2 are disposed in front of the road on which the vehicle 10 is running based on information from roads and GPS information inputted to the ECU 40. When the overhead wire determination means determines that the overhead wires 2 are not disposed in the area in front of the road on which the vehicle 10 is running in the driving mode using the motor 32 (the motor driving mode or the combined use driving mode), the ECU 40 automatically switches to the internal combustion engine driving mode irrespective of which driving mode is selected by the selection switch 50 before the vehicle 10 enters the area where the overhead wires 2 are not disposed.

It should be noted that when the vehicle position determination means determines that the pantographs 31 are at positions where they can receive electrical power from the overhead wires 2 in a case where the driving mode using the motor 32 is selected, the R-ECU 43 (the power collector control means) sets the pantographs 31 at the operating position to collect electrical power and supply the electrical power to the motor 32. Then, when the RPM of the motor 32 reaches an RPM set in advance, the R-ECU 43 sends an engine stop signal to the ECU 40 so as to stop the engine 20, and the ECU 40 stops the engine 20 via the ENG-ECU 41. Conversely, the operation of the engine 20 is continued until the RPM of the motor 32 reaches the RPM set in advance. On the other hand, in a case where the internal combustion engine driving mode not using the motor 32 is selected, the engine 20 is started if the engine 20 is at a standstill, and the actuator 30a is controlled to set the pantographs 31 at the retracted position so as to inhibit them from collecting electrical power.

Incidentally, a construction as shown in FIG. 3 can be considered as an operation system suitable for the hybrid vehicle with the power collector according to the present embodiment. Referring to FIG. 3, reference numeral 1A designates a freeway such as an expressway, and reference numeral 1B designates a connecting road or an ordinary road for entry into and exit from the freeway 1A. A driving lane as part of the freeway 1A is equipped with the overhead wires 2. Note that reference numeral 3 designates a post for supporting the overhead wires 2. On roadsides of the roads 1A and 1B, transmitting and receiving units 4 are disposed as necessary to carry out road-to-vehicle communication with the running vehicle 10. The transmitting and receiving units 4 are connected to an information center 5. At the information center 5, information on the vehicle's 10 entry and exit to and from the freeway 1A equipped with the overhead wires 2 is collected advance from communication information obtained from the vehicle 10 on the roads 1A and 1B via the transmitting and receiving units 4, and information on a request for use of overhead wires (power request information) is sent to a power feed control unit (a power feed control means) 6. The power feed control unit 6 is adapted to control the state of power feeding from to the overhead wires 2 in each part based on the usage request information.

Because the hybrid vehicle with the power collector and the operation system therefor according to the first embodiment of the present invention are constructed as described above, mode switching can be performed, for example, as shown in FIG. 4 when the hybrid vehicle with the power collector is running.

First, it is assumed that the vehicle 10 is running in the internal combustion engine driving mode on the road 1 which is not equipped with the overhead wires 2.

Here, on condition that the driving mode using the motor 32 (the trolley driving mode or the power collector driving mode) or the automatic mode is selected using the selection switch 50, the ECU 40 determines whether or not the driving mode using the motor 32 (the trolley driving mode or the power collector driving mode) is selectable using the selection switch 50 (step S1). When the vehicle position determination means determines that the own vehicle 10 can collect power from the overhead wires 2, and the overhead wire determination means determines that the overhead wires 2 are disposed in front of the vehicle 10 (a predetermined range in front of the vehicle 10), it is determined the driving mode using the motor 32 (the trolley driving mode or the power collector driving mode) is selectable. When either of the determination results is negative, it is determined that the driving mode using the motor 32 is not selectable.

When the trolley driving mode (the motor driving mode) is selectable, the pantographs 31 are raised to the operating position (step S2), electrical power collected by the pantographs 31 is supplied to the driving motor 32 (step S3), it is determined whether or not the RPM of the driving motor 32 has become equal to or greater than the RPM set in advance (step S4). When the RPM of the driving motor 32 has become equal to or greater than the RPM set in advance, it is determined that the motor 32 is enabled to carry out powering, and then engine 20 is stopped so as to make a transition to trolley driving (motor driving) (step S5).

On the other hand, when it is determined that the trolley driving mode (the motor driving mode) is not selectable during the trolley driving (the motor driving), the engine 20 being at a standstill is started (step S6), the pantographs 31 are lowered to the retracted position (S7), and the driving motor 32 is stopped to make a transition to engine driving (internal combustion engine driving).

Thus, according to the hybrid vehicle with the power collector of the present embodiment, because the first driving force transmission system that transmits rotational driving force of the engine 20 to the drive wheels 26 and the second driving force transmission system that transmits rotational driving force of the motor 32 to the drive wheels 36 are constructed completely separately with respect to each of the drive wheels of the rear two axles, the hybrid vehicle with the power collector can be constructed merely by adding the second drive system comprised of the power collector 30, the driving motor 32, and so on as well as second driving force transmission systems 33 and 34 to a general vehicle that rotatively drives the drive wheels 26 by only rotational driving force of the engine 20 and without making any modifications to the first drive system of the general vehicle.

As a result, the hybrid vehicle with the power collector can be manufactured at low cost by using many of components of a general engine-driven vehicle. It should be noted that in the case of a general engine-driven vehicle, there may be a case where a propeller shaft is provided between the first final reduction gear 24 and the second final reduction gear 34 so as to transmit rotational driving force of the engine 20 to the drive wheels 36. In this case, a final reduction gear 27 of a second embodiment, described later, is suitably used as the first final reduction gear.

Moreover, because the ECU 40 carries out integrated control of the ENG-ECU (the internal combustion engine control means) 41, the M-ECU (the motor control means) 42, and the R-ECU (the power collector control means) 43, the engine 20 and the driving motor 32 can be appropriately and smoothly used as the situation demands, and also, an existing computer unit or existing computer software can be used as the ENG-ECU (the internal combustion engine control means) 41, resulting in cost reduction.

Further, because the ECU 40 stops the engine 20 being operation on condition that the RPM of the driving motor 32 has become equal to or greater than the predetermined RPM set in advance, rotational driving force of the driving motor 32 is secured when the engine 20 is stopped, and this prevents interruption of driving force for driving the vehicle 10.

Moreover, when it is determined that the front road 1 is not equipped with the overhead wires 2 during driving in the driving mode using the driving motor 32, the driving mode is automatically switched to the internal combustion engine driving mode irrespective of which driving mode is selected before the vehicle 10 enters the area unequipped with the overhead wires 2, and thus rotational driving force of the engine is secured even when electrical power to the driving motor 32 cannot be secured, and in this case as well, interruption of driving force for driving the vehicle can be prevented.

Moreover, because the pantographs 31 can be automatically set at the retracted position and the operating position in an appropriate manner according to whether or not the pantographs 31 are at positions where they can receive electrical power from the overhead wires 2, and as a result, burdens on the driver can be reduced.
Further, because the electric energy recovery unit recovers braking energy of the vehicle and stores the same as electric energy in the battery 47, and also collects surplus electric energy that is not used for driving in electrical power received from the overhead wires 2 and stores the same in the battery 47. As a result, energy can be used more effectively.
Moreover, according to the operation system for the hybrid vehicle with the power collector of the present embodiment, because the power feed control unit 6 acquires information on a request for use of the overhead wires from vehicles through road-to-vehicle communication between both the overhead wire-equipped road 1A and the overhead wire-unequipped road 1B and vehicles running on these roads and capable of using the overhead wires, and based on the information, the state of power feeding to the overhead wires 2 is controlled, electrical power can be fed to the overhead wires 2 in an appropriate manner, and the vehicle 10 can run while reliably receiving electrical power from the overhead wires 2. Thus, motor driving can be continued to the greatest extent practicable, and exhaust gas emission and noise resulting from engine driving can be reduced.
Also, when the operation system for the hybrid vehicle with the power collector of the present embodiment is applied to large commercial vehicles such as trucks and buses, the cost of installing power collectors can be substantially reduced by increasing the usage frequencies thereof because in many cases, the vehicles drive over a long distance on expressways that can be easily equipped with overhead wires, and moreover, because travel businesses or transport businesses own the vehicles, proper maintenance of the power collectors can be performed. Therefore, the application to the large-sized commercial vehicles is suitable for spreading the use of hybrid vehicle with the power collector.

Next, a description will be given of a second embodiment of the present invention.
FIGS. 5A and 5B are skeleton diagrams showing a construction of a drive system of a hybrid vehicle with a power collector according to the present embodiment, in which FIG. 5A shows an overall construction thereof, and FIG. 5B shows a construction of a final reduction gear thereof.
As shown in FIG. 1, the vehicle according to the present embodiment is constructed as a rear-one axle vehicle, and constructed such that a final reduction gear 27 is mounted on a rear axle 25, and rotational driving force from the engine 20 is inputted to the final

reduction gear 27 via the clutch 21, the transmission 22, and the propeller shaft 23. Also, rotational driving force from the motor 32 is inputted to the final reduction gear 27 via the propeller shaft 33.

As shown in FIG. 5B, the final reduction gear 27 is constructed such that a front input shaft 27a joined to the front propeller shaft 23 and an input shaft 27b joined to the rear propeller shaft 33 are coaxially arranged in opposed relation to each other, and the input shafts 27A and 27B are inputted to a drive pinion gear 28 via a gear. The drive pinion gear 28 is constructed such that output shafts 27L and 27R are coaxially arranged in opposed relation to each other via a differential gear incorporated in a differential case 29 integral with a ring gear. The left output shaft 27L is joined to the drive shaft 25L of the left drive wheel 26L, and the right output shaft 27R is joined to the drive shaft 25R of the right drive wheel 26R.

The one which is applied to the first final reduction gear (the front final reduction gear) when the respective drive wheels 26 and 36 of the rear two axles are driven by the engine 20 in the rear two-axle vehicle according to the first embodiment can also be used as the final reduction gear 27 described above.

Parts of the present embodiment other than the above described parts are identical in construction to those of the first embodiment, and therefore, description thereof is omitted.

Thus, the clutch 21, the transmission 22, the propeller shaft 23, and the input shaft 27a of the final reduction gear 27 constitute a first driving force transmission system that transmits rotational driving force of the engine 20 to the drive wheels 26, and the first driving force transmission system and the engine 20 constitute a first drive system.

Also, the propeller shaft 33 and the input shaft 27b of the final reduction gear 27 constitute a second driving force transmission system that transmits rotational driving force of the engine 32 to the drive wheels 26, and the second driving force transmission system, the power collector 33, and the motor 32 constitute a second drive system.

Because the hybrid vehicle with the power collector of the second embodiment of the present invention is constructed as described above, substantially the same effects as those in the first embodiment can be obtained, and because it is arranged such that the common drive wheels 26 are driven by the engine 20 and the motor 32, the vehicle can be manufactured at low cost by minimal component replacement using the existing final reduction gear 27 and addition of the second drive system on a general vehicle driven by only the engine 20.

While the present invention has been described with reference to the embodiments, it is to be understood that the invention is not limited to the embodiments, and various changes may be made as appropriate to the embodiments without departing from the spirit and scope of the present invention.

For example, although in the above described embodiments, the present invention is applied to heavy trucks, the present invention may also be applied to a variety of other vehicles although the present invention is suitable for large commercial vehicles such as trucks and buses.
Moreover, although in the above described embodiments, the overhead wires 2 are provided above the posts 3, the overhead wires 2 may be laid on the road. In this case, the power collector 30 is provided in a lower part of the vehicle 10.

To increase the frequency of running on electrical power from the viewpoint of reducing the consumption of fossil fuels and the emission of exhaust gases including CO_2, the present invention can be widely applied to vehicles and vehicle operation systems, and in particular, the present invention is suitably used for large commercial vehicles such as trucks and buses to construct a new vehicle operation system, and can be used in large commercial vehicle manufacturing industries, vehicle driving control industries, and so on.

List of reference numbers

10	Hybrid vehicle with power collector (vehicle)
25, 35	Rear axle
26, 36	Drive wheel
20	Engine (internal combustion engine for driving)
21	Clutch
22	Transmission
23, 33	Propeller shaft
24, 27, 34	Final reduction gear
28	Drive pinion gear
29	Differential case integral with ring gear
30	Power collector
31, 31a, 31b	Pantograph as power collection unit (trolley pole)
32	Electric motor
2, 2a, 2b	Overhead wire
40	ECU as integrated control means (electronic control unit)
41	ENG-ECU as internal combustion engine controlling means (engine controlling electronic control unit)
42	M-ECU as motor controlling means (motor controlling electronic control unit)
43	R-ECU as power collector controlling means (power collector controlling electronic control unit)
44	Charge control circuit
45	Inverter
46	Regenerative control means
47	Battery (storage means)
48	Transmitting and receiving unit
50	Selection switch (driving mode selection means)

Claims

1. A hybrid vehicle with a power collector, comprising:

a first drive system comprising a driving internal combustion engine, which drives drive wheels, and a first driving force transmission system that transmits rotational driving force of the driving internal combustion engine to the drive wheels;

a second drive system comprising a driving motor, which rotates on electrical power received by the power collector and drives drive wheels, and a second driving force transmission system that is different from the first driving force transmission system and transmits rotational drive force of the driving motor to the drive wheels; and

integrated control means for carrying out integrated control of said first driving system and said second driving system.

2. A hybrid vehicle with a power collector according to claim 1, wherein first drive wheels driven by said first driving force transmission system and second drive wheels driven by said second driving force transmission system are separate drive wheels.

3. A hybrid vehicle with a power collector according to claim 1, wherein first drive wheels driven by said first driving force transmission system and second drive wheels driven by said second driving force transmission system are common drive wheels, said first driving force transmission system is connected to a first input shaft of a final reduction gear for the common drive wheels, and said second driving force transmission system is connected to a second input shaft of the final reduction gear for the common drive wheels.

4. A hybrid vehicle with a power collector according to any of claims 1 to 3, comprising:

internal combustion engine control means for controlling the driving internal combustion engine;

power collector control means for controlling the power collector; and

motor control means for controlling the driving motor,

wherein said integrated control means carries out integrated control of said internal combustion engine control means, said power collector control means, and said motor control means.

5. A hybrid vehicle with a power collector according to claim 4, wherein

as vehicle driving modes, there are provided a motor driving mode in which the vehicle is driven by only rotational driving force of the driving motor, and an internal combustion engine driving mode in which the vehicle is driven by only rotational driving force of the internal combustion engine,

the vehicle comprises driving mode selection means for selecting any of the driving modes,

when said driving mode selection means switches from the driving mode using the driving internal combustion engine to the motor driving mode, said integrated control means stops the driving internal combustion engine being in operation on condition that an RPM of the driving motor becomes equal to or more than a predetermined RPM set in advance.

6. A hybrid vehicle with a power collector according to claim 5, further comprising overhead wire determination means for determining whether the overhead wires are installed in front of the road on which the vehicle is running,

wherein when said overhead wire determination means determines that the overhead wires are not installed in front of the vehicle, said integrated control means automatically switches to the internal combustion engine driving mode irrespective of which driving mode is selected by said driving mode selection means before the vehicle enters the area unequipped with the overhead wires.

7. A hybrid vehicle with a power collector according to claim 6, further comprising vehicle position determination means adapted to be movable between an operating position at which electrical power is received from the overhead wires and a retracted position at which electrical power is not received from the overhead wires, for determining whether the power collector is at such a position as to be able to receive electrical power from the overhead wires,

wherein when said vehicle position determination means determines that the power collector is at such a position as to be able to receive electrical power from the overhead wires in a case where said driving mode selection means selects the driving mode using the driving motor, said power collector control means sets the power collector at the operating position so as to collect power, and in a case where said driving mode selection means selects the internal combustion engine driving mode, sets the power collector at the retracted position so as not to collect power.

8. A hybrid vehicle with a power collector according to any of claims 1 to 7, comprising:

a storage unit that, in a case where electrical power is not received from the overhead wires, temporarily supplies electrical power to the driving motor and enables the driving motor to run; and

an energy recovery unit that recovers braking energy of the vehicle and stores the same as electric energy in said storage unit, and also collects surplus electric energy that is not used for driving in electrical power received from the overhead wires and stores the same in said storage unit.

9. An operation system for operating a hybrid vehicle with a power collector according to any of claims 1 to 8, comprising:

an overhead wire-equipped road having a driving lane equipped with the overhead wires;

an overhead wire-unequipped connecting road unequipped with the overhead wires and connecting to said overhead wire-equipped road;

road-to-vehicle communication means for carrying out communication between both said overhead wire-equipped road and said overhead wire-unequipped road and the hybrid vehicle with the power collector and vehicles capable of using the overhead wires which are running on any of the roads; and

power feed control means for acquiring information on a request for use of the overhead wires from each of the vehicles via said road-to-vehicle communication means, and controlling a state of power feeding to the overhead wires based on the information.

Fig.1

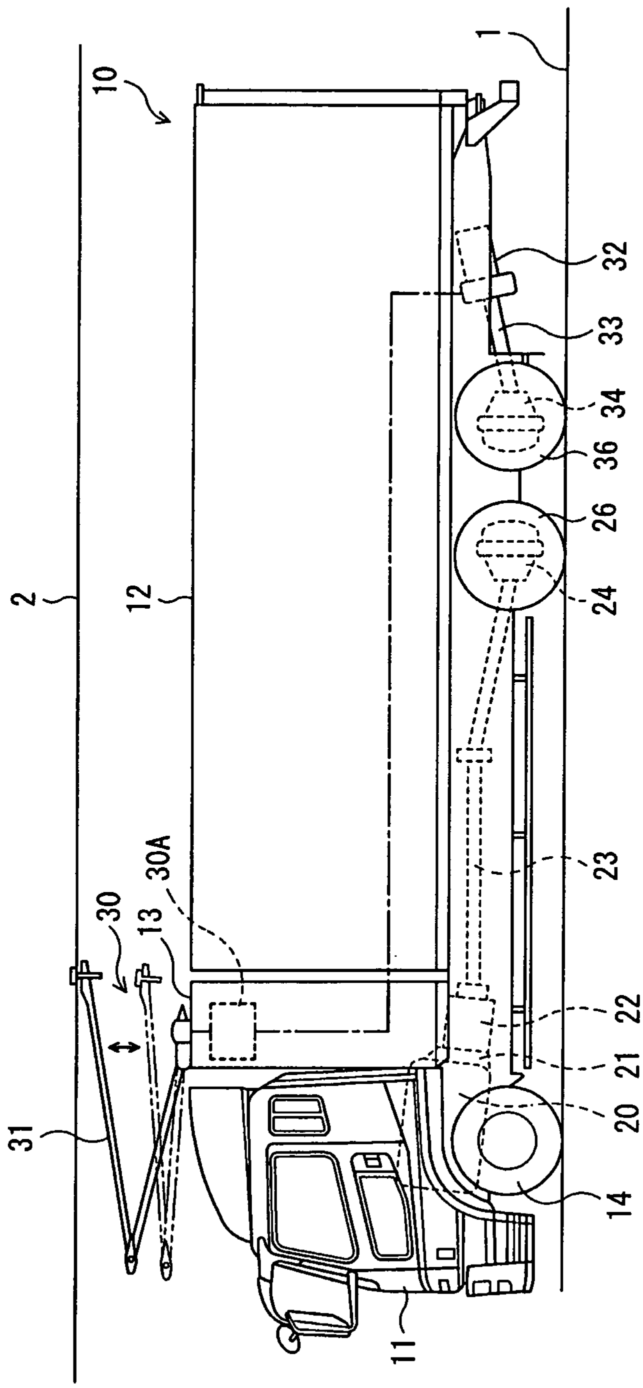

Fig.2

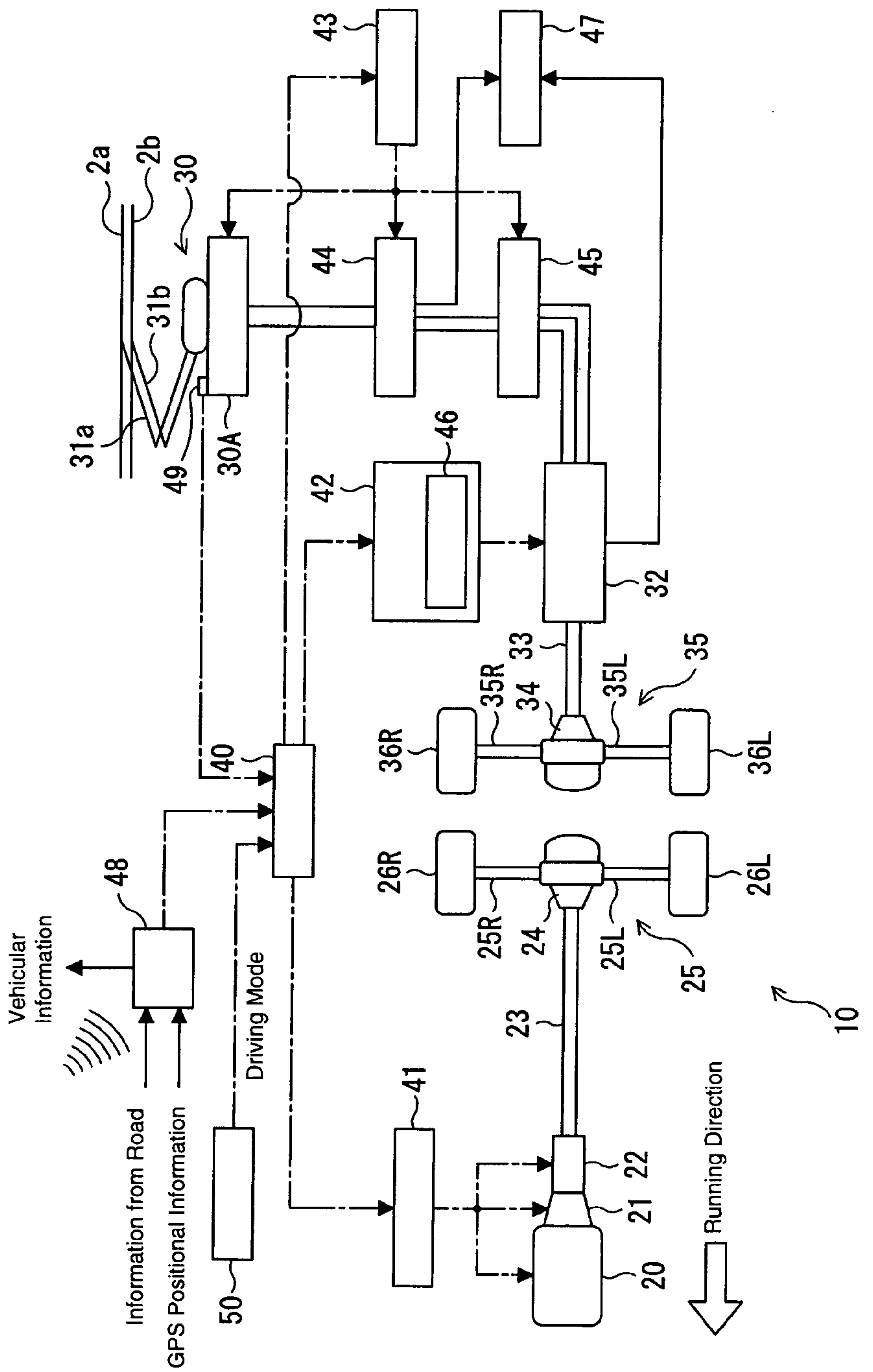
2a
2b
30
31b
31a
49
30A
43
47
44
45
42
46
32
33
34
35
35R
35L
36R
36L
40
48
Vehicular Information
Information from Road
GPS Positional Information
Driving Mode
50
41
26R
26L
25R
25L
24
25
23
22
21
20
10
Running Direction

Fig.3

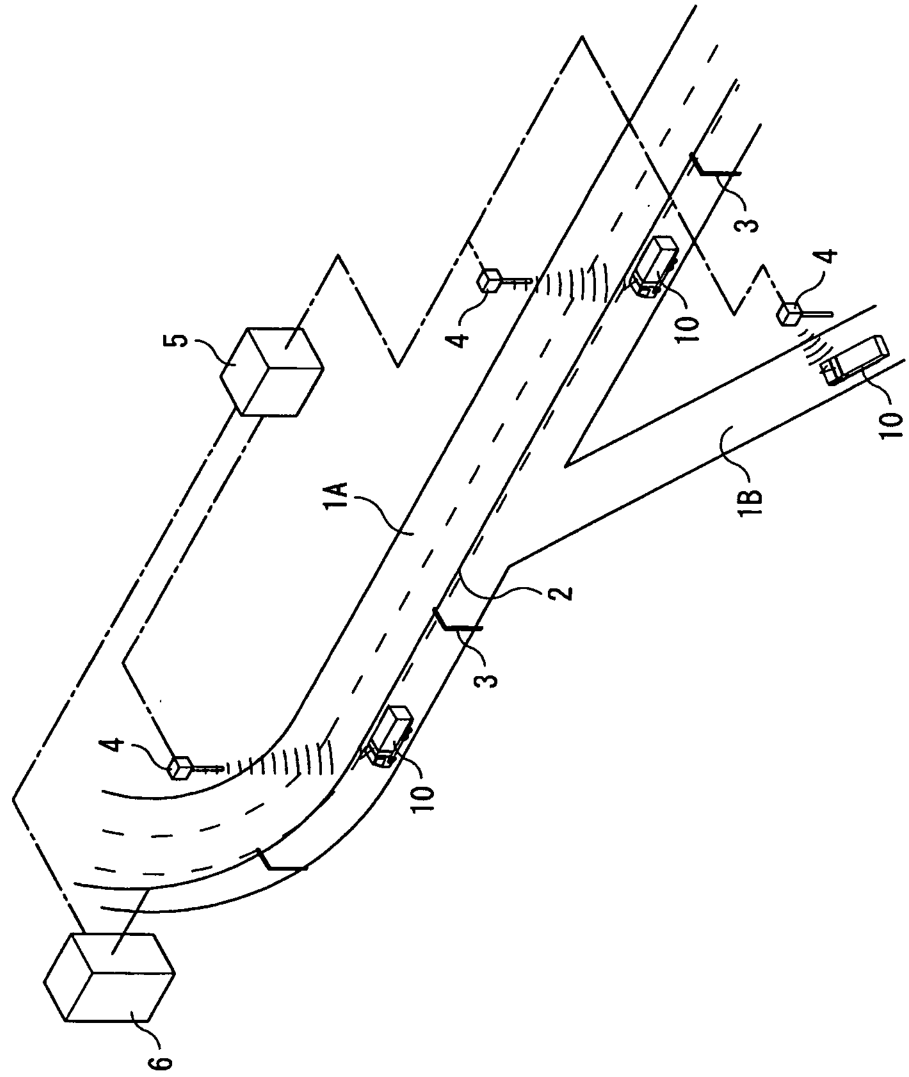

Fig.4

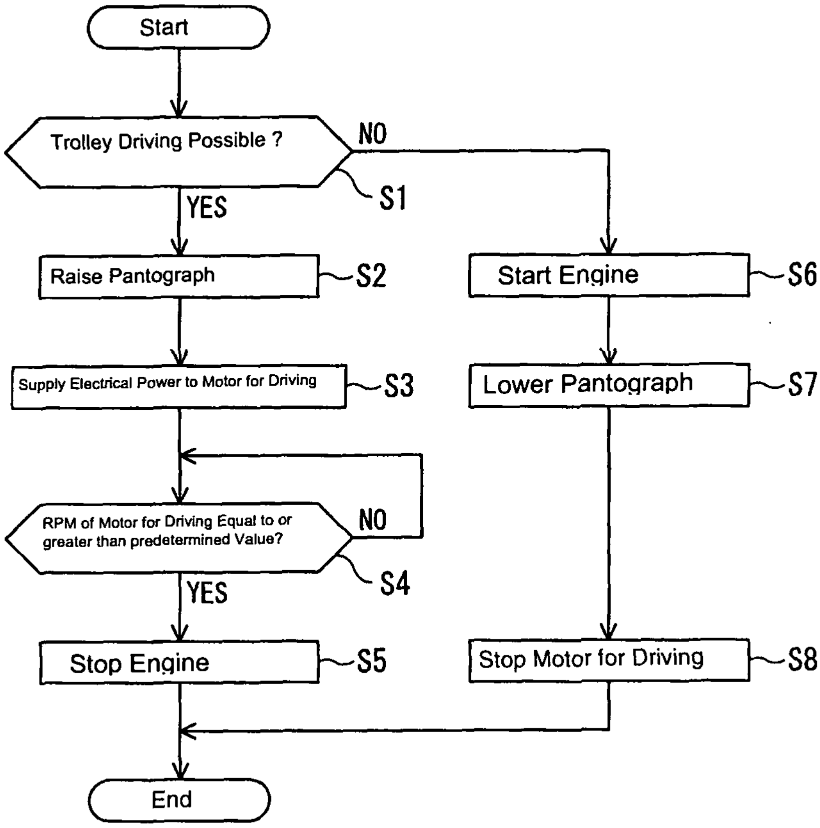
Start
Trolley Driving Possible ?
NO
S1
YES
Raise Pantograph
S2
Supply Electrical Power to Motor for Driving
S3
RPM of Motor for Driving Equal to or greater than predetermined Value?
NO
S4
YES
Stop Engine
S5
Start Engine
S6
Lower Pantograph
S7
Stop Motor for Driving
S8
End

Fig.5

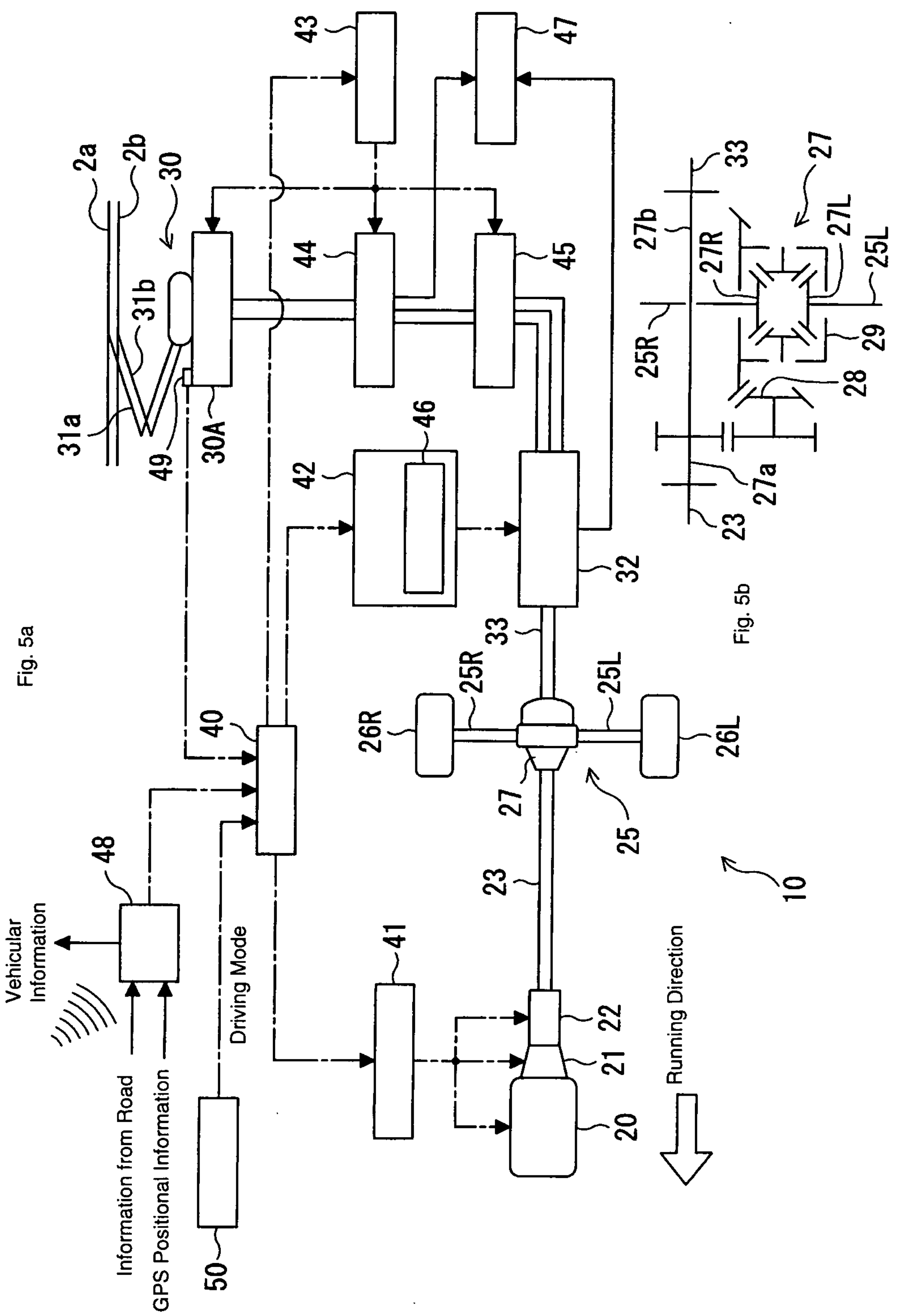
Fig. 5a
Fig. 5b
Vehicular Information
Information from Road
GPS Positional Information
Driving Mode
Running Direction

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/002098

A CLASSIFICATION OF SUBJECT MATTER
INV. B60K6/52 B60W10/06 B60W10/08 B60W20/00 B60K6/48
B60K6/485

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

B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60K B60W

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

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

EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X Y	DE 23 45 018 A1 (SAVIEM) 4 April 1974 (1974-04-04) the whole document -----	1,3,4,8 5
X	GB 2 013 149 A (BOSCH GMBH ROBERT) 8 August 1979 (1979-08-08) the whole document -----	1,3,4
X	DE 30 45 114 A1 (DAIMLER BENZ AG [DE]) 3 June 1982 (1982-06-03) the whole document -----	1,2
X	FR 2 799 697 A1 (TONARELLI GIOVANNI [FR]) 20 April 2001 (2001-04-20) the whole document -----	1-3
	-/-	

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 May 2010	30/07/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P B 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel (+31-70) 340-2040, Fax (+31-70) 340-3016	Plenk, Rupert

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/002098

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
Y	DE 32 31 882 A1 (VOLKSWAGENWERK AG [DE]) 1 March 1984 (1984-03-01) the whole document	5
Y	WO 2009/007879 A2 (GIURCA LIVIU GRIGORIAN [RO]) 15 January 2009 (2009-01-15) pages 6-10; figures 1-10	5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/002098

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons

1 [ ] Claims Nos
because they relate to subject matter not required to be searched by this Authority, namely

2 [ ] Claims Nos
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be earned out, specifically

3 [ ] Claims Nos
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6 4(a)

Box No. III Observations **where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application as follows

see additional sheet

1 [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims

2 [ ] As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees

3 [ ] As only some of the required additional search fees were timely paid by the applicant this international search report covers only those claims for which fees were paid, specifically claims Nos

4 [X] No required additional search fees were timely paid by the applicant Consequently, this international search report is restricted to the invention first mentioned in the claims, it is covered by claims Nos

1-5, 8

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable the payment of a protest fee

[ ] The additional search fees were accompanied by the applicant s protest but the applicable protest fee was not paid within the time limit specified in the invitation

[ ] No protest accompanied the payment of additional search fees

FURTHER INFORMATION CONTINUED FROM POT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-5, 8

Hybrid vehicle design with first and second drive system comprising an engine or a motor, respectively, as well as first and second transmission systems different from each other

1.1. claim: 5

mode switch based on motor speed

1.2. claim: 8

regenerative braking

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2. claims: 6, 7, 9

hybrid vehicle with determination of whether overhead wires are present using e.g. gps or road to vehicle communication

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/002098

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WO 2009007879 A2	15-01-2009	NONE	