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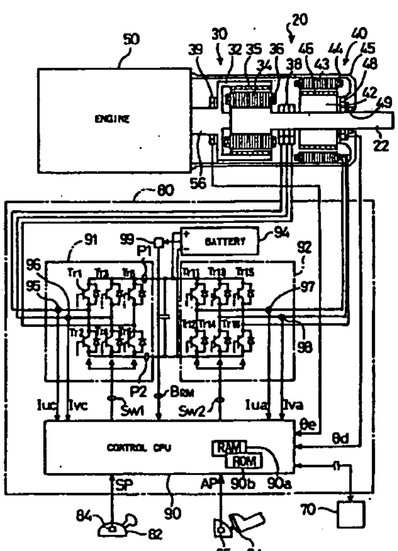
(54) Hybrid vehicle power output apparatus and method of controlling the same at engine idle

(57) A power output apparatus (20) of the invention includes an engine (50), a clutch motor (30), an assist motor (40), and a controller (80) for controlling the clutch motor (30) and the assist motor (40). In response to an engine stop signal to stop operation of the engine (50), the controller (80) successively lowers a torque command value of the clutch motor (30) and a target engine torque and a target engine speed of the engine (50) to make the engine (50) kept at an idle. The assist motor (40) is controlled to use power stored in a battery (94) and make up for a decrease in torque output to a drive shaft (22) accompanied by the decrease in torque command value of the clutch motor (30). When the engine (50) falls in the idling state, supply of fuel into the engine (50) is stopped to terminate operation of the engine (50). In this state, the drive shaft (22) is driven and operated only by the torque of the assist motor (40), which is generated by the power stored in the battery (94). This control procedure can stop the engine (50) without varying the torque output to the drive shaft (22).

Fig. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention generally relates to a power output apparatus and a method of controlling the same. More specifically, the invention pertains to a power output apparatus for efficiently transmitting or outputting a power from an engine to a drive shaft and a method of controlling such a power output apparatus.

Description of the Related Art

In proposed power output apparatuses mounted on a vehicle, an output shaft of an engine is electromagnetically connected to a drive shaft linked with a rotor of a motor via an electromagnetic coupling, so that power of the engine is transmitted to the drive shaft (as disclosed in, for example, JAPANESE PATENT LAYING-OPEN GAZETTE No. 53-133814). When the revolving speed of the motor, which starts driving the vehicle, reaches a predetermined level, the proposed power output apparatus supplies an exciting current to the electromagnetic coupling in order to crank the engine, and subsequently carries out fuel injection into the engine as well as spark ignition, thereby starting the engine and enabling the engine to supply power. When the vehicle speed is lowered and the revolving speed of the motor decreases to or below the predetermined level, on the other hand, the power output apparatus stops the supply of exciting current to the electromagnetic coupling as well as fuel injection into the engine and spark ignition, thereby terminating operation of the engine.

In the known power output apparatus described above, the torque output to the drive shaft is significantly varied at the time of starting and stopping the engine. This results in a rough ride. At the time of starting the engine, the torque output from the motor is used to crank the engine, and the torque output to the drive shaft is decreased by the amount required for cranking. At the time of stopping the engine, the supply of exciting current is stopped while the power from the engine is transmitted to the drive shaft via the electromagnetic coupling, and the torque output to the drive shaft is decreased by the amount of power transmitted from the engine. Such a fall in output torque occurs unexpectedly since the driver does not determine the time of starting or stopping the engine. Compared with the expected variation, the unexpected variation in output torque to the drive shaft gives a greater shock to the driver, thereby resulting in a rough drive.

SUMMARY OF THE INVENTION

The object of the invention is thus to provide a power output apparatus which can transmit or output a power from an engine to a drive shaft at a high efficiency.

Another object of the invention is to stop the engine without varying the torque output to the drive shaft, and a method of controlling such a power output apparatus.

The above and other related objected are realized at least partly by a first power output apparatus for outputting a power to a drive shaft. The first power output apparatus comprises: an engine having an output shaft; engine driving means for driving the engine; a first motor comprising a first rotor connected with the output shaft of the engine and a second rotor connected with the drive shaft, the second rotor being coaxial to and rotatable relative to the first rotor, whereby power is transmitted between the output shaft of the engine and the drive shaft via an electromagnetic connection of the first rotor and the second rotor; a first motor-driving circuit for controlling degree of electromagnetic connection of the first rotor and the second rotor in the first motor and regulating rotation of the second rotor relative to the first rotor; a second motor connected with the drive shaft; a second motor-driving circuit for driving and controlling the second motor; a storage battery being charged with power regenerated by the first motor via the first motor-driving circuit, being charged with power regenerated by the second motor via the second motor-driving circuit, discharging power required to drive the first motor via the first motor-driving circuit, and discharging power required to drive the second motor via the second motor-driving circuit; power decrease signal detection means for detecting power decrease signal to decrease power output from the engine; driving circuit control means for, when the power decrease signal detection means detects the power decrease signal, controlling the first motor-driving circuit in response to the signal to gradually decrease the degree of electromagnetic connection of the first rotor with the second rotor in the first motor and controlling the second motor-driving circuit to enable the second motor to use power stored in the storage battery and make up for a decrease in power transmitted by the first motor accompanied by the decrease in degree of electromagnetic connection; and engine power decreasing means for controlling the engine driving means to decrease the power output from the engine with the decrease in the degree of electromagnetic connection of the first rotor with the second rotor accomplished by the driving circuit control means.

The first power output apparatus of the invention can efficiently transmit or output the power from the engine to the drive shaft by the functions of the first and the second motors. In response to the power decrease signal, the degree of electromagnetic coupling of the first rotor with the second rotor in the first motor is gradually decreased. The second motor is then controlled to make up for the decrease in transmitted power, which is accompanied by the decrease in degree of electromagnetic coupling, with the power stored in the secondary cell. This structure effectively decreases the power output from the engine without varying the power output to the drive shaft.

In accordance with one aspect of the first power output apparatus, the power decrease signal detection means comprises means for detecting an engine stop signal to stop operation of the engine, and the engine power decreasing means comprises means for controlling the engine driving means to stop supply of fuel into the engine and terminate operation of the engine when the driving circuit control means releases the electromagnetic connection of the first rotor with the second rotor in the first motor.

In accordance with one aspect, the present invention is directed to a second power output apparatus for outputting a power to a drive shaft. The second power output apparatus comprises: an engine having an output shaft; engine driving means for driving the engine; a complex motor comprising a first rotor connected with the output shaft of the engine, a second rotor connected with the drive shaft being coaxial to and rotatable relative to the first rotor, and a stator for rotating the second rotor, the first rotor and the second rotor constituting a first motor, the second rotor and the stator constituting a second motor; a first motor-driving circuit for driving and controlling the first motor in the complex motor; a second motor-driving circuit for driving and controlling the second motor in the complex motor; a storage battery being charged with power regenerated by the first motor via the first motor-driving circuit, being charged with power regenerated by the second motor via the second motor-driving circuit, discharging power required to drive the first motor via the first motor-driving circuit, and discharging power required to drive the second motor via the second motor-driving circuit; power decrease signal detection means for detecting power decrease signal to decrease power output from the engine; driving circuit control means for, when the power decrease signal detection means detects the power decrease signal, controlling the first motor-driving circuit in response to the signal to gradually decrease the degree of electromagnetic connection of the first rotor with the second rotor in the first motor and controlling the second motor-driving circuit to enable the second motor to use power stored in the storage battery and make up for a decrease in power transmitted by the first motor accompanied by the decrease in degree of electromagnetic connection; and engine power decreasing means for controlling the engine driving means to decrease the power output from the engine with the decrease in the degree of electromagnetic connection of the first rotor with the second rotor accomplished by the driving circuit control means.

The second power output apparatus of the invention can efficiently transmit or output the power from the engine to the drive shaft by the functions of the first motor, which consists of the first rotor and the second rotor of the complex motor, and the second motor, which consists of the second rotor and the stator. In response to the power decrease signal, the degree of electromagnetic coupling of the first rotor with the second rotor in the first motor is gradually decreased. The second motor is then controlled to make up for the decrease in transmitted power, which is accompanied by the decrease in degree of electromagnetic coupling, with the power stored in the secondary cell. This structure effectively decreases the power output from the engine without varying the power output to the drive shaft. The structure including the first motor and the second motor integrally joined with each other realizes a compact power output apparatus.

In accordance with one aspect of the second power output apparatus, the power decrease signal detection means comprises means for detecting an engine stop signal to stop operation of the engine, and the engine power decreasing means comprises means for controlling the engine driving means to stop supply of fuel into the engine and terminate operation of the engine when the driving circuit control means releases the electromagnetic connection of the first rotor with the second rotor in the first motor.

In accordance with another aspect, the invention is also directed to a third power output apparatus for outputting a power to a drive shaft. The third power output apparatus comprises: an engine having an output shaft; engine driving means for driving the engine; a first motor comprising a first rotor connected with the output shaft of the engine and a second rotor connected with the drive shaft, the first motor being coaxial to and rotatable relative to the first rotor, whereby power is transmitted between the output shaft of the engine and the drive shaft via an electromagnetic connection of the first rotor and the second rotor; a first motor-driving circuit for controlling degree of electromagnetic connection of the first rotor and the second rotor in the first motor and regulating rotation of the second rotor relative to the first rotor; a second motor connectied with the output shaft of the engine; a second motor-driving circuit for driving and controlling the second motor; a storage battery being charged with power regenerated by the first motor via the first motor-driving circuit, being charged with power regenerated by the second motor via the second motor-driving circuit, discharging power required to drive the first motor via the first motor-driving circuit, and discharging power required to drive the second motor via the second motor-driving circuit; power decrease signal detection means for detecting power decrease signal to decrease power output from the engine; engine power decreasing means for, when the power decrease signal detection means detects the power decrease signal, controlling the engine driving means in response to the signal to gradually decrease the power output from the engine; and driving circuit control means for controlling the first motor-driving circuit and the second motor-driving circuit to enable the first motor and the second motor to use power stored in the storage battery and make up for the decrease in power output from the engine accomplished by the engine power decreasing means.

The third power output apparatus of the invention can efficiently transmit or output the power from the engine to the drive shaft by the functions of the first and the second motors. In response to the power decrease signal, the power output from the engine is gradually decreased. The first motor and the second motor are then controlled to make up for the decrease in power output from the engine with the power stored in the secondary cell. This structure effectively decreases the power output from the engine without varying the power output to the drive shaft.

In accordance with one aspect of the third power output apparatus, the driving circuit control means comprises meane for controlling the first motor-driving circuit to enable the first motor to make up for a decrease in revolving speed of the output shaft of the engine among the decrease in power output from the engine, and controlling the second motor-driving circuit to enable the second motor to make up for a decrease in torque among the decrease in power output from the engine. In this structure, the power decrease signal detection means comprises meane for detecting an engine stop signal to stop operation of the engine, and the engine power decreasing means comprises meane for controlling the engine driving means to stop supply of fuel into the engine and terminate operation of the engine when the power output from the engine becomes equal to zero.

In accordance with still another aspect, the invention also provides a fourth power output apparatus for outputting a power to a drive shaft. The fourth power output apparatus comprises: an engine having an output shaft; engine driving means for driving the engine; a complex motor comprising a first rotor connected with the output shaft of the engine, a second rotor connected with the drive shaft being coaxial to and rotatable relative to the first rotor, and a stator for rotating the first rotor, the first rotor and the second rotor constituting a first motor, the first rotor and the stator constituting a second motor; a first motor-driving circuit for driving and controlling the first motor in the complex motor; a second motor-driving circuit for driving and controlling the second motor in the complex motor;

a storage battery being charged with power regenerated by the first motor via the first motor-driving circuit, being charged with power regenerated by the second motor via the second motor-driving circuit, discharging power required to drive the first motor via the first motor-driving circuit, and discharging power required to drive the second motor via the second motor-driving circuit; power decrease signal detection means for detecting power decrease signal to decrease power output from the engine; engine power decreasing means for, when the power decrease signal detection means detects the power decrease signal, controlling the engine driving means in response to the signal to gradually decrease the power output from the engine; and driving circuit control means for controlling the first motor-driving circuit and the second motor-driving circuit to enable the first motor and the second motor to use power stored in the storage battery and make up for the decrease in power output from the engine accomplished by the engine power decreasing means.

The fourth power output apparatus of the invention can efficiently transmit or output the power from the engine to the drive shaft by the functions of the first motor, which consists of the first rotor and the second rotor of the complex motor, and the second motor, which consists of the first rotor and the stator. In response to the power decrease signal, the power output from the engine is gradually decreased. The first motor and the second motor are then controlled to make up for the decrease in power output from the engine with the power stored in the secondary cell. This structure effectively decreases the power output from the engine without varying the power output to the drive shaft. The structure including the first motor and the second motor integrally joined with each other realizes a compact power output apparatus.

In accordance with one aspect of the fourth power output apparatus,the driving circuit control means comprises means for controlling the first motor-driving circuit to enable the first motor to make up for a decrease in revolving speed of the output shaft of the engine among the decrease in power output from the engine, and controlling the second motor-driving circuit to enable the second motor to make up for a decrease in torque among the decrease in power output from the engine. In this structure,the power decrease signal detection means comprises means for detecting an engine stop signal to stop operation of the engine, and the engine power decreasing means comprises means for controlling the engine driving means to stop supply of fuel into the engine and terminate operation of the engine when the power output from the engine becomes equal to zero.

The above objects are also realized at least partly by a first method of controlling a power output apparatus for outputting a power to a drive shaft. The first method comprises the steps of: (a) providing an engine having an output shaft; engine driving means for driving the engine; a first motor comprising a first rotor connected with the output shaft of the engine and a second rotor connected with the drive shaft, the first motor being coaxial to and rotatable relative to the first rotor, whereby power is transmitted between the output shaft of the engine and the drive shaft via an electromagnetic connection of the first rotor and the second rotor; a second motor connected with the drive shaft; and a storage battery being charged with power regenerated by the first motor, being charged with power regenerated by the second motor, discharging power required to drive the first motor, and discharging power required to drive the second motor; (b) detecting power decrease signal to decrease power output from the engine; (c) controlling the first motor in response to the power decrease signal, to gradually decrease the degree of electromagnetic connection of the first rotor with the second rotor in the first motor; (d) controlling the second motor to enable the second motor to use power stored in the storage battery and make up for a decrease in power transmitted by the first motor accompanied by the decrease in degree of electromagnetic connection; and (e) controlling the engine driving means to decrease the power output from the engine with the decrease in degree of electromagnetic connection of the first rotor with the second rotor accomplished in the step (c).

In accordance with one aspect of the first method, the power decrease signal detected represents an engine stop signal to stop operation of the engine, and the step (e) further comprises the step of controlling the engine driving means to stop supply of fuel into the engine and terminate operation of the engine when the electromagnetic connection of the first rotor with the second rotor in the first motor has been decreased to a release position in response to the engine stop signal.

In accordance with one aspect, the invention is also directed to a second method of controlling a power output apparatus for outputting a power to a drive shaft. The second method comprises the steps of: (a) providing an engine having an output shaft; engine driving means for driving the engine; a first motor comprising a first rotor connected with the output shaft of the engine and a second rotor connected with the drive shaft, the second rotor being coaxial to and rotatable relative to the first rotor, whereby power is transmitted between the output shaft of the engine and the drive shaft via an electromagnetic connection of the first rotor and the second rotor; a second motor connected with the output shaft of the engine; and a storage battery being charged with power regenerated by the first motor, being charged with power regenerated by the second motor, discharging power required to drive the first motor, and discharging power required to drive the second motor; (b) detecting power decrease signal to decrease power output from the engine; (c) controlling the engine driving means in response to the power decrease signal, to gradually decrease the power output from the engine; and (d) controlling the first motor and the second motor to enable the first motor and the second motor to use power stored in the storage battery and make up for the decrease in power output from the engine accomplished in the step (c).

In accordance with one aspect of the second method, the step (d) further comprises the steps of: (e) controlling the first motor to enable the first motor to make up for a decrease in revolving speed of the output shaft of the engine among the decrease in power output from the engine; and (f) controlling the second motor to enable the second motor to make up for a decrease in torque among the decrease in power output from the engine.

These and other objects, features, aspects, and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic view illustrating structure of a power output apparatus 20 as a first embodiment according to the present invention;

Fig. 2 is a cross sectional view illustrating detailed structures of a clutch motor 30 and an assist motor 40 included in the power output apparatus 20 of Fig. 1;

Fig. 3 is a schematic view illustrating general structure of a vehicle with the power output apparatus 20 of Fig. 1 incorporated therein;

Fig. 4 is a graph showing the operation principle of the power output apparatus 20;

Fig. 5 is a flowchart showing a torque control routine executed by the controller 80;

Fig. 6 is a flowchart showing essential steps of controlling the clutch motor 30 executed by the controller 80;

Figs. 7 and 8 are flowcharts showing essential steps of controlling the assist motor 40 executed by the controller 80;

Fig. 9 is a flowchart showing an engine stop-time torque control routine executed by the controller 80;

Fig. 10 is a flowchart showing essential steps of controlling the assist motor 40 executed by the controller 80 when the engine 50 stops operation;

Fig. 11 schematically illustrates a power output apparatus 20A as a modification of the first embodiment;

Fig. 12 schematically illustrates structure of another power output apparatus 20B as a second embodiment according to the present invention;

Fig. 13 is a flowchart showing a torque control routine executed by the controller 80 in the second embodiment;

Fig. 14 is a flowchart showing an engine stop-time torque control routine executed by the controller 80 in the second embodiment;

Fig. 15 schematically illustrates a power output apparatus 20C as a modification of the second embodiment; and

Fig. 16 schematically illustrates a power output apparatus 20D as another modification of the second embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a schematic view illustrating structure of a power output apparatus 20 as a first embodiment according to the present invention; Fig. 2 is a cross sectional view illustrating detailed structures of a clutch motor 30 and an assist motor 40 included in the power output apparatus 20 of Fig. 1; and Fig. 3 is a schematic view illustrating a general structure of a vehicle with the power output apparatus 20 of Fig. 1 incorporated therein. The general structure of the vehicle is described first as a matter of convenience.

Referring to Fig. 3, the vehicle is provided with an engine 50 driven by gasoline as a power source. The air ingested from an air supply system via a throttle valve 66 is mixed with fuel, that is, gasoline in this embodiment, injected from a fuel injection valve 51. The air/fuel mixture is supplied into a combustion chamber 52 to be explosively ignited and burned. Linear motion of a piston 54 pressed down by the explosion of the air/fuel mixture is converted to rotational motion of a crankshaft 56. The throttle valve 66 is driven to open and close by an actuator 68. An ignition plug 62 converts a high voltage applied from an igniter 58 via a distributor 60 to a spark, which explosively ignites and combusts the air/fuel mixture.

Operation of the engine 50 is controlled by an electronic control unit (hereinafter referred to as EFIECU) 70. The EFIECU 70 receives information from various sensors, which detect operating conditions of the engine 50. These sensors include a throttle valve position sensor 67 for detecting the position of the throttle valve 66, a manifold vacuum sensor 72 for measuring a load applied to the engine 50, a water temperature sensor 74 for measuring the temperature of cooling water in the engine 50, and a speed sensor 76 and an angle sensor 78 mounted on the distributor 60 for measuring the revolving speed and rotational angle of the crankshaft 56. A starter switch 79 for detecting a starting condition ST of an ignition key (not shown) is also connected to the EFIECU 70. Other sensors and switches connecting with the EFIECU 70 are omitted from the drawings.

The crankshaft 56 of the engine 50 is linked with a drive shaft 22 via a clutch motor 30 and an assist motor 40 (described later in detail). The drive shaft 22 further connects with a differential gear 24, which eventually transmits the torque output from the drive shaft 22 of the power output apparatus 20 to left and right driving wheels 26 and 28. The clutch motor 30 and the assist motor 40 are driven and controlled by a controller 80. The controller 80 includes an internal control CPU and receives inputs from a gearshift position sensor 84 attached to a gearshift 82 and an accelerator position sensor 65 attached to an accelerator pedal 64, as described later in detail. The controller 80 sends and receives a variety of data and information to and from the EFIECU 70 through communication. Details of the control procedure including a communication protocol will be described later.

Referring to Fig. 1, the power output apparatus 20 essentially includes the engine 50, the clutch motor 30 with an outer rotor 32 and an inner rotor 34, the assist motor 40 with a rotor 42, and the controller 80 for driving and controlling the clutch motor 30 and the assist motor 40. The outer rotor 32 of the clutch motor 30 is mechanically connected to the crankshaft 56 of the engine 50, whereas the inner rotor 34 thereof is mechanically linked with the rotor 42 of the assist motor 40.

As shown in Fig. 1, the clutch motor 30 is constructed as a synchronous motor having permanent magnets 35 attached to an inner surface of the outer rotor 32 and three-phase coils 36 wound on slots formed in the inner rotor 34. Power is supplied to the three-phase coils 36 via a rotary transformer 38. A thin laminated sheet of non-directional electromagnetic steel is used to form teeth and slots for the three-phase coils 36 in the inner rotor 34. A resolver 39 for measuring a rotational angle θe of the crankshaft 56 is attached to the crankshaft 56. The resolver 39 may also serve as the angle sensor 78 mounted on the distributor 60.

The assist motor 40 is also constructed as a synchronous motor having three-phase coils 44, which are wound on a stator 43 fixed to a casing 45 to generate a rotating magnetic field. The stator 43 is also made of a thin laminated sheet of non-directional electromagnetic steel. A plurality of permanent magnets 46 are attached to an outer surface of the rotor 42. In the assist motor 40, interaction between a magnetic field formed by the permanent magnets 46 and a rotating magnetic field formed by the three-phase coils 44 leads to rotation of the rotor 42. The rotor 42 is mechanically linked with the drive shaft 22 working as the torque output shaft of the power output apparatus 20. A resolver 48 for measuring a rotational angle θd of the drive shaft 22 is attached to the drive shaft 22, which is further supported by a bearing 49 held in the casing 45.

The inner rotor 34 of the clutch motor 30 is mechanically linked with the rotor 42 of the assist motor 40 and further with the drive shaft 22. When the rotation and axial torque of the crankshaft 56 of the engine 50 are transmitted via the outer rotor 32 to the inner rotor 34 of the clutch motor 30, the rotation and torque by the assist motor 40 are added to or subtracted from the transmitted rotation and torque.

While the assist motor 40 is constructed as a conventional permanent magnet-type three-phase synchronous motor, the clutch motor 30 includes two rotating elements or rotors, that is, the outer rotor 32 with the permanent magnets 35 and the inner rotor 34 with the three-phase coils 36. The detailed structure of the clutch motor 30 is described with the cross sectional view of Fig. 2. The outer rotor 32 of the clutch motor 30 is attached to a circumferential end of a wheel 57 set around the crankshaft 56, by means of a pressure pin 59a and a screw 59b. A central portion of the wheel 57 is protruded to form a shaft-like element, to which the inner rotor 34 is rotatably attached by means of bearings 37A and 37B. One end of the drive shaft 22 is fixed to the inner rotor 34.

A plurality of permanent magnets 35, four in this embodiment, are attached to the inner surface of the outer rotor 32 as mentioned previously. The permanent magnets 35 are magnetized in the direction towards the axial center of the clutch motor 30, and have magnetic poles of alternately inverted directions. The three-phase coils 36 of the inner rotor 34 facing to the permanent magnets 35 across a little gap are wound on a total of 24 slots (not shown) formed in the inner rotor 34. Supply of electricity to the respective coils forms magnetic fluxes running through the teeth (not shown), which separate the slots from one another. Supply of a three-phase alternating current to the respective coils rotates this magnetic field. The three-phase coils 36 are connected to receive electric power supplied from the rotary transformer 38. The rotary transformer 38 includes primary windings 38a fixed to the casing 45 and secondary windings 38b attached to the drive shaft 22 coupled with the inner rotor 34. Electromagnetic induction allows electric power to be transmitted from the primary windings 38a to the secondary windings 38b or vice versa. The rotary transformer 38 has windings for three phases, that is, U, V, and W phases, to enable the transmission of three-phase electric currents.

Interaction between a magnetic field formed by one adjacent pair of permanent magnets 35 and a rotating magnetic field formed by the three-phase coils 36 of the inner rotor 34 leads to a variety of behaviors of the outer rotor 32 and the inner rotor 34. The frequency of the three-phase alternating current supplied to the three-phase coils 36 is generally equal to a difference between the revolving speed (revolutions per second) of the outer rotor 32 directly connected to the crankshaft 56 and the revolving speed of the inner rotor 34. This results in a slip between the rotations of the outer rotor 32 and the inner rotor 34. Details of the control procedures of the clutch motor 30 and the assist motor 40 will be described later based on the flowcharts.

As mentioned above, the clutch motor 30 and the assist motor 40 are driven and controlled by the controller 80. Referring back to Fig. 1, the controller 80 includes a first driving circuit 91 for driving the clutch motor 30, a second driving circuit 92 for driving the assist motor 40, a control CPU 90 for controlling both the first and second driving circuits 91 and 92, and a battery 94 including a number of secondary cells. The control CPU 90 is a one-chip microprocessor including a RAM 90a used as a working memory, a ROM 90b in which various control programs are stored, an input/output port (not shown), and a serial communication port (not shown) through which data are sent to and received from the EFIECU 70. The control CPU 90 receives a variety of data through the input/output port. The input data include a rotational angle θe of the crankshaft 56 of the engine 50 from the resolver 39, a rotational angle θd of the drive shaft 22 from the resolver 48, an accelerator pedal position AP (pressing amount of the accelerator pedal 64) from the accelerator position sensor 65, a gearshift position SP from the gearshift position sensor 84, clutch motor currents Iuc and Ivc from two ammeters 95 and 96 in the first driving circuit 91, assist motor currents Iua and Iva from two ammeters 97 and 98 in the second driving circuit 92, and a residual capacity BRM of the battery 94 from a residual capacity meter 99. The residual capacity meter 99 may determine the residual capacity BRM of the battery 94 by any known method; for example, by measuring the specific gravity of an electrolytic solution in the battery 94 or the whole weight of the battery 94, by computing the currents and time of charge and discharge, or by causing an instantaneous short-circuit between terminals of the battery 94 and measuring an internal resistance against the electric current.

The control CPU 90 outputs a first control signal SW1 for driving six transistors Tr1 through Tr6 working as switching elements of the first driving circuit 91 and a second control signal SW2 for driving six transistors Tr11 through Tr16 working as switching elements of the second driving circuit 92. The six transistors Tr1 through Tr6 in the first driving circuit 91 constitute a transistor inverter and are arranged in pairs to work as a source and a drain with respect to a pair of power lines P1 and P2. The three-phase coils (U,V,W) 36 of the clutch motor 30 are connected via the rotary transformer 38 to the respective contacts of the paired transistors. The power lines P1 and P2 are respectively connected to plus and minus terminals of the battery 94. The first control signal SW1 output from the control CPU 90 successively controls the power-on time of the paired transistors Tr1 through Tr6. The electric current flowing through each coil 36 undergoes PWM (pulse width modulation) to give a quasi-sine wave, which enables the three-phase coils 36 to form a rotating magnetic field.

The six transistors Tr11 through Tr16 in the second driving circuit 92 also constitute a transistor inverter and are arranged in the same manner as the transistors Tr1 through Tr6 in the first driving circuit 91. The three-phase coils (U,V,W) 44 of the assist motor 40 are connected to the respective contacts of the paired transistors. The second control signal SW2 output from the control CPU 90 successively controls the power-on time of the paired transistors Tr11 through Tr16. The electric current flowing through each coil 44 undergoes PWM to give a quasi-sine wave, which enables the three-phase coils 44 to form a rotating magnetic field.

The power output apparatus 20 thus constructed works in accordance with the operation principles described below, especially with the principle of torque conversion. By way of example, it is assumed that the engine 50 driven by the EFIECU 70 rotates at a revolving speed Ne equal to a predetermined value N1. While the transistors Tr1 through Tr6 in the first driving circuit 91 are in OFF position, the controller 80 does not supply any current to the three-phase coils 36 of the clutch motor 30 via the rotary transformer 38. No supply of electric current causes the outer rotor 32 of the clutch motor 30 to be electromagnetically disconnected from the inner rotor 34. This results in racing the crankshaft 56 of the engine 50. Under the condition that all the transistors Tr1 through Tr6 are in OFF position, there is no regeneration of energy from the three-phase coils 36, and the engine 50 is kept at an idle.

As the control CPU 90 of the controller 80 outputs the first control signal SW1 to control on and off the transistors Tr1 through Tr6 in the first driving circuit 91, a constant electric current is flown through the three-phase coils 36 of the clutch motor 30, based on the difference between the revolving speed Ne of the crankshaft 56 of the engine 50 and a revolving speed Nd of the drive shaft 22 (that is, difference Nc (=Ne-Nd) between the revolving speed of the outer rotor 32 and that of the inner rotor 34 in the clutch motor 30). A certain slip accordingly exists between the outer rotor 32 and the inner rotor 34 connected with each other in the clutch motor 30. At this moment, the inner rotor 34 rotates at the revolving speed Nd, which is lower than the revolving speed Ne of the crankshaft 56 of the engine 50. In this state, the clutch motor 30 functions as a generator and carries out the regenerative operation to regenerate an electric current via the first driving circuit 91. In order to allow the assist motor 40 to consume energy identical with the electrical energy regenerated by the clutch motor 30, the control CPU 90 controls on and off the transistors Tr11 through Tr16 in the second driving circuit 92. The on-off control of the transistors Tr11 through Tr16 enables an electric current to flow through the three-phase coils 44 of the assist motor 40, and the assist motor 40 consequently carries out the power operation to produce a torque.

Referring to Fig. 4, while the crankshaft 56 of the engine 50 is driven at a revolving speed N1 and a torque T1, energy in a region G1 is regenerated as electric power by the clutch motor 30. The regenerated power is supplied to the assist motor 40 and converted to energy in a region G2, which enables the drive shaft 22 to rotate at a revolving speed N2 and a torque T2. The torque conversion is carried out in the manner discussed above, and the energy corresponding to the slip in the clutch motor 30 or the revolving speed difference Nc (=Ne-Nd) is consequently given as a torque to the drive shaft 22.

In another example, it is assumed that the engine 50 is driven at a revolving speed Ne=N2 and a torque Te=T2, whereas the drive shaft 22 is rotated at the revolving speed N1, which is greater than the revolving speed N2. In this state, the inner rotor 34 of the clutch motor 30 rotates relative to the outer rotor 32 in the direction of rotation of the drive shaft 22 at a revolving speed defined by the absolute value of the revolving speed difference Nc (=Ne-Nd). While functioning as a normal motor, the clutch motor 30 consumes electric power to apply the energy of rotational motion to the drive shaft 22. When the control CPU 90 of the controller 80 controls the second driving circuit 92 to enable the assist motor 40 to regenerate electrical energy, a slip between the rotor 42 and the stator 43 of the assist motor 40 makes the regenerative current flow through the three-phase coils 44. In order to allow the clutch motor 30 to consume the energy regenerated by the assist motor 40, the control CPU 90 controls both the first driving circuit 91 and the second driving circuit 92. This enables the clutch motor 30 to be driven without using any electric power stored in the battery 94.

Referring back to Fig. 4, when the crankshaft 56 of the engine 50 is driven at the revolving speed N2 and the torque T2, energy in the sum of regions G2 and G3 is regenerated as electric power by the assist motor 40 and supplied to the clutch motor 30. Supply of the regenerated power enables the drive shaft 22 to rotate at the revolving speed N1 and the torque T1.

Other than the torque conversion and revolving speed conversion discussed above, the power output apparatus 20 of the embodiment can charge the battery 94 with an excess of electrical energy or discharge the battery 94 to supplement the electrical energy. This is implemented by controlling the mechanical energy output from the engine 50 (that is, the product of the torque Te and the revolving speed Ne), the electrical energy regenerated or consumed by the clutch motor 30, and the electrical energy regenerated or consumed by the assist motor 40. The output energy from the engine 50 can thus be transmitted as power to the drive shaft 22 at a higher efficiency.

The torque conversion discussed above is implemented by a torque control process illustrated in the flowchart of Fig. 5. The torque control routine of Fig. 5 is executed to control the torque while the battery 94 is not charged or discharged.

When the program enters the torque control routine, the control CPU 90 of the controller 80 first receives data of revolving speed Nd of the drive shaft 22 at step S100. The revolving speed Nd of the drive shaft 22 can be computed from the rotational angle θd of the drive shaft 22 read from the resolver 48. The control CPU 90 then reads the accelerator pedal position AP from the accelerator position sensor 65 at step S101. The driver steps in the accelerator pedal 64 when feeling insufficiency of output torque. The value of the accelerator pedal position AP accordingly corresponds to the desired output torque (that is, torque of the drive shaft 22) which the driver requires. At subsequent step S102, the control CPU 90 computes a target output torque (torque of drive shaft 22) Td* corresponding to the input accelerator pedal position AP. The target output torque Td* is also referred to as the output torque command value. Output torque command values Td* have previously been set for the respective accelerator pedal positions AP. In response to an input of the accelerator pedal position AP, the output torque command value Td* corresponding to the input accelerator pedal position AP is extracted from the preset output torque command values Td*.

At step S103, an energy Pd to be output to the drive shaft 22 is calculated according to the expression Pd=Td*xNd, that is, multiplying the extracted output torque command value Td* (of the drive shaft 22) by the input revolving speed Nd of the drive shaft 22. The program then proceeds to step S104 at which the control CPU 90 sets a target engine torque Te* and a target engine speed Ne* of the engine 50 based on the output energy Pd thus obtained. Here it is assumed that all the energy Pd to be output to the drive shaft 22 is supplied from the engine 50. Since the energy supplied by the engine 50 is equal to the product of the torque Te and the revolving speed Ne of the engine 50, the relationship between the output energy Pd and the target engine torque Te* and the target engine speed Ne* can be expressed as Pd=Te*xNe*. There are, however, numerous combinations of the target engine torque Te* and the target engine speed Ne* satisfying the above relationship. In this embodiment, an optimal combination of the target engine torque Te* and the target engine speed Ne* is selected in order to realize operation of the engine 50 at the possible highest efficiency.

At subsequent step S106, the control CPU 90 sets a torque command value Tc* of the clutch motor 30, based on the target engine torque Te* set at step S104. In order to keep the revolving speed Ne of the engine 50 at a substantially constant level, it is required to make the torque of the clutch motor 30 balance the torque of the engine 50. The processing at step S106 accordingly sets the torque command value Tc* of the clutch motor 30 equal to the target engine torque Te* of the engine 50.

After setting the torque command value Tc* of the clutch motor 30 at step S106, the program proceeds to steps S108, S110, and S111 to control the clutch motor 30, the assist motor 40, and the engine 50, respectively. As a matter of convenience, the control operations of the clutch motor 30, the assist motor 40, and the engine 50 are shown as separate steps. In the actual procedure, however, these control operations are carried out comprehensively. For example, the control CPU 90 simultaneously controls the clutch motor 30 and the assist motor 40 by interrupt process, while transmitting an instruction to the EFIECU 70 through communication to control the engine 50 concurrently.

The control of the clutch motor 30 (step S108 of Fig. 5) is implemented according to a clutch motor control routine illustrated in the flowchart of Fig. 6. When the program enters the clutch motor control routine, the control CPU 90 of the controller 80 first reads a rotational angle θd of the drive shaft 22 from the resolver 48 at step S112 and a rotational angle θe of the crankshaft 56 of the engine 50 from the resolver 39 at step S114. The control CPU 90 then computes a relative angle θc of the drive shaft 22 and the crankshaft 56 by the equation of θc=θe-θd at step S116.

The program proceeds to step S118, at which the control CPU 90 receives inputs of clutch motor currents Iuc and Ivc, which respectively flow through the U phase and V phase of the three-phase coils 36 in the clutch motor 30, from the ammeters 95 and 96. Although the currents naturally flow through all the three phases U, V, and W, measurement is required only for the currents passing through the two phases since the sum of the currents is equal to zero. At subsequent step S120, the control CPU 90 executes transformation of coordinates (three-phase to two-phase transformation) using the values of currents flowing through the three phases obtained at step S118. The transformation of coordinates maps the values of currents flowing through the three phases to the values of currents passing through d and q axes of the permanent magnet-type synchronous motor and is executed according to Equation (1) given below:

$$\begin{bmatrix} Idc \\ Iqc \end{bmatrix} = \sqrt{2} \begin{bmatrix} -\sin(\theta c - 120) & \sin\theta c \\ -\cos(\theta c - 120) & \cos\theta c \end{bmatrix} \begin{bmatrix} Iuc \\ Ivc \end{bmatrix} \qquad (1)$$

The transformation of coordinates is carried out because the currents flowing through the d and q axes are essential for the torque control in the permanent magnet-type synchronous motor. Alternatively, the torque control may be executed directly with the currents flowing through the three phases. After the transformation to the currents of two axes, the control CPU 90 computes deviations of currents Idc and Iqc actually flowing through the d and q axes from current command values Idc* and Iqc* of the respective axes, which are calculated from the torque command value Tc* of the clutch motor 30, and determines voltage command values Vdc and Vqc for the d and q axes at step S122. In accordance with a concrete procedure, the control CPU 90 executes operations following Equations (2) and Equations (3) given below:

$$\Delta Idc = Idc^* - Idc \qquad (2)$$

$$\Delta Iqc = Iqc^* - Iqc$$

$$Vdc = Kp1 \cdot \Delta Idc + \Sigma Ki1 \cdot \Delta Idc \qquad (3)$$

$$Vqc = Kp2 \cdot \Delta Iqc + \Sigma Ki2 \cdot \Delta Iqc$$

wherein Kp1, Kp2, Ki1, and Ki2 represent coefficients, which are adjusted to be suited to the characteristics of the motor applied.

The voltage command value Vdc (Vqc) includes a part in proportion to the deviation ΔI from the current command value I* (first term in right side of Equation (3)) and a summation of historical data of the deviations ΔI for 'i' times (second term in right side). The control CPU 90 then re-transforms the coordinates of the voltage command values thus obtained (two-phase to three-phase transformation) at step S124. This corresponds to an inverse of the transformation executed at step S120. The inverse transformation determines voltages Vuc, Vvc, and Vwc actually applied to the three-phase coils 36 as given below:

$$\begin{bmatrix} Vuc \\ Vvc \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos\theta c & -\sin\theta c \\ \cos(\theta c - 120) & -\sin(\theta c - 120) \end{bmatrix} \begin{bmatrix} Vdc \\ Vqc \end{bmatrix} \qquad (4)$$

$$Vwc = -Vuc - Vvc$$

The actual voltage control is executed through on-off operation of the transistors Tr1 through Tr6 in the first driving circuit 91. At step S126, the on- and off-time of the transistors Tr1 through Tr6 in the first driving circuit 91 is PWM (pulse width modulation) controlled in order to attain the voltage command values determined by Equation (4) above.

The torque command value Tc* is positive when a positive torque is applied to the drive shaft 22 in the direction of rotation of the crankshaft 56. By way of example, it is assumed that a positive value is set to the torque command value Tc*. When the revolving speed Ne of the engine 50 is greater than the revolving speed Nd of the drive shaft 22 on this assumption, that is, when the revolving speed difference Nc (=Ne-Nd) is positive, the clutch motor 30 is controlled to carry out the regenerative operation and produce a regenerative current corresponding to the revolving speed difference Nc. When the revolving speed Ne of the engine 50 is less than the revolving speed Nd of the drive shaft 22, that is, when the revolving speed difference Nc (=Ne-Nd) is negative, on the contrary, the clutch motor 30 is controlled to carry out the power operation and rotate relative to the crankshaft 56 in the direction of rotation of the drive shaft 22 at a revolving speed defined by the absolute value of the revolving speed difference Nc. For the positive torque command value Tc*, both the regenerative operation and the power operation of the clutch motor 30 implement the identical switching control. In accordance with a concrete procedure, the transistors Tr1 through Tr6 of the first driving circuit 91 are controlled to enable a positive torque to be applied to the drive shaft 22 by the combination of the magnetic field generated by the permanent magnets 35 set on the outer rotor 32 with the rotating magnetic field generated by the currents flowing through the three-phase coils 36 on the inner rotor 34 in the clutch motor 30. The identical switching control is executed for both the regenerative operation and the power operation of the clutch motor 30 as long as the sign of the torque command value Tc* is not changed. The clutch motor control routine of Fig. 6 is thus applicable to both the regenerative operation and the power operation. Under the condition of braking the drive shaft 22 or moving the vehicle in reverse, the torque command value Tc* has the negative sign. The clutch motor control routine of Fig. 6 is also applicable to the control procedure under such conditions, when the relative angle θc is varied in the reverse direction at step S126.

Figs. 7 and 8 are flowcharts showing details of the control process of the assist motor 40 executed at step S110 in the flowchart of Fig. 5. Referring to the flowchart of Fig. 7, when the program enters the assist motor control routine, the control CPU 90 first receives data of revolving speed Nd of the drive shaft 22 at step S131. The revolving speed Nd of the drive shaft 22 is computed from the rotational angle θd of the drive shaft 22 read from the resolver 48. The control CPU 90 then receives data of revolving speed Ne of the engine 50 at step S132. The revolving speed Ne of the engine 50 may be computed from the rotational angle θe of the crankshaft 56 read from the resolver 39 or directly measured by the speed sensor 76 mounted on the distributor 60. In the latter case, the control CPU 90 receives data of revolving speed Ne of the engine 50 through communication with the EFIECU 70, which connects with the speed sensor 76.

A revolving speed difference Nc between the input revolving speed Nd of the drive shaft 22 and the input revolving speed Ne of the engine 50 is calculated according to the equation Nc=Ne-Nd at step S133. At subsequent step S134, electric power (energy) Pc regenerated or consumed by the clutch motor 30 is calculated according to Equation (5) given as:

$$Pc = Ksc \times Nc \times Tc \qquad (5)$$

wherein Ksc represents the efficiency of regenerative operation or power operation in the clutch motor 30. The product NcxTc defines the energy corresponding to the region G1 in the graph of Fig. 4, wherein Nc and Tc respectively denote the revolving speed difference and the actual torque produced by the clutch motor 30.

At step S135, a torque command value Ta* of the assist motor 40 is determined by Equation (6) given as:

$$Ta^* = ksa \times Pc/Nd \qquad (6)$$

wherein ksa represents the efficiency of regenerative operation or power operation in the assist motor 40. The torque command value Ta* of the assist motor 40 thus obtained is compared with a maximum torque Tamax, which the assist motor 40 can potentially apply, at step S136. When the torque command value Ta* exceeds the maximum torque Tamax, the program proceeds to step S138 at which the torque command value Ta* is restricted to the maximum torque Tamax.

After the torque command value Ta* is set equal to the maximum torque Tamax at step S138 or after the torque command value Ta* is determined not to exceed the maximum torque Tamax at step S136, the program proceeds to step S140 in the flowchart of Fig. 8. The control CPU 90 reads the rotational angle θd of the drive shaft 22 from the resolver 48 at step S140, and receives data of assist motor currents Iua and Iva, which respectively flow through the U phase and V phase of the three-phase coils 44 in the assist motor 40, from the ammeters 97 and 98 at step S142. The control CPU 90 then executes transformation of coordinates for the currents of the three phases at step S144, computes voltage command values Vda and Vqa at step S146, and executes inverse transformation of coordinates for the voltage command values at step S148. At subsequent step S150, the control CPU 90 determines the on-and off-time of the transistors Tr11 through Tr16 in the second driving circuit 92 for PWM (pulse width modulation) control. The processing executed at steps S144 through S150 is similar to that executed at steps S120 through S126 of the clutch motor control routine shown in the flowchart of Fig. 6.

The assist motor 40 is subject to the power operation for the positive torque command value Ta* and the regenerative operation for the negative torque command value Ta*. Like the power operation and the regenerative operation of the clutch motor 30, the assist motor control routine of Figs. 7 and 8 is applicable to both the power operation and the regenerative operation of the assist motor 40. This is also true when the drive shaft 22 rotates in reverse of the rotation of the crankshaft 56, that is, when the vehicle moves back. The torque command value Ta* of the assist motor 40 is positive when a positive torque is applied to the drive shaft 22 in the direction of rotation of the crankshaft 56.

The control of the engine 50 (step S111 in Fig. 5) is executed in the following manner. In order to attain stationary driving at the target engine torque Te* and the target engine speed Ne* (set at step S104 in Fig. 5), the control CPU 90 regulates the torque Te and the revolving speed Ne of the engine 50 to make them approach the target engine torque Te* and the target engine speed Ne*, respectively. In accordance with a concrete procedure, the control CPU 90 sends an instruction to the EFIECU 70 through communication to regulate the amount of fuel injection or the throttle valve position. Such regulation makes the torque Te and the revolving speed Ne of the engine 50 eventually approach the target engine torque Te* and the target engine speed Ne*.

This procedure enables the output (TexNe) of the engine 50 to undergo go the free torque conversion and be eventually transmitted to the drive shaft 22.

Charging control of the battery 94 starts when the residual capacity BRM of the battery 94 becomes equal to or less than a charge-initiating value BL, which has previously been set as a value requiring the charging process. Charging energy Pbi required for charging the battery 94 is added to the output energy Pd calculated at step S103 in the torque control routine of Fig. 5. The processing at step S104 and subsequent steps is executed with the newly set output energy Pd. On the other hand, the charging energy Pbi is subtracted from the power Pc of the clutch motor 30 calculated at step S134 in the assist motor control routine of Fig. 7. The processing at step S135 and subsequent steps is executed with the newly set clutch motor power Pc. This procedure enables the battery 94 to be charged with the charging energy Pbi.

On the other hand, discharge control of the battery 94 starts when the residual capacity BRM of the battery 94 becomes equal to or more than a discharge-initiating value BH, which has been set as a value requiring the discharging process. A discharging energy Pbo required for discharging the battery 94 is subtracted from the output energy Pd calculated at step S103 in the torque control routine of Fig. 5. The processing at step S104 and subsequent steps is executed with the newly set output energy Pd. On the other hand, the discharging energy Pbo is added to the power Pc of the clutch motor 30 calculated at step S134 in the assist motor control routine of Fig. 7. The processing at step S135 and subsequent steps is executed with the newly set clutch motor power Pc. This procedure enables the battery 94 to be discharged with the discharging energy Pbo.

Discharge control of the battery 94 is implemented, for example, by terminating the operation of the engine 50 and allowing the vehicle to be driven only by the power from the battery 94. Driving the vehicle with the power discharged from the battery 94 under the non-driving condition of the engine 50 starts when the residual capacity BRM of the battery 94 becomes equal to or greater than the discharge-initiating value BH, which has been set as a value requiring the discharging process, or when the driver gives a clear instruction to start the discharging process. An engine stop-time torque control routine illustrated in the flowchart of Fig. 9 is executed to terminate operation of the engine 50 and drive the vehicle with the power stored in the battery 94. In place of the torque control routine of Fig. 5, the engine stop-time torque control routine of Fig. 9 is executed repeatedly at predetermined time intervals when the controller 80 receives a battery discharge signal representing that the residual capacity BRM of the battery 94 becomes equal to or greater than the discharge-initiating value BH or a clear instruction from the driver as a stop signal to stop operation of the engine 50.

When the program enters the engine stop-time torque control routine, the control CPU 90 first receives data of accelerator pedal position AP from the accelerator position sensor 65 at step S160 and computes an output torque command value Td* corresponding to the input accelerator pedal position AP at step S162. The torque command value Tc* of the clutch motor 30 is compared with a subtraction amount ΔTc at step S164. In order to gradually decrease the output energy Pd of the engine 50 to the non-loading state, the torque command value Tc* of the clutch motor 30 acting as the torque Te of the engine 50 is gradually decreased by subtraction amounts ΔTc. The subtraction amount ΔTc is determined depending upon the interval of executing this routine and the performance of the clutch motor 30 and the engine 50. When this routine is activated for the first time in response to the stop signal to stop operation of the engine 50, the torque command value Tc* of the clutch motor 30 is generally greater than the subtraction amount ΔTc since the clutch motor 30 transmits the torque Te of the engine 50 to the drive shaft 22.

When the torque command value Tc* of the clutch motor 30 is greater than the subtraction amount ΔTc, the program proceeds to step S166 at which the control CPU 90 subtracts the subtraction amount ΔTc from the torque command value Tc* set in the previous cycle of this routine to determine a new torque command value Tc* of the clutch motor 30 as expressed by Equation (7) given below:

$$\text{New } Tc^* = \text{Previous } Tc^* - \Delta Tc \qquad (7)$$

At subsequent step S168, the control CPU 90 further calculates the torque command value Ta* of the assist motor 40 by subtracting the new torque command value Tc* from the output torque command value Td* as expressed by Equation (8) given below:

$$Ta^* = Td^* - Tc^* \qquad (8)$$

The control CPU 90 computes a new output energy Pd of the engine 50 by subtracting a subtraction amount ΔPd from the output energy Pd set in the previous cycle of this routine at step S170. The output energy Pd of the engine 50 is decreased by the subtraction amount ΔPd every time when this routine is executed. The output energy Pd thus gradually decreases to the non-loading state. In this embodiment, in order to allow the target engine torque Te* and the target engine speed Ne* of the engine 50 to gradually approach the idling state, the subtraction amount ΔPd is set to be a little greater than the value calculated according to Equation (9) given below:

$$\Delta Pd = \Delta Tc \times Ne \qquad (9)$$

At step S172, the control CPU 90 sets the target engine torque Te* and the target engine speed Ne* of the engine 50, based on the torque command value Tc* of the clutch motor 30 and the output energy Pd of the engine 50 respectively set at steps S166 and S170. The target engine torque Te* is set equal to the torque command value Tc* of the clutch motor 30 in order to effect stable rotation of the engine 50. The target engine speed Ne* is calculated according to Equation (10) given below:

$$Pd = Te^* \times Ne^* \qquad (10)$$

As described previously, the subtraction amount ΔPd is set to be a little greater than the product of the subtraction amount ΔTc and the revolving speed Ne of the engine 50 in this embodiment. This means that the target engine speed Ne* is set to be a little smaller than the actual revolving speed Ne of the engine 50. Provided that the subtraction amount ΔTc is set equal to the value calculated by Equation (9), the target engine speed Ne* is equal to the actual revolving speed Ne of the engine 50. In this case, the revolving speed Ne of the engine 50 is unchanged while the target engine torque Te* is decreased.

After setting the torque command values Tc* and Ta* and the target engine torque Te* and the target engine speed Ne*, the control CPU 90 controls the clutch motor 30 (step S174), the assist motor 40 (step S176), and the engine 50 (step S178) to attain these values. The control of the clutch motor 30 executed at step S174 follows the clutch motor control routine shown in the flowchart of Fig. 6. The repeated execution of the engine stop-time torque control routine makes the target engine speed Ne* of the engine 50 equal to or less than the revolving speed Nd of the drive shaft 22. Under such conditions, the clutch motor 30 is controlled with the power stored in the battery 94 to attain the revolving speed (Nd-Ne) at the torque command value Tc*.

The control of the assist motor 40 executed at step S176 follows an assist motor control routine shown in the flowchart of Fig. 10, instead of the assist motor control routine of Figs. 7 and 8. The processing executed at steps S190 through S197 in the assist motor control routine of Fig. 10 is identical with the processing executed at steps S136 through S150 in the assist motor control routine of Figs. 7 and 8. Since the torque command value Ta* of the assist motor 40 has been set in the engine stop-time torque control routine of Fig. 9, the processing for determining the torque command value Ta* in the assist motor control routine of Figs. 7 and 8 is not required. Power regenerated by the clutch motor 30 is not sufficient for PWM (pulse width modulation) control of the assist motor 40 to give voltages corresponding to the preset torque command value Ta*. The deficiency is supplied by the power stored in the battery 94.

Irrespective of the output energy Pd of the engine 50, the torque output to the drive shaft 22 as a result of the torque control becomes equal to the output torque command value Td*, which is the sum of the torque command value Tc* of the clutch motor 30 and the torque command value Ta* of the assist motor 40. The output torque depends upon the accelerator pedal position AP. As long as the accelerator pedal position AP is kept unchanged, the repeated execution of this routine does not vary the torque output to the drive shaft 22.

As the engine stop-time torque control routine is repeatedly executed, the torque command value Tc* of the clutch motor 30 becomes equal to or less than the subtraction amount ΔTc at step S164. Under such conditions, the engine 50 is kept substantially at an idle and the vehicle is driven substantially only by the torque Ta of the assist motor 40. When the program recognizes this state, the control CPU 90 sets the torque command value Tc* of the clutch motor 30 equal to zero at step S180. The control CPU 90 further sets the torque command value Ta* of the assist motor 40 equal to the output torque command value Td* at step S182 and allocates the value '0' to both the target engine torque Te* and the target engine speed Ne* of the engine 50 at step S184. After the processing at steps S180 through S184, the program goes to steps S174 through S178 to control the clutch motor 30, the assist motor 40, and the engine 50 as described previously. The procedure of engine stop-time torque control completely releases the electromagnetic coupling of the drive shaft 22 with the crankshaft 56 via the clutch motor 30, stops operation of the engine 50, and enables the vehicle to be driven only by the torque Ta of the assist motor 40, which is generated by the power stored in the battery 94.

As discussed above, the power output apparatus 20 of the first embodiment can stop operation of the engine 50 without varying the output torque to the drive shaft 22. Namely the structure of the embodiment prevents the unexpected variation in torque output to the drive shaft 22 and ensures a good ride. The fixed output torque to the drive shaft 22 effectively prevents undesirable vibrations of the vehicle. The energy output from the engine 50 is used as the power in the process of stopping operation of the engine 50. This further enhances the energy efficiency.

In the power output apparatus 20 of the first embodiment, the engine stop-time torque control routine of Fig. 9 is repeatedly executed when the controller 80 receives a battery discharge signal representing that the residual capacity BRM of the battery 94 becomes equal to or greater than the discharge-initiating value BH or a clear instruction on from the driver as a stop signal to stop operation of the engine 50. Alternatively, the same routine may be executed repeatedly when the battery discharge signal or the clear instruction from the driver is input as an energy decrease signal representing that the output energy Pd of the engine 50 has decreased. In the latter case, at step S164 in the flowchart of Fig. 9, the torque command value Tc* of the clutch motor 30 is compared with the decreased target engine torque Te* of the engine 50, which is calculated from the decreased output energy Pd of the engine 50, instead of with the subtraction amount ΔTc. When the torque command value Tc* is greater than the decreased target engine torque Te*, the program executes the processing at steps S166 through S178. When the torque command value Tc* becomes equal to the decreased target engine torque Te*, on the other hand, the program executes only step S168 prior to the processing at steps S174 through S178. This structure can decrease the output energy Pd of the engine 50 without varying the output torque to the drive shaft 22.

In the structure of the power output apparatus 20 shown in Fig. 1, the clutch motor 30 and the assist motor 40 are separately attached to the different positions of the drive shaft 22. Like a modified power output apparatus 20A illustrated in Fig. 11, however, the clutch motor and the assist motor may integrally be joined with each other. A clutch motor 30A of the power output apparatus 20A includes an inner rotor 34A connecting with the crankshaft 56 and an outer rotor 32A linked with the drive shaft 22. Three-phase coils 36A are attached to the inner rotor 34A, and permanent magnets 35A are set on the outer rotor 32A in such a manner that the outer surface and the inner surface thereof have different magnetic poles. An assist motor 40A includes the outer rotor 32A of the clutch motor 30A and a stator 43 with three-phase coils 44 mounted thereon. In this structure, the outer rotor 32A of the clutch motor 30A also works as a rotor of the assist motor 40A. Since the three-phase coils 36A are mounted on the inner rotor 34A connecting with the crankshaft 56, a rotary transformer 38A for supplying electric power to the three-phase coils 36A of the clutch motor 30A is attached to the crankshaft 56.

In the power output apparatus 20A, the voltage applied to the three-phase coils 36A on the inner rotor 34A is controlled against the inner-surface magnetic pole of the permanent magnets 35A set on the outer rotor 32A. This allows the clutch motor 30A to work in the same manner as the clutch motor 30 of the power output apparatus 20 shown in Fig. 1. The voltage applied to the three-phase coils 44 on the stator 43 is controlled against the outer-surface magnetic pole of the permanent magnets 35A set on the outer rotor 32A. This allows the assist motor 40A to work in the same manner as the assist motor 40 of the power output apparatus 20. The torque control routine of Fig. 5 and the engine stop-time torque control routine of Fig. 9 are also applicable to the power output apparatus 20A shown in Fig. 11, which accordingly implements the same operations and exerts the same effects as those of the power output apparatus 20 shown in Fig. 1.

As discussed above, the outer rotor 32A functions concurrently as one of the rotors in the clutch motor 30A and as the rotor of the assist motor 40A, thereby effectively reducing the size and weight of the whole power output apparatus 20A.

Fig. 12 schematically illustrates an essential part of another power output apparatus 20B as a second embodiment of the present invention. The power output apparatus 20B of Fig. 11 has a similar structure to that of the power output apparatus 20 of Fig. 1, except that the assist motor 40 is attached to the crankshaft 56 placed between the engine 50 and the clutch motor 30. In the power output apparatus 20B of the second embodiment, like numerals and symbols denote like elements as those of the power output apparatus 20 of Fig. 1. The symbols used in the description have like meanings unless otherwise specified.

The following describes the essential operation of the power output apparatus 20B shown in Fig. 12. By way of example, it is assumed that the engine 50 is driven with a torque Te and at a revolving speed Ne. When a torque Ta is added to the crankshaft 56 by the assist motor 40 linked with the crankshaft 56, the sum of the torques (Te+Ta) consequently acts on the crankshaft 56. When the clutch motor 30 is controlled to produce the torque Tc equal to the sum of the torques (Te+Ta), the torque Tc (=Te+Ta) is transmitted to the drive shaft 22.

When the revolving speed Ne of the engine 50 is greater than the revolving speed Nd of the drive shaft 22, the clutch motor 30 regenerates electric power based on the revolving speed difference Nc between the revolving speed Ne of the engine 50 and the revolving speed Nd of the drive shaft 22. The regenerated power is supplied to the assist motor 40 via the power lines P1 and P2 and the second driving circuit 92 to activate the assist motor 40. Provided that the torque Ta of the assist motor 40 is substantially equivalent to the electric power regenerated by the clutch motor 30, free torque conversion is allowed for the energy output from the engine 50 within a range holding the relationship of Equation (11) given below. Since the relationship of Equation (11) represents the ideal state with an efficiency of 100%, (TcxNd) is a little smaller than (TexNe) in the actual state.

$$Te \times Ne = Tc \times Nd \qquad (11)$$

Referring to Fig. 4, under the condition that the crankshaft 56 rotates with the torque T1 and at the revolving speed N1, the energy corresponding to the sum of the regions G1+G3 is regenerated by the clutch motor 30 and supplied to the assist motor 40. The assist motor 40 converts the received energy in the sum of the regions G1+G3 to the energy corresponding to the sum of the regions G2+G3 and transmits the converted energy to the crankshaft 56.

When the revolving speed Ne of the engine 50 is smaller than the revolving speed Nd of the drive shaft 22, the clutch motor 30 works as a normal motor. In the clutch motor 30, the inner rotor 34 rotates relative to the outer rotor 32 in the direction of rotation of the drive shaft 22 at a revolving speed defined by the absolute value of the revolving speed difference Nc (=Ne-Nd). Provided that the torque Ta of the assist motor 40 is set to a negative value, which enables the assist motor 40 to regenerate electric power substantially equivalent to the electrical energy consumed by the clutch motor 30, free torque conversion is also allowed for the energy output from the engine 50 within the range holding the relationship of Equation (11) given above.

Referring to Fig. 4, under the condition that the crankshaft 56 rotates with the torque T2 and at the revolving speed N2, the energy corresponding to the region G2 is regenerated by the assist motor 40 and consumed by the clutch motor 30 as the energy corresponding to the region G1.

The control procedure of the second embodiment discussed above follows the torque control routine shown in the flowchart of Fig. 13. When the program enters the torque control routine, the control CPU 90 of the controller 80 first executes the processing of steps S200 through S208, which is identical with that of steps S100 through S104 in the flowchart of Fig. 5. The control CPU 90 reads the revolving speed Nd of the drive shaft 22 at step S200 and the accelerator pedal position AP at step S202, and calculates the output torque command value Td* from the input accelerator pedal position AP at step S204. The control CPU 90 then computes the energy Pd to be output from the drive shaft 22 based on the calculated output torque command value Td* and the input revolving speed Nd of the drive shaft 22 at step S206, and sets the target engine torque Te* and the target engine speed Ne* of the engine 50 at step S208.

At subsequent step S210, the control CPU 90 computes the torque command value Ta* of the assist motor 40 according to Equation (12) given as:

$$Ta^* = Ksc \times (Td^* - Te^*) \qquad (12)$$

At step S212, the torque command value Tc* of the clutch motor 30 is calculated from the torque command value Ta* of the assist motor 40 thus obtained according to Equation (13) expressed as:

$$Tc^* = Te^* + Ta^* \qquad (13)$$

The control CPU 90 controls the clutch motor 30 at step S214, the assist motor 40 at step S216, and the engine 50 at step S217 based on the torque command values Ta* and Tc*, the target engine torque Te*, and the target engine speed Ne* thus obtained. The concrete procedure of the clutch motor control (step S214) is identical with that described above according to the flowchart of Fig. 6, whereas the concrete procedure of the engine control (step S217) is identical with that of the first embodiment discussed above. The assist motor control executed at step S216 essentially follows the processing of steps S192 through S196 in the assist motor control routine of Fig. 10, except that the rotational angle θe of the crankshaft 56 of the engine 50 measured with the resolver 39 is processed in place of the rotational angle θd of the drive shaft 22. This modification is ascribed to the position of the assist motor 40, which is attached to the crankshaft 56.

The power output apparatus 20B of the second embodiment can effectively control charge and discharge of the battery 94. The vehicle may be driven only by the power stored in the battery 94 while operation of the engine 50 stops. The following describes the procedure of terminating operation of the engine 50 and driving the vehicle with the power discharged from the battery 94, based on an engine-stop time torque control routine of the second embodiment shown in the flowchart of Fig. 14. Like the similar routine of the first embodiment, the engine stop-time torque control routine of Fig. 14 is executed repeatedly at predetermined time intervals, in place of the torque control routine of Fig. 13, when the controller 80 receives a battery discharge signal representing that the residual capacity BRM of the battery 94 becomes equal to or greater than the discharge-initiating value BH or a clear instruction from the driver as a stop signal to stop operation of the engine 50.

When the program enters the engine stop-time torque control routine, the control CPU 90 first receives data of accelerator pedal position AP from the accelerator position sensor 65 at step S220 and computes the output torque command value Td* corresponding to the input accelerator pedal position AP at step S222. The output energy Pd of the engine 50 is compared with a threshold value Pdref at step S224. The threshold value Pdref is set to be a little greater than the output energy Pd of the engine 50 at an idle. When this routine is activated for the first time in response to the stop signal to stop operation of the engine 50, the output energy Pd is generally greater than the threshold value Pdref since the vehicle is driven by the power output from the engine 50.

When the output energy Pd is greater than the threshold value Pdrefat step S224, the program proceeds to step S226 at which the control CPU 90 subtracts the subtraction amount ΔPd from the output energy Pd set in the previous cycle of this routine to determine a new output energy Pd. At subsequent step S228, the control CPU 90 sets a target engine torque Te* and a target engine speed Ne* of the engine 50 by considering the efficiency of the engine 50 and other conditions according to Equation (14) given below:

$$Pd = Te^{*} \times Ne^{*} \qquad (14)$$

It is preferable that the target engine torque Te* and the target engine speed Ne* are set to gradually attain the idling state of the engine 50. The torque command value Ta* of the assist motor 40 is computed at step S230 according to Equation (15) given below:

$$Ta^{*} = Td^{*} - Te^{*} \qquad (15)$$

whereas the torque command value Tc* of the clutch motor 30 is set equal to the output torque command value Td* at step S232.

The control CPU 90 executes control of the clutch motor 30 (step S234), control of the assist motor 40 (step S236), and control of the engine 50 (at step S238), which are identical with the processing executed at step S214 through S217 in the torque control routine of Fig. 13.

The repeated execution of this routine makes the target engine speed Ne* of the engine 50 equal to or less than the revolving speed Nd of the drive shaft 22. Under such conditions, the clutch motor 30 is controlled with the power stored in the battery 94 to attain the revolving speed (Nd-Ne) at the torque command value Tc*. Power regenerated by the clutch motor 30 is not sufficient for PWM control of the assist motor 40 to give voltages corresponding to the preset torque command value Ta*. The deficiency is supplied by the power stored in the battery 94.

Irrespective of the decrease in output energy Pd of the engine 50, the torque output to the drive shaft 22 as a result of the torque control becomes equal to the output torque command value Td*, which depends upon the accelerator pedal position AP. As long as the accelerator pedal position AP is kept unchanged, the repeated execution of this routine does not vary the torque output to the drive shaft 22.

As the engine stop-time torque control routine is repeatedly executed, the output energy Pd of the engine 50 becomes equal to or less than the threshold value Pdref at step S224. Under such conditions, the engine 50 is kept substantially at an idle. When the program recognizes this state, the control CPU 90 sets the target engine torque Te* and the target engine speed Ne* of the engine 50 equal to zero at step S240, sets the torque command value Ta* of the assist motor 40 equal to the output torque command value Td* at step S242, and sets the torque command value Tc* of the clutch motor 30 equal to the output torque command value Td* at step S244. This is followed by the control of the clutch motor 30 (step S234), the assist motor 40 (step S236), and the engine 50 (step S238). The procedure of engine stop-time torque control terminates operation of the engine 50 and enables the vehicle to be driven by the torque Tc of the clutch motor 30, which is generated by the power discharged from the battery 94. The assist motor 40 receives the reaction force of the torque command value Tc* output from the clutch motor 30 to the drive shaft 22. When the engine 50 stops operation, the revolving speed Ne of the engine 50 becomes equal to zero and a constant current, which can generate a torque against the torque command value Tc*, flows through the three-phase coils of the assist motor 40. The crankshaft 56 is accordingly electromagnetically-locked by the assist motor 40.

As discussed above, the power output apparatus 20B of the second embodiment can stop operation of the engine 50 without varying the output torque to the drive shaft 22. Namely the structure of the second embodiment prevents the unexpected variation in torque output to the drive shaft 22 and ensures a good ride. The fixed output torque to the drive shaft 22 effectively prevents undesirable vibrations of the vehicle.

In the power output apparatus 20B of the second embodiment, the engine stop-time torque control routine of Fig. 14 is repeatedly executed when the controller 80 receives a battery discharge signal representing that the residual capacity BRM of the battery 94 becomes equal to or greater than the discharge-initiating value BH or a clear instruction on from the driver as a stop signal to stop operation of the engine 50. Alternatively, the same routine may be executed repeatedly when the battery discharge signal or the clear instruction from the driver is input as an energy decrease signal representing that the output energy Pd of the engine 50 has decreased. In the latter case, at step S224 in the flowchart of Fig. 14, the output energy Pd of the engine 50 is compared with a target output energy Pd* of the engine 50, instead of with the threshold value Pdref. When the output energy Pd is greater than the target output energy Pd*, the program executes the processing at steps S226 through S238. When the output energy Pd becomes equal to the target output energy Pd*, on the other hand, the program executes steps S230 through S238. This structure can decrease the output energy Pd of the engine 50 without varying the output torque to the drive shaft 22.

In the power output apparatus 20B of Fig. 12 given as the second embodiment discussed above, the assist motor 40 is attached to the crankshaft 56 placed between the engine 50 and the clutch motor 30. Like another power output apparatus 20C illustrated in Fig. 15, however, the engine 50 may be interposed between the clutch motor 30 and the assist motor 40, both of which are linked with the crankshaft 56.

In the power output apparatus 20B of Fig. 12, the clutch motor 30 and the assist motor 40 are separately attached to the different positions of the crankshaft 56. Like a power output apparatus 20D shown in Fig. 16, however, the clutch motor and the assist motor may integrally be joined with each other. A clutch motor 30D of the power output apparatus 20D includes an outer rotor 32D connecting with the crankshaft 56 and an inner rotor 34 linked with the drive shaft 22. Three-phase coils 36 are attached to the inner rotor 34, and permanent magnets 35D are set on the outer rotor 32D in such a manner that the outer surface and the inner surface thereof have different magnetic poles. An assist motor 40D includes the outer rotor 32D of the clutch motor 30D and a stator 43 with three-phase coils 44 mounted thereon. In this structure, the outer rotor 32D of the clutch motor 30D also works as a rotor of the assist motor 40D.

In the power output apparatus 20D, the voltage applied to the three-phase coils 36 on the inner rotor 34 is controlled against the inner-surface magnetic pole of the permanent magnets 35D set on the outer rotor 32D. This allows the clutch motor 30D to work in the same manner as the clutch motor 30 of the power output apparatus 20B shown in Fig. 12. The voltage applied to the three-phase coils 44 on the stator 43 is controlled against the outer-surface magnetic pole of the permanent magnets 35D set on the outer rotor 32D. This allows the assist motor 40D to work in the same manner as the assist motor 40 of the power output apparatus 20B. The torque control routine of Fig. 13 and the engine stop-time torque control routine of Fig. 14 are also applicable to the power output apparatus 20D shown in Fig. 16, which accordingly implements the same operations and exerts the same effects as those of the power output apparatus 20B shown in Fig. 12.

Like the power output apparatus 20A shown in Fig. 11, in the power output apparatus 20D of Fig. 16, the outer rotor 32D functions concurrently as one of the rotors in the clutch motor 30D and as the rotor of the assist motor 40D, thereby effectively reducing the size and weight of the whole power output apparatus 20D.

There may be many other modifications, alternations, and changes without departing from the scope or spirit of essential characteristics of the invention. It is thus clearly understood that the above embodiments are only illustrative and not restrictive in any sense.

The gasoline engine driven by means of gasoline is used as the engine 50 in the above power output apparatuses. The principle of the invention is, however, applicable to other internal combustion engines and external combustion engines, such as Diesel engines, turbine engines, and jet engines.

Permanent magnet (PM)-type synchronous motors are used for the clutch motor 30 and the assist motor 40 in the power output apparatuses described above. Other motors such as variable reluctance (VR)-type synchronous motors, vernier motors, d.c. motors, induction motors, superconducting motors, and stepping motors may be used for the regenerative operation and the power operation.

The rotary transformer 38 used as means for transmitting electric power to the clutch motor 30 may be replaced by a slip ring-brush contact, a slip ring-mercury contact, a semiconductor coupling of magnetic energy, or the like.

In the above power output apparatuses, transistor inverters are used for the first and the second driving circuits 91 and 92. Other examples applicable to the driving circuits 91 and 92 include IGBT (insulated gate bipolar mode transistor) inverters, thyristor inverters, voltage PWM (pulse width modulation) inverters, square-wave inverters (voltage inverters and current inverters), and resonance inverters.

The battery 94 may include Pb cells, NiMH cells, Li cells, or the like cells. A capacitor may be used in place of the battery 94.

Although the power output apparatus is mounted on the vehicle in the above embodiments, it may be mounted on other transportation means like ships and airplanes as well as a variety of industrial machines.

The scope and spirit of the present invention are limited only by the terms of the appended claims.

Claims

1. A power output apparatus for outputting power to a drive shaft, said power output apparatus comprising:

an engine having an output shaft;
engine driving means for driving said engine;

a first motor comprising a first rotor connected with said output shaft of said engine and a second rotor connected with said drive shaft, said second rotor being coaxial to and rotatable relative to said first rotor, whereby power is transmitted between said output shaft of said engine and said drive shaft via an electromagnetic connection of said first rotor and said second rotor;
a first motor-driving circuit for controlling degree of electromagnetic connection of said first rotor and said second rotor in said first motor and regulating rotation of said second rotor relative to said first rotor;
a second motor connected with said drive shaft;
a second motor-driving circuit for driving and controlling said second motor;
a storage battery being charged with power regenerated by said first motor via said first motor-driving circuit, being charged with power regenerated by said second motor via said second motor-driving circuit, discharging power required to drive said first motor via said first motor-driving circuit, and discharging power required to drive said second motor via said second motor-driving circuit;
power decrease signal detection means for detecting power decrease signal to decrease power output from said engine;
driving circuit control means for, when said power decrease signal detection means detects the power decrease signal, controlling said first motor-driving circuit in response to said signal to gradually decrease the degree of electromagnetic connection of said first rotor with said second rotor in said first motor and controlling said second motor-driving circuit to enable said second motor to use power stored in said storage battery and make up for a decrease in power transmitted by said first motor accompanied by the decrease in degree of electromagnetic connection; and
engine power decreasing means for controlling said engine driving means to decrease the power output from said engine with the decrease in the degree of electromagnetic connection of said first rotor with said second rotor accomplished by said driving circuit control means.

2. A power output apparatus in accordance with claim 1, wherein said power decrease signal detection means comprises means for detecting an engine stop signal to stop operation of said engine; and

   wherein said engine power decreasing means comprises means for controlling said engine driving means to stop supply of fuel into said engine and terminate operation of said engine when said driving circuit control means releases the electromagnetic connection of said first rotor with said second rotor in said first motor.

3. A power output apparatus for outputting power to a drive shaft, said power output apparatus comprising:

   an engine having an output shaft;
   engine driving means for driving said engine;
   a complex motor comprising a first rotor connected with said output shaft of said engine, a second rotor connected with said drive shaft being coaxial to and rotatable relative to said first rotor, and a stator for rotating said second rotor, said first rotor and said second rotor constituting a first motor, said second rotor and said stator constituting a second motor;
   a first motor-driving circuit for driving and controlling said first motor in said complex motor;
   a second motor-driving circuit for driving and controlling said second motor in said complex motor;
   a storage battery being charged with power regenerated by said first motor via said first motor-driving circuit, being charged with power regenerated by said second motor via said second motor-driving circuit, discharging power required to drive said first motor via said first motor-driving circuit, and discharging power required to drive said second motor via said second motor-driving circuit;
   power decrease signal detection means for detecting power decrease signal to decrease power output from said engine;
   driving circuit control means for, when said power decrease signal detection means detects the power decrease signal, controlling said first motor-driving circuit in response to said signal to gradually decrease the degree of electromagnetic connection of said first rotor with said second rotor in said first motor and controlling said second motor-driving circuit to enable said second motor to use power stored in said storage battery and make up for a decrease in power transmitted by said first motor accompanied by the decrease in degree of electromagnetic connection; and
   engine power decreasing means for controlling said engine driving means to decrease the power output from said engine with the decrease in the degree of electromagnetic connection of said first rotor with said second rotor accomplished by said driving circuit control means.

4. A power output apparatus in accordance with claim 3, wherein said power decrease signal detection means comprises means for detecting an engine stop signal to stop operation of said engine; and

wherein said engine power decreasing means comprises means for controlling said engine driving means to stop supply of fuel into said engine and terminate operation of said engine when said driving circuit control means releases the electromagnetic connection of said first rotor with said second rotor in said first motor.

5. A power output apparatus for outputting power to a drive shaft, said power output apparatus comprising:

an engine having an output shaft;
engine driving means for driving said engine;
a first motor comprising a first rotor connected with said output shaft of said engine and a second rotor connected with said drive shaft, said first motor being coaxial to and rotatable relative to said first rotor, whereby power is transmitted between said output shaft of said engine and said drive shaft via an electromagnetic connection of said first rotor and said second rotor;
a first motor-driving circuit for controlling degree of electromagnetic connection of said first rotor and said second rotor in said first motor and regulating rotation of said second rotor relative to said first rotor;
a second motor connectied with the output shaft of said engine;
a second motor-driving circuit for driving and controlling said second motor;
a storage battery being charged with power regenerated by said first motor via said first motor-driving circuit, being charged with power regenerated by said second motor via said second motor-driving circuit, discharging power required to drive said first motor via said first motor-driving circuit, and discharging power required to drive said second motor via said second motor-driving circuit;
power decrease signal detection means for detecting power decrease signal to decrease power output from said engine;
engine power decreasing means for, when said power decrease signal detection means detects the power decrease signal, controlling said engine driving means in response to said signal to gradually decrease the power output from said engine; and
driving circuit control means for controlling said first motor-driving circuit and said second motor-driving circuit to enable said first motor and said second motor to use power stored in said storage battery and make up for the decrease in power output from said engine accomplished by said engine power decreasing means.

6. A power output apparatus in accordance with claim 5, wherein said driving circuit control means comprises meane for controlling said first motor-driving circuit to enable said first motor to make up for a decrease in revolving speed of the output shaft of said engine among the decrease in power output from said engine, and controlling said second motor-driving circuit to enable said second motor to make up for a decrease in torque among the decrease in power output from said engine.

7. A power output apparatus in accordance with claim 6, wherein said power decrease signal detection means comprises meane for detecting an engine stop signal to stop operation of said engine; and

wherein said engine power decreasing means comprises meane for controlling said engine driving means to stop supply of fuel into said engine and terminate operation of said engine when the power output from said engine becomes equal to zero.

8. A power output apparatus for outputting power to a drive shaft, said power output apparatus comprising:

an engine having an output shaft;
engine driving means for driving said engine;
a complex motor comprising a first rotor connected with said output shaft of said engine, a second rotor connected with said drive shaft being coaxial to and rotatable relative to said first rotor, and a stator for rotating said first rotor, said first rotor and said second rotor constituting a first motor, said first rotor and said stator constituting a second motor;
a first motor-driving circuit for driving and controlling said first motor in said complex motor;
a second motor-driving circuit for driving and controlling said second motor in said complex motor;
a storage battery being charged with power regenerated by said first motor via said first motor-driving circuit, being charged with power regenerated by said second motor via said second motor-driving circuit, discharging power required to drive said first motor via said first motor-driving circuit, and discharging power required to drive said second motor via said second motor-driving circuit;
power decrease signal detection means for detecting power decrease signal to decrease power output from said engine;

engine power decreasing means for, when said power decrease signal detection means detects the power decrease signal, controlling said engine driving means in response to said signal to gradually decrease the power output from said engine; and

driving circuit control means for controlling said first motor-driving circuit and said second motor-driving circuit to enable said first motor and said second motor to use power stored in said storage battery and make up for the decrease in power output from said engine accomplished by said engine power decreasing means.

9. A power output apparatus in accordance with claim 8, wherein said driving circuit control means comprises means for controlling said first motor-driving circuit to enable said first motor to make up for a decrease in revolving speed of the output shaft of said engine among the decrease in power output from said engine, and controlling said second motor-driving circuit to enable said second motor to make up for a decrease in torque among the decrease in power output from said engine.

10. A power output apparatus in accordance with claim 9, wherein said power decrease signal detection means comprises means for detecting an engine stop signal to stop operation of said engine; and

wherein said engine power decreasing means comprises means for controlling said engine driving means to stop supply of fuel into said engine and terminate operation of said engine when the power output from said engine becomes equal to zero.

11. A method of controlling a power output apparatus for outputting power to a drive shaft, said method comprising the steps of:

(a) providing an engine having an output shaft; engine driving means for driving said engine; a first motor comprising a first rotor connected with said output shaft of said engine and a second rotor connected with said drive shaft, said first motor being coaxial to and rotatable relative to said first rotor, whereby power is transmitted between said output shaft of said engine and said drive shaft via an electromagnetic connection of said first rotor and said second rotor; a second motor connected with said drive shaft; and a storage battery being charged with power regenerated by said first motor, being charged with power regenerated by said second motor, discharging power required to drive said first motor, and discharging power required to drive said second motor;

(b) detecting power decrease signal to decrease power output from said engine;

(c) controlling said first motor in response to the power decrease signal, to gradually decrease the degree of electromagnetic connection of said first rotor with said second rotor in said first motor;

(d) controlling said second motor to enable said second motor to use power stored in said storage battery and make up for a decrease in power transmitted by said first motor accompanied by the decrease in degree of electromagnetic connection; and

(e) controlling said engine driving means to decrease the power output from said engine with the decrease in degree of electromagnetic connection of said first rotor with said second rotor accomplished in said step (c).

12. A method in accordance with claim 11, wherein the power decrease signal detected represents an engine stop signal to stop operation of said engine,

said step (e) further comprising the step of controlling said engine driving means to stop supply of fuel into said engine and terminate operation of said engine when the electromagnetic connection of said first rotor with said second rotor in said first motor has been decreased to a release position in response to the engine stop signal.

13. A method of controlling a power output apparatus for outputting power to a drive shaft, said method comprising the steps of:

(a) providing an engine having an output shaft; engine driving means for driving said engine; a first motor comprising a first rotor connected with said output shaft of said engine and a second rotor connected with said drive shaft, said second rotor being coaxial to and rotatable relative to said first rotor, whereby power is transmitted between said output shaft of said engine and said drive shaft via an electromagnetic connection of said first rotor and said second rotor; a second motor connected with the output shaft of said engine; and a storage battery being charged with power regenerated by said first motor, being charged with power regenerated by said second motor, discharging power required to drive said first motor, and discharging power required to drive said second motor;

(b) detecting power decrease signal to decrease power output from said engine;

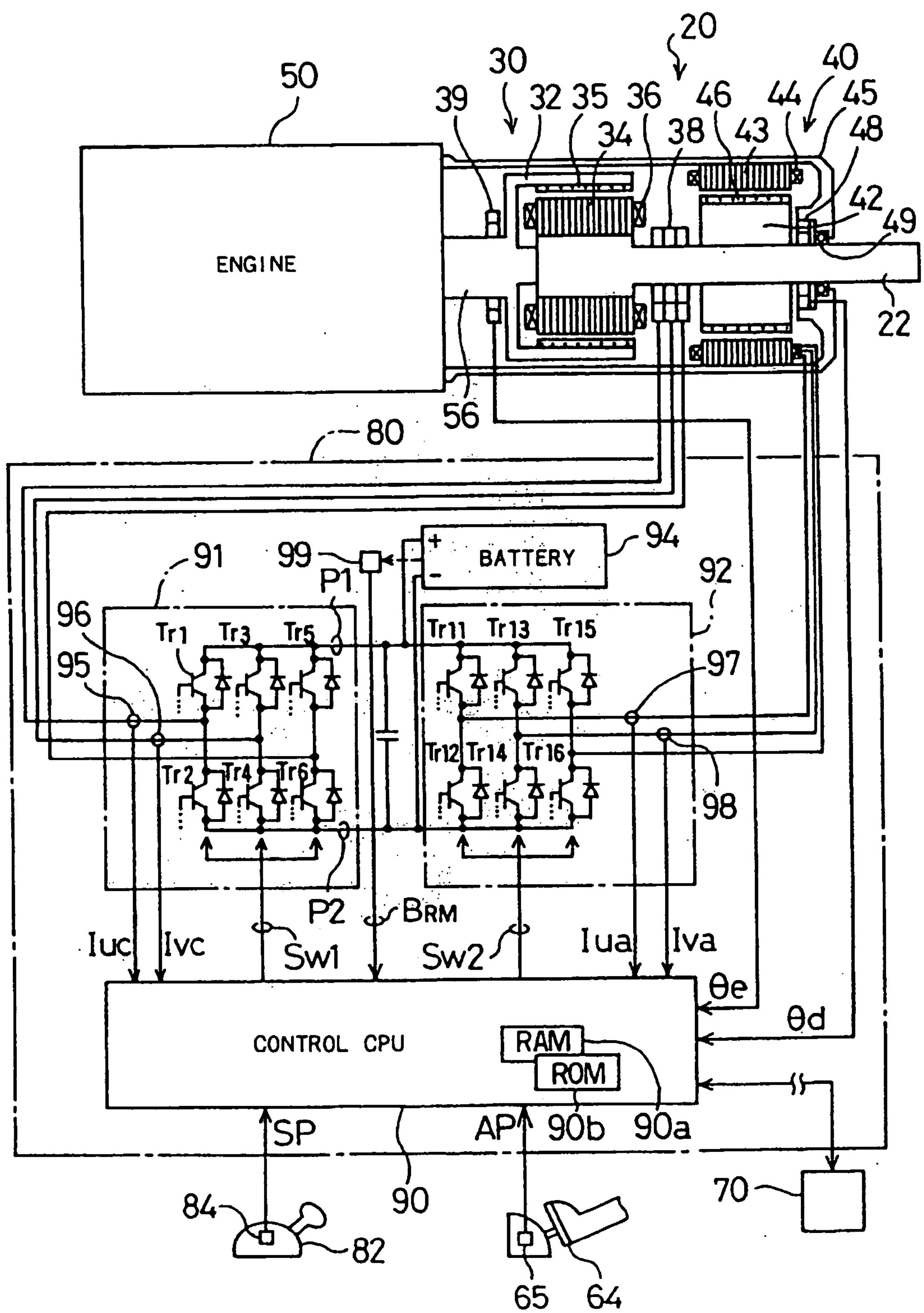
(c) controlling said engine driving means in response to the power decrease signal, to gradually decrease the power output from said engine; and

(d) controlling said first motor and said second motor to enable said first motor and said second motor to use power stored in said storage battery and make up for the decrease in power output from said engine accomplished in said step (c).

14. A method in accordance with claim 13, wherein said step (d) further comprises the steps of:

(e) controlling said first motor to enable said first motor to make up for a decrease in revolving speed of the output shaft of said engine among the decrease in power output from said engine; and
(f) controlling said second motor to enable said second motor to make up for a decrease in torque among the decrease in power output from said engine.

Fig. 1



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Sw2
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82
65
64

Fig. 2

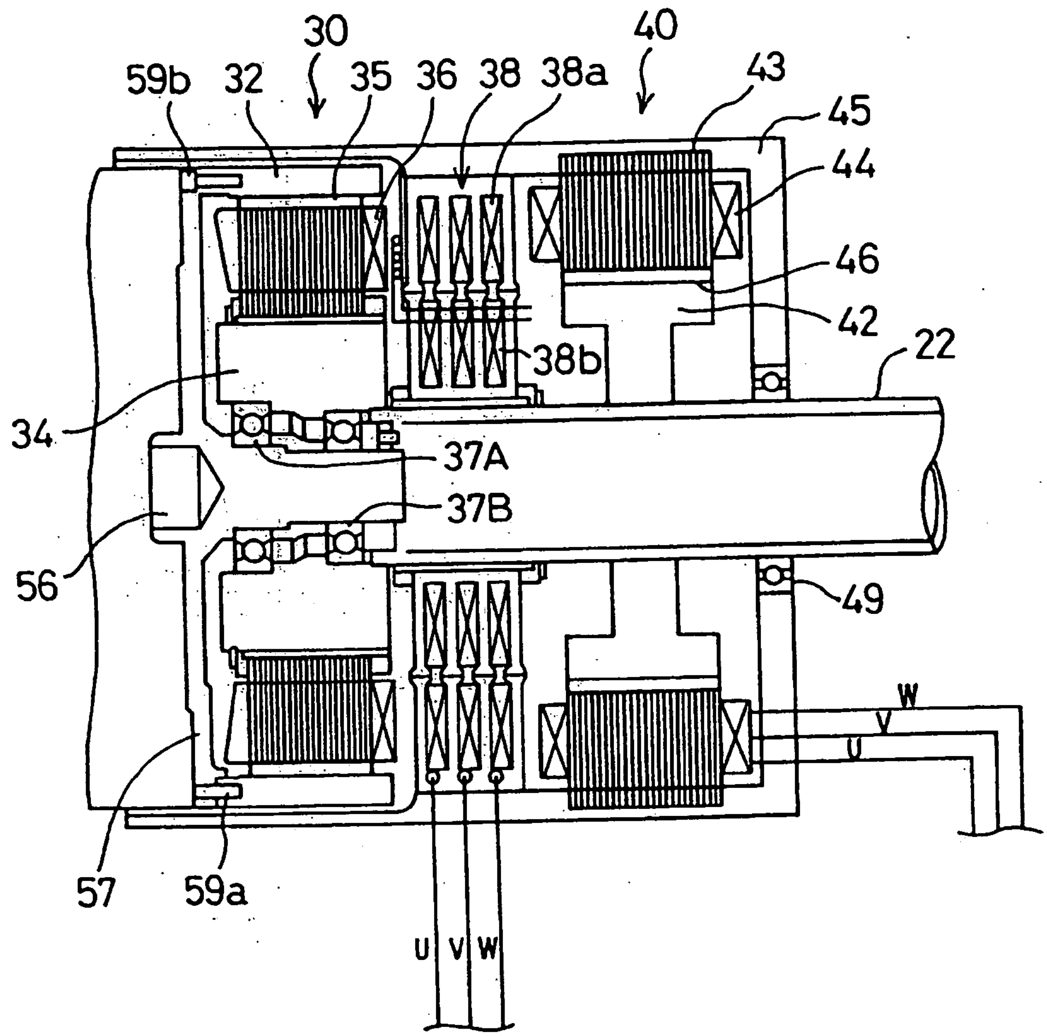

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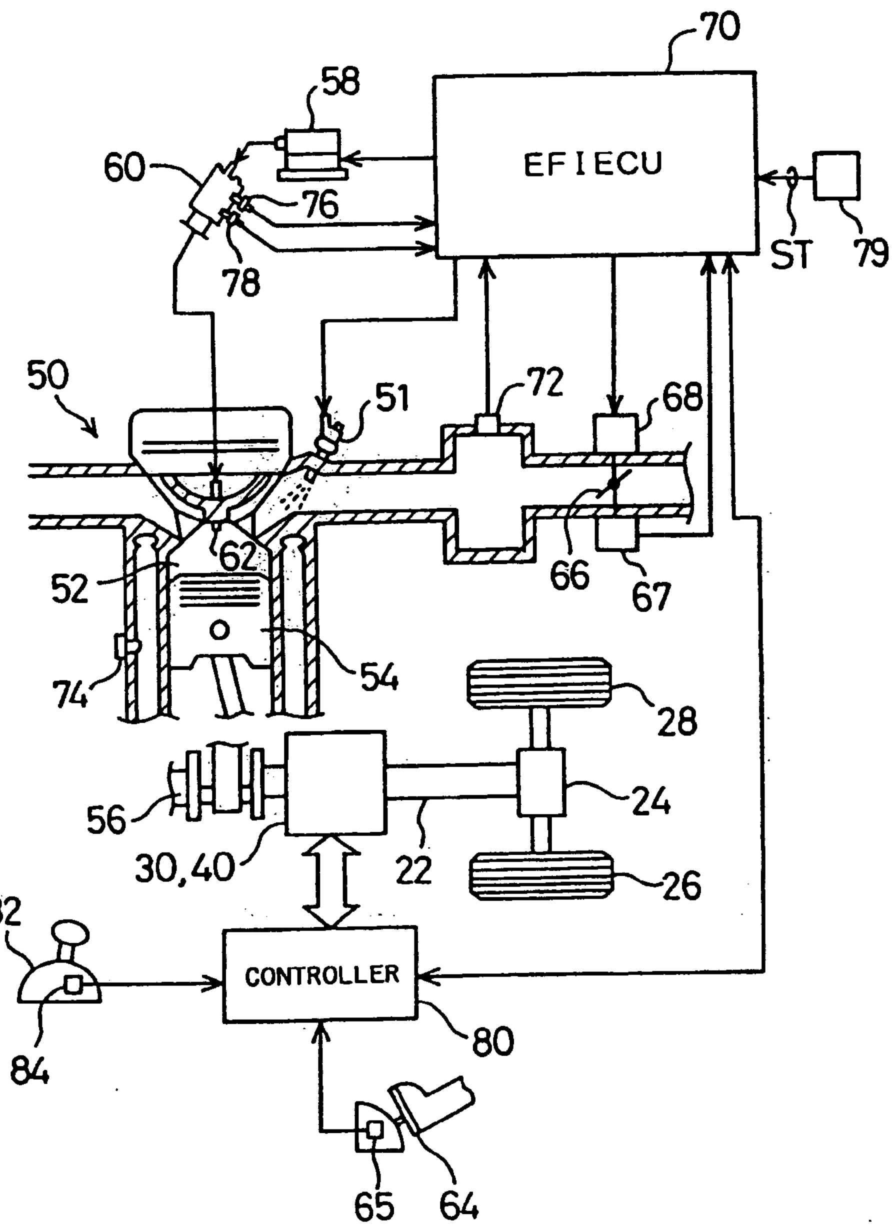
Fig. 3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CONTROLLER
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Fig. 4

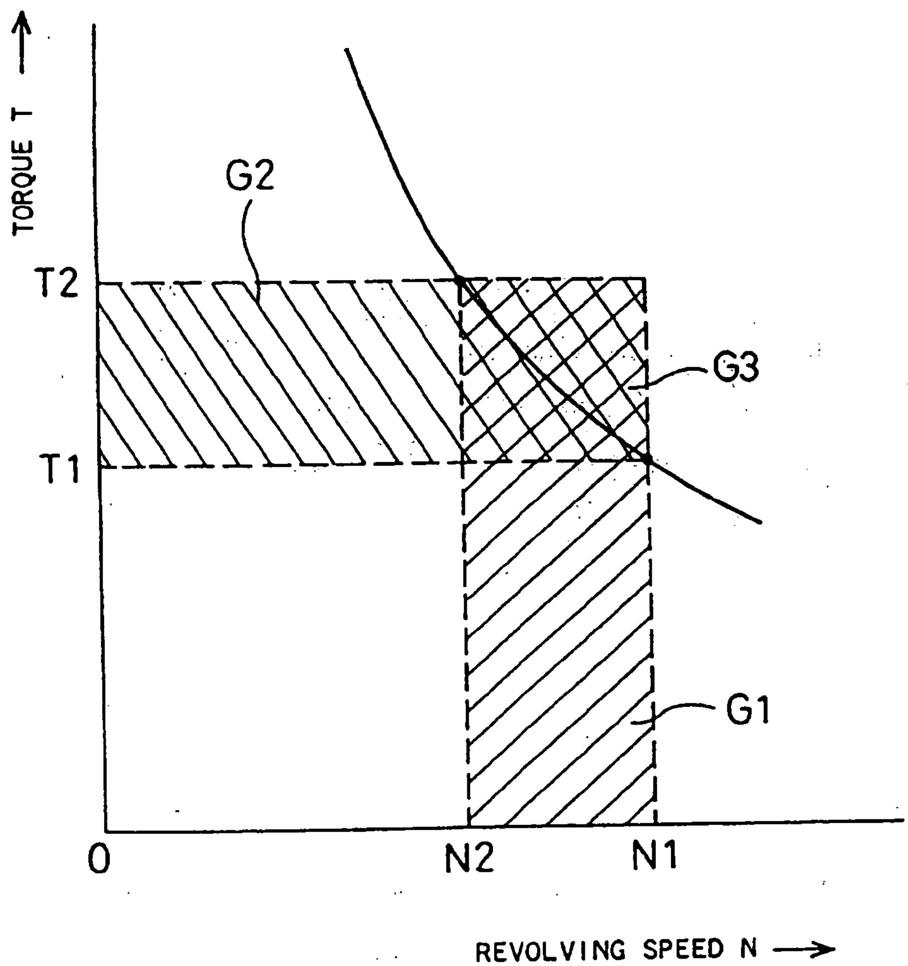


Fig. 5

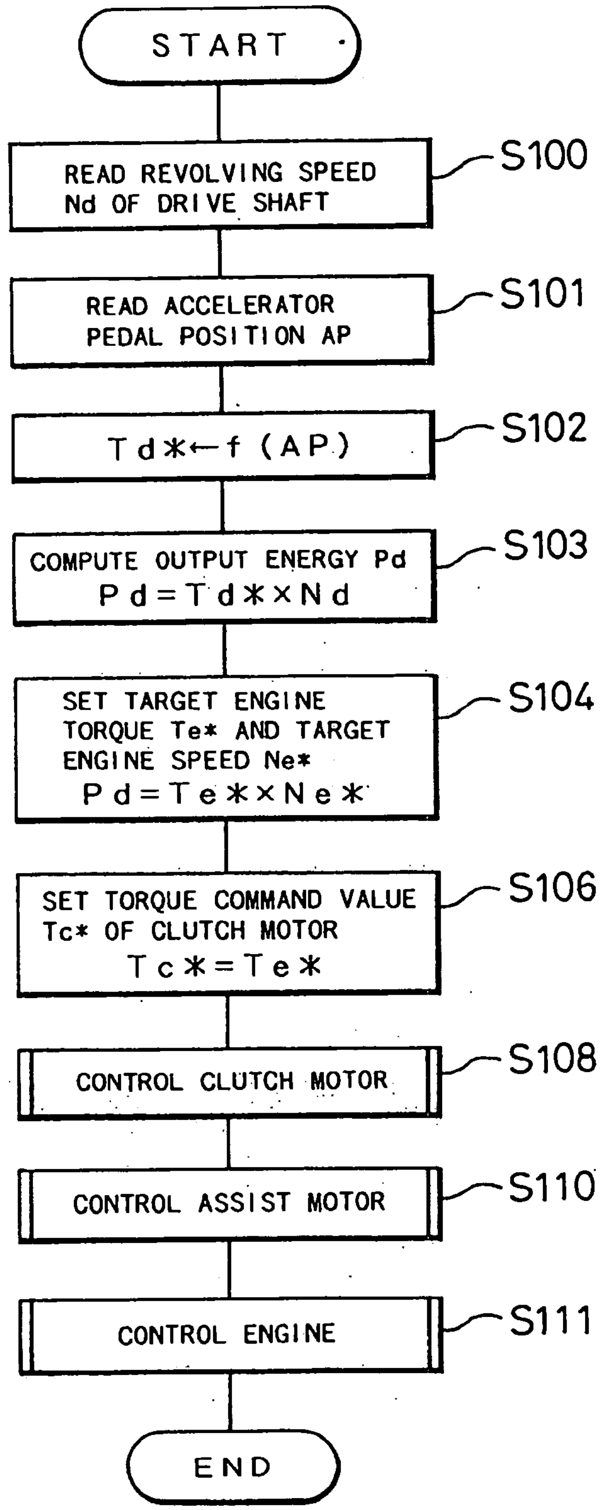

START
READ REVOLVING SPEED Nd OF DRIVE SHAFT
S100
READ ACCELERATOR PEDAL POSITION AP
S101
Td*←f (AP)
S102
COMPUTE OUTPUT ENERGY Pd
Pd=Td*×Nd
S103
SET TARGET ENGINE TORQUE Te* AND TARGET ENGINE SPEED Ne*
Pd=Te*×Ne*
S104
SET TORQUE COMMAND VALUE Tc* OF CLUTCH MOTOR
Tc*=Te*
S106
CONTROL CLUTCH MOTOR
S108
CONTROL ASSIST MOTOR
S110
CONTROL ENGINE
S111
END

Fig. 6

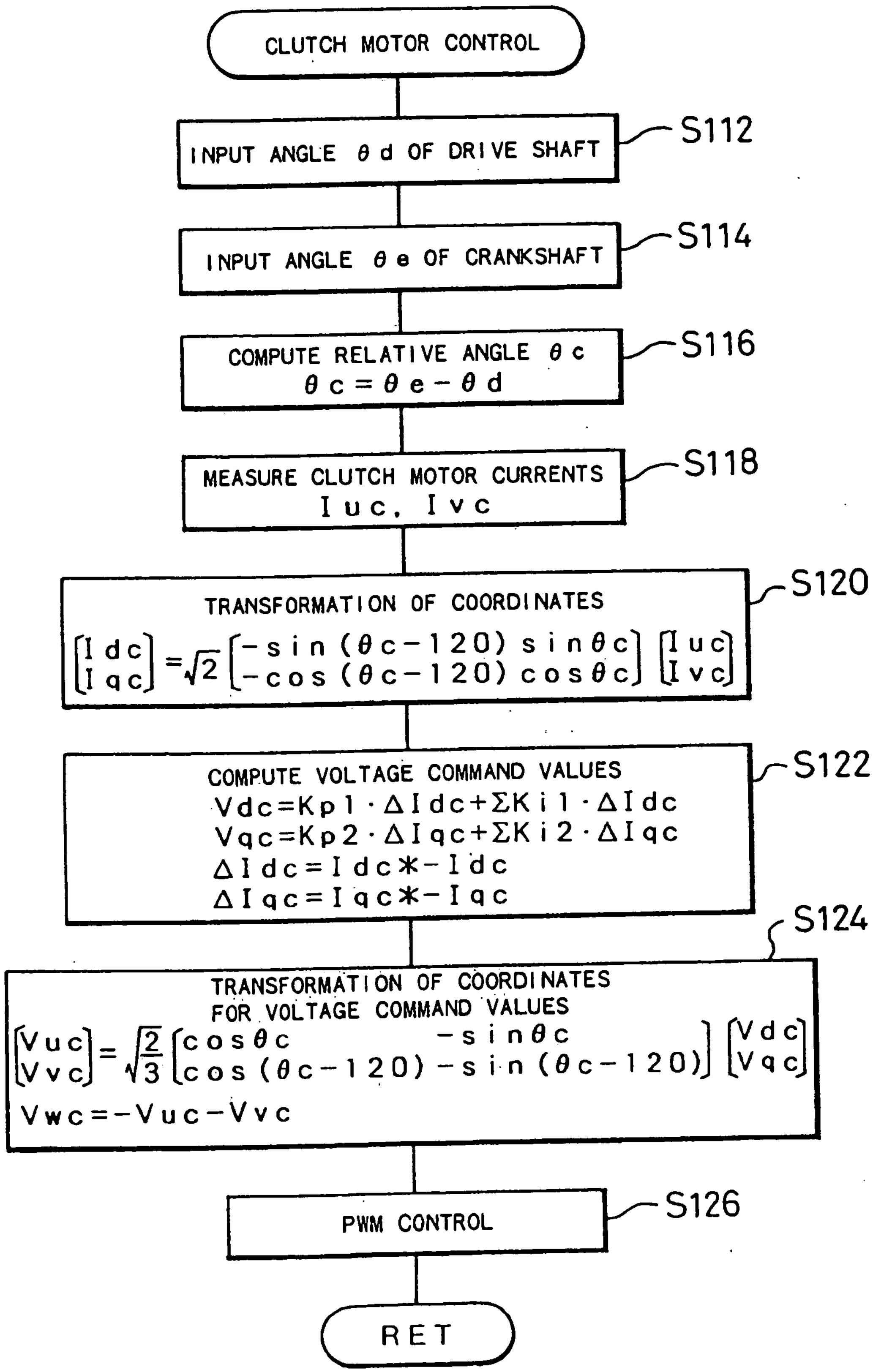

CLUTCH MOTOR CONTROL
INPUT ANGLE θd OF DRIVE SHAFT
S112
INPUT ANGLE θe OF CRANKSHAFT
S114
COMPUTE RELATIVE ANGLE θc
θc = θe − θd
S116
MEASURE CLUTCH MOTOR CURRENTS
Iuc, Ivc
S118
TRANSFORMATION OF COORDINATES
[Idc; Iqc] = √2 [−sin(θc−120) sinθc; −cos(θc−120) cosθc] [Iuc; Ivc]
S120
COMPUTE VOLTAGE COMMAND VALUES
Vdc=Kp1·ΔIdc+ΣKi1·ΔIdc
Vqc=Kp2·ΔIqc+ΣKi2·ΔIqc
ΔIdc=Idc*−Idc
ΔIqc=Iqc*−Iqc
S122
TRANSFORMATION OF COORDINATES
FOR VOLTAGE COMMAND VALUES
[Vuc; Vvc] = √(2/3) [cosθc −sinθc; cos(θc−120) −sin(θc−120)] [Vdc; Vqc]
Vwc=−Vuc−Vvc
S124
PWM CONTROL
S126
RET

Fig. 7

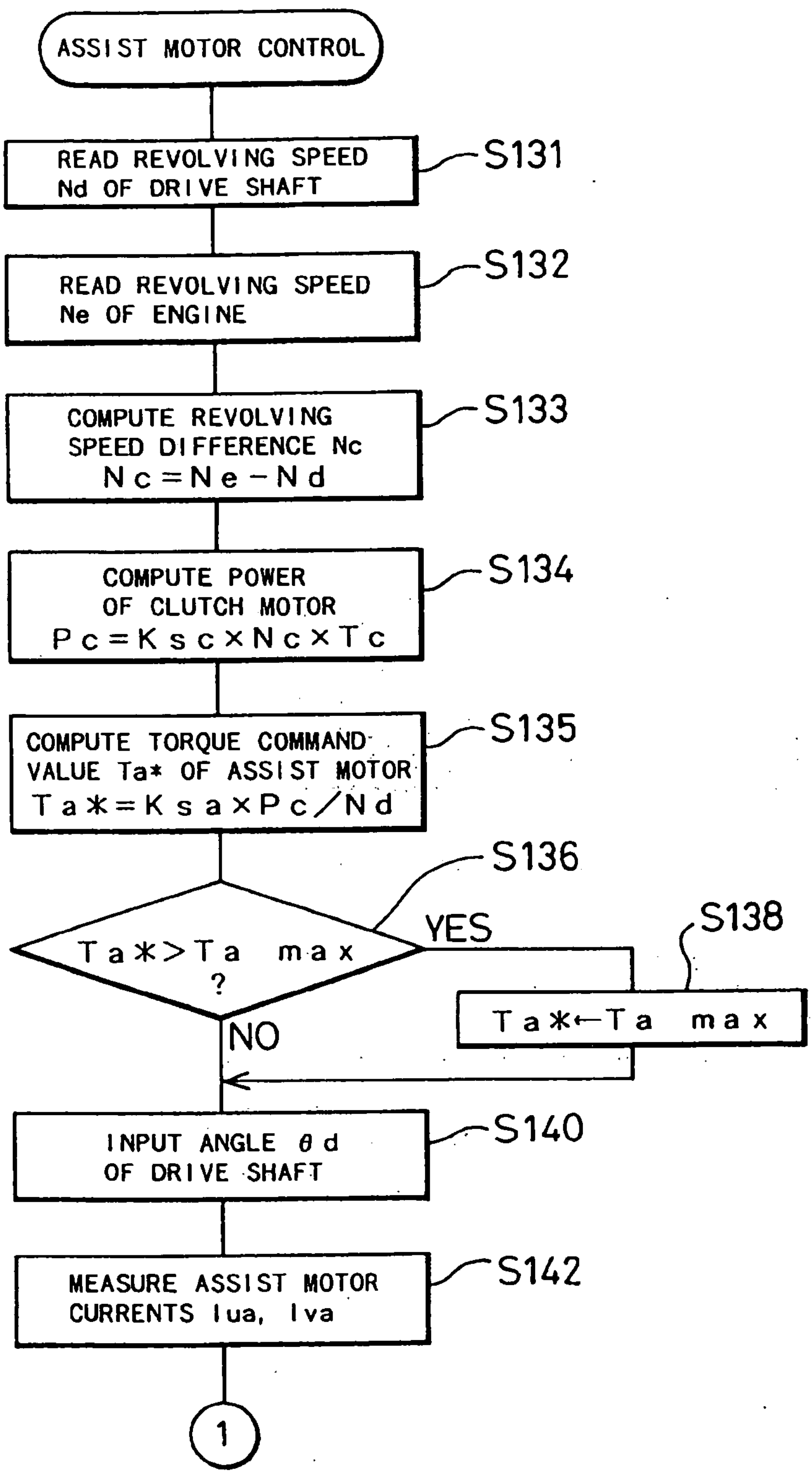

ASSIST MOTOR CONTROL
READ REVOLVING SPEED Nd OF DRIVE SHAFT
S131
READ REVOLVING SPEED Ne OF ENGINE
S132
COMPUTE REVOLVING SPEED DIFFERENCE Nc
Nc=Ne−Nd
S133
COMPUTE POWER OF CLUTCH MOTOR
Pc=Ksc×Nc×Tc
S134
COMPUTE TORQUE COMMAND VALUE Ta* OF ASSIST MOTOR
Ta*=Ksa×Pc/Nd
S135
Ta*>Ta max ?
S136
YES
NO
Ta*←Ta max
S138
INPUT ANGLE θd OF DRIVE SHAFT
S140
MEASURE ASSIST MOTOR CURRENTS Iua, Iva
S142
1

Fig. 8

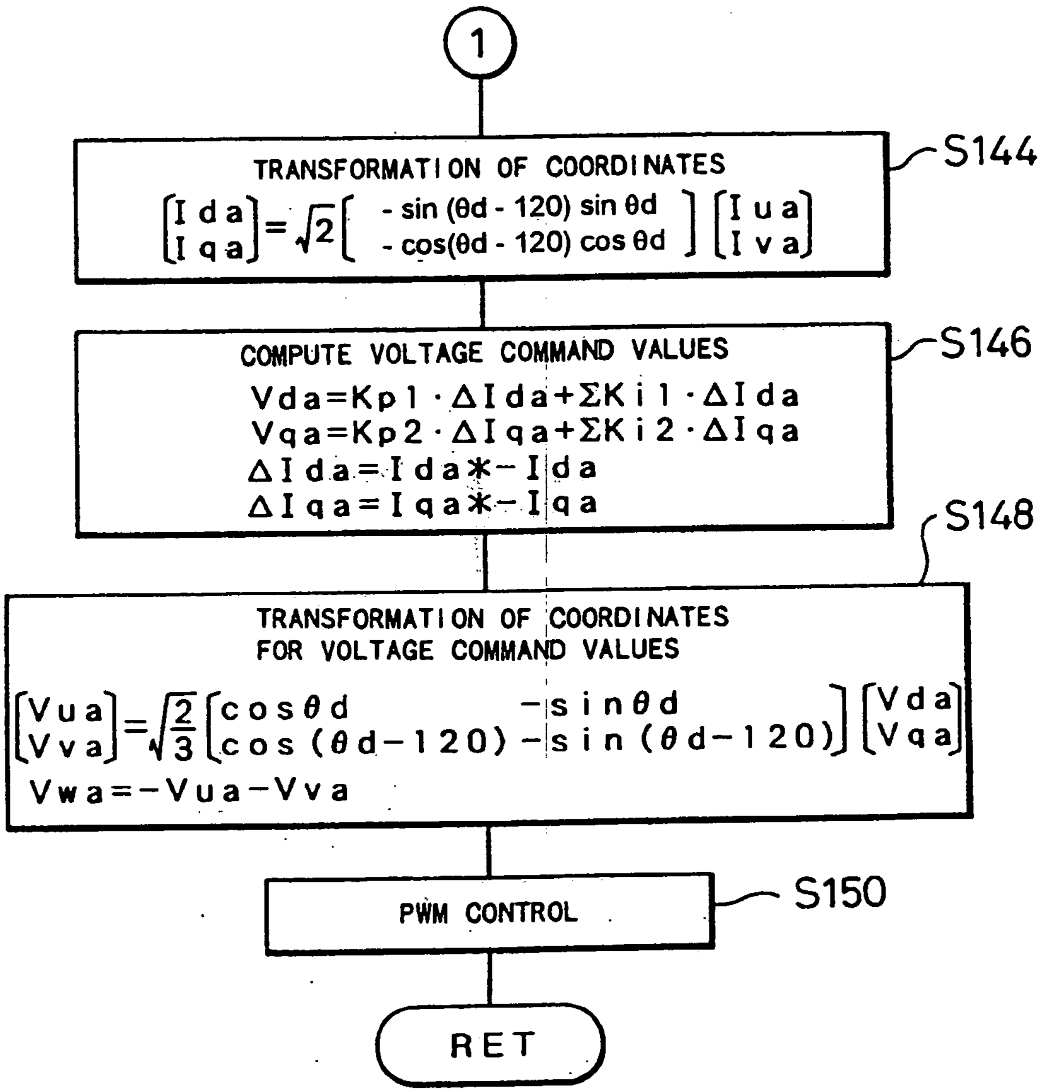

1
TRANSFORMATION OF COORDINATES
[Ida; Iqa] = √2 [-sin (θd - 120) sin θd ; -cos(θd - 120) cos θd] [Iua; Iva]
S144
COMPUTE VOLTAGE COMMAND VALUES
Vda=Kp1·ΔIda+ΣKi1·ΔIda
Vqa=Kp2·ΔIqa+ΣKi2·ΔIqa
ΔIda=Ida*−Ida
ΔIqa=Iqa*−Iqa
S146
TRANSFORMATION OF COORDINATES
FOR VOLTAGE COMMAND VALUES
[Vua; Vva] = √(2/3) [cosθd −sinθd ; cos(θd−120) −sin(θd−120)] [Vda; Vqa]
Vwa=−Vua−Vva
S148
PWM CONTROL
S150
RET

Fig. 9

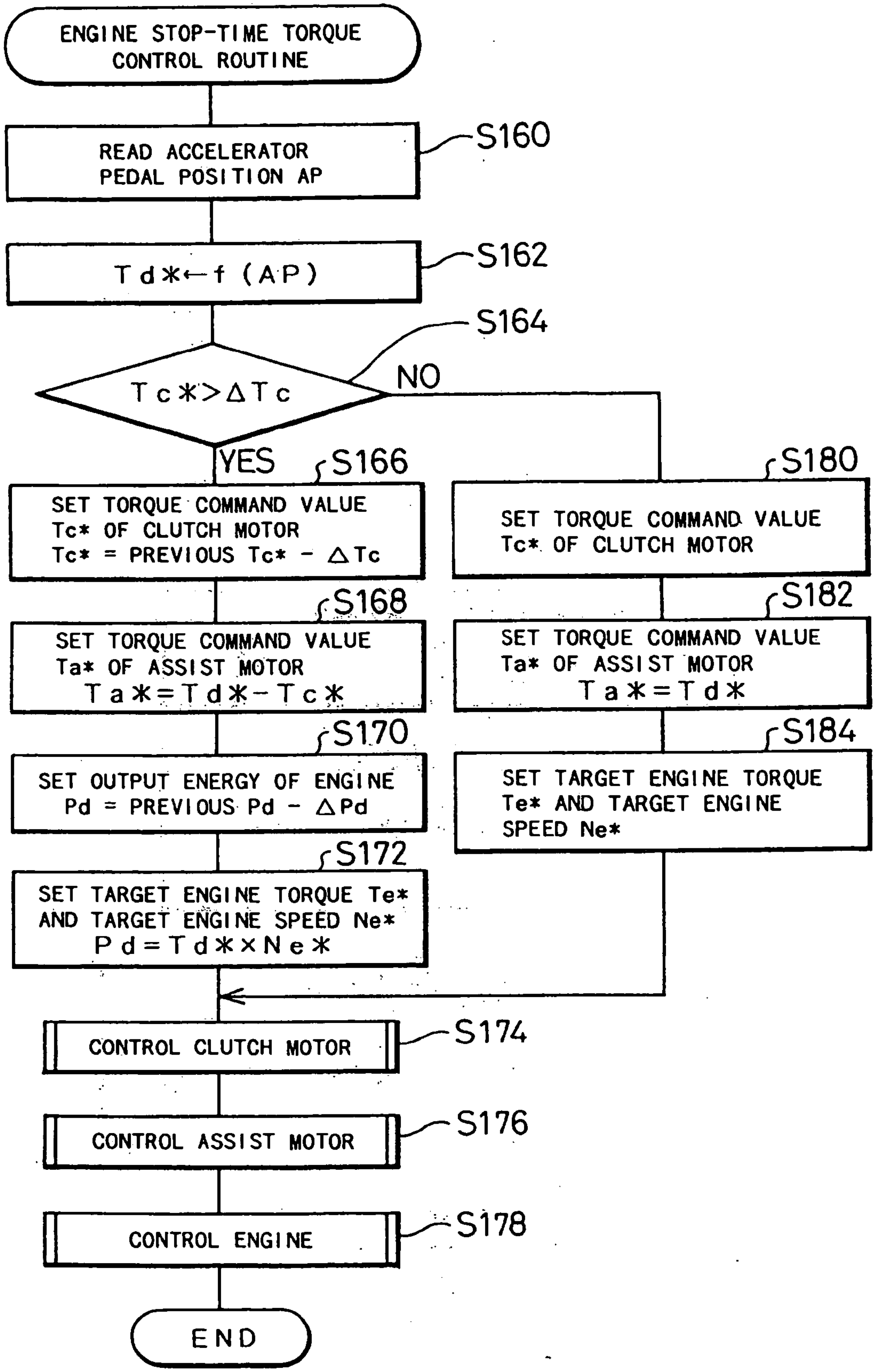

ENGINE STOP-TIME TORQUE CONTROL ROUTINE
READ ACCELERATOR PEDAL POSITION AP
S160
Td*←f (AP)
S162
S164
Tc*>ΔTc
NO
YES
S166
SET TORQUE COMMAND VALUE Tc* OF CLUTCH MOTOR Tc* = PREVIOUS Tc* − ΔTc
S168
SET TORQUE COMMAND VALUE Ta* OF ASSIST MOTOR Ta*=Td*−Tc*
S170
SET OUTPUT ENERGY OF ENGINE Pd = PREVIOUS Pd − ΔPd
S172
SET TARGET ENGINE TORQUE Te* AND TARGET ENGINE SPEED Ne* Pd=Td*×Ne*
S180
SET TORQUE COMMAND VALUE Tc* OF CLUTCH MOTOR
S182
SET TORQUE COMMAND VALUE Ta* OF ASSIST MOTOR Ta*=Td*
S184
SET TARGET ENGINE TORQUE Te* AND TARGET ENGINE SPEED Ne*
CONTROL CLUTCH MOTOR
S174
CONTROL ASSIST MOTOR
S176
CONTROL ENGINE
S178
END

Fig. 10

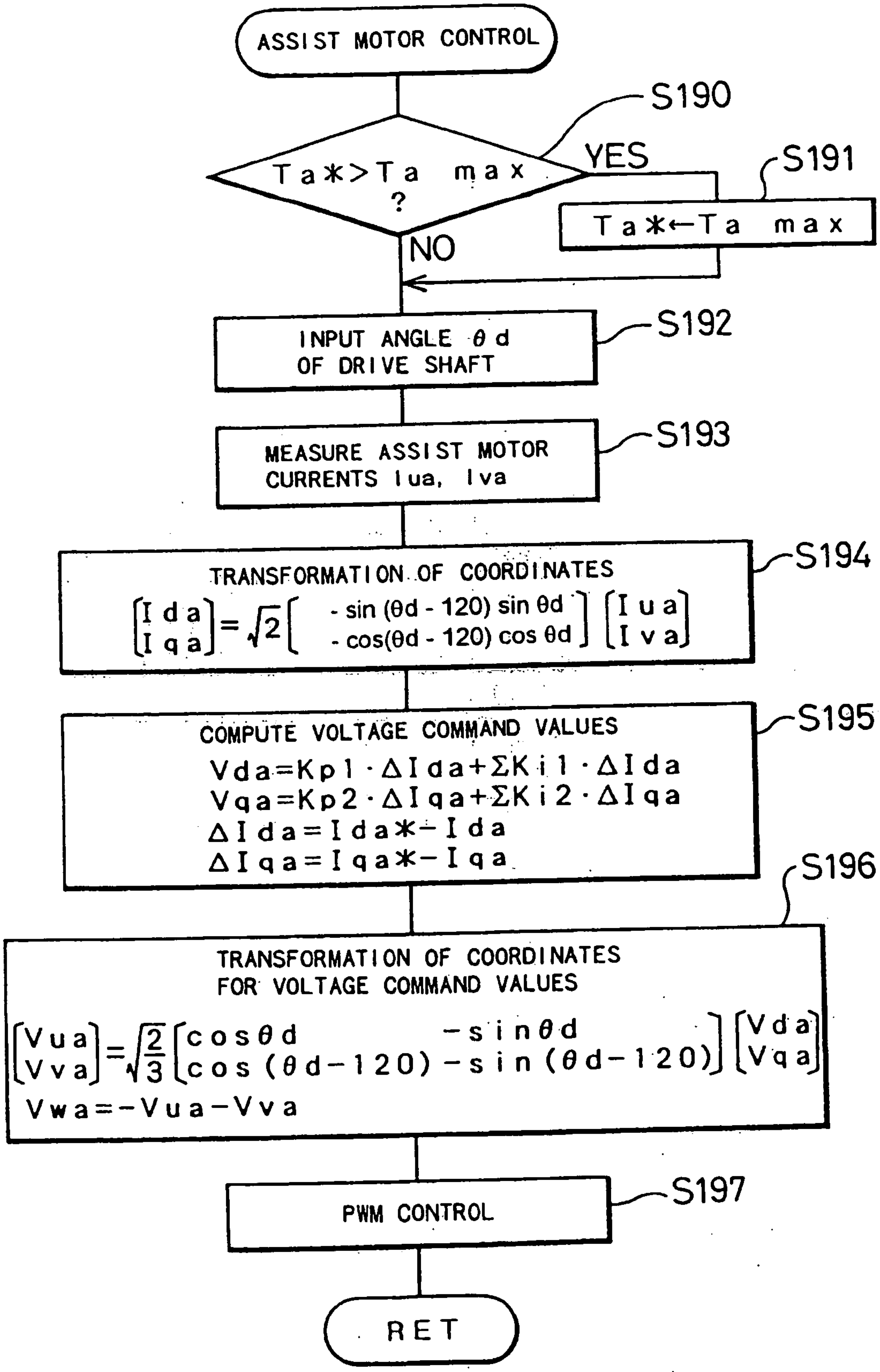

ASSIST MOTOR CONTROL
S190
Ta*>Ta max ?
YES
NO
S191
Ta*←Ta max
S192
INPUT ANGLE θd OF DRIVE SHAFT
S193
MEASURE ASSIST MOTOR CURRENTS Iua, Iva
S194
TRANSFORMATION OF COORDINATES
[Ida; Iqa] = √2 [-sin(θd - 120) sin θd; -cos(θd - 120) cos θd] [Iua; Iva]
S195
COMPUTE VOLTAGE COMMAND VALUES
Vda=Kp1·ΔIda+ΣKi1·ΔIda
Vqa=Kp2·ΔIqa+ΣKi2·ΔIqa
ΔIda=Ida*−Ida
ΔIqa=Iqa*−Iqa
S196
TRANSFORMATION OF COORDINATES FOR VOLTAGE COMMAND VALUES
[Vua; Vva] = √(2/3) [cosθd −sinθd; cos(θd−120) −sin(θd−120)] [Vda; Vqa]
Vwa=−Vua−Vva
S197
PWM CONTROL
RET

Fig. 13

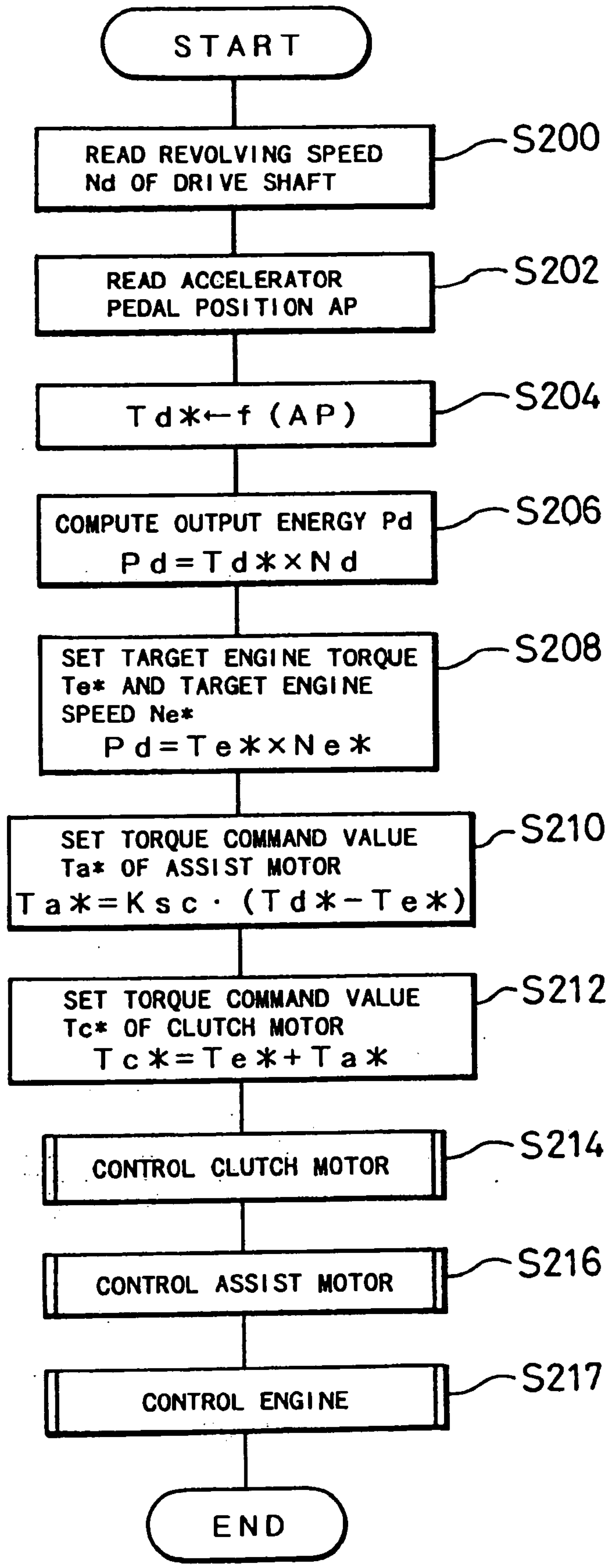

START
READ REVOLVING SPEED Nd OF DRIVE SHAFT
S200
READ ACCELERATOR PEDAL POSITION AP
S202
Td*←f (AP)
S204
COMPUTE OUTPUT ENERGY Pd
Pd=Td*×Nd
S206
SET TARGET ENGINE TORQUE Te* AND TARGET ENGINE SPEED Ne*
Pd=Te*×Ne*
S208
SET TORQUE COMMAND VALUE Ta* OF ASSIST MOTOR
Ta*=Ksc·(Td*−Te*)
S210
SET TORQUE COMMAND VALUE Tc* OF CLUTCH MOTOR
Tc*=Te*+Ta*
S212
CONTROL CLUTCH MOTOR
S214
CONTROL ASSIST MOTOR
S216
CONTROL ENGINE
S217
END

Fig. 11

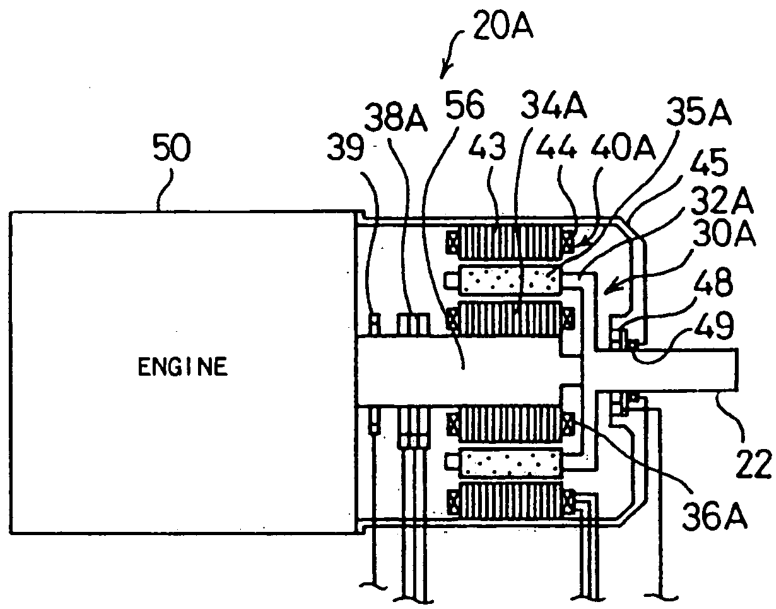

20A
50
39
38A
56
43
34A
44
40A
35A
45
32A
30A
48
49
ENGINE
22
36A

Fig. 12

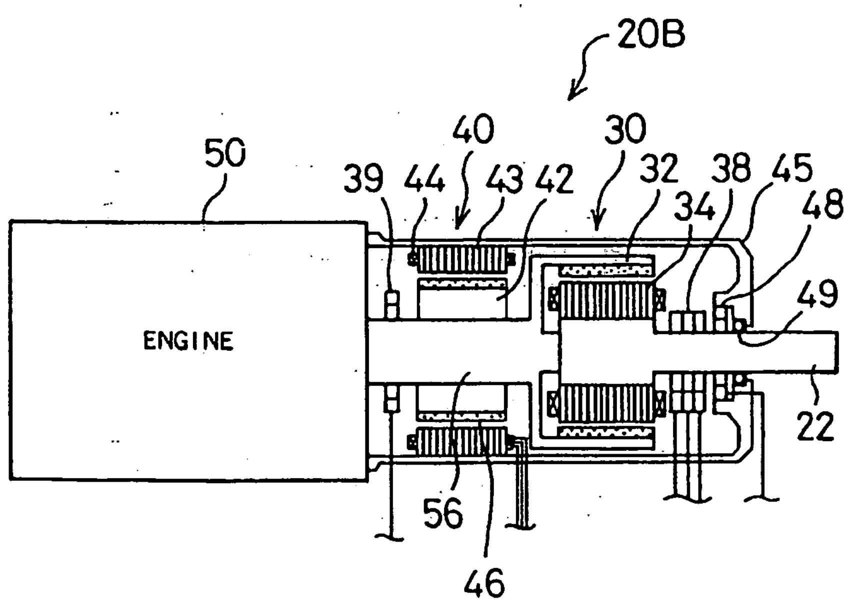

20B
50
40
30
39
44
43
42
32
38
45
34
48
49
ENGINE
22
56
46

Fig. 14

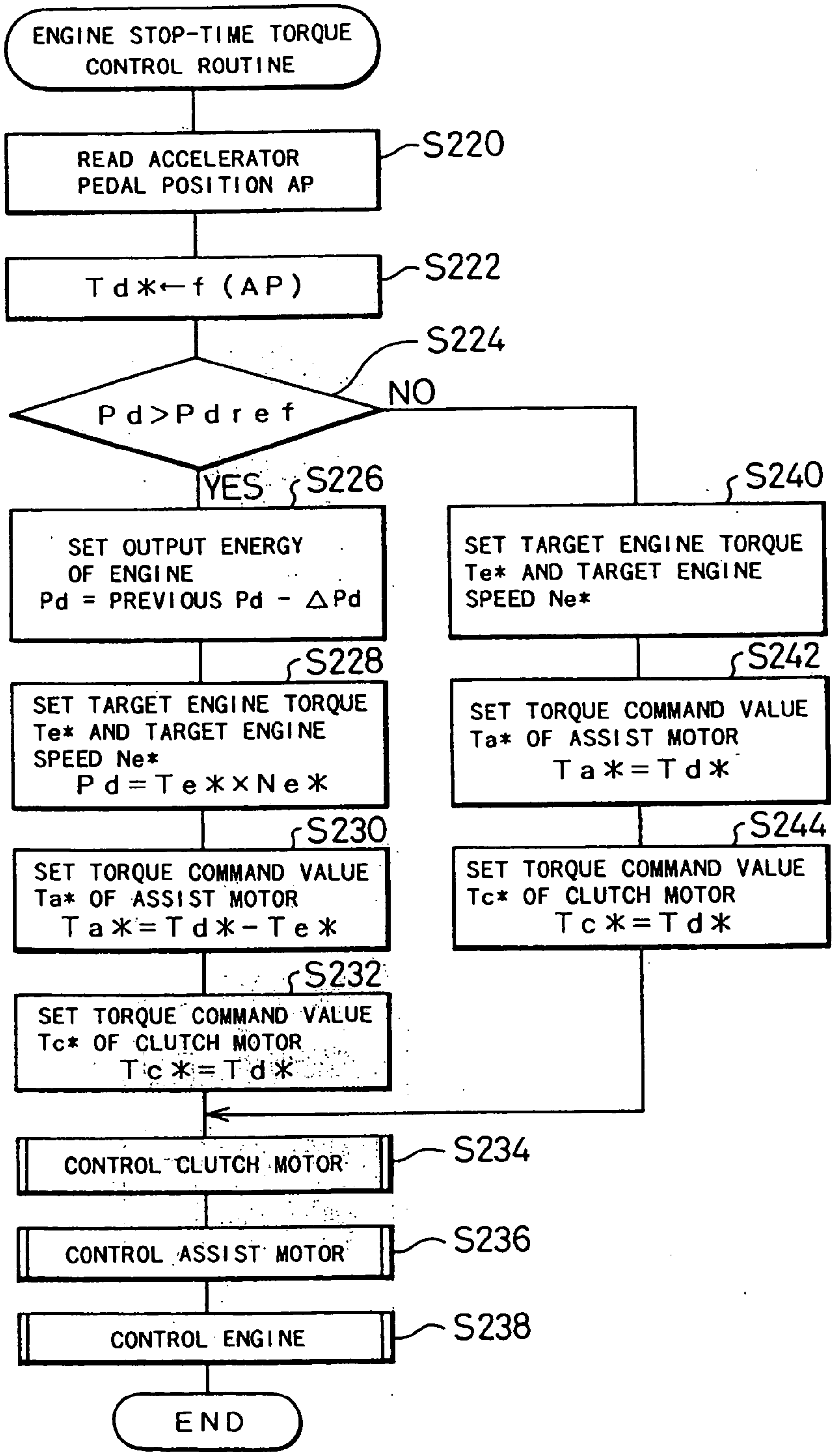

ENGINE STOP-TIME TORQUE CONTROL ROUTINE
READ ACCELERATOR PEDAL POSITION AP
S220
Td*←f (AP)
S222
Pd>Pdref
S224
NO
YES
S226
SET OUTPUT ENERGY OF ENGINE Pd = PREVIOUS Pd − ΔPd
S228
SET TARGET ENGINE TORQUE Te* AND TARGET ENGINE SPEED Ne* Pd=Te*×Ne*
S230
SET TORQUE COMMAND VALUE Ta* OF ASSIST MOTOR Ta*=Td*−Te*
S232
SET TORQUE COMMAND VALUE Tc* OF CLUTCH MOTOR Tc*=Td*
S240
SET TARGET ENGINE TORQUE Te* AND TARGET ENGINE SPEED Ne*
S242
SET TORQUE COMMAND VALUE Ta* OF ASSIST MOTOR Ta*=Td*
S244
SET TORQUE COMMAND VALUE Tc* OF CLUTCH MOTOR Tc*=Td*
CONTROL CLUTCH MOTOR
S234
CONTROL ASSIST MOTOR
S236
CONTROL ENGINE
S238
END

Fig. 15

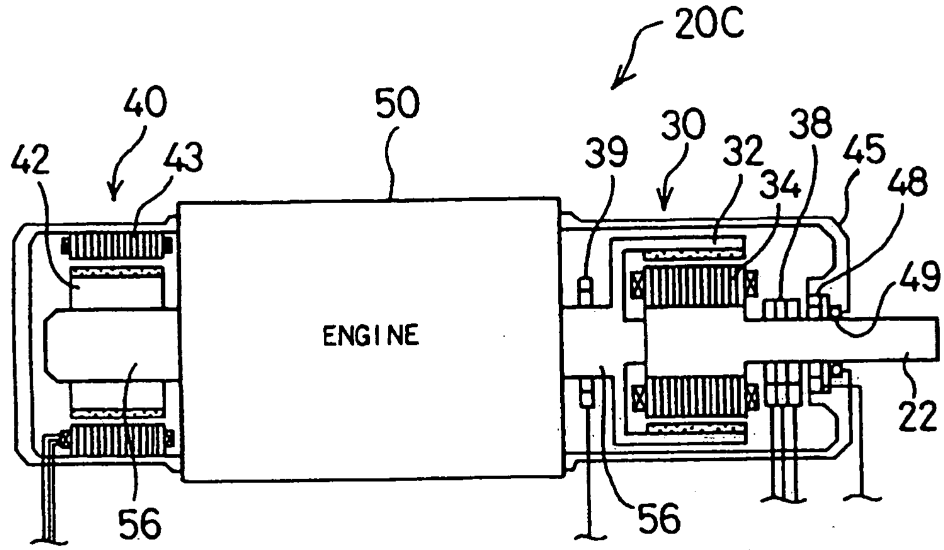
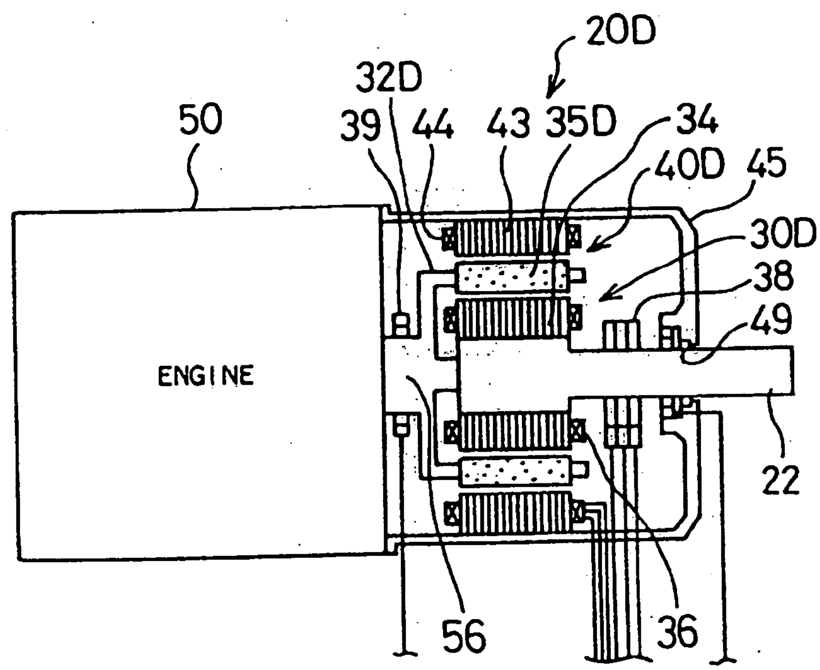

20C
40
50
42
43
39
30
32
38
45
34
48
49
ENGINE
22
56
56

Fig. 16


20D
32D
50
39
44
43
35D
34
40D
45
30D
38
49
ENGINE
22
56
36

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 10 8009

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	AU 58401 73 A (STEPHEN JOHN ELLIOTT) * claim 1; figure 2 * ---	1,3,5,8, 11,13	B60K6/04
Y A	EP 0 645 278 A (TOYOTA MOTOR CO LTD) * page 3, line 23 - line 31; claims 1,3,6 * ---	1,3,5,8, 11,13	
A	US 3 623 568 A (MORI YOICHI) * column 11, line 45 - line 71; claim 1 * ---	1-14	
A	DE 30 25 756 A (HIENZ GEORG) * figures * ---	1,3,5,8, 13	
E	EP 0 725 474 A (NIPPON DENSO CO) * claims 1,18,25,26 * -----	1,3,5,8	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B60K
B60L
H02K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 January 1998	Bufacchi, B

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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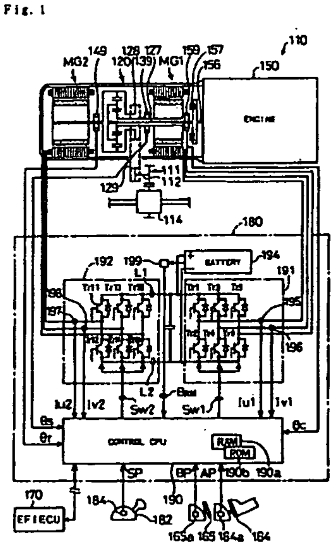
(54) **Power output apparatus, engine controller, and methods of controlling power output apparatus and engine**

(57) A power output apparatus 110 includes a planetary gear 120 having a planetary carrier, a sun gear, and a ring gear, an engine 150 having a crankshaft 156 linked with the planetary carrier, a first motor MG1 attached to the sun gear, and a second motor MG2 attached to the ring gear. In response to an engine operation stop instruction, the power output apparatus 110 stops a fuel injection into the engine 150 and controls the first motor MG1, in order to enable a torque acting in reverse of the rotation of the crankshaft 156 to be output to the crankshaft 156 via the planetary gear 120 and a carrier shaft 127 until the revolving speed of the engine 150 becomes close to zero. This structure allows the revolving speed of the engine 150 to quickly approach to zero.

Fig. 1



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2.16.7/3.6

Description

1.Field of the Invention

The present invention relates to an engine controller, a power output apparatus, and methods of controlling an engine and the power output apparatus. More specifically the present invention pertains to a technique of stopping the operation of an engine in a system including the engine for outputting power through combustion of a fuel and a motor connected to an output shaft of the engine via a damper as well as to a technique of stopping the operation of an engine in a power output apparatus for outputting power to a drive shaft.

2. Description of the Related Art

Known power output apparatuses for carrying out torque conversion of power output from an engine and outputting the converted power to a drive shaft include a combination of a fluid-based torque converter with a transmission. In such a power output apparatus, the torque converter is disposed between an output shaft of the engine and a rotating shaft linked with the transmission, and transmits the power between the rotating shaft and the output shaft through a flow of the sealed fluid. Since the torque converter transmits the power through a flow of the fluid, there is a slip between the output shaft and the rotating shaft, which leads to an energy loss corresponding to the slip. The energy loss is expressed as the product of the revolving speed difference between the rotating shaft and the output shaft and the torque transmitted to the output shaft, and is consumed as heat.

In a vehicle with such a power output apparatus mounted thereon as its power source, at the time when there is a large slip between the rotating shaft and the output shaft, that is, when a significantly large power is required, for example, at the time of starting the vehicle or running the vehicle on an upward slope at a low speed, a large energy loss in the torque converter undesirably lowers the energy efficiency. Even in a stationary driving state, the efficiency of power transmission by the torque converter is not 100%, and the fuel consumption rate in the conventional power output apparatus is thereby lower than that in a manual transmission.

In order to solve such problems, the applicants have proposed a system that does not include the fluid-based torque converter but has an engine, a planetary gear unit as three shaft-type power input/output means, a generator, a motor, and a battery and outputs the power from the motor to the drive shaft by utilizing the power output from the engine or electric power stored in the battery (JAPANESE PATENT LAYING-OPEN GAZETTE No. 50-30223). In this reference, however, there is no description of the control procedure when the operation of the engine is stopped.

In this power output apparatus, the output shaft of the engine and the rotating shaft of the motor are mechanically linked with each other by the three shaft-type power input/output means, and thus mechanically constitute one vibrating system. When the engine is an internal combustion engine, for example, a torque variation due to a gas explosion or reciprocating motions of the piston in the internal combustion engine causes torsional vibrations on the output shaft of the internal combustion engine and the rotating shaft of the motor. When the natural frequency of the shaft coincides with the forcible frequency, a resonance occurs. This may result in a foreign noise from the three shaft-type power input/output means and even in a fatigue destruction of the shaft in some cases. Such a resonance occurs in many cases at a revolving speed lower than the minimum of an operable revolving speed range of the engine, although it depends upon the type of the engine and the structure of the three shaft-type power input/output means.

The resonance of the torsional vibrations that may occur in the system at the time of stopping the operation of the engine is observed not only in the power output apparatus but in any driving system, wherein the output shaft of the engine and the rotating shaft of the motor are mechanically linked with each other. The primary countermeasure against these troubles is that the output shaft of the engine and the rotating shaft of the motor are mechanically linked with each other via a damper. The dampers having a significant effect on reduction of the amplitude of the torsional vibrations, however, require a special damping mechanism. This increases the required number of parts and makes the damper undesirably bulky. The small-sized simply-structured dampers, on the other hand, have little effects.

The motor is generally under the PI control. In the procedure of outputting a torque from the motor to the output shaft of the engine and thereby positively stopping the operation of the engine, the I term (integral term) may result in undershooting the output shaft of the engine, which causes a vibration of the whole driving system. When the driving system is mounted, for example, on a vehicle, the vibration due to undershooting is transmitted to the vehicle body and makes the driver uncomfortable.

SUMMARY OF THE INVENTION

One object of the present invention is to provide a power output apparatus for outputting power from an engine to a drive shaft with a high efficiency, as well as a method of controlling such a power output apparatus.

Another object of the present invention is to provide a control technique of stopping the operation of an engine in a power output apparatus, which includes the engine, three shaft-type power input/output means, and two motors.

Still another object of the invention is to provide a power output apparatus which can prevent a resonance of torsional vibrations that may occur in the system when the operation of the engine is stopped, as well as to provide a method of controlling such a power output apparatus.

In the process of applying a torque from the motor to the output shaft of the engine to stop the operation of the engine, the control procedure of the motor may cause the revolving speed of the output shaft of the engine to undershoot and become smaller than zero. This may result in undesirable vibrations of the whole power output apparatus. In case that the power output apparatus is mounted on a vehicle, for example, the vibrations due to the undershoot are transmitted to the vehicle body and makes the driver uncomfortable.

This problem, that is, the resonance of torsional vibrations that may occur in the system in the course of stopping the operation of the engine, is not restricted to the power output apparatus, but arises in any driving system wherein the output shaft of the engine and the rotating shaft of the motor are mechanically connected to each other. The primary countermeasure against this problem is that the output shaft of the engine and the rotating shaft of the motor are mechanically linked with each other via a damper. The dampers having a significant effect on reduction of the amplitude of the torsional vibrations, however, require a special damping mechanism. This increases the required number of parts and makes the damper undesirably bulky. The small-sized simply-structured dampers, on the other hand, have little effects.

This problem is found not only in the structure that directly outputs power but in the structure of series hybrid that has a motor and a generator directly connected to each other and obtains a torque by the motor driven by means of the electric power generated by the generator while the vehicle is on a run.

SUMMARY OF THE INVENTION

One object of the present invention is thus to provide a power output apparatus that prevents resonance of torsional vibrations which may occur in a system in the course of stopping the operation of an engine, as well as a method of controlling such a power output apparatus.

Another object of the present invention is accordingly to reduce vibrations that may occur in the course of stopping the operation of an engine.

Still another object of the present invention is thus to provide an engine controller that prevents resonance of torsional vibrations which may occur in a system in the course of stopping the operation of an engine, irrespective of the type of a damper, as well as a method of controlling the engine.

At least part of the above and the other related objects is realized by a power output apparatus for outputting power to a drive shaft, which includes: an engine having an output shaft; a first motor having a rotating shaft and inputting and outputting power to and from the rotating shaft; a second motor inputting and outputting power to and from the drive shaft; three shaft-type power input/output means having three shafts respectively linked with the drive shaft, the output shaft, and the rotating shaft, the three shaft-type power input/output means inputting and outputting power to and from a residual one shaft, based on predetermined powers input to and output from any two shafts among the three shafts; fuel stop instruction means for giving an instruction to stop fuel supply to the engine when a condition of stopping operation of the engine is fulfilled; and stop-time control means for causing a torque to be applied to the output shaft of the engine and thereby restricting a deceleration of revolving speed of the output shaft to a predetermined range in response to the instruction to stop the fuel supply to the engine, so as to implement a stop-time control for stopping the operation of the engine.

The present invention is also directed to a method of controlling such a power output apparatus. The method controls the power output apparatus, which includes: an engine having an output shaft; a first motor having a rotating shaft and inputting and outputting power to and from the rotating shaft; a second motor inputting and outputting power to and from the drive shaft; and three shaft-type power input/output means having three shafts respectively linked with the drive shaft, the output shaft, and the rotating shaft, the three shaft-type power input/output means inputting and outputting power to and from a residual one shaft, based on predetermined powers input to and output from any two shafts among the three shafts. The method includes the steps of:

giving an instruction to stop fuel supply to the engine when a condition of stopping operation of the engine is fulfilled; and
causing a torque to be applied to the output shaft of the engine and thereby restricting a deceleration of revolving speed of the output shaft to a predetermined range in response to the instruction to stop the fuel supply to the engine, so as to implement a stop-time control for stopping the operation of the engine.

When the condition to stop the operation of the engine is fulfilled, the power output apparatus of the present invention gives an instruction to stop fuel supply to the engine and carries out the stop-time control. The stop-time control applies a torque to the output shaft of the engine and thereby restricts the deceleration of the revolving speed of the output shaft to a predetermined range, so as to stop the operation of the engine. The torque may be applied from either the first motor or the second motor to the output shaft of the engine.

This procedure restricts the deceleration of the revolving speed of the output shaft to a predetermined range and enables the revolving speed of the output shaft to quickly pass through a range of torsional vibrations. This structure also saves the consumption of electric power by the motor.

A variety of structures may be applied to the stop-time control. One available structure carries out open-loop control of the torque applied to the output shaft. In this case, the power output apparatus further includes target torque storage means for determining a time-based variation in target value of the torque applied to the output shaft of the engine, based on a behavior at the time of stopping the operation of the engine. The stop-time control means has means for driving the first motor, as the stop-time control, to apply a torque corresponding to the target value to the output shaft of the engine along a time course after the stop of the engine via the three shaft-type power input/output means.

This structure does not carry out the feedback control based on the revolving speed of the output shaft and accordingly reduces the variation in torque on the drive shaft without causing a variation in torque due to the state of the power output apparatus or an external disturbance. Even when the revolving speed of the output shaft is significantly different from a target revolving speed (generally equal to zero under the condition of the vehicle at a stop), this structure does not execute the feedback control based on the revolving speed difference to output a large torque and thus effectively saves the consumption of electric power.

In order to optimize such open-loop control, the power output apparatus may further include: deceleration computing means for computing the deceleration of revolving speed of the output shaft during the course of the stop-time control; learning means for varying a learnt value according to the deceleration computed by the deceleration computing means and storing the learnt value; and deceleration range determination means for determining the predetermined range in the stop-time control carried out by the stop-time control means, based on the learnt value stored by the learning means. This structure learns the range of deceleration and thereby realizes the preferable control.

In accordance with another possible application, the power output apparatus further includes revolving speed detection means for measuring the revolving speed of the output shaft, and the stop-time control means has means for driving the first motor, as the stop-time control, in order to enable the revolving speed of the output shaft measured by the revolving speed detection means to approach a predetermined value via a predetermined pathway. The predetermined pathway represents a time course of revolving speed of the output shaft of the engine after the stop of fuel supply to the engine.

In response to the instruction to stop the operation of the engine, the power output apparatus of this structure enables the revolving speed of the output shaft of the engine to approach a predetermined value via a predetermined pathway. The revolving speed of the output shaft of the engine can be made to reach the predetermined value within a short time or within a relatively long time by regulating the predetermined pathway. In case that the predetermined value is equal to zero, the rotation of the output shaft of the engine can be stopped quickly or gently.

In the power output apparatus of this structure, the stop-time control may drive the first motor to apply a torque in reverse of the rotation of the output shaft via the three shaft-type power input/output means to the output shaft, until the revolving speed of the output shaft measured by the revolving speed detection means becomes coincident with the predetermined value. This structure enables the revolving speed of the output shaft of the engine to approach the predetermined value more quickly. When a specific revolving speed range that causes a resonance of a torsional vibration exists between the predetermined value and the revolving speed of the output shaft of the engine at the time when the instruction to stop the operation of the engine is given, the structure allows the revolving speed of the output shaft of the engine to swiftly pass through this specific range and thereby effectively prevents a resonance.

In the power output apparatus of this structure, as part of the stop-time control, the first motor may be driven to apply a predetermined torque in the direction of rotation of the output shaft via the three shaft-type power input/output means to the output shaft, when the revolving speed of the output shaft measured by the revolving speed detection means decreases to a reference value, which is not greater than the predetermined value. This structure prevents the revolving speed of the engine from undershooting and reduces the possible vibration in the course of stopping the rotation of the output shaft.

A variety of techniques may be applied to determine the reference value. One possible structure computes the deceleration of revolving speed of the output shaft during the course of the stop-time control, and sets a larger value to the reference value against a greater absolute value of the deceleration. The larger reference value for the greater deceleration effectively prevents the revolving speed of the output shaft from undershooting. Another possible structure determines the magnitude of a braking force applied to the drive shaft during the course of the stop-time control, and sets a larger value to the reference value when the braking force detection means determines that the braking force has a large magnitude. During application of the braking force, it can be assumed that a large force is applied to stop the engine. The larger reference value accordingly prevents the revolving speed of the output shaft from undershooting.

In the power output apparatus of the present invention, the stop-time control means may drive the first motor to make the power input to and output from the rotating shaft equal to zero. The first motor does not consume any electric power, so that this structure improves the energy efficiency of the whole power output apparatus. Since the first motor does not forcibly change the driving state of the output shaft of the engine, the torque shock due to an operation stop of the engine can be effectively reduced. The engine and the first motor are stably kept in the driving state having the least sum of the energies consumed thereby (for example, the frictional work).

In the power output apparatus of the present invention, the predetermined value may be a revolving speed that is lower than a resonance range of torsional vibrations in a system including the output shaft and the three shaft-type power input/output means. This structure effectively prevents torsional vibrations.

In accordance with another preferable structure, the second motor is driven to continue power input and output to and from the drive shaft, when the instruction to stop the operation of the engine is given in the course of continuous power input and output to and from the drive shaft. This structure enables the operation of the engine to be stopped while the power is continuously input to and output from the drive shaft. The input and output of the power to and from the drive shaft is implemented by the second motor.

The present invention is also directed to an engine controller having an engine for outputting power through combustion of a fuel and a motor connected to an output shaft of the engine via a damper. The engine controller controls operation and stop of the engine and includes: fuel stop means for stopping fuel supply to the engine when a condition to stop the operation of the engine is fulfilled; and stop-time control means for causing a torque to be applied to the output shaft of the engine and thereby restricting a deceleration of revolving speed of the output shaft to a predetermined range in response to the stop of fuel supply to the engine, so as to implement a stop-time control for stopping the operation of the engine.

The present invention is further directed to a method of controlling stop of an engine, which outputs power through combustion of a fuel and has an output shaft connected to a motor via a damper. The method includes the steps of:

stopping fuel supply to the engine when a condition to stop operation of the engine is fulfilled; and causing a torque to be applied to the output shaft of the engine and thereby restricting a deceleration of revolving speed of the output shaft to a predetermined range in response to the stop of fuel supply to the engine, so as to implement a stop-time control for stopping the operation of the engine.

The engine controller and the corresponding method of the present invention controls stop of the engine that has an output shaft connected to a motor via a damper, and reduces the torsional vibrations that may occur on the output shaft of the engine connected to the motor via the damper. When the condition to stop the operation of the engine is fulfilled, the engine controller stops the fuel supply to the engine and applies a torque to the output shaft of the engine, thereby restricting the deceleration of the revolving speed of the output shaft to a predetermined range and stopping the operation of the engine. The torsional vibrations on the output shaft tend to occur at a predetermined deceleration. The restriction of the deceleration of the revolving speed of the output shaft to the predetermined range thus effectively reduces the torsional vibrations.

A variety of structures may be applied to the stop-time control that restricts the deceleration of the revolving speed of the output shaft to a predetermined range. One available structure carries out open-loop control that specifies a variation in target value of the torque applied to the output shaft along the time axis. In this case, the engine controller further includes target torque storage means for determining a time-based variation in target value of the torque applied to the output shaft of the engine, based on a behavior at the time of stopping the operation of the engine. The stop-time control means has means for driving the motor, as the stop-time control, to apply a torque corresponding to the target value to the output shaft of the engine along a time course after the stop of the engine.

This structure does not carry out the feedback control based on the revolving speed of the output shaft and accordingly does not vary the torque applied to the output shaft by an external disturbance. Even when the revolving speed of the output shaft is significantly different from a target revolving speed (generally equal to zero under the condition of the vehicle at a stop), this structure does not execute the feedback control based on the revolving speed difference to output a large torque and thus effectively saves the consumption of electric power.

In order to optimize such open-loop control, the engine controller may further include: deceleration computing means for computing the deceleration of revolving speed of the output shaft during the course of the stop-time control; learning means for varying a learnt value according to the deceleration computed by the deceleration computing means and storing the learnt value; and deceleration range determination means for determining the predetermined range in the stop-time control carried out by the stop-time control means, based on the learnt value stored by the learning means. This structure learns the range of deceleration and thereby realizes the preferable control.

In accordance with another possible application, the engine controller further includes revolving speed detection means for measuring the revolving speed of the output shaft, and the stop-time control means has means for driving the motor, as the stop-time control, in order to enable the revolving speed of the output shaft measured by the revolving speed detection means to approach a predetermined value via a predetermined pathway. The predetermined pathway represents a time course of revolving speed of the output shaft of the engine after the stop of fuel supply to the engine.

In response to the instruction to stop the operation of the engine, the engine controller of this structure enables the revolving speed of the output shaft of the engine to approach a predetermined value via a predetermined pathway. The revolving speed of the output shaft of the engine can be made to reach the predetermined value within a short time or within a relatively long time by regulating the predetermined pathway. In any case, the deceleration is restricted to a predetermined range that is out of a specific range causing torsional vibrations on the output shaft.

In the engine controller of this structure, the stop-time control may drive the motor to apply a torque in reverse of the rotation of the output shaft to the output shaft, until the revolving speed of the output shaft measured by the revolving speed detection means becomes coincident with the predetermined value. This structure enables the revolving speed of the output shaft of the engine to approach the predetermined value more quickly. When a specific revolving speed range that causes a resonance of a torsional vibration exists between the predetermined value and the revolving speed of the output shaft of the engine at the time when the instruction to stop the operation of the engine is given, the structure allows the revolving speed of the output shaft of the engine to swiftly pass through this specific range and thereby effectively prevents a resonance.

In the engine controller of this structure, as part of the stop-time control, the motor may be driven to apply a predetermined torque in the direction of rotation of the output shaft to the output shaft, when the revolving speed of the output shaft measured by the revolving speed detection means decreases to a reference value, which is not greater than the predetermined value. This structure prevents the revolving speed of the engine from undershooting and reduces the possible vibration in the course of stopping the rotation of the output shaft.

A variety of techniques may be applied to determine the reference value. One possible structure computes the deceleration of revolving speed of the output shaft during the course of the stop-time control, and sets a larger value to the reference value against a greater absolute value of the deceleration. The larger reference value for the greater deceleration effectively prevents the revolving speed of the output shaft from undershooting.

In the engine controller of the present invention, the predetermined value may be a revolving speed that is lower than a resonance range of torsional vibrations in a system including the output shaft and a rotor of the motor. This structure effectively prevents torsional vibrations.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 schematically illustrates structure of a power output apparatus 110 embodying the present invention;

Fig. 2 is an enlarged view illustrating an essential part of the power output apparatus 110 of the embodiment;

Fig. 3 schematically illustrates general structure of a vehicle with the power output apparatus 110 of the embodiment incorporated therein;

Fig. 4 is a graph showing the operation principle of the power output apparatus 110 of the embodiment;

Fig. 5 is a nomogram showing the relationship between the revolving speed and the torque on the three shafts linked with the planetary gear 120 in the power output apparatus 110 of the embodiment;

Fig. 6 is a nomogram showing the relationship between the revolving speed and the torque on the three shafts linked with the planetary gear 120 in the power output apparatus 110 of the embodiment;

Fig. 7 is a flowchart showing an engine stop control routine executed by the control CPU 190 of the controller 180;

Fig. 8 is a map showing the relationship between the time counter TC and the target revolving speed Ne* of the engine 150;

Fig. 9 is a flowchart showing a required torque setting routine executed by the control CPU 190 of the controller 180;

Fig. 10 shows the relationship between the revolving speed Nr of the ring gear shaft 126, the accelerator pedal position AP, and the torque command value Tr*;

Fig. 11 is a flowchart showing a control routine of the first motor MG1 executed by the control CPU 190 of the controller 180;

Fig. 12 is a flowchart showing a control routine of the second motor MG2 executed by the control CPU 190 of the controller 180;

Fig. 13 is a nomogram showing the state when the engine stop control routine of Fig. 7 is carried out for the first time;

Fig. 14 is a nomogram showing the state when the processing of steps S106 through S116 in the engine stop control routine has repeatedly been executed;

Fig. 15 is a nomogram showing the state when the revolving speed Ne of the engine 150 becomes equal to or less than the threshold value Nref;

Fig. 16 shows variations in revolving speed Ne of the engine 150 and torque Tm1 of the first motor MG1;

Fig. 17 is a flowchart showing a modified engine stop control routine;

Fig. 18 schematically illustrates another power output apparatus 110A as a modified example;

DESCRIPTION OF THE PREFERRED EMBODIMENTS

One mode of carrying out the present invention is described as a preferred embodiment. Fig. 1 schematically illustrates structure of a power output apparatus 110 embodying the present invention; Fig. 2 is an enlarged view illustrating an essential part of the power output apparatus 110 of the embodiment; and Fig. 3 schematically illustrates general structure of a vehicle with the power output apparatus 110 of the embodiment incorporated therein. The general structure of the vehicle is described first for the convenience of explanation.

Referring to Fig. 3, the vehicle is provided with an engine 150 which consumes gasoline as a fuel and outputs power. The air ingested from an air supply system via a throttle valve 166 is mixed with a fuel, that is, gasoline in this embodiment, injected from a fuel injection valve 151. The air/fuel mixture is supplied into a combustion chamber 152 to be explosively ignited and burned. Linear motion of a piston 154 pressed down by the explosion of the air/fuel mixture is converted to rotational motion of a crankshaft 156. The throttle valve 166 is driven to open and close by an actuator 168. An ignition plug 162 converts a high voltage applied from an igniter 158 via a distributor 160 to a spark, which explosively ignites and combusts the air/fuel mixture.

Operation of the engine 150 is controlled by an electronic control unit (hereinafter referred to as EFIECU) 170. The EFIECU 170 receives information from various sensors, which detect operating conditions of the engine 150. These sensors include a throttle valve position sensor 167 for detecting a valve travel or position of the throttle valve 166, a manifold vacuum sensor 172 for measuring a load applied to the engine 150, a water temperature sensor 174 for measuring the temperature of cooling water in the engine 150, and a speed sensor 176 and an angle sensor 178 mounted on the distributor 160 for measuring the revolving speed (the number of revolutions per a predetermined time period) and the rotational angle of the crankshaft 156. A starter switch 179 for detecting a starting condition ST of an ignition key (not shown) is also connected to the EFIECU 170. Other sensors and switches connecting with the EFIECU 170 are omitted from the illustration.

The crankshaft 156 of the engine 150 is linked with a planetary gear 120, a first motor MG1, and a second motor MG2 (described later) via a damper 157 that reduces the amplitude of torsional vibrations occurring on the crankshaft 156. The crankshaft 156 is further connected to a differential gear 114 via a power transmission gear 111, which is linked with a drive shaft 112 working as the rotating shaft of the power transmission gear 111. The power output from the power output apparatus 110 is thus eventually transmitted to left and right driving wheels 116 and 118. The first motor MG1 and the second motor MG2 are electrically connected to and controlled by a controller 180. The controller 180 includes an internal control CPU and receives inputs from a gearshift position sensor 184 attached to a gearshift 182, an accelerator position sensor 164a attached to an accelerator pedal 164, and a brake pedal position sensor 165a attached to a brake pedal 165, as described later in detail. The controller 180 sends and receives a variety of data and information to and from the EFIECU 170 through communication. Details of the control procedure including a communication protocol will be described later.

Referring to Fig. 1, the power output apparatus 110 of the embodiment primarily includes the engine 150, the damper 157 for connecting the crankshaft 156 of the engine 150 to a carrier shaft 127 so as to reduce the amplitude of the torsional vibrations of the crankshaft 156, the planetary gear 120 having a planetary carrier 124 linked with the carrier shaft 127, the first motor MG1 linked with a sun gear 121 of the planetary gear 120, the second motor MG2 linked with a ring gear 122 of the planetary gear 120, and the controller 180 for driving and controlling the first and the second motors MG1 and MG2.

The following describes structure of the planetary gear 120 and the first and the second motors MG1 and MG2 based on the drawing of Fig. 2. The planetary gear 120 includes the sun gear 121 linked with a hollow sun gear shaft 125 which the carrier shaft 127 passes through, the ring gear 122 linked with a ring gear shaft 126 coaxial with the carrier shaft 127, a plurality of planetary pinion gears 123 arranged between the sun gear 121 and the ring gear 122 to revolve around the sun gear 121 while rotating on its axis, and the planetary carrier 124 connecting with one end of the carrier shaft 127 to support the rotating shafts of the planetary pinion gears 123. In the planetary gear 120, three shafts, that is, the sun gear shaft 125, the ring gear shaft 126, and the carrier shaft 127 respectively connecting with the sun gear 121, the ring gear 122, and the planetary carrier 124, work as input and output shafts of the power. Determination of the power input to or output from any two shafts among the three shafts automatically determines the power input to or output from the residual one shaft. The details of the input and output operations of the power into and from the three shafts of the planetary gear 120 will be discussed later. Resolvers 139, 149, and 159 for measuring rotational angles θs, θr, and θc of the sun gear shaft 125, the ring gear shaft 126, and the carrier shaft 127 are respectively attached to the sun gear shaft 125, the ring gear shaft 126, and the carrier shaft 127.

A power feed gear 128 for taking out the power is linked with the ring gear 122 and arranged on the side of the first motor MG1. The power feed gear 128 is further connected to the power transmission gear 111 via a chain belt 129, so that the power is transmitted between the power feed gear 128 and the power transmission gear 111.

The first motor MG1 is constructed as a synchronous motor-generator and includes a rotor 132 having a plurality of permanent magnets 135 on its outer surface and a stator 133 having three-phase coils 134 wound thereon to form a revolving magnetic field. The rotor 132 is linked with the sun gear shaft 125 connecting with the sun gear 121 of the planetary gear 120. The stator 133 is prepared by laying thin plates of non-directional electromagnetic steel one upon another and is fixed to a casing 119. The first motor MG1 works as a motor for rotating the rotor 132 through the interaction between a magnetic field produced by the permanent magnets 135 and a magnetic field produced by the three-phase coils 134, or as a generator for generating an electromotive force on either ends of the three-phase coils 134 through the interaction between the magnetic field produced by the permanent magnets 135 and the rotation of the rotor 132.

Like the first motor MG1, the second motor MG2 is also constructed as a synchronous motor-generator and includes a rotor 142 having a plurality of permanent magnets 145 on its outer surface and a stator 143 having three-phase coils 144 wound thereon to form a revolving magnetic field. The rotor 142 is linked with the ring gear shaft 126 connecting with the ring gear 122 of the planetary gear 120, whereas the stator 14 is fixed to the casing 119. The stator 143 of the motor MG2 is also produced by laying thin plates of non-directional electromagnetic steel one upon another. Like the first motor MG1, the second motor MG2 also works as a motor or a generator.

The controller 180 for driving and controlling the first and the second motor MG1 and MG2 has the following configuration. Referring back to Fig. 1, the controller 180 includes a first driving circuit 191 for driving the first motor MG1, a second driving circuit 192 for driving the second motor MG2, a control CPU 190 for controlling both the first and the second driving circuits 191 and 192, and a battery 194 including a number of secondary cells. The control CPU 190 is a one-chip microprocessor including a RAM 190a used as a working memory, a ROM 190b in which various control programs are stored, an input/output port (not shown), and a serial communication port (not shown) through which data are sent to and received from the EFIECU 170. The control CPU 190 receives a variety of data via the input port. The input data include a rotational angle θs of the sun gear shaft 125 measured with the resolver 139, a rotational angle θr of the ring gear shaft 126 measured with the resolver 149, a rotational angle θc of the carrier shaft 127 measured with the resolver 159, an accelerator pedal position AP (step-on amount of the accelerator pedal 164) output from the accelerator position sensor 164a, a brake pedal position BP (step-on amount of the brake pedal 165) output from the brake pedal position sensor 165a, a gearshift position SP output from the gearshift position sensor 184, values of currents Iu1 and Iv1 from two ammeters 195 and 196 disposed in the first driving circuit 191, values of currents Iu2 and Iv2 from two ammeters 197 and 198 disposed in the second driving circuit 192, and a remaining charge BRM of the battery 194 measured with a remaining charge meter 199. The remaining charge meter 199 may determine the remaining charge BRM of the battery 194 by any known method; for example, by measuring the specific gravity of an electrolytic solution in the battery 194 or the whole weight of the battery 194, by computing the currents and time of charge and discharge, or by causing an instantaneous short circuit between terminals of the battery 194 and measuring an internal resistance against the electric current.

The control CPU 190 outputs a first control signal SW1 for driving six transistors Tr1 through Tr6 working as switching elements of the first driving circuit 191 and a second control signal SW2 for driving six transistors Tr11 through Tr16 working as switching elements of the second driving circuit 192. The six transistors Tr1 through Tr6 in the first driving circuit 191 constitute a transistor inverter and are arranged in pairs to work as a source and a drain with respect to a pair of power lines L1 and L2. The three-phase coils (U,V,W) 134 of the first motor MG1 are connected to the respective contacts of the paired transistors in the first driving circuit 191. The power lines L1 and L2 are respectively connected to plus and minus terminals of the battery 194. The control signal SW1 output from the control CPU 190 thus successively controls the power-on time of the paired transistors Tr1 through Tr6. The electric currents flowing through the three-phase coils 134 undergo PWM (pulse width modulation) control to give quasi-sine waves, which enable the three-phase coils 134 to form a revolving magnetic field.

The six transistors Tr11 through Tr16 in the second driving circuit 192 also constitute a transistor inverter and are arranged in the same manner as the transistors Tr1 through Tr6 in the first driving circuit 191. The three-phase coils

(U,V,W) 144 of the second motor MG2 are connected to the respective contacts of the paired transistors in the second driving circuit 191. The second control signal SW2 output from the control CPU 190 thus successively controls the power-on time of the paired transistors Tr11 through Tr16. The electric currents flowing through the three-phase coils 144 undergo PWM control to give quasi-sine waves, which enable the three-phase coils 144 to form a revolving magnetic field.

The following describes the operation of the power output apparatus 110 of the first embodiment having the above construction. In the following discussion, the term 'power' is expressed by the product of the torque acting on a shaft and the revolving speed of the shaft and represents the magnitude of energy output per unit time. The term 'power state' denotes a driving point defined by a combination of the torque and the revolving speed that gives a certain power. There are, however, numerous combinations of the torque and the revolving speed to define a driving point that gives a certain power. The power output apparatus is controlled based on the energy flow at each moment, in other words, based on the energy balance per unit time. The term 'energy' herein is thus used as the synonym of 'power' and represents energy per unit time. In the same manner, both the terms 'electric power' and 'electrical energy' represent electrical energy per unit time.

The power output apparatus 110 of the embodiment thus constructed works in accordance with the operation principles discussed below, especially with the principle of torque conversion. By way of example, it is assumed that the engine 150 is driven at a driving point P1 of the revolving speed Ne and the torque Te and that the ring gear shaft 126 is driven at another driving point P2, which is defined by another revolving speed Nr and another torque Tr but gives an amount of energy identical with an energy Pe output from the engine 150. This means that the power output from the engine 150 is subjected to torque conversion and applied to the ring gear shaft 126. The relationship between the torque and the revolving speed of the engine 150 and the ring gear shaft 126 under such conditions is shown in the graph of Fig. 4.

According to the mechanics, the relationship between the revolving speed and the torque of the three shafts in the planetary gear 120 (that is, the sun gear shaft 125, the ring gear shaft 126, and the carrier shaft 127) can be expressed as nomograms illustrated in Figs. 5 and 6 and solved geometrically. The relationship between the revolving speed and the torque of the three shafts in the planetary gear 120 may be analyzed numerically through calculation of energies of the respective shafts, without using the nomograms. For the clarity of explanation, the nomograms are used in this embodiment.

In the nomogram of Fig. 5, the revolving speed of the three shafts is plotted as ordinate and the positional ratio of the coordinate axes of the three shafts as abscissa. When a coordinate axis S of the sun gear shaft 125 and a coordinate axis R of the ring gear shaft 126 are positioned on either ends of a line segment, a coordinate axis C of the carrier shaft 127 is given as an interior division of the axes S and R at the ratio of 1 to ρ, where ρ represents a ratio of the number of teeth of the sun gear 121 to the number of teeth of the ring gear 122 and expressed as Equation (1) given below:

$$\rho = \frac{\textit{the humber of teeth of the sun gear}}{\textit{the humber of teeth of the ring gear}} \quad (1)$$

As mentioned above, the engine 150 is driven at the revolving speed Ne, while the ring gear shaft 126 is driven at the revolving speed Nr. The revolving speed Ne of the engine 150 can thus be plotted on the coordinate axis C of the carrier shaft 127 linked with the crankshaft 156 of the engine 150, and the revolving speed Nr of the ring gear shaft 126 on the coordinate axis R of the ring gear shaft 126. A straight line passing through both the points is drawn, and a revolving speed Ns of the sun gear shaft 125 is then given as the intersection of this straight line and the coordinate axis S. This straight line is hereinafter referred to as a dynamic collinear line. The revolving speed Ns of the sun gear shaft 125 can be calculated from the revolving speed Ne of the engine 150 and the revolving speed Nr of the ring gear shaft 126 according to a proportional expression given as Equation (2) below. In the planetary gear 120, the determination of the rotations of the two gears among the sun gear 121, the ring gear 122, and the planetary carrier 124 results in automatically setting the rotation of the residual one gear.

$$Ns = Nr - (Nr - Ne)\,\frac{1+\rho}{\rho} \quad (2)$$

The torque Te of the engine 150 is then applied (upward in the drawing) to the dynamic collinear line on the coordinate axis C of the carrier shaft 127 functioning as a line of action. The dynamic collinear line against the torque can be regarded as a rigid body to which a force is applied as a vector. Based on the technique of dividing the force into two different parallel lines of action, the torque Te acting on the coordinate axis C is divided into a torque Tes on the coordinate axis S and a torque Ter on the coordinate axis R. The magnitudes of the torques Tes and Ter are given by Equations (3) and (4) below:

$$Tes = Te \times \frac{\rho}{1+\rho} \quad (3)$$

$$Ter = Te \times \frac{1}{1+\rho} \quad (4)$$

The equilibrium of forces on the dynamic collinear line is essential for the stable state of the dynamic collinear line. In accordance with a concrete procedure, a torque Tm1 having the same magnitude as but the opposite direction to the torque Tes is applied to the coordinate axis S, whereas a torque Tm2 having the same magnitude as but the opposite direction to a resultant force of the torque Ter and the torque that has the same magnitude as but the opposite direction to the torque Tr output to the ring gear shaft 126 is applied to the coordinate axis R. The torque Tm1 is given by the first motor MG1, and the torque Tm2 by the second motor MG2. The first motor MG1 applies the torque Tm1 in reverse of its rotation and thereby works as a generator to regenerate an electrical energy Pm1, which is given as the product of the torque Tm1 and the revolving speed Ns, from the sun gear shaft 125. The second motor MG2 applies the torque Tm2 in the direction of its rotation and thereby works as a motor to output an electrical energy Pm2, which is given as the product of the torque Tm2 and the revolving speed Nr, as a power to the ring gear shaft 126.

In case that the electrical energy Pm1 is identical with the electrical energy Pm2, all the electric power consumed by the second motor MG2 can be regenerated and supplied by the first motor MG1. In order to attain such a state, all the input energy should be output; that is, the energy Pe output from the engine 150 should be equal to an energy Pr output to the ring gear shaft 126. Namely the energy Pe expressed as the product of the torque Te and the revolving speed Ne is made equal to the energy Pr expressed as the product of the torque Tr and the revolving speed Nr. Referring to Fig. 4, the power that is expressed as the product of the torque Te and the revolving speed Ne and output from the engine 150 driven at the driving point P1 is subjected to torque conversion and output to the ring gear shaft 126 as the power of the same energy but expressed as the product of the torque Tr and the revolving speed Nr. As discussed previously, the power output to the ring gear shaft 126 is transmitted to a drive shaft 112 via the power feed gear 128 and the power transmission gear 111, and further transmitted to the driving wheels 116 and 118 via the differential gear 114. A linear relationship is accordingly held between the power output to the ring gear shaft 126 and the power transmitted to the driving wheels 116 and 118. The power transmitted to the driving wheels 116 and 118 can thus be controlled by adjusting the power output to the ring gear shaft 126.

Although the revolving speed Ns of the sun gear shaft 125 is positive in the nomogram of Fig. 5, it may be negative according to the revolving speed Ne of the engine 150 and the revolving speed Nr of the ring gear shaft 126 as shown in the nomogram of Fig. 6. In the latter case, the first motor MG1 applies the torque in the direction of its rotation and thereby works as a motor to consume the electrical energy Pm1 given as the product of the torque Tm1 and the revolving speed Ns. The second motor MG2, on the other hand, applies the torque in reverse of its rotation and thereby works as a generator to regenerate the electrical energy Pm2, which is given as the product of the torque Tm2 and the revolving speed Nr, from the ring gear shaft 126. In case that the electrical energy Pm1 consumed by the first motor MG1 is made equal to the electrical energy Pm2 regenerated by the second motor MG2 under such conditions, all the electric power consumed by the first motor MG1 can be supplied by the second motor MG2.

The above description refers to the fundamental torque conversion in the power output apparatus 110 of the embodiment. The power output apparatus 110 can, however, perform other operations as well as the above fundamental operation that carries out the torque conversion for all the power output from the engine 150 and outputs the converted torque to the ring gear shaft 126. The possible operations include an operation of charging the battery 194 with the surplus electrical energy and an operation of supplementing an insufficient electrical energy with the electric power stored in the battery 194. These operations are implemented by regulating the power output from the engine 150 (that is, the product of the torque Te and the revolving speed Ne), the electrical energy Pm1 regenerated or consumed by the first motor MG1, and the electrical energy Pm2 regenerated or consumed by the second motor MG2.

The operation principle discussed above is on the assumption that the efficiency of power conversion by the planetary gear 120, the motors MG1 and MG2, and the transistors Tr1 through Tr16 is equal to the value '1', which represents 100%. In the actual state, however, the conversion efficiency is less than the value '1', and it is required to make the energy Pe output from the engine 150 a little greater than the energy Pr output to the ring gear shaft 126 or alternatively to make the energy Pr output to the ring gear shaft 126 a little smaller than the energy Pe output from the engine 150. By way of example, the energy Pe output from the engine 150 may be calculated by multiplying the energy Pr output to the ring gear shaft 126 by the reciprocal of the conversion efficiency. In the state of the nomogram of Fig. 5, the torque Tm2 of the second motor MG2 may be calculated by multiplying the electric power regenerated by the first motor MG1 by the efficiencies of both the motors MG1 and MG2. In the state of the nomogram of Fig. 6, on the other hand, the torque Tm2 of the second motor MG2 may be calculated by dividing the electric power consumed by the first motor MG1 by the efficiencies of both the motors MG1 and MG2. In the planetary gear 120, there is an energy loss or heat loss due to a mechanical friction or the like, though the amount of energy loss is significantly small, compared with the whole amount of energy concerned. The efficiency of the synchronous motors used as the first and the second motors MG1 and MG2 is very close to the value '1'. Known devices such as GTOs applicable to the transistors Tr1 through Tr16 have extremely small ON-resistance. The efficiency of power conversion is thus practically equal to the value '1'. For the matter of convenience, in the following discussion of the embodiment, the efficiency is considered equal to the value '1' (=100%), unless otherwise specified.

The following describes a control procedure of stopping the operation of the engine 150 while the vehicle is at a run through the above torque control, based on an engine stop control routine shown in the flowchart of Fig. 7. The engine stop control routine of Fig. 7 is executed when the driver gives a switching instruction to the motor driving mode only with the second motor MG2 or when the control CPU 190 of the controller 180 carries out an operation mode determination routine (not shown) and selects the motor driving mode only with the second motor MG2.

When the program enters the engine stop control routine, the control CPU 190 of the controller 180 first outputs an engine operation stop signal to the EFIECU 170 through communication to stop the operation of the engine 150 at step S100. In response to the engine operation stop signal, the EFIECU 170 stops fuel injection from the fuel injection valve 151 and application of a voltage to the ignition plug 162 and fully closes the throttle valve 166. These processes stop the operation of the engine 150.

The control CPU 190 then reads the revolving speed Ne of the engine 150 at step S102. The revolving speed Ne of the engine 150 may be calculated from the rotational angle θc of the carrier shaft 127 read from the resolver 159, which is attached to the carrier shaft 127 connecting with the crankshaft 156 via the damper 157. Alternatively the revolving speed Ne of the engine 150 may be measured directly with the speed sensor 176 attached to the distributor 160. In the latter case, the control CPU 190 receives data of the revolving speed Ne from the EFIECU 170 connected to the speed sensor 176 through communication.

After receiving the revolving speed Ne of the engine 150, the control CPU 190 sets an initial value on a time counter TC based on the input revolving speed Ne at step S104. The time counter TC is an argument used to set a target revolving speed Ne* of the engine 150 at step S108 (described later) and is incremented at step S106 every time when the processing of steps S106 through S116 is repeated. The initial value on the time counter TC is set based on a map showing the relationship between the time counter TC as the argument and the target revolving speed Ne* of the engine 150, for example, a map shown in Fig. 8. In accordance with a concrete procedure, the value of the time counter TC corresponding to the input revolving speed Ne (target revolving speed Ne*) plotted on the ordinate is read from the map of Fig. 8.

The control CPU 190 increments the preset time counter TC at step S106, and sets the target revolving speed Ne* of the engine 150 corresponding to the incremented time counter TC using the map shown in Fig. 8 at step S108. In accordance with a concrete procedure, the target revolving speed Ne* corresponding to the time counter TC plotted on the abscissa is read from the map of Fig. 8. A process of determining the target revolving speed Ne* corresponding to the value 'TC+1', which is the initial value on the time counter TC plus one, is shown in the map of Fig. 8. The control CPU 190 subsequently receives the revolving speed Ne of the engine 150 at step S110, and sets a torque command value Tm1* of the first motor MG1 based on the input revolving speed Ne and the preset target revolving speed Ne* according to Equation (5) given below at step S112. The first term on the right side of Equation (5) is a proportional term to cancel the deviation of the actual revolving speed Ne from the target revolving speed Ne*, and the second term on the right side is an integral term to cancel the stationary deviation. K1 and K2 denote proportional constants.

$$Tm1^* \leftarrow K1(Ne^* - Ne) + K2\int (Ne^* - Ne)\,dt \qquad (5)$$

The control CPU 190 then sets a torque command value Tm2* of the second motor MG2 based on a torque command value Tr* to be output to the ring gear shaft 126 and the preset torque command value Tm1* of the first motor MG1 according to Equation (6) given below at step S114. The second term on the right side of Equation (6) represents a torque applied to the ring gear shaft 126 via the planetary gear 120 when the torque defined by the torque command value Tm1* is output from the first motor MG1 while the engine 150 is at a stop. K3 denotes a proportional constant. The proportional constant K3 is equal to one in the state of equilibrium on the dynamic collinear line in the nomogram. In a transient state in the course of stopping the operation of the engine 150, part of the torque output from the first motor MG1 is used to change the motion of the inertial system consisting of the engine 150 and the first motor MG1. The proportional constant K3 is accordingly smaller than one. A concrete procedure for accurately determining this torque calculates a torque (inertial torque) used to change the motion of the inertial system by multiplying a moment of inertia seen from the first motor MG1 of the inertial system by an angular acceleration of the sun gear shaft 125, subtracts the inertial torque from the torque command value Tm1*, and divides the difference by the gear ratio ρ. Since the torque command value Tm1* set by this routine is a relatively small value, the procedure of this embodiment utilizes the proportional constant K3 to simplify the calculation. The torque command value Tr* to be output to the ring gear shaft 126 is set based on the step-on amount of the accelerator pedal 164 by the driver according to a required torque setting routine shown in the flowchart of Fig. 9. The following discusses the procedure of setting the torque command value Tr*.

$$Tm2^* \leftarrow Tr^* - K3 \times \frac{Tm1^*}{\rho} \quad (6)$$

The required torque setting routine of Fig. 9 is repeatedly executed at predetermined time intervals (for example, at every 8 msec). When the program enters the routine of Fig. 9, the control CPU 190 of the controller 180 first reads the revolving speed Nr of the ring gear shaft 126 at step S130. The revolving speed Nr of the ring gear shaft 126 may be calculated from the rotational angle θr of the ring gear shaft 126 read from the resolver 149. The control CPU 190 then reads the accelerator pedal position AP detected by the accelerator pedal position sensor 164a at step S132. The driver steps on the accelerator pedal 164 when feeling insufficiency of the output torque. The value of the accelerator pedal position AP accordingly represents the desired torque to be output to the ring gear shaft 126 and eventually to the driving wheels 116 and 118. The control CPU 190 subsequently determines the torque command value Tr*, that is, the target torque to be output to the ring gear shaft 126, based on the input revolving speed Nr of the ring gear shaft 126 and the input accelerator pedal position AP at step S134. Not the torque to be output to the driving wheels 116 and 118 but the torque to be output to the ring gear shaft 126 is calculated here from the accelerator pedal position AP and the revolving speed Nr. This is because the ring gear shaft 126 is mechanically linked with the driving wheels 116 and 118 via the power feed gear 128, the power transmission gear 111, and the differential gear 114 and the determination of the torque to be output to the ring gear shaft 126 thus results in determining the torque to be output to the driving wheels 116 and 118. In this embodiment, a map representing the relationship between the torque command value Tr*, the revolving speed Nr of the ring gear shaft 126, and the accelerator pedal position AP is prepared in advance and stored in the ROM 190b. In accordance with a concrete procedure, at step S134, the torque command value Tr* corresponding to the input accelerator pedal position AP and the input revolving speed Nr of the ring gear shaft 126 is read from the map stored in the ROM 190b. An example of available maps is shown in Fig. 10.

Referring back to the flowchart of Fig. 7, after setting the torque command value Tm1* of the first motor MG1 at step S112 and the torque command value Tm2* of the second motor MG2 at step S114, the program repeatedly executes a control routine of the first motor MG1 shown in the flowchart of Fig. 11 and a control routine of the second motor MG2 shown in the flowchart of Fig. 12 at predetermined time intervals (for example, at every 4 msec) through an interruption process, thereby controlling the first motor MG1 and the second motor MG2 to output the torques defined by the preset torque command values. The control procedures of the first motor MG1 and the second motor MG2 will be described later.

The control CPU 190 of the controller 180 then compares the revolving speed Ne of the engine 150 with a threshold value Nref at step S116. The threshold value Nref is set to be close to the target revolving speed Ne* of the engine 150 determined by the processing in the motor driving mode with only the second motor MG2. In this embodiment, the target revolving speed Ne* of the engine 150 determined by the processing in the motor driving mode with only the second motor MG2 is equal to zero, and the threshold value Nref is set to be close to zero. The threshold value Nref is smaller than the lower limit of a specific revolving speed range, in which the system connecting to the crankshaft 156 and the carrier shaft 127 linked with each other via the damper 157 causes a resonance. In case that the revolving speed Ne of the engine 150 is greater than the threshold value Nref, the program determines a transient state in the course of stopping the operation of the engine 150 and that the revolving speed Ne of the engine 150 is still not less than the lower limit of the specific revolving speed range that causes a resonance. The program accordingly returns to step S106 and repeats the processing of steps S106 through S116. Every time when the processing of steps S106 through S116 is repeated, the time counter TC is incremented and a smaller value is read from the map shown in Fig. 8 and set to the target revolving speed Ne* of the engine 150. The revolving speed Ne of the engine 150 thus decreases by a similar slope to that of the target revolving speed Ne* shown in the map of Fig. 8. In case that the slope of the target revolving speed Ne* is set to be not less than the slope of a natural variation in revolving speed Ne at the time of stopping the fuel injection to the engine 150, the revolving speed Ne of the engine 150 can be decreased abruptly. In case that the slope of the target revolving speed Ne* is set to be less than the slope of the natural variation in revolving speed Ne, on the contrary, the revolving speed Ne of the engine 150 can be decreased gently. In this embodiment, the slope of the target revolving speed Ne* is set to be not less than the slope of the natural variation in revolving speed Ne, on the assumption that the revolving speed Ne passes through the specific revolving speed range that causes a resonance.

In case that the revolving speed Ne of the engine 150 becomes equal to or less than the threshold value Nref at step S116, on the other hand, the program sets a cancel torque Tc to the torque command value Tm1* of the first motor MG1 at step S118, sets the torque command value Tm2* of the second motor MG2 according to Equation (6) given above at step S120, and waits for a predetermined time period at step S122. The cancel torque Tc prevents the revolving speed Ne of the engine 150 from taking a negative value, that is, undershooting. The reason why the revolving speed Ne of the engine 150 undershoots when the operation of the engine 150 is positively stopped by the first motor MG1 under the PI control, has been described previously.

After the predetermined time period has elapsed while the first motor MG1 outputs the cancel torque Tc, the program sets the torque command value Tm1* of the first motor MG1 equal to zero at step S124 and the torque command value Tm2* of the second motor MG2 equal to the torque command value Tr* at step S126. The program then exits from this routine and executes the processing in the motor driving mode with only the second motor MG2 (not shown).

The control operation of the first motor MG1 follows the control routine of the first motor MG1 shown in the flowchart of Fig. 11. When the program enters the routine of Fig. 11, the control CPU 190 of the controller 180 first receives the rotational angle θs of the sun gear shaft 125 from the revolver 139 at step S180, and calculates an electrical angle θ1 of the first motor MG1 from the rotational angle θs of the sun gear shaft 125 at step S181. In this embodiment, since a synchronous motor of four-pole pair (that is, four N poles and four S poles) is used as the first motor MG1, the rotational angle θs of the sun gear shaft 125 is quadrupled to yield the electrical angle θ1 (θ1=4θs). The CPU190 then detects values of currents Iu1 and Iv1 flowing through the U phase and V phase of the three-phase coils 134 in the first motor MG1 with the ammeters 195 and 196 at step S182. Although the currents naturally flow through all the three phases U, V, and W, measurement is required only for the currents passing through the two phases since the sum of the currents is equal to zero. At subsequent step S184, the control CPU 190 executes transformation of coordinates (three-phase to two-phase transformation) using the values of currents flowing through the three phases obtained at step S182. The transformation of coordinates maps the values of currents flowing through the three phases to the values of currents passing through d and q axes of the permanent magnet-type synchronous motor and is executed according to Equation (7) given below. The transformation of coordinates is carried out because the currents flowing through the d and q axes are essential for the torque control in the permanent magnet-type synchronous motor. Alternatively, the torque control may be executed directly with the currents flowing through the three phases.

$$\begin{bmatrix} Id1 \\ Iq1 \end{bmatrix} = \sqrt{2}\begin{bmatrix} -\sin(\theta 1-120) & \sin\theta 1 \\ -\cos(\theta 1-120) & \cos\theta 1 \end{bmatrix}\begin{bmatrix} Iu1 \\ Iv1 \end{bmatrix} \quad (7)$$

After the transformation to the currents of two axes, the control CPU 190 computes deviations of currents Id1 and Iq1 actually flowing through the d and q axes from current command values Id1* and Iq1* of the respective axes, which are calculated from the torque command value Tm1* of the first motor MG1, and subsequently determines voltage command values Vd1 and Vq1 with respect to the d and q axes at step S186. In accordance with a concrete procedure, the control CPU 190 executes arithmetic operations of Equations (8) and Equations (9) given below. In Equations (9), Kp1, Kp2, Ki1, and Ki2 represent coefficients, which are adjusted to be suited to the characteristics of the motor applied. Each voltage command value Vd1 (Vq1) includes a part in proportion to the deviation ΔI from the current command value I* (the first term on the right side of Equation (9)) and a summation of historical data of the deviations ΔI for 'i' times (the second term on the right side).

$$\Delta Id1 = Id1^{*} - Id1 \quad (8)$$

$$\Delta Iq1 = Iq1^{*} - Iq1$$

$$Vd1 = Kp1 \cdot \Delta Id1 + \Sigma\, Ki1 \cdot \Delta Id1 \quad (9)$$

$$Vq1 = Kp2 \cdot \Delta Iq1 + \Sigma\, Ki2 \cdot \Delta Iq1$$

The control CPU 190 then re-transforms the coordinates of the voltage command values thus obtained (two-phase to three-phase transformation) at step S188. This corresponds to an inverse of the transformation executed at step S184. The inverse transformation determines voltages Vu1, Vv1, and Vw1 actually applied to the three-phase coils 134 as expressed by Equations (10) given below:

$$\begin{bmatrix} Vu1 \\ Vv1 \end{bmatrix} = \sqrt{\frac{2}{3}}\begin{bmatrix} \cos\theta 1 & -\sin\theta 1 \\ \cos(\theta 1-120) & -\sin(\theta 1-120) \end{bmatrix}\begin{bmatrix} Vd1 \\ Vq1 \end{bmatrix} \quad (10)$$

$$Vw1 = -Vu1 - Vv1$$

The actual voltage control is accomplished by on-off operation of the transistors Tr1 through Tr6 in the first driving circuit 191. At step S189, the on- and off-time of the transistors Tr1 through Tr6 in the first driving circuit 191 is PWM (pulse width modulation) controlled, in order to attain the voltage command values Vu1, Vv1, and Vw1 determined by Equations (10) given above.

It is assumed that the torque command value Tm1* of the first motor MG1 is positive when the torque Tm1 is applied in the direction shown in the nomograms of Figs. 5 and 6. For an identical positive torque command value Tm1*, the first motor MG1 is controlled to carry out the regenerative operation when the torque command value Tm1* acts in reverse of the rotation of the sun gear shaft 125 as in the state of the nomogram of Fig. 5, and controlled to carry out the power operation when the torque command value Tm1* acts in the direction of rotation of the sun gear shaft 125 as in the state of the nomogram of Fig. 6. For the positive torque command value Tm1*, both the regenerative operation and the power operation of the first motor MG1 implement the identical switching control. In accordance with a concrete procedure, the transistors Tr1 through Tr6 in the first driving circuit 191 are controlled to enable a positive torque to be applied to the sun gear shaft 125 by the combination of the magnetic field generated by the permanent magnets 135 set on the outer surface of the rotor 132 with the revolving magnetic field generated by the currents flowing through the three-phase coils 134. The identical switching control is executed for both the regenerative operation and the power operation of the first motor MG1 as long as the sign of the torque command value Tm1* is not changed. The control routine of the first motor MG1 shown in the flowchart of Fig. 11 is thus applicable to both the regenerative operation and the power operation. When the torque command value Tm1* is negative, the rotational angle θs of the sun gear shaft 125 read at step S180 is varied in a reverse direction. The control routine of the first motor MG1 shown in Fig. 11 is thus also applicable to this case.

The control operation of the second motor MG2 follows the control routine of the second motor MG2 shown in the flowchart of Fig. 12. The control procedure of the second motor MG2 is identical with that of the first motor MG1, except that the torque command value Tm2* and the rotational angle θr of the ring gear shaft 126 are used in place of the torque command value Tm1* and the rotational angle θs of the sun gear shaft 125. When the program enters the routine of Fig. 12, the control CPU 190 of the controller 180 first receives the rotational angle θr of the ring gear shaft 126 from the revolver 149 at step S190, and calculates an electrical angle θ2 of the second motor MG2 from the observed rotational angle θr of the ring gear shaft 126 at step S191. At subsequent step S192, phase currents Iu2 and Iv2 of the second motor MG2 are measured with the ammeters 197 and 198. The control CPU 190 then executes transformation of coordinates for the phase currents at step S194, computes voltage command values Vd2 and Vq2 at step S196, and executes inverse transformation of coordinates for the voltage command values at step S198. The control CPU 190 subsequently determines the on- and off-time of the transistors Tr11 through Tr16 in the second driving circuit 192 for the second motor MG2 and carries out the PWM control at step S199.

The second motor MG2 is also controlled to carry out either the regenerative operation or the power operation, based on the relationship between the direction of the torque command value Tm2* and the direction of the rotation of the ring gear shaft 126. Like the first motor MG1, the control process of the second motor MG2 shown in the flowchart of Fig. 12 is applicable to both the regenerative operation and the power operation. In this embodiment, it is assumed that the torque command value Tm2* of the second motor MG2 is positive when the torque Tm2 is applied in the direction shown in the nomogram of Fig. 5.

The following describes variations in revolving speed Ne of the engine 150 and torque Tm1 of the first motor MG1 during the control process to stop the engine 150, with the nomograms of Figs. 13 through 15 and the graph of Fig. 16. Fig. 13 is a nomogram showing the state when the engine stop control routine of Fig. 7 is carried out for the first time; Fig. 14 is a nomogram showing the state when the processing of steps S106 through S116 in the engine stop control routine has repeatedly been executed; and Fig. 15 is a nomogram showing the state when the revolving speed Ne of the engine 150 becomes equal to or less than the threshold value Nref. As discussed above, in this embodiment, the slope of the target revolving speed Ne* in the map of Fig. 8 is set to be not less than the slope of the natural variation in revolving speed Ne. As shown in Figs. 13 and 14, the torque Tm1 output from the first motor MG1 thus acts to forcibly decrease the revolving speed Ne of the engine 150. When the engine stop control routine is carried out for the first time, the torque Tm1 is applied in reverse of the rotation of the sun gear shaft 125, and the first motor MG1 accordingly functions as a generator. The revolving speed Ns of the sun gear shaft 125 then takes a negative value as shown in Fig. 14, and the first motor MG1 functions as a motor. At this moment, the first motor MG1 is under the PI control based on the revolving speed Ne of the engine 150 and the target revolving speed Ne*. The revolving speed Ne of the engine 150 thus varies with a little delay from the target revolving speed Ne* as shown in Fig. 16. As discussed previously with the nomogram of Fig. 6, the revolving speed Ns of the sun gear shaft 125 may take a negative value according to the revolving speed Ne of the engine 150 and the revolving speed Nr of the ring gear shaft 126 in the state prior to the output of an engine operation stop instruction. The nomogram of Fig. 14 may accordingly represent the state when the engine stop control routine is carried out for the first time. In this case, the first motor MG1 functions as a motor from the beginning.

In the state of the nomograms of Figs. 13 and 14, the fuel supply to the engine 150 is stopped, and no torque is accordingly output from the engine 150. The first motor MG1 outputs the torque Tm1 that forcibly reduces the revolving speed Ne of the engine 150, and a torque Tsc is then applied to the carrier shaft 127 as a reaction of the torque Tm1. The ring gear shaft 126, on the other hand, receives the torque Tm2 output from the second motor MG2 and a torque Tsr output via the planetary gear 120 accompanied by the torque Tm1 output from the first motor MG1. The torque Tsr applied to the ring gear shaft 126 can be calculated by taking into account the equilibrium on the dynamic collinear line and the variation in motion of the inertial system consisting of the engine 150 and the first motor MG1. The torque Tsr is almost equivalent to the second term on the right side of Equation (6). Namely the torque approximate to the torque command value Tr* is thus output to the ring gear shaft 126.

When the revolving speed Ne of the engine 150 becomes equal to or less than the threshold value Nref at step S116 in the engine stop control routine of Fig. 7, the first motor MG1 outputs the cancel torque Tc. The engine 150 accordingly stops without undershooting the revolving speed Ne of the engine 150 as shown by the broken lines in Fig. 16, and the operation mode is smoothly shifted to the motor driving mode with only the second motor MG2. In this embodiment, the torque command value Tm1* of the first motor MG1 is set equal to zero in the motor driving mode with only the second motor MG2. The dynamic collinear line is thus stably kept in the state having the least sum of the energy required for racing the engine 150 and the energy required for racing the first motor MG1. Since the engine 150 is a gasoline engine in the embodiment, the energy required for racing the engine 150, that is, the energy required for friction and compression of the piston in the engine 150, is greater than the energy required for racing the rotor 132 of the first motor MG1. The dynamic collinear line is accordingly in the state of stopping the engine 150 and racing the first motor MG1 as shown in the nomogram of Fig. 15. The cancel torque Tc output from the first motor MG1 is also shown in the nomogram of Fig. 15.

As discussed above, the power output apparatus 110 of the embodiment quickly reduces the revolving speed Ne of the engine 150 to zero in response to an instruction for stopping the operation of the engine 150. This allows the revolving speed Ne of the engine 150 to swiftly pass through the specific revolving speed range that causes a resonance of the torsional vibrations on the engine 150 and the first motor MG1 as the inertial mass. This results in enabling the simplified structure of the damper 157 for reducing the amplitude of the torsional vibrations.

In the power output apparatus 110 of the embodiment, the first motor MG1 outputs the cancel torque Tc in the direction of increasing the revolving speed Ne of the engine 150, immediately before the revolving speed Ne of the engine 150 becomes equal to zero. This structure effectively prevents the revolving speed Ne of the engine 150 from undershooting, thereby preventing occurrence of a vibration and a foreign noise due to undershooting.

The power output apparatus 110 of the embodiment uses the map wherein the slope of the target revolving speed Ne* is greater than the slope of the natural variation in revolving speed Ne of the engine 150 (for example, the map of Fig. 8), and accordingly enables the first motor MG1 to output the torque Tm1 that forcibly reduces the revolving speed Ne of the engine 150. In accordance with an alternative application, another map wherein the slope of the target revolving speed Ne* is less than the slope of the natural variation in revolving speed Ne of the engine 150 is used in place of the map of Fig. 8, so as to enable a gentle variation in revolving speed Ne of the engine 150. This alternative structure allows the revolving speed Ne of the engine 150 to be gently varied.

In accordance with still another possible application, another map wherein the slope of the target revolving speed Ne* is identical with the slope of the natural variation in revolving speed Ne of the engine 150 is used in place of the map of Fig. 8, so as to enable a natural variation in revolving speed Ne of the engine 150. In this case, the torque command value Tm1* of the first motor MG1 is set equal to zero when the operation of the engine 150 is stopped. The flowchart of Fig. 17 shows an engine stop control routine in this modified application. In this routine, the program sets the torque command value Tm1* of the first motor MG1 equal to zero at step S202 and sets the torque command value Tm2* of the second motor MG2 equal to the torque command value Tr* at step S210. No torque is accordingly output from the first motor MG1. While the kinetic energy of the engine 150 and the first motor MG1 is consumed by the friction and compression of the piston in the engine 150, the dynamic collinear line is shifted toward the state having the least sum of the energy required for racing the engine 150 and the energy required for racing the first motor MG1 (that is, the state in the nomogram of Fig. 15). When no torque is output from the first motor MG1, the first MG1 does not consume any electric power. This structure accordingly improves the energy efficiency of the whole power output apparatus. The engine stop control routine of Fig. 17 can be regarded as the processing routine in the motor driving mode with only the second motor MG2.

In the power output apparatus 110 of the embodiment, the target revolving speed Ne* of the engine 150 is set equal to zero in the motor driving mode with only the second motor MG2 and the threshold value Nref is then set approximate to or equal to zero. In accordance with another possible application, the target revolving speed Ne* of the engine 150 may be set equal to a specific value other than zero in the motor driving mode with only the second motor MG2. In this case, the threshold value Nref is set approximate to or equal to the specific value. By way of example, the idle revolving speed is set to the target revolving speed Ne* of the engine 150, and the threshold value Nref is set approximate to or equal to the idle revolving speed.

In the power output apparatus 110 of the embodiment discussed above, the control procedure is applied to regulate the revolving speed Ne of the engine 150 at the time of stopping the operation of the engine 150 while the vehicle is at a run, that is, while the ring gear shaft 126 rotates. The control procedure is also applicable to regulate the revolving speed Ne of the engine 150 at the time of stopping the operation of the engine 150 while the vehicle is at a stop, that is, while the ring gear shaft 126 does not rotate.

In the power output apparatus 110 of the embodiment, the torque command value Tm1* of the first motor MG1 and the torque command value Tm2* of the second motor MG2 are set in the engine stop control routine. In accordance with an alternative application, the torque command value Tm1* of the first motor MG1 is set in the control routine of the first motor MG1 and the torque command value Tm2* of the second motor MG2 in the control routine of the second motor MG2.

In the power output apparatus 110 of the embodiment, the power output to the ring gear shaft 126 is taken out of the arrangement between the first motor MG1 and the second motor MG2 via the power feed gear 128 linked with the ring gear 122. Like another power output apparatus 110A shown in Fig. 18 as a modified example, however, the power may be taken out of the casing 119, from which the ring gear shaft 126 is extended. Fig. 19 shows still another power output apparatus 110B as another modified example, wherein the engine 150, the planetary gear 120, the second motor MG2, and the first motor MG1 are arranged in this sequence. In this case, a sun gear shaft 125B may not have a hollow structure, whereas a hollow ring gear shaft 126B is required. This modified structure enables the power output to the ring gear shaft 126B to be taken out of the arrangement between the engine 150 and the second motor MG2.

The following describes another power output apparatus 110' as a second embodiment according to the present invention. The power output apparatus 110' of the second embodiment shown in Fig. 20 has a similar hardware structure to that of the power output apparatus 110 of the first embodiment, except that the engine 150 has an open-close timing changing mechanism 153 in the second embodiment. The difference in hardware structure, which is discussed below, leads to the different processing routines carried out by the controller 180.

Referring to Fig. 20, the open-close timing changing mechanism 153 adjusts the open-close timing of an intake valve 150a of the engine 150. Fig. 21 shows the detailed structure of the open-close timing changing mechanism 153. The intake valve 150a is generally opened and closed by a cam attached to an intake cam shaft 240, whereas an exhaust valve 150b is opened and closed by a cam attached to an exhaust cam shaft 244. An intake cam shaft timing gear 242 linked with the intake cam shaft 240 and an exhaust cam shaft timing gear 246 linked with the exhaust cam shaft 244 are connected with the crankshaft 156 via a timing belt 248, in order to open and close the intake valve 150a and the exhaust valve 150b at a timing corresponding to the revolving speed of the engine 150. In addition to these conventional elements, the open-close timing changing mechanism 153 further includes an OCV 254 that is connected with the intake cam shaft timing gear 242 and the intake cam shaft 240 via an oil pressure-driven VVT pulley 250 and functions as a control valve of input oil pressure of the VVT pulley 250. The VVT pulley 250 includes a set of movable pistons 252 that reciprocate in an axial direction by means of the oil pressure. The oil pressure input to the VVT pulley 250 is fed by an engine oil pump 256.

The open-close timing changing mechanism 153 works based on the following operation principle. The EFIECU 170 determines the open-close timing of the valve according to the driving conditions of the engine 150 and outputs a control signal to control the on-off state of the OCV 254. The output control signal varies the oil pressure input to the VVT pulley 250 and thereby shifts the movable pistons 252 in the axial direction. The movable pistons 252 have threads running in an oblique direction with respect to the axis. The movement in the axial direction accordingly causes rotation of the movable pistons 252 and changes the orientation of the intake cam shaft 240 and the intake cam shaft timing gear 242 connecting with the movable pistons 252. This results in varying the open-close timing of the intake valve 150a and changing the valve overlap. In the example of Fig. 21, the VVT pulley 250 is disposed only on the side of the intake cam shaft 240 and does not exist on the side of the exhaust cam shaft 244, so that the valve overlap is controlled by regulating the open-close timing of the intake valve 150a.

The controller 180 carries out the following control operation in the second embodiment. Fig. 22 is a flowchart showing an engine stop control routine carried out in the second embodiment. The engine stop control routine is executed at every 8 msec by the interrupting operation after the controller 180 determines that the engine 150 is to be stopped, based on the driving state of the vehicle and the remaining charge SOC of the battery 194, and sends a stop instruction to the EFIECU 170 so as to cease the fuel injection into the engine 150. When the program enters the routine of Fig. 22, the control CPU 190 of the controller 180 (see Fig. 1) sets a current target torque STG of the first motor MG1 to a variable STGold at step S300, sets a reduction torque STGmn at step S305, and sets a processing time mntg of slower speed reduction at step S310. The reduction torque STGmn is set in advance against the revolving speed Nr of the ring gear shaft 126, that is, the vehicle speed, as shown in the graph of Fig. 23. In accordance with a concrete procedure of this embodiment, at step S305, the reduction torque STGmn corresponding to the revolving speed Nr of the ring gear shaft 126 is read from a map that represents the relationship of Fig. 23 and is stored in advance in the ROM 190b. The reduction torque STGmn denotes a torque applied by the first motor MG1 to the carrier shaft 127 and thereby to the crankshaft 156, in order to reduce the revolving speed of the engine 150 under the ceasing condition of fuel injection. The processing time mntg of slower speed reduction represents a time period specified as a degree of relieving the reduction rate of the revolving speed in the speed reduction process of an open-loop control discussed later, in order to prevent a torque shock. The processing time mntg of slower speed reduction is set to a small value according to the revolving speed Nr of the ring gear shaft 126 as shown in the graph of Fig. 24. The revolving speed Nr of the ring gear shaft 126 corresponds to the vehicle speed, so that the longer processing time mntg of slower speed reduction is desirably set for the lower vehicle speed to relieve the reduction rate of the torque command value. This effectively prevents a torque shock. The processing time mntg will be discussed more in the open-loop control carried out at step S350.

After setting these variables, the control CPU 190 determines whether or not Condition 1 is fulfilled at step S320. Condition 1 represents a preset condition to allow a start of the engine stop control and is, in this embodiment, that 300 msec has elapsed since an instruction was given to cease the fuel injection to the engine 150. The instruction to cease the fuel injection may not cause an immediate decrease in output torque of the engine 150. The waiting time of 300 msec is thus to ensure that the output torque of the engine 150 has certainly been decreased. In response to an instruction of the EFIECU 170, after the fuel cutting operation, the engine 150 controls the open-close timing changing mechanism 153 to set the open-close timing of the valve to the greatest lag angle. Such setting decreases the load applied at the time of a restart of the engine 150 and reduces the shock in the process of motoring the engine 150. In case that Condition 1 is not fulfilled, the program proceeds to step S330 to continue the PID control based on the difference between the actual revolving speed and the target revolving speed of the engine 150 and keep the revolving speed of the engine 150.

In case that Condition 1 is fulfilled and a start of the engine stop control is allowed, on the other hand, the program proceeds to step S340 to compare the revolving speed Ne of the engine 150 with a predetermined value Nkn. The predetermined value Nkn used herein is a condition to stop the open-loop control when the execution of the engine stop control has lowered the revolving speed Ne of the engine 150. In this embodiment, the predetermined value Nkn is set equal to 200 rpm under the condition of the vehicle at a stop, 250 rpm under the condition of the vehicle on a run with the brake off, and 350 rpm under the condition of the vehicle on a run with the brake on. These values were experimentally determined to prevent the revolving speed of the engine 150 from undershooting.

In case that the engine speed Ne is not smaller than the predetermined value Nkn at step S340, the program proceeds to step S350 to carry out the open-loop control and reduce the engine speed. The open-loop control will be discussed later with the flowchart of Fig. 25. Execution of the open-loop control gradually decreases the revolving speed Ne of the engine 150. When the revolving speed Ne of the engine 150 has decreased to be lower than the predetermined value Nkn, it is determined whether or not the current target torque STG is substantially equal to zero at step S360. In case that the current target torque STG is not substantially equal to zero, the program proceeds to step S370 to carry out the processing to prevent the revolving speed of the engine 150 from undershooting.

After the processing at any one of steps S330, S350, S360, and S370, the program goes to step S380 to restrict the torque range and to step S390 to set a calculated target torque ttg subjected to the processing of torque range restriction to the target torque STG. The program then exits from this routine. The processing of torque range restriction limits the calculated target torque ttg to the rated torque range of the first motor MG1 or to an available torque range based on the remaining charge of the battery 194.

The above procedure is repeatedly executed to regulate the revolving speed of the engine 150. Until 300 msec has elapsed since a stop of fuel supply to the engine 150, the PID control is carried on to keep the engine speed at the target revolving speed (steps S320 and S330). After 300 msec has elapsed, the PID control is replaced by the open-loop control to apply a torque from the first motor MG1 to the output shaft of the engine 150 or the crankshaft 156 in reverse of the rotation of the crankshaft 156 and thereby reduce the revolving speed of the engine 150 in a predetermined range of deceleration (steps S320, S340, and S350). This process is shown by Section A of Fig. 27. When the revolving speed Ne of the engine 150 becomes lower than the predetermined value Nkn, the open-loop control is concluded and the processing is carried out to prevent undershoot (steps S320, S340, S360, and S370). This process causes the target torque to gradually decrease and approach zero as shown by Section B of Fig. 27.

The flowchart of Fig. 25 shows the details of the open-loop control executed at step S350. When the program enters the open-loop control routine, it is first determined whether the vehicle is at a stop or on a run at step S351. In case that the vehicle is on a run, the program proceeds to step S352 to carry out the processing of slower speed reduction using the target torque STGold and the reduction torque STGmn set at the start of the engine stop control and calculate a tentative target torque ttg. The processing of slower speed reduction is carried on for the processing time nmtg previously set according to the vehicle speed (see step S310 in the flowchart of Fig. 22 and Fig. 24). The processing of slower speed reduction mathematically represents an integration process, but may be realized by calculating the weighting average of the currently observed value and the target value in case that the processing is repeatedly executed at predetermined intervals like this embodiment. In this embodiment, the calculation of weighting average is carried out at every processing time nmtg and the weight added to the currently observed value is approximately one sixteenth the weight added to the target value. Immediately after the program enters the processing to stop the engine 150, the target torque STG is set up a specified value by the PIP control described above (see Fig. 22 step S330). The processing of slower speed reduction thus does not abruptly set the reduction torque STGmn to the target torque immediately after the start of the engine stop control but gradually makes the value of the tentative target torque ttg approach the reduction torque STGmn set based on the map of Fig. 23. The longer processing time nmtg of slower speed reduction is set for the lower vehicle speed. The tentative target torque ttg accordingly approaches the reduction torque STGmn at the gentler rate against the lower vehicle speed.

When it is determined that the vehicle is at a stop at step S351, on the other hand, there is no need of varying the processing time of slower speed reduction according to the vehicle speed. The program thus proceeds to step S353 to carry out the processing of slower speed reduction for a fixed processing time (128 msec in this embodiment). The difference of the processing at step S353 under the condition of the vehicle at a stop from the processing at step S352 under the condition of the vehicle on a run is that the reduction torque STGmn set according to the vehicle speed is replaced by the sum of the fixed reduction torque and a learnt value stgkg of the target torque. In accordance with a concrete procedure, at step S353, the processing of slower speed reduction is carried out using the current target torque STGold and the torque (-14+stgkg)-STGold. While the vehicle is on a run, the driver hardly feels the torque shock due to a stop of the engine 150. While the vehicle is at a stop, on the contrary, the driver readily feels the torque shock due to a stop of the engine 150. The program accordingly learns the behavior of reduction of the target torque under the condition of the vehicle at a stop, and thus enables the engine 150 to be stopped with substantially no undershoot. The concrete procedure of obtaining the learnt value stgkg will be discussed later.

The above processing is executed at predetermined intervals, so that the tentative target torque gradually approaches the reduction torque STGmn at the rate depending upon the processing time nmtg of slower speed reduction. After the tentative target torque ttg becomes coincident with the reduction torque STGmn, the first motor MG1 outputs a substantially fixed torque.

After the processing of slower speed reduction either under the condition of the vehicle on a run or under the condition of the vehicle at a stop, it is determined whether or not Condition 2 is fulfilled at step S354. Condition 2 includes the following three conditions:

(1) The revolving speed Ne of the engine 150 is not greater than 400 rpm;
(2) The vehicle is at a stop; and
(3) The learnt value stgkg has not yet been updated (that is, a flag Xstg representing execution of the learning process is not equal to one).

In case that any one of these three conditions is not fulfilled, the program immediately goes to NEXT and exits from this routine. In case that all the three conditions are fulfilled, on the other hand, the program halts the torque reduction and starts the processing to gradually decrease the target torque to zero. At step S355, a deceleration ΔN of the revolving speed is computed.

The deceleration ΔN of the revolving speed is defined as the difference between the previous revolving speed detected at a previous cycle and the current revolving speed detected at a current cycle. In this embodiment, detection of the revolving speed Ne is carried out at every 16 msec. The program then goes to step S356 to determine whether or not the deceleration ΔN of the revolving speed is within a range of -54 to -44. In case that the deceleration ΔN of the revolving speed is within this range, the program goes to NEXT and exits from this routine. In case that the deceleration ΔN of the revolving speed is greater than the value -44, a tentative learnt value tstg is decremented by one at step S357. In case that the deceleration ΔN of the revolving speed is smaller than the value -54, on the other hand, the tentative learnt value tstg is incremented by one at step S358. The procedure checks the reduction rate of the engine speed Ne in Section A of Fig. 27 and varies the tentative learnt value tstg in order to affect the learnt value stgkg in the process of determining the reduction torque under the condition of the vehicle at a stop in a next cycle of the open-loop control. In the case of the smaller reduction rate, such variation in tentative learnt value tstg increases the absolute value of the target reduction torque, which is a negative value and is expressed as (-14+stgkg)-STGold) calculated at step S353. In the case of the greater reduction rate, on the contrary, the variation decreases the absolute value. The reduction rate of the revolving speed Ne of the engine 150 at the time of stopping the engine 150 is accordingly adjusted to the appropriate range of -54 Nm/16 msec to -44 Nm/16 msec through the learning control.

The program then goes to step S359 to restrict the tentative learnt value tstg to a predetermined range and set the flag Xstg representing execution of the learning process equal to one. The procedure does not directly set the learnt value stgkg but sets the tentative learnt value tstg, in order to prevent the learnt value used for the processing of slower speed reduction (step S353) from being changed at every cycle of this open-loop control routine. The learnt value stgkg is used in a next cycle of the engine stop control.

The open-loop control routine discussed above is carried out after 300 msec has elapsed since a stop of fuel supply to the engine 150, and gradually increases the magnitude of the negative torque applied from the first motor MG1 to the output shaft of the engine 150 (that is, the torque applied in reverse of the rotation of the output shaft) toward the final torque determined according to the state of the vehicle, that is, at a stop or on a run. When the revolving speed Ne of the engine 150 gradually decreases as shown by Section A of Fig. 27 to or below 400 rpm, in case that the vehicle is at a stop, the learnt value tstg depends upon the deceleration ΔN of the revolving speed.

In case that the revolving speed Ne of the engine 150 gradually decreases and eventually becomes smaller than the predetermined value Nkn, the open-loop control is replaced by the processing to prevent undershoot (executed at step S370 in the flowchart of Fig. 22). The flowchart of Fig. 26 shows the details of the processing to prevent undershoot. When the program enters the routine of Fig. 26, the tentative target torque ttg is computed at step S371 according to the equation of:

$$ttg = STGold + 2 \ [Nm]$$

It is then determined whether or not the calculated tentative target torque ttg is not greater than -2 at step S372. In case that ttg is greater than -2, the tentative target torque ttg is set equal to -2 at step S373. The processing of steps S372 and S373 accordingly sets the upper limit (=-2) of the tentative target torque ttg.

This procedure gradually decreases the magnitude of the torque, which has been applied to reduce the revolving speed Ne of the output shaft of the engine 150, within a range that does not exceed -2 [Nm]. The variation in tentative target torque ttg according to the above equation decrements the magnitude of the torque, which has acted in the direction of decelerating the output shaft of the engine 150, by 2 [Nm] at every 8 msec that is the interval of the interrupting process. The torque thus gradually approaches zero (see Section B of Fig. 27).

After the processing of either step S372 or step S373, it is determined whether or not the revolving speed Ne of the engine 150 is less than 40 rpm at step S374. In case that the revolving speed Ne of the engine 150 is less than 40 rpm, the program determines no further necessity of applying the braking torque to the output shaft of the engine 150, and sets the tentative target torque ttg equal to zero at step S375.

The program then goes to step S376 to determine whether or not Condition 3 is fulfilled. Condition 3 includes the following two conditions:

(1) The vehicle is at a stop; and

(2) The learnt value stgkg has been updated (that is, the flag Xstg representing execution of the learning process is equal to one).

In case that either one of these two conditions is not fulfilled, the program goes to NEXT and exist from this routine. In case that both the conditions are fulfilled, on the other hand, the program proceeds to step S377 to set the tentative learned value tstg to a learned value STGkg and to step S378 to reset the flag Xstg to zero. After the processing, the program exits from this routine.

The processing to prevent undershoot decreases the magnitude of the torque applied to the output shaft of the engine 150 toward -2 as shown by Section B of Fig. 27. When the revolving speed Ne of the engine 150 becomes less than 40 rpm, the braking torque is set equal to zero. This procedure effectively prevents the revolving speed Ne of the engine 150 from being lower than zero, that is, prevents undershoot.

The primary effects of the second embodiment are given below:

(1) While there is a requirement of continuous operation of the engine 150, the PID control is carried on to keep the revolving speed Ne of the engine 150 at a target revolving speed.

(2) when there is no requirement of continuous operation of the engine 150, the EFIECU 170 stops fuel supply to the engine 150. After 300 msec has elapsed since the stop of fuel supply, the open-loop control is carried out to cause the first motor MG1 to apply the torque in reverse of the rotation of the output shaft of the engine 150 to the carrier shaft 127, which is connected to the crankshaft 156 or the output shaft of the engine 150. The open-loop control does not execute the feed back control of the target torque of the first motor MG1 based on the deviation of the revolving speed Ne of the engine 150 from the target revolving speed (=0), but determines the target torque based on a predetermined algorithm. In the above embodiment, as shown in Fig. 27, the algorithm gradually increases the magnitude of the target torque at a predetermined rate. Such control effectively prevents a large torque from being abruptly applied in reverse of the rotation of the engine 150 at the time of stopping the engine 150 to cause a torque shock and worsen the drivability. As shown in Fig. 27, after the processing of slower speed reduction, the torque of a fixed magnitude is applied in reverse of the rotation of the output shaft of the engine 150. This makes the reaction torque constant and further improves the drivability.

(3) The first motor MG1 applies the torque in reverse of the rotation of the output shaft of the engine 150, so that the revolving speed Ne of the output shaft of the engine 150 is lowered at a predetermined deceleration (approximately -50 rpm/16 msec in this embodiment). The deceleration is limited to the range that does not cause torsional vibrations of the output shaft, and no torsional vibrations accordingly occur on the crankshaft 156 and the carrier shaft 127 connected to each other via the damper 157.

(4) When the revolving speed Ne of the engine 150 becomes lower than a predetermined level (400 rpm in this embodiment), in case that the vehicle is at a stop, the learning process is carried out to make the deceleration within a predetermined range in a next cycle of the engine stop control.

(5) When the revolving speed Ne of the engine 150 further decreases to or below the predetermined value Nkn (200 rpm through 350 rpm in this embodiment), the magnitude of the torque applied by the first motor MG1 is gradually decreased at a predetermined rate toward zero. This process effectively prevents the revolving speed Ne of the output shaft of the engine 150 from being lower than zero, that is, prevents the reverse rotation of the crankshaft 156. The crankshaft 156 is generally designed on the assumption of no reverse rotation. The reverse rotation of the crankshaft 156 may, for example, cause a lock of the lead angle in the open-close timing changing mechanism 153. In the structure of this embodiment, the magnitude of the torque applied to the output shaft of the engine 150 is decreased with a decrease in revolving speed Ne of the engine 150. When the revolving speed Ne of the engine 150 becomes lower than 40 rpm, the braking torque is set equal to zero. This structure effectively prevents the reverse rotation of the crankshaft 156.

(6) The predetermined value Nkn used as the criterion of the control procedure is set equal to 200 rpm under the condition of the vehicle at a stop, 250 rpm under the condition of the vehicle on a run with the brake off, and 350 rpm under the condition of the vehicle on a run with the brake on. This enables the torque applied to the output shaft of the engine 150 in the direction of reducing the revolving speed to be substantially constant irrespective of the driving state of the vehicle. The revolving speed of the engine 150 subjected to the open-loop control can thus been decreased gently to zero.

The power output apparatuses 110 and 110' of the first and the second embodiments and their modified examples discussed above are applied to the FR-type or FF-type two-wheel-drive vehicle. As shown in Fig. 28, however, a power output apparatus 110C given as another modified example is applied to a four-wheel-drive vehicle. In this structure, the second motor MG2 is separated from the ring gear shaft 126 and independently arranged in the rear-wheel portion of the vehicle, so as to drive the rear driving wheels 117 and 119. The ring gear shaft 126 is, on the other hand, connected to the differential gear 114 via the power feed gear 128 and the power transmission gear 111, in order to drive the front driving wheels 116 and 118. Either one of the engine stop control routines shown in Figs. 7 and 22 is also applicable to this structure.

The power output apparatus 110 of the embodiment and their modified examples discussed above are applied to the FR-type or FF-type two-wheel-drive vehicle. In another modified example of Fig. 28, however, a power output apparatus 110C is applied to a four-wheel-drive vehicle. In this structure, the second motor MG2 is separated from the ring gear shaft 126 and independently arranged in the rear-wheel portion of the vehicle, so as to drive the rear driving wheels 117 and 119. The ring gear shaft 126 is, on the other hand, connected to the differential gear 114 via the power feed gear 128 and the power transmission gear 111, in order to drive the front driving wheels 116 and 118. The engine stop control routine of Fig. 7 is also applicable to this structure.

Permanent magnet (PM)-type synchronous motors are used as the first motor MG1 and the second motor MG2 in the power output apparatus 110 of the embodiment. Any other motors which can implement both the regenerative operation and the power operation, such as variable reluctance (VR)-type synchronous motors, vernier motors, d.c. motors, induction motors, superconducting motors, and stepping motors, may, however, be used according to the requirements.

Transistor inverters are used as the fist and the second driving circuits 191 and 192 in the power output apparatus 110 of the embodiment. Other available examples include IGBT (insulated gate bipolar mode transistor) inverters, thyristor inverters, voltage PWM (pulse width modulation) inverters, square-wave inverters (voltage inverters and current inverters), and resonance inverters.

The battery 194 in the above embodiment may include Pb cells, NiMH cells, Li cells, or the like cells. A capacitor may be used in place of the battery 194.

In the power output apparatus 110 of the embodiment, the crankshaft 156 of the engine 150 is connected to the first motor MG1 via the damper 157 and the planetary gear 120. When the operation of the engine 150 is stopped, the variation in revolving speed Ne of the engine 150 is regulated by the output torque from the first motor MG1 via the planetary gear 120. Like another power output apparatus 310 shown in Fig. 29 as still another modified example, a crankshaft CS of an engine EG is directly connected to a rotating shaft RS of a motor MG via a damper DNP. The variation in revolving speed Ne of the engine EG is regulated by the motor MG when the operation of the engine EG is stopped. This structure exerts the same effects as those of the power output apparatus 110 of the above embodiment. In the above embodiments, the first motor MG1 and the second motor MG2 are arranged to be coaxial with the shaft of power transmission. The arrangement of these motors with respect to the shaft of power transmission may, however, be determined arbitrarily based on the design requirements.

The present invention is not restricted to the above embodiment or its modified examples, but there may be many modifications, changes, and alterations without departing from the scope or spirit of the main characteristics of the present invention. For example, although the power output apparatus is mounted on the vehicle in the above embodiment, it may be mounted on other transportation means like ships and airplanes as well as a variety of industrial machines.

It should be clearly understood that the above embodiment is only illustrative and not restrictive in any sense. The scope and spirit of the present invention are limited only by the terms of the appended claims.

Claims

1. A power output apparatus for outputting power to a drive shaft, said power output apparatus comprising:

   an engine having an output shaft;
   a first motor having a rotating shaft and inputting and outputting power to and from said rotating shaft;
   a second motor inputting and outputting power to and from said drive shaft;
   three shaft-type power input/output means having three shafts respectively linked with said drive shaft, said output shaft, and said rotating shaft, said three shaft-type power input/output means inputting and outputting power to and from a residual one shaft, based on predetermined powers input to and output from any two shafts among said three shafts;
   fuel stop instruction means for giving an instruction to stop fuel supply to said engine when a condition of stopping operation of said engine is fulfilled; and
   stop-time control means for causing a torque to be applied to said output shaft of said engine and thereby restricting a deceleration of revolving speed of said output shaft to a predetermined range in response to said instruction to stop the fuel supply to said engine, so as to implement a stop-time control for stopping the operation of said engine.

2. A power output apparatus in accordance with claim 1, said power output apparatus further comprising:

   target torque storage means for determining a time-based variation in target value of the torque applied to said output shaft of said engine, based on a behavior at the time of stopping the operation of said engine,
   wherein said stop-time control means comprises:

   means for driving said first motor, as said stop-time control, to apply a torque corresponding to said target value to said output shaft of said engine along a time course after the stop of fuel supply to said engine via said three shaft-type power input/output means.

3. A power output apparatus in accordance with claim 2, said power output apparatus further comprising:

   deceleration computing means for computing the deceleration of revolving speed of said output shaft during the course of said stop-time control;
   learning means for varying a learnt value according to the deceleration computed by said deceleration computing means and storing said learnt value; and
   deceleration range determination means for determining said predetermined range in said stop-time control carried out by said stop-time control means, based on said learnt value stored by said learning means.

4. A power output apparatus in accordance with claim 1, said power output apparatus further comprising:

   revolving speed detection means for measuring the revolving speed of said output shaft,
   wherein said stop-time control means further comprises:

   means for driving said first motor, as said stop-time control, in order to enable the revolving speed of said output shaft measured by said revolving speed detection means to approach a predetermined value via a predetermined pathway.

5. A power output apparatus in accordance with claim 1, said power output apparatus further comprising:

   revolving speed detection means for measuring the revolving speed of said output shaft,
   wherein said stop-time control means further comprises:

   means for driving said first motor, as said stop-time control, to apply a torque in reverse of the rotation of said output shaft via said three shaft-type power input/output means to said output shaft, until the revolving speed of said output shaft measured by said revolving speed detection means becomes coincident with said predetermined value.

6. A power output apparatus in accordance with claim 5, wherein said stop-time control means further comprises means for driving said first motor, as part of said stop-time control, to apply a predetermined torque in the direction of rotation of said output shaft via said three shaft-type power input output means to said output shaft, when the revolving speed of said output shaft measured by said revolving speed detection means decreases to a reference value, which is not greater than said predetermined value.

7. A power output apparatus in accordance with claim 5, said power output apparatus further comprising:

deceleration computing means for computing the deceleration of revolving speed of said output shaft during the course of said stop-time control; and
reference value setting means for setting a larger value to said reference value against a greater absolute value of the deceleration.

8. A power output apparatus in accordance with claim 5, said power output apparatus further comprising:

braking force detection means for determining magnitude of a braking force applied to said drive shaft during the course of said stop-time control; and
reference value setting means for setting a larger value to said reference value when said braking force detection means determines that the braking force has a large magnitude.

9. A power output apparatus in accordance with claim 5, wherein said predetermined value is a revolving speed that is lower than a resonance range of torsional vibrations in a system including said output shaft and said three shaft-type power input/output means.

10. A power output apparatus in accordance with claim 1, said power output apparatus further comprising:

second motor control means for driving said second motor to continue power input and output to and from said drive shaft, when said instruction to stop the operation of said engine is given in the course of continuous power input and output to and from said drive shaft.

11. An engine controller comprising an engine for outputting power through combustion of a fuel and a motor connected to an output shaft of said engine via a damper, said engine controller controlling operation and stop of said engine and comprising:

fuel stop means for stopping fuel supply to said engine when a condition to stop the operation of said engine is fulfilled; and
stop-time control means for causing a torque to be applied to said output shaft of said engine and thereby restricting a deceleration of revolving speed of said output shaft to a predetermined range in response to the stop of fuel supply to said engine, so as to implement a stop-time control for stopping the operation of said engine.

12. An engine controller in accordance with claim 11, said engine controller further comprising:

target torque storage means for determining a time-based variation in target value of the torque applied by said motor to said output shaft of said engine, based on a behavior at the time of stopping the operation of said engine,
wherein said stop-time control means comprises:

means for driving said motor, as said stop-time control, to apply a torque corresponding to said target value to said output shaft of said engine along a time course after the stop of fuel supply to said engine.

13. An engine controller in accordance with claim 12, said engine controller further comprising:

deceleration computing means for computing the deceleration of revolving speed of said output shaft during the course of said stop-time control;

learning means for varying a learnt value according to the deceleration computed by said deceleration computing means and storing said learnt value; and
deceleration range determination means for determining said predetermined range in said stop-time control carried out by said stop-time control means, based on said learnt value stored by said learning means.

14. An engine controller in accordance with claim 11, said engine controller further comprising:

revolving speed detection means for measuring the revolving speed of said output shaft,
wherein said stop-time control means further comprises:

means for driving said motor, as said stop-time control, in order to enable the revolving speed of said output shaft measured by said revolving speed detection means to approach a predetermined value via a predetermined pathway.

15. An engine controller in accordance with claim 11, said engine controller further comprising:

revolving speed detection means for measuring the revolving speed of said output shaft,
wherein said stop-time control means comprises:

means for driving said motor, as said stop-time control, to apply a torque in reverse of the rotation of said output shaft to said output shaft, until the revolving speed of said output shaft measured by said revolving speed detection means becomes coincident with said predetermined value.

16. An engine controller in accordance with claim 11, said engine controller further comprising:

revolving speed detection means for measuring the revolving speed of said output shaft,
wherein said stop-time control means further comprises means for driving said motor, as part of said stop-time control, to apply a predetermined torque in the direction of rotation of said output shaft to said output shaft, when the revolving speed of said output shaft measured by said revolving speed detection means decreases to a reference value, which is not greater than said predetermined value.

17. An engine controller in accordance with claim 15, said engine controller further comprising:

deceleration computing means for computing the deceleration of revolving speed of said output shaft during the course of said stop-time control; and
reference value setting means for setting a larger value to said reference value against a greater absolute value of the deceleration.

18. An engine controller in accordance with claim 15, wherein said predetermined value is a revolving speed that is lower than a resonance range of torsional vibrations in a system including said output shaft and a rotor of said motor.

19. A method of controlling a power output apparatus, which comprises: an engine having an output shaft; a first motor having a rotating shaft and inputting and outputting power to and from said rotating shaft; a second motor inputting and outputting power to and from said drive shaft; and three shaft-type power input/output means having three shafts respectively linked with said drive shaft, said output shaft, and said rotating shaft, said three shaft-type power input/output means inputting and outputting power to and from a residual one shaft, based on predetermined powers input to and output from any two shafts among said three shafts, said method comprising the steps of:

giving an instruction to stop fuel supply to said engine when a condition of stopping operation of said engine is fulfilled; and
causing a torque to be applied to said output shaft of said engine and thereby restricting a deceleration of revolving speed of said output shaft to a predetermined range in response to said instruction to stop the fuel supply to said engine, so as to implement a stop-time control for stopping the operation of said engine.

20. A method of controlling stop of an engine, said engine outputting power through combustion of a fuel and having an output shaft connected to a motor via a damper, said method comprising the steps of:

stopping fuel supply to said engine when a condition to stop operation of said engine is fulfilled; and

causing a torque to be applied to said output shaft of said engine and thereby restricting a deceleration of revolving speed of said output shaft to a predetermined range in response to the stop of fuel supply to said engine, so as to implement a stop-time control for stopping the operation of said engine.

Fig. 1

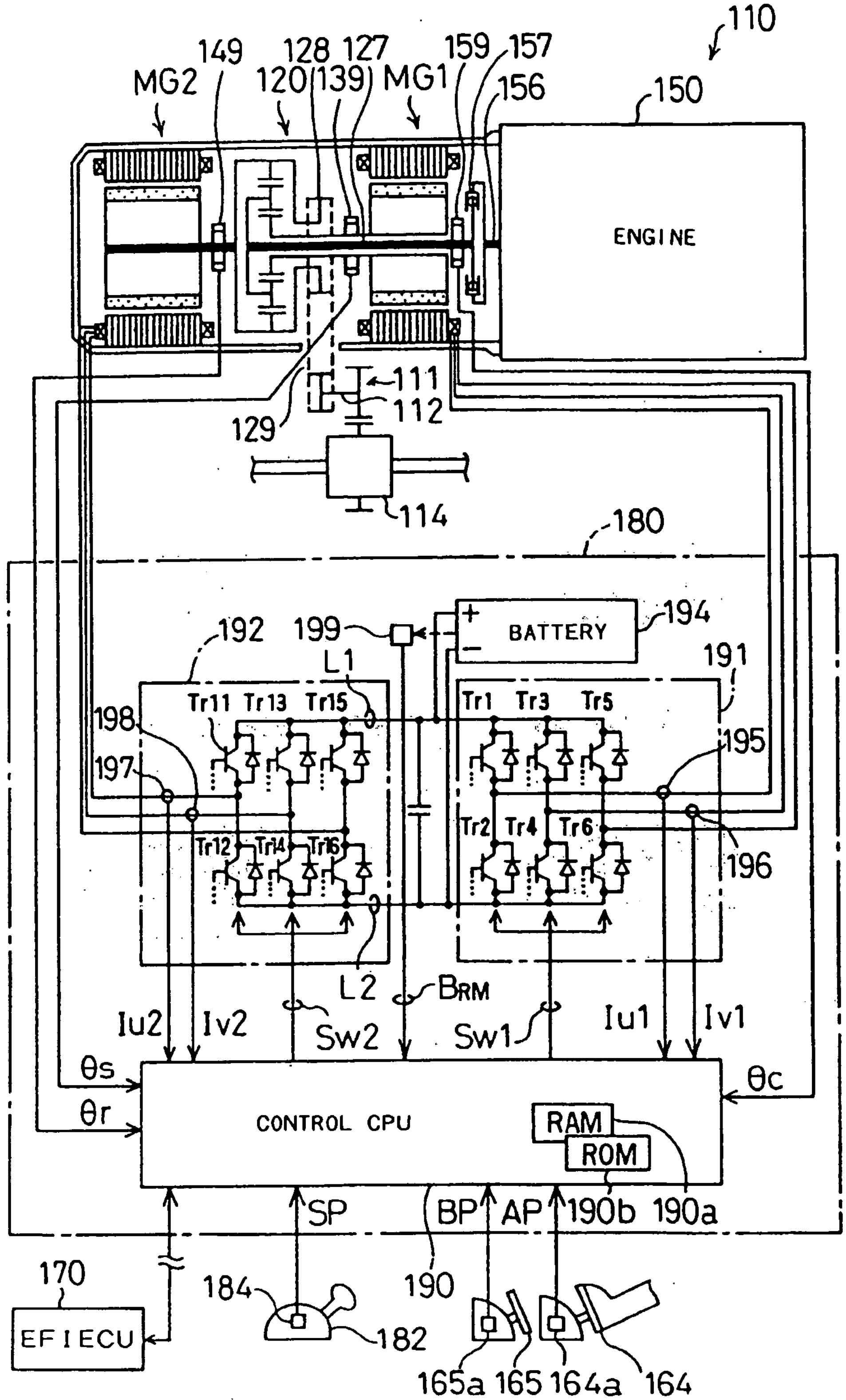
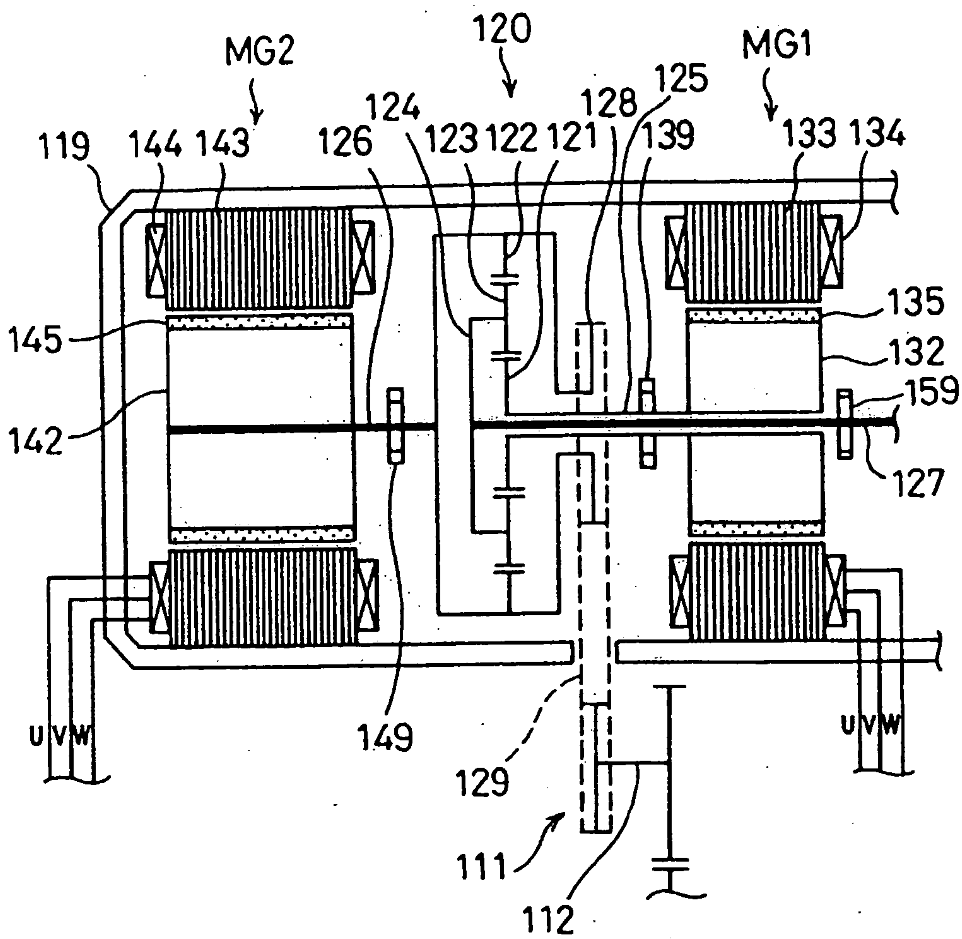

110
MG2
149
128 127
120 (139) MG1
159 157
156
150
ENGINE
111
112
129
114
180
192
199
BATTERY
194
L1
191
Tr11 Tr13 Tr15
Tr1 Tr3 Tr5
198
195
197
Tr12 Tr14 Tr16
Tr2 Tr4 Tr6
196
L2
BRM
Iu2
Iv2
Sw2
Sw1
Iu1
Iv1
θs
θr
θc
CONTROL CPU
RAM
ROM
SP
BP
AP
190b
190a
170
EFIECU
184
190
182
165a 165 164a 164

Fig. 2



MG2
120
MG1
124
128
125
119
144
143
126
123
122
121
139
133
134
135
145
132
159
142
127
149
UVW
UVW
129
111
112

Fig. 3

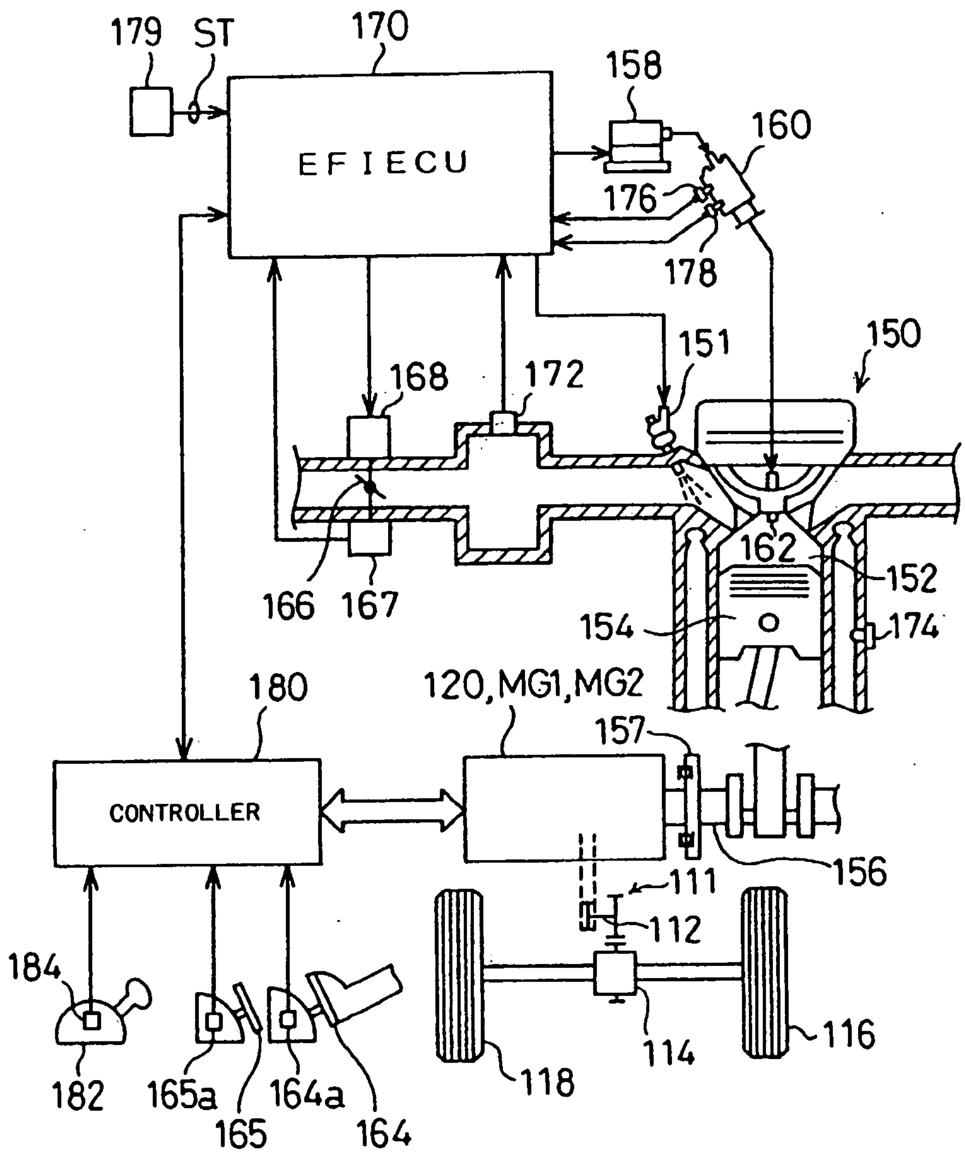

179
ST
170
EFIECU
158
160
176
178
151
150
168
172
162
152
166
167
154
174
180
120,MG1,MG2
157
CONTROLLER
156
111
112
184
182
165a
165
164a
164
118
114
116

Fig. 4

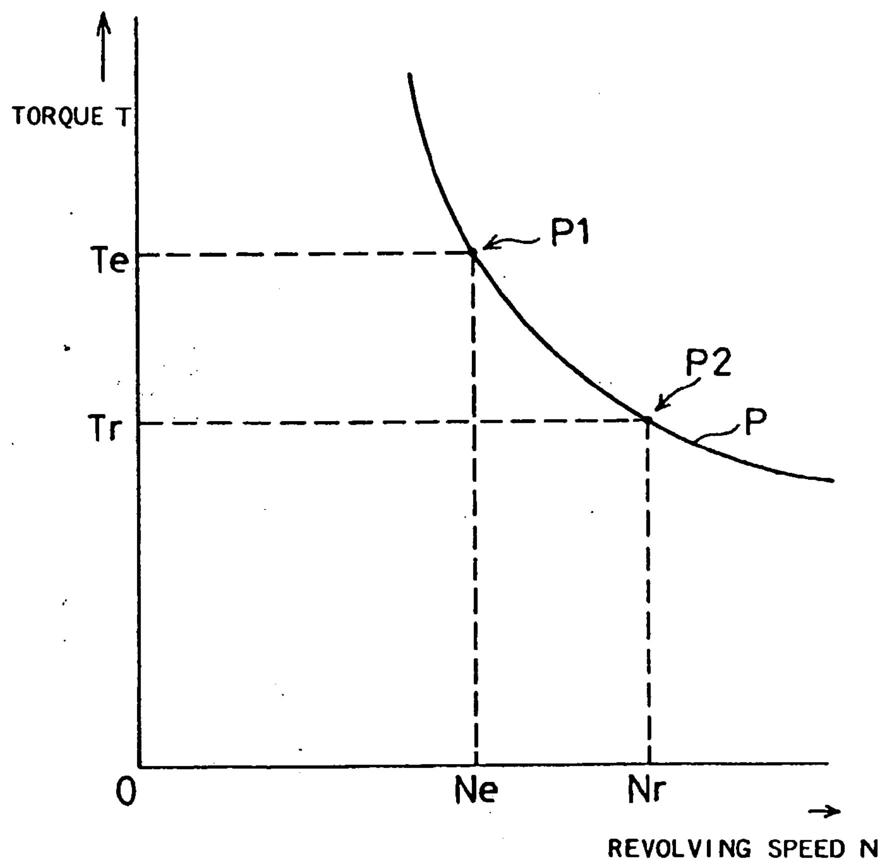


Fig. 5

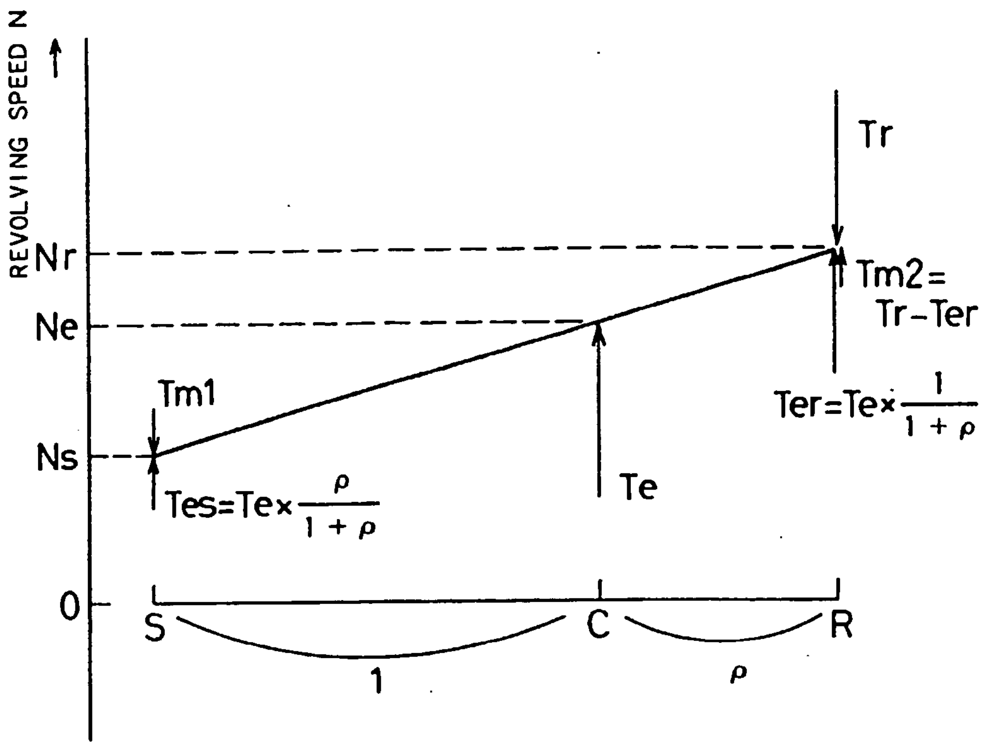

REVOLVING SPEED N
Nr
Ne
Ns
0
Tr
Tm2=
Tr−Ter
Ter=Te× 1/(1+ρ)
Tm1
Tes=Te× ρ/(1+ρ)
Te
S
C
R
1
ρ

Fig. 6

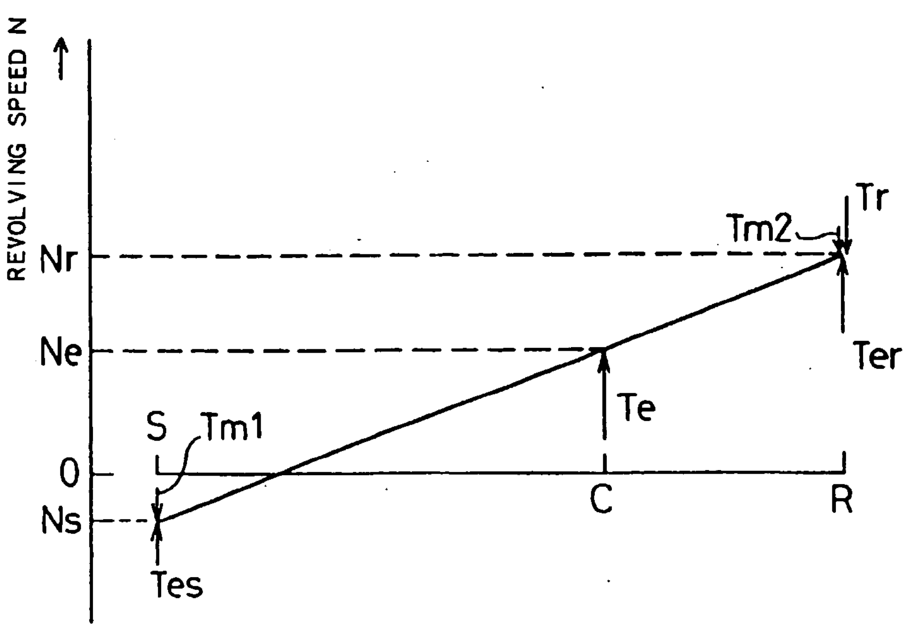

REVOLVING SPEED N
Nr
Ne
0
Ns
Tr
Tm2
Ter
Te
S
Tm1
C
R
Tes

Fig. 7

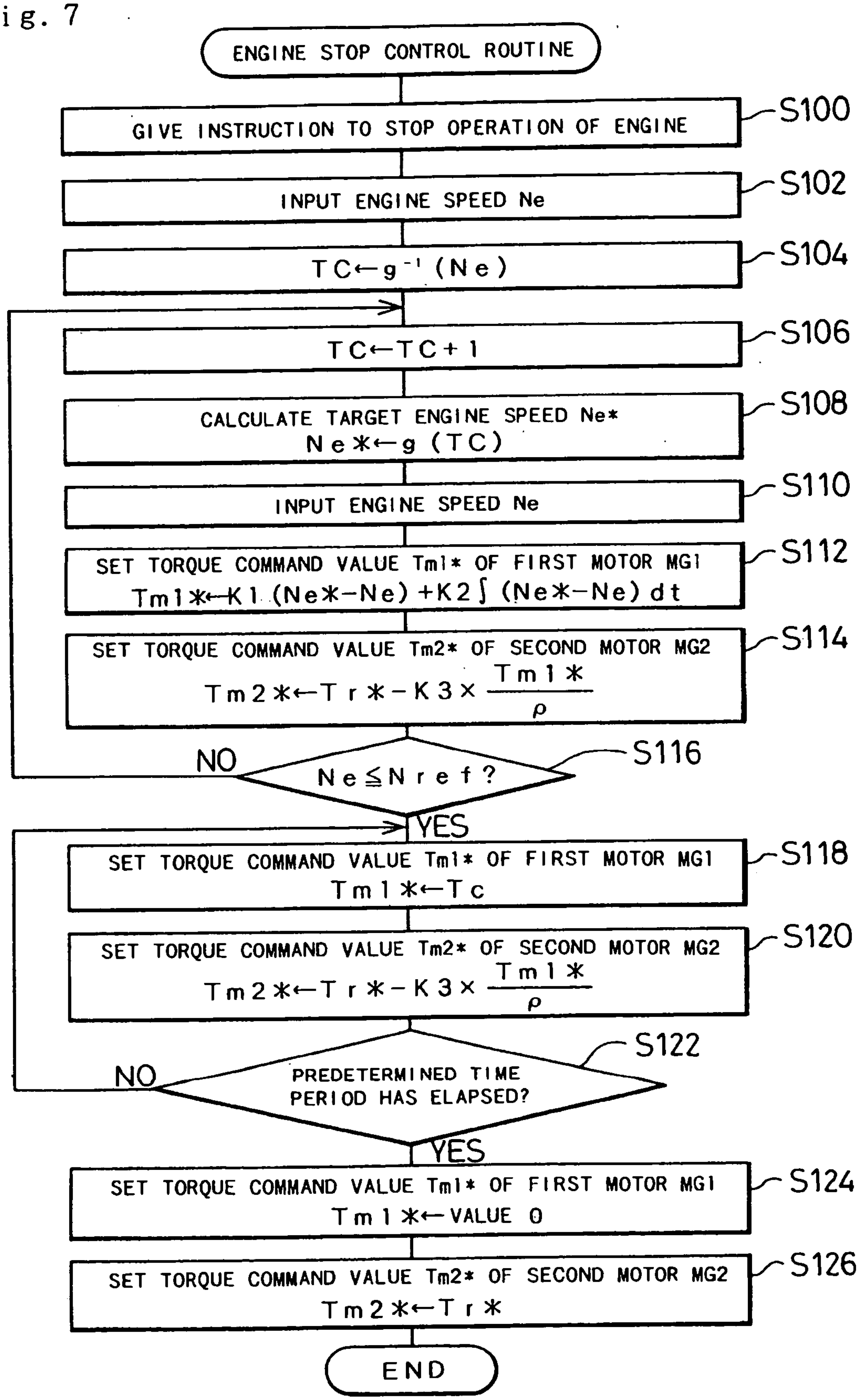

ENGINE STOP CONTROL ROUTINE
GIVE INSTRUCTION TO STOP OPERATION OF ENGINE
S100
INPUT ENGINE SPEED Ne
S102
TC←g⁻¹(Ne)
S104
TC←TC+1
S106
CALCULATE TARGET ENGINE SPEED Ne*
Ne*←g(TC)
S108
INPUT ENGINE SPEED Ne
S110
SET TORQUE COMMAND VALUE Tm1* OF FIRST MOTOR MG1
Tm1*←K1(Ne*−Ne)+K2∫(Ne*−Ne)dt
S112
SET TORQUE COMMAND VALUE Tm2* OF SECOND MOTOR MG2
Tm2*←Tr*−K3×Tm1*/ρ
S114
Ne≦Nref?
S116
NO
YES
SET TORQUE COMMAND VALUE Tm1* OF FIRST MOTOR MG1
Tm1*←Tc
S118
SET TORQUE COMMAND VALUE Tm2* OF SECOND MOTOR MG2
Tm2*←Tr*−K3×Tm1*/ρ
S120
PREDETERMINED TIME PERIOD HAS ELAPSED?
S122
NO
YES
SET TORQUE COMMAND VALUE Tm1* OF FIRST MOTOR MG1
Tm1*←VALUE 0
S124
SET TORQUE COMMAND VALUE Tm2* OF SECOND MOTOR MG2
Tm2*←Tr*
S126
END

Fig. 8

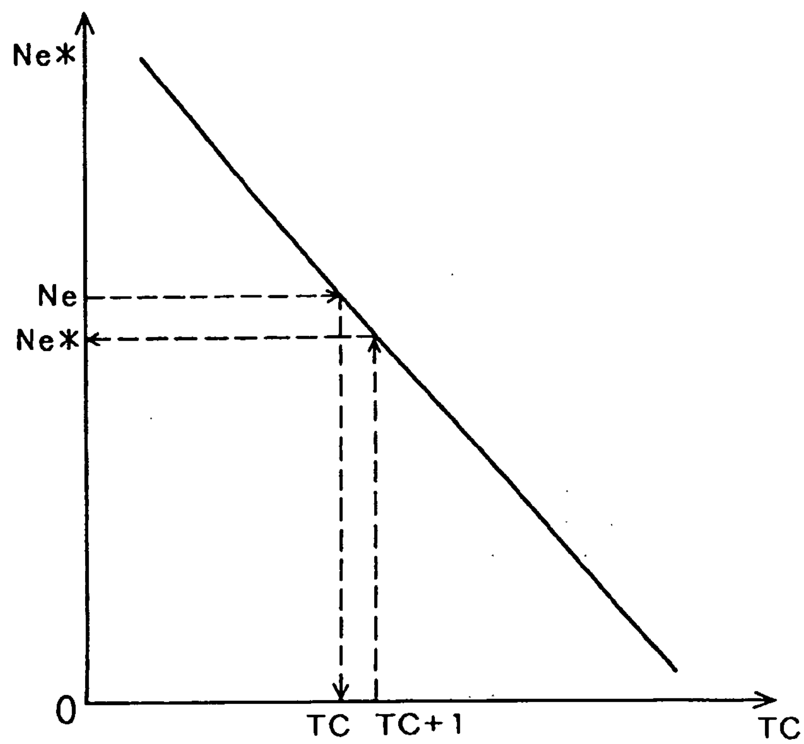


Fig. 9

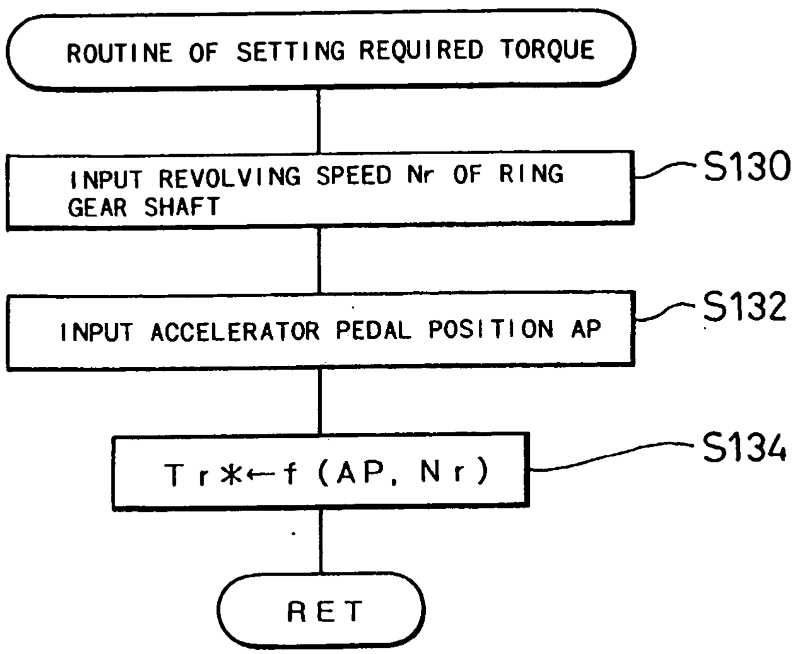

ROUTINE OF SETTING REQUIRED TORQUE
INPUT REVOLVING SPEED Nr OF RING GEAR SHAFT
S130
INPUT ACCELERATOR PEDAL POSITION AP
S132
Tr*←f (AP, Nr)
S134
RET

Fig. 10

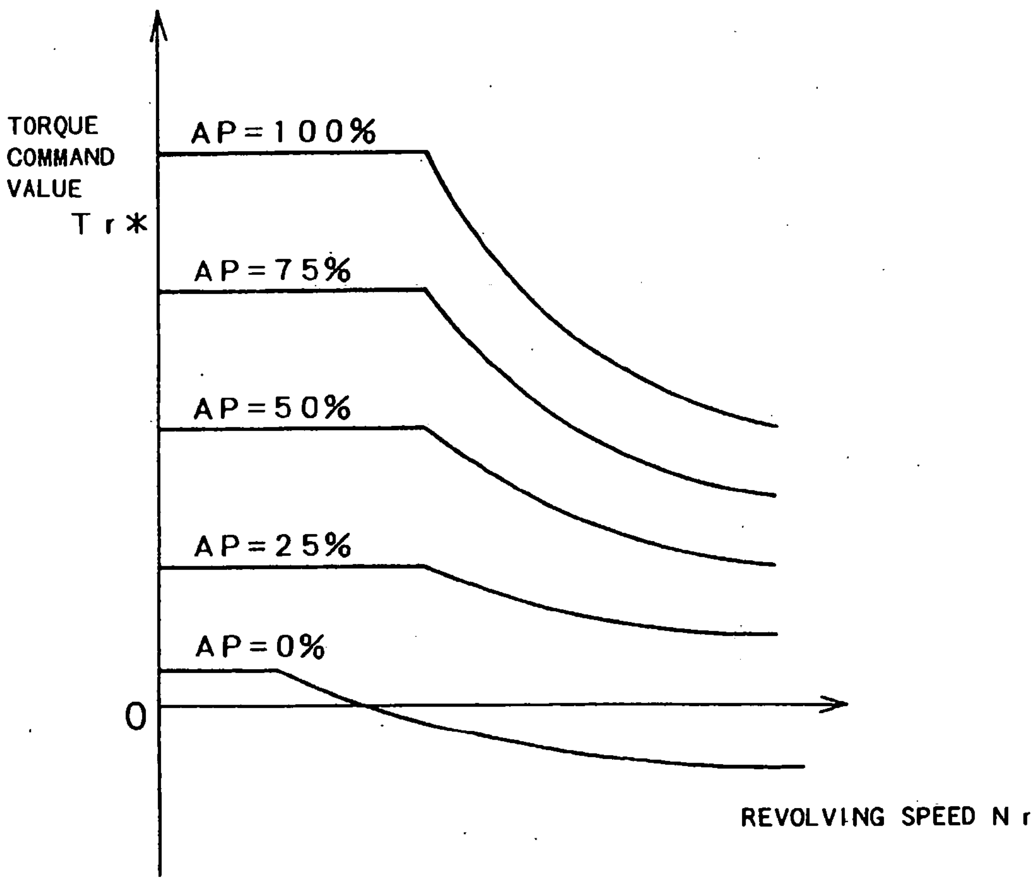

TORQUE
COMMAND
VALUE
Tr*
AP=100%
AP=75%
AP=50%
AP=25%
AP=0%
0
REVOLVING SPEED Nr

Fig. 11

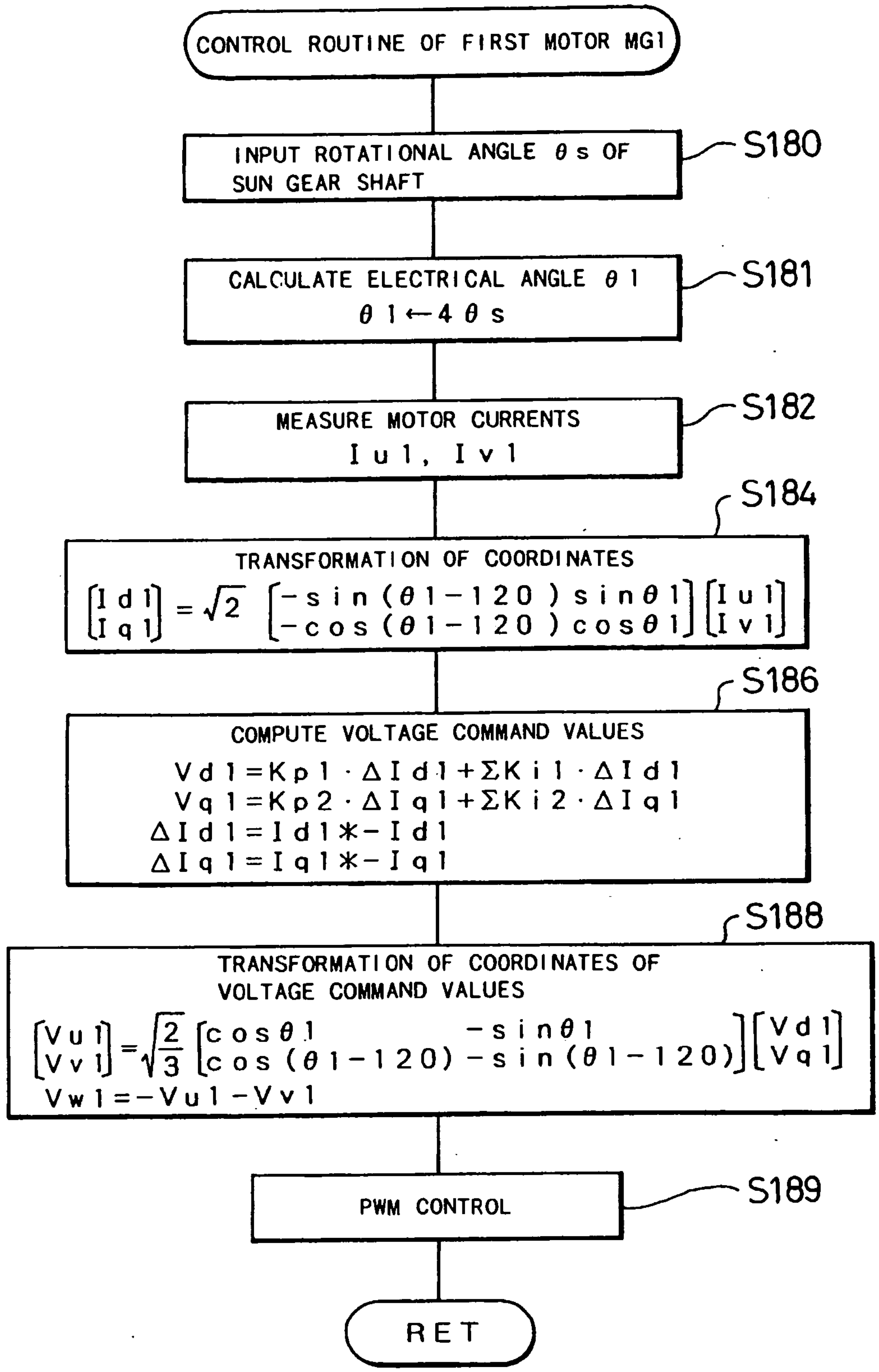

CONTROL ROUTINE OF FIRST MOTOR MG1
INPUT ROTATIONAL ANGLE θs OF SUN GEAR SHAFT
S180
CALCULATE ELECTRICAL ANGLE θ1
θ1←4θs
S181
MEASURE MOTOR CURRENTS
Iu1, Iv1
S182
S184
TRANSFORMATION OF COORDINATES
$\begin{bmatrix} Id1 \\ Iq1 \end{bmatrix} = \sqrt{2} \begin{bmatrix} -\sin(\theta 1-120) & \sin\theta 1 \\ -\cos(\theta 1-120) & \cos\theta 1 \end{bmatrix} \begin{bmatrix} Iu1 \\ Iv1 \end{bmatrix}$
S186
COMPUTE VOLTAGE COMMAND VALUES
$Vd1 = Kp1 \cdot \Delta Id1 + \Sigma Ki1 \cdot \Delta Id1$
$Vq1 = Kp2 \cdot \Delta Iq1 + \Sigma Ki2 \cdot \Delta Iq1$
$\Delta Id1 = Id1^* - Id1$
$\Delta Iq1 = Iq1^* - Iq1$
S188
TRANSFORMATION OF COORDINATES OF VOLTAGE COMMAND VALUES
$\begin{bmatrix} Vu1 \\ Vv1 \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos\theta 1 & -\sin\theta 1 \\ \cos(\theta 1-120) & -\sin(\theta 1-120) \end{bmatrix} \begin{bmatrix} Vd1 \\ Vq1 \end{bmatrix}$
$Vw1 = -Vu1 - Vv1$
PWM CONTROL
S189
RET

Fig. 12

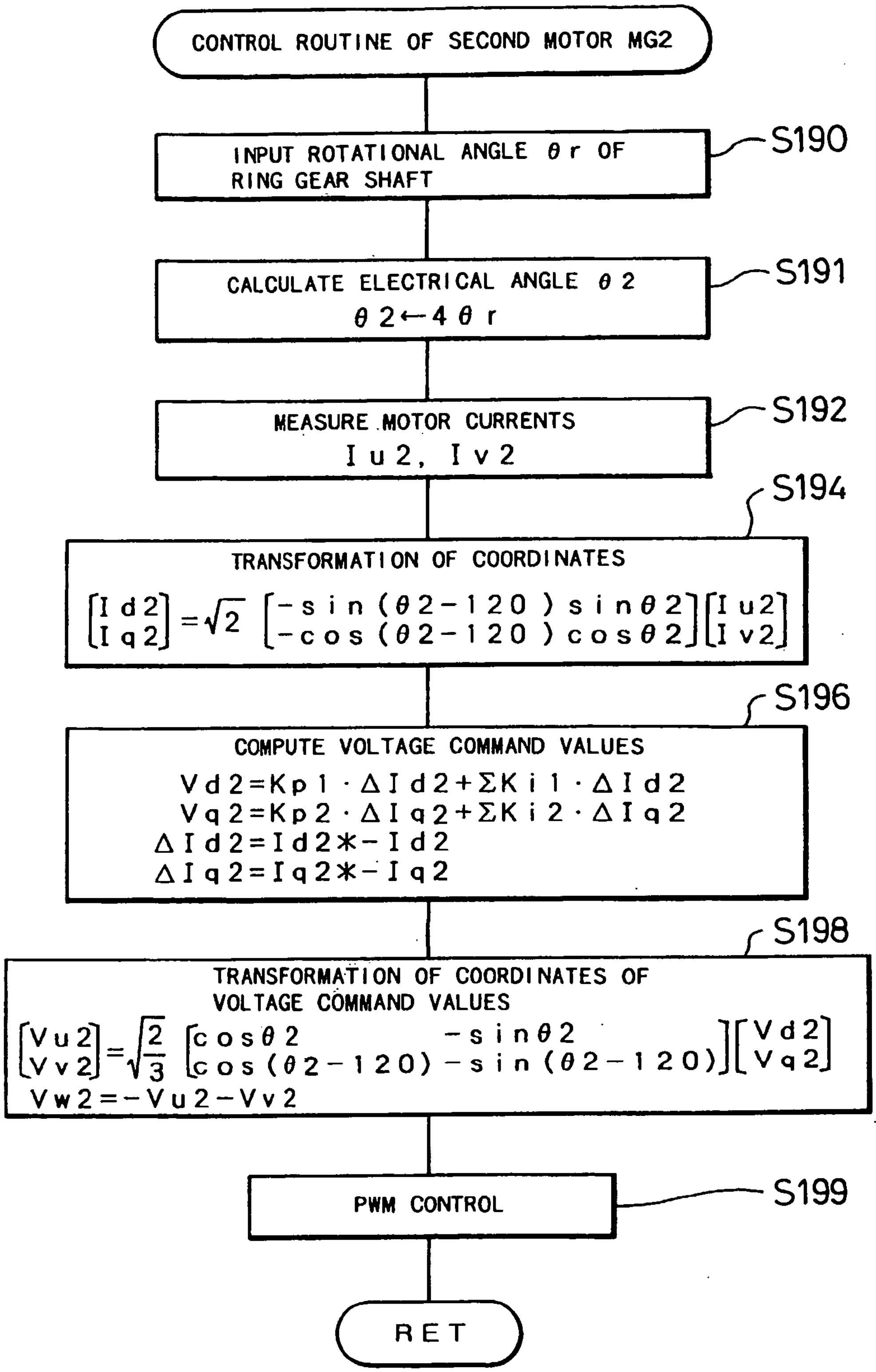

CONTROL ROUTINE OF SECOND MOTOR MG2
INPUT ROTATIONAL ANGLE θr OF RING GEAR SHAFT
S190
CALCULATE ELECTRICAL ANGLE θ2
θ2←4θr
S191
MEASURE MOTOR CURRENTS
Iu2, Iv2
S192
TRANSFORMATION OF COORDINATES
[Id2; Iq2] = √2 [−sin(θ2−120) sinθ2; −cos(θ2−120) cosθ2] [Iu2; Iv2]
S194
COMPUTE VOLTAGE COMMAND VALUES
Vd2=Kp1·ΔId2+ΣKi1·ΔId2
Vq2=Kp2·ΔIq2+ΣKi2·ΔIq2
ΔId2=Id2*−Id2
ΔIq2=Iq2*−Iq2
S196
TRANSFORMATION OF COORDINATES OF VOLTAGE COMMAND VALUES
[Vu2; Vv2] = √(2/3) [cosθ2 −sinθ2; cos(θ2−120) −sin(θ2−120)] [Vd2; Vq2]
Vw2=−Vu2−Vv2
S198
PWM CONTROL
S199
RET

Fig. 13

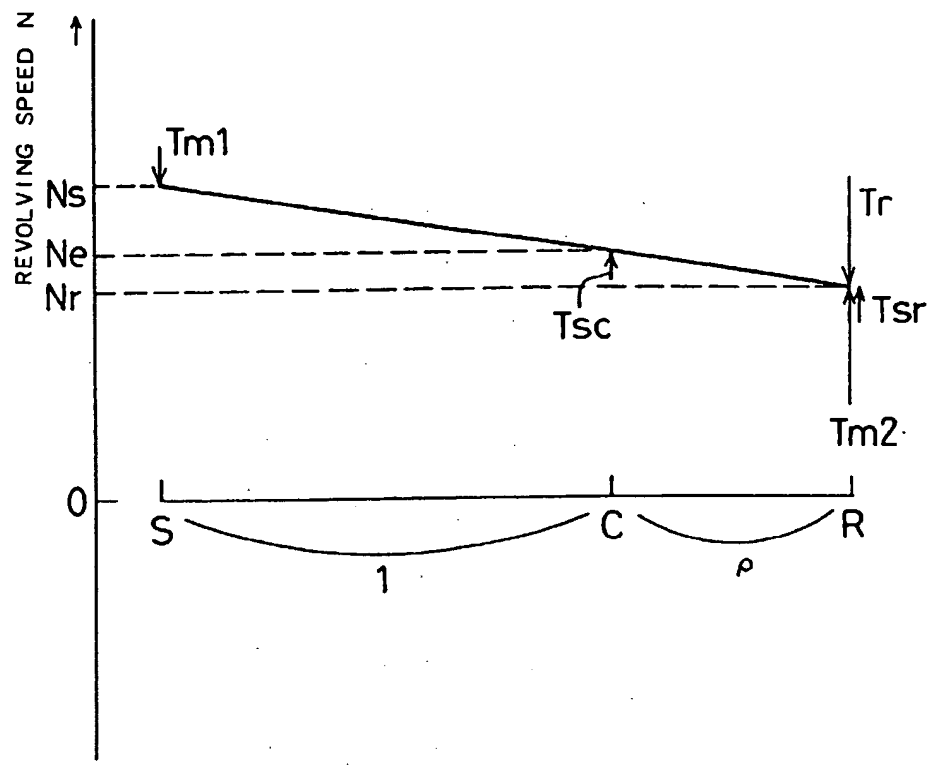

REVOLVING SPEED N
Tm1
Ns
Ne
Nr
Tr
Tsc
Tsr
Tm2
0
S
C
R
1
ρ

Fig. 14

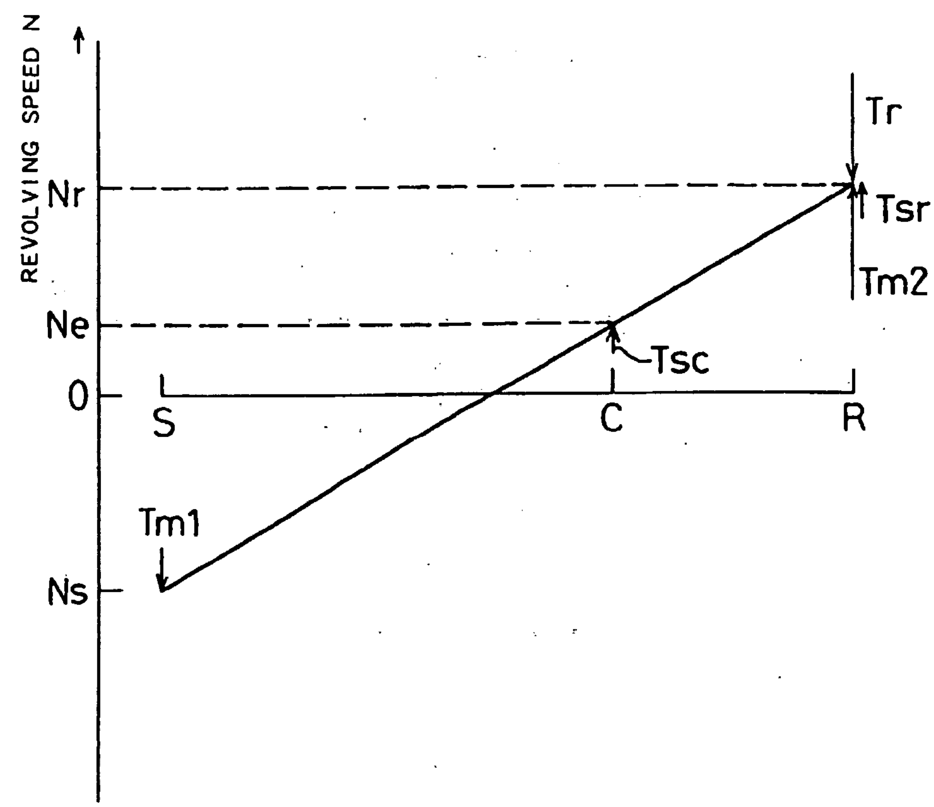

REVOLVING SPEED N
Tr
Nr
Tsr
Tm2
Ne
Tsc
0
S
C
R
Tm1
Ns

Fig. 15

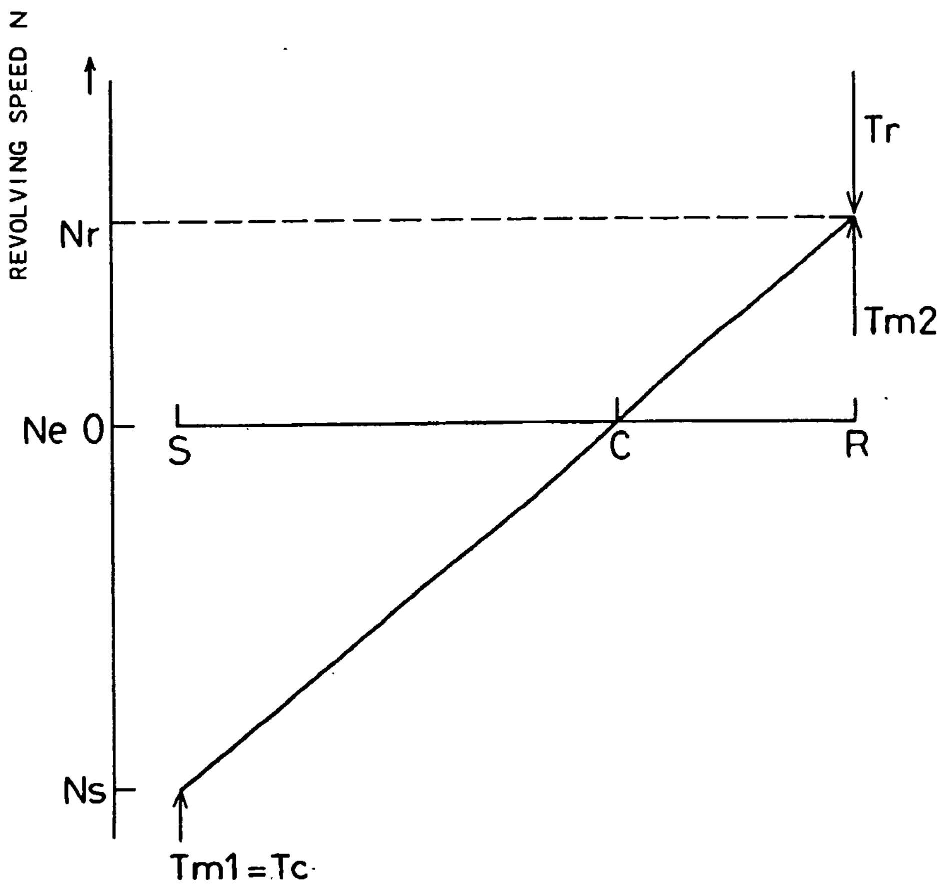


Fig. 16

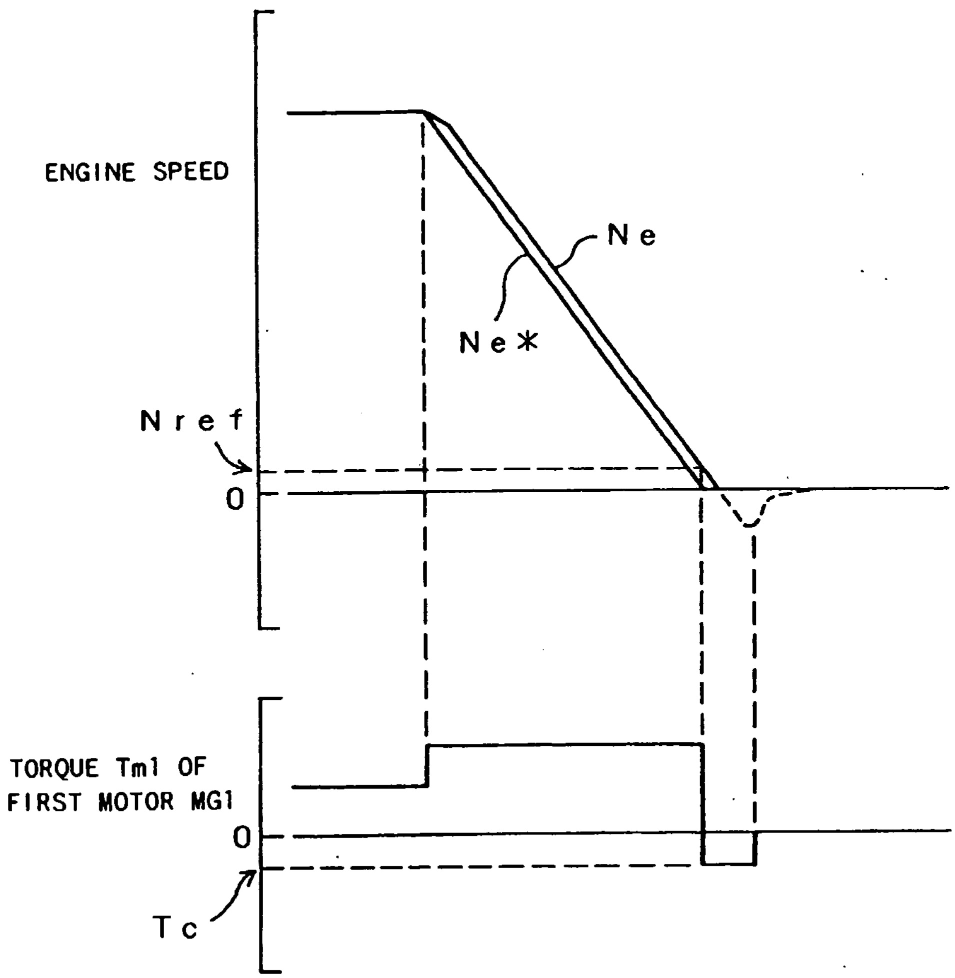


Fig. 17

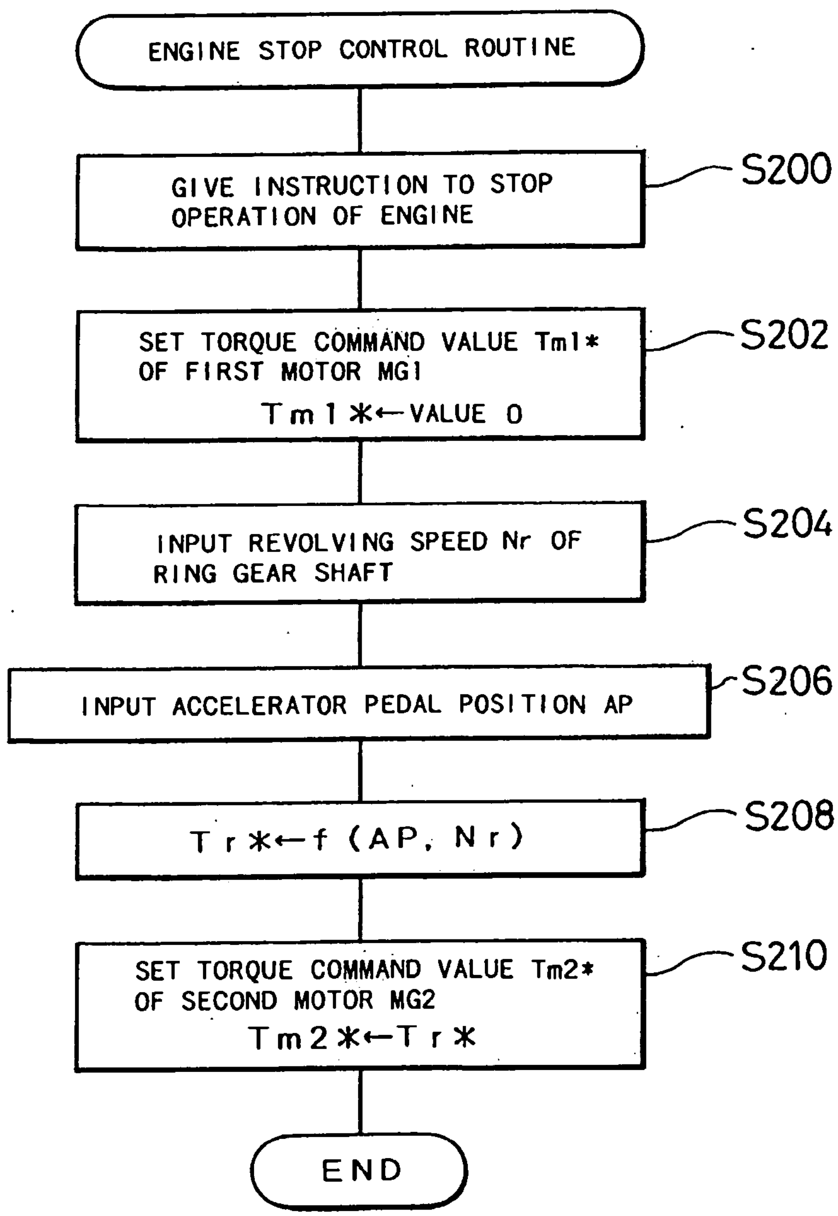

ENGINE STOP CONTROL ROUTINE
GIVE INSTRUCTION TO STOP OPERATION OF ENGINE
S200
SET TORQUE COMMAND VALUE Tm1* OF FIRST MOTOR MG1
Tm1*←VALUE 0
S202
INPUT REVOLVING SPEED Nr OF RING GEAR SHAFT
S204
INPUT ACCELERATOR PEDAL POSITION AP
S206
Tr*←f (AP, Nr)
S208
SET TORQUE COMMAND VALUE Tm2* OF SECOND MOTOR MG2
Tm2*←Tr*
S210
END

Fig. 18

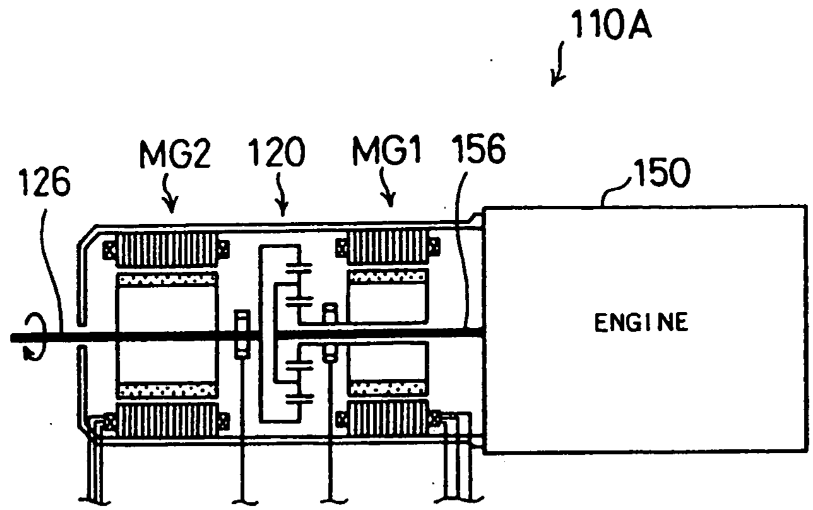

110A
126
MG2
120
MG1
156
150
ENGINE

Fig. 19

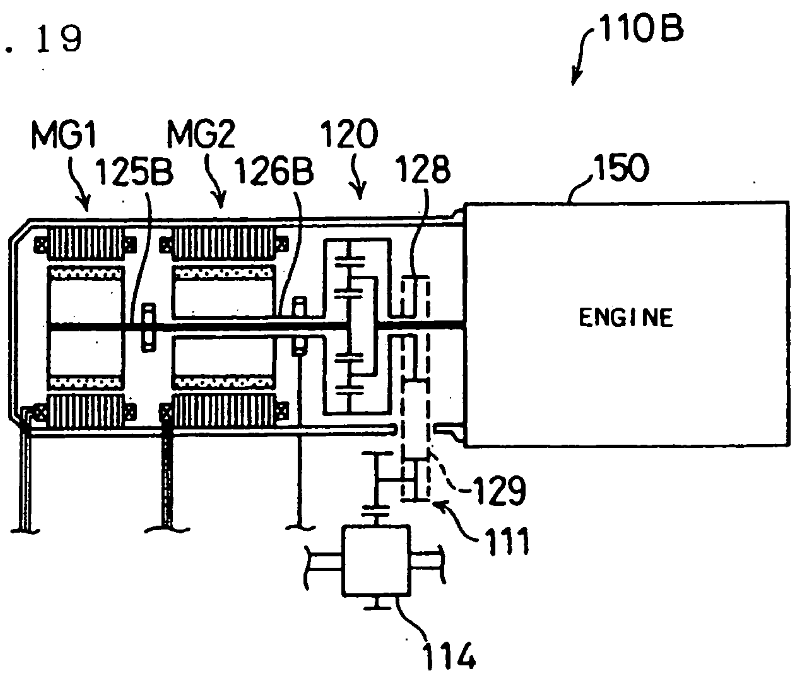

110B
MG1
MG2
120
125B
126B
128
150
ENGINE
129
111
114

Fig. 20

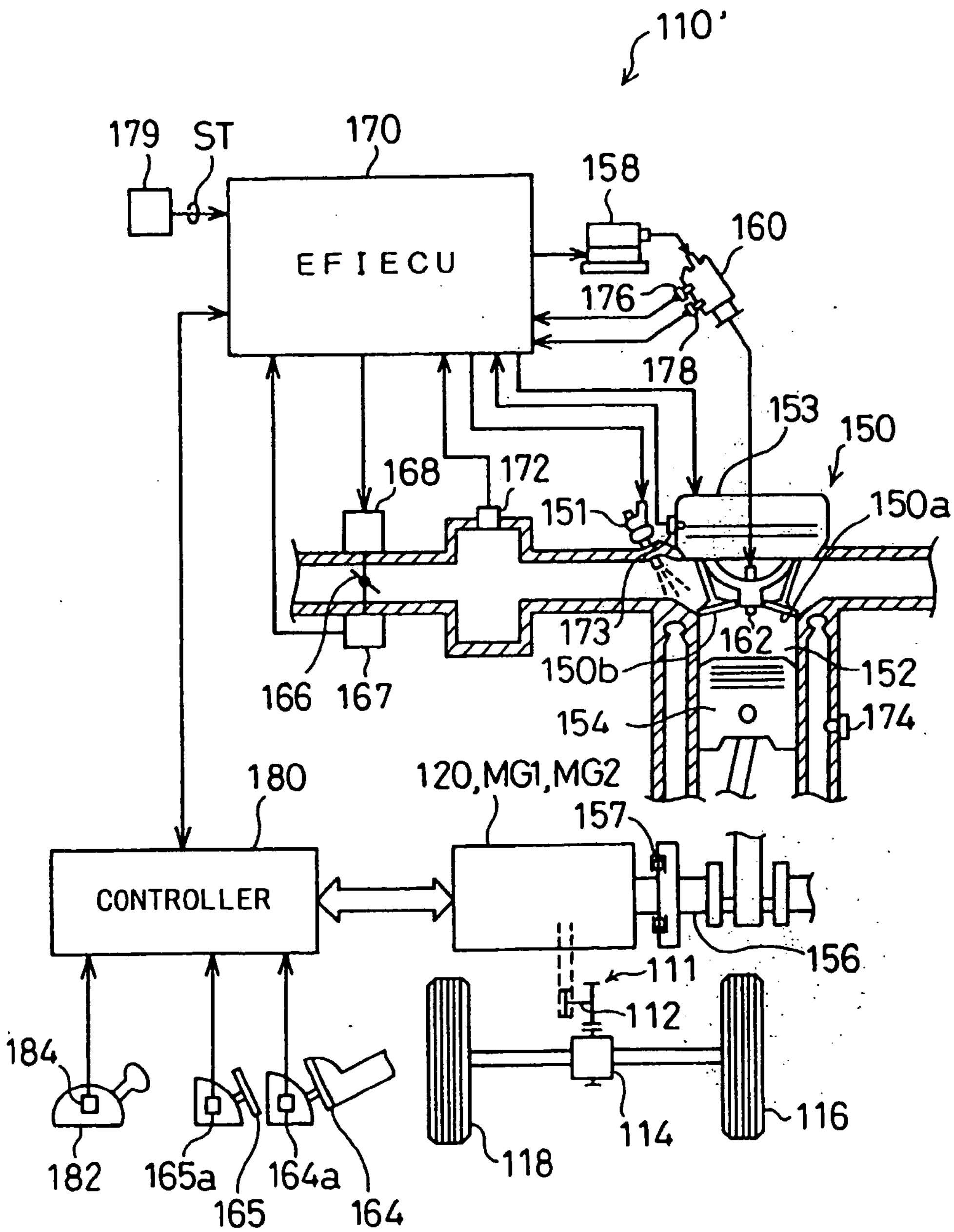
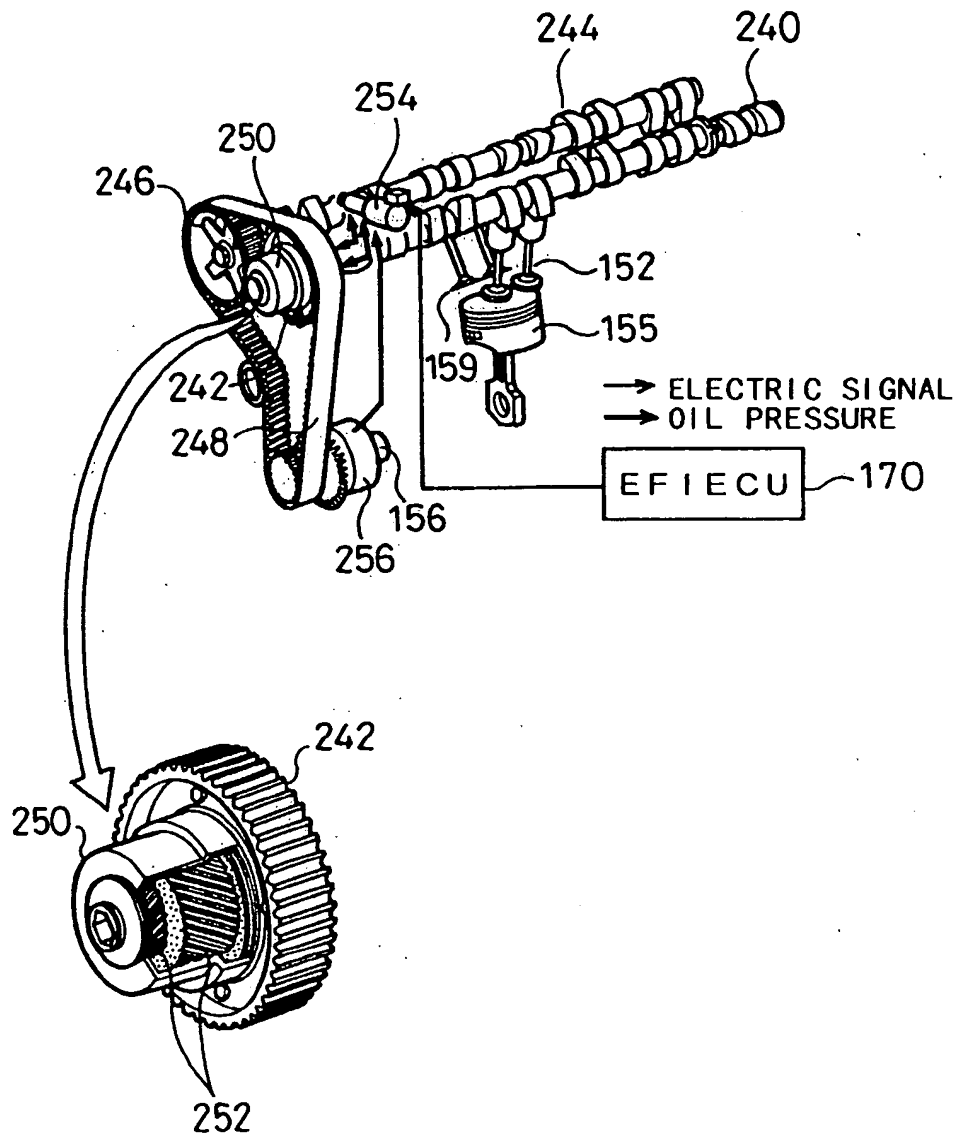

110'
179
ST
170
EFIECU
158
160
176
178
153
150
168
172
151
150a
173
162
166
167
150b
152
154
174
180
120,MG1,MG2
157
CONTROLLER
156
111
112
184
114
116
118
182
165a
165
164a
164

Fig. 21



244
240
254
250
246
152
155
159
242
ELECTRIC SIGNAL
OIL PRESSURE
248
EFIECU
170
156
256
242
250
252

Fig. 22

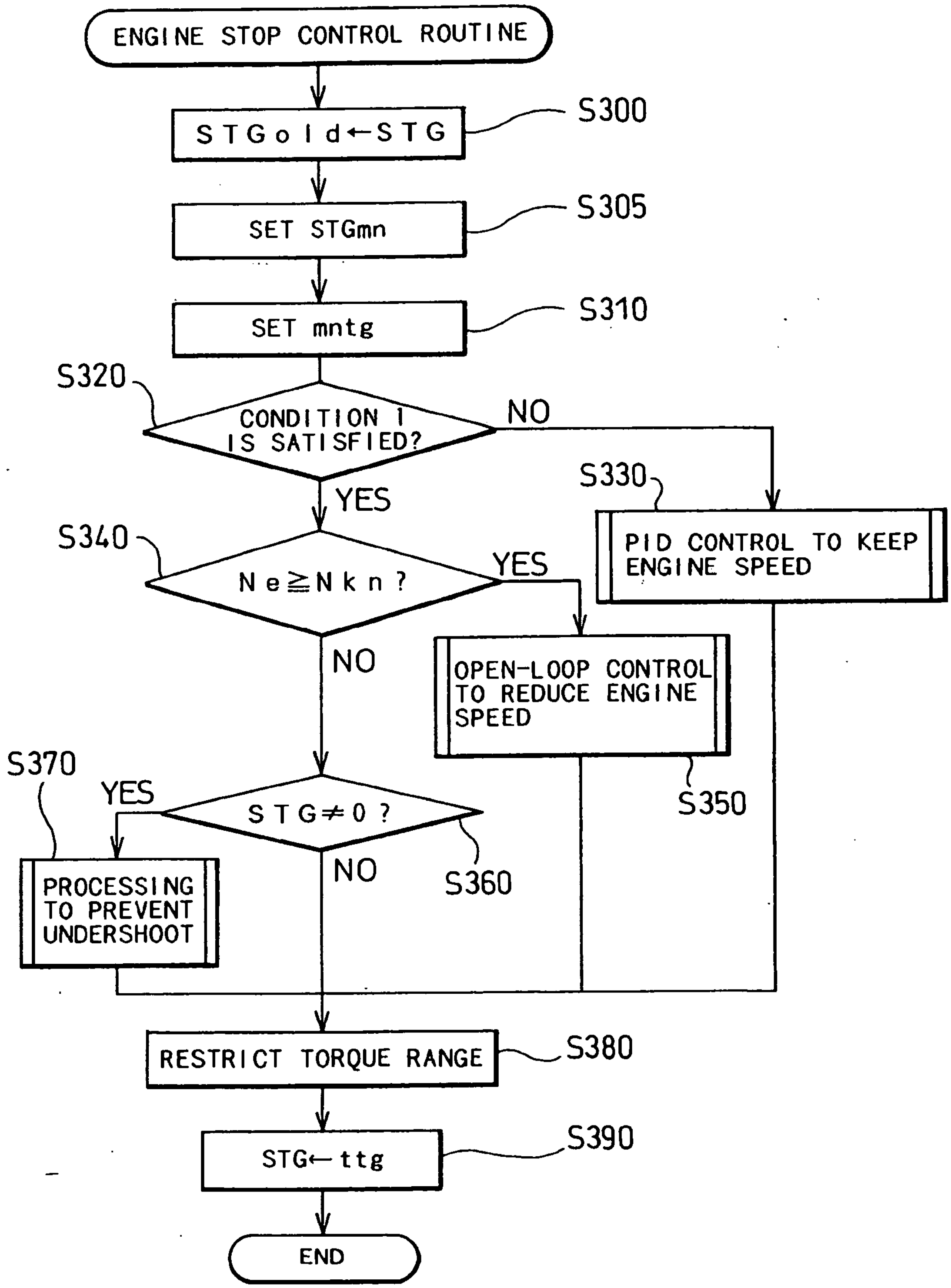

ENGINE STOP CONTROL ROUTINE
STGold←STG
S300
SET STGmn
S305
SET mntg
S310
S320
CONDITION 1 IS SATISFIED?
NO
YES
S330
PID CONTROL TO KEEP ENGINE SPEED
S340
Ne≧Nkn ?
YES
NO
OPEN-LOOP CONTROL TO REDUCE ENGINE SPEED
S350
S370
YES
STG≠0 ?
NO
S360
PROCESSING TO PREVENT UNDERSHOOT
RESTRICT TORQUE RANGE
S380
STG←ttg
S390
END

Fig. 23

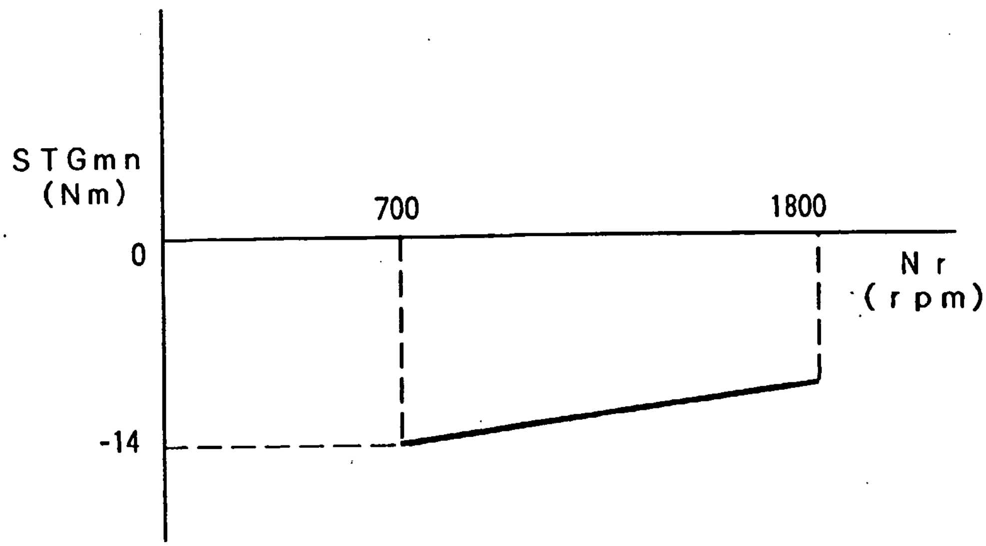


Fig. 24

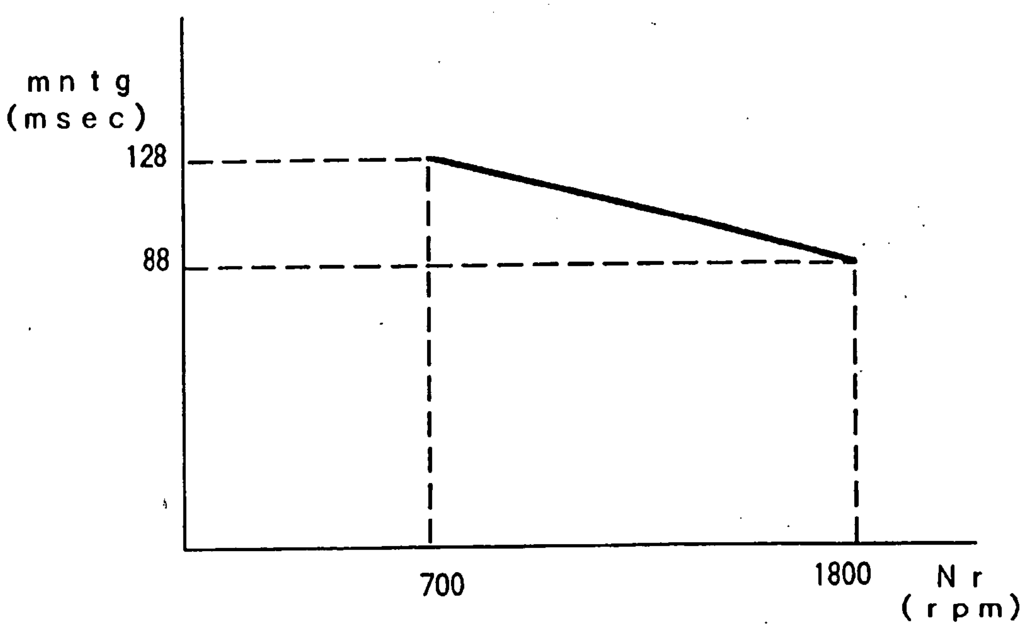


Fig. 25

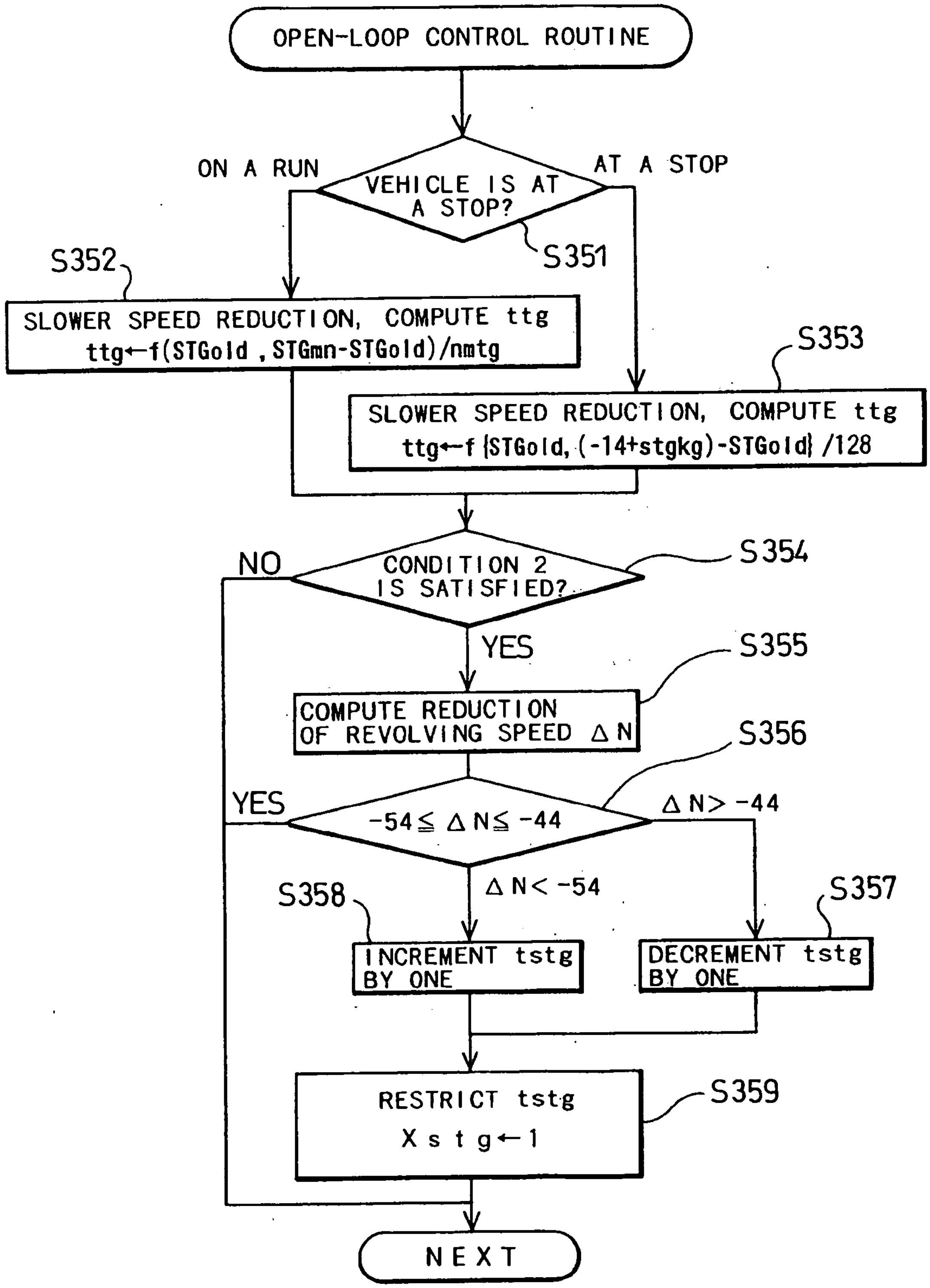

OPEN-LOOP CONTROL ROUTINE
VEHICLE IS AT A STOP?
S351
ON A RUN
AT A STOP
S352
SLOWER SPEED REDUCTION, COMPUTE ttg
ttg←f(STGold , STGmn-STGold)/nmtg
S353
SLOWER SPEED REDUCTION, COMPUTE ttg
ttg←f {STGold, (-14+stgkg)-STGold} /128
CONDITION 2 IS SATISFIED?
S354
NO
YES
COMPUTE REDUCTION OF REVOLVING SPEED ΔN
S355
-54≦ΔN≦-44
S356
YES
ΔN> -44
ΔN< -54
S358
INCREMENT tstg BY ONE
S357
DECREMENT tstg BY ONE
RESTRICT tstg
Xstg←1
S359
NEXT

Fig. 26

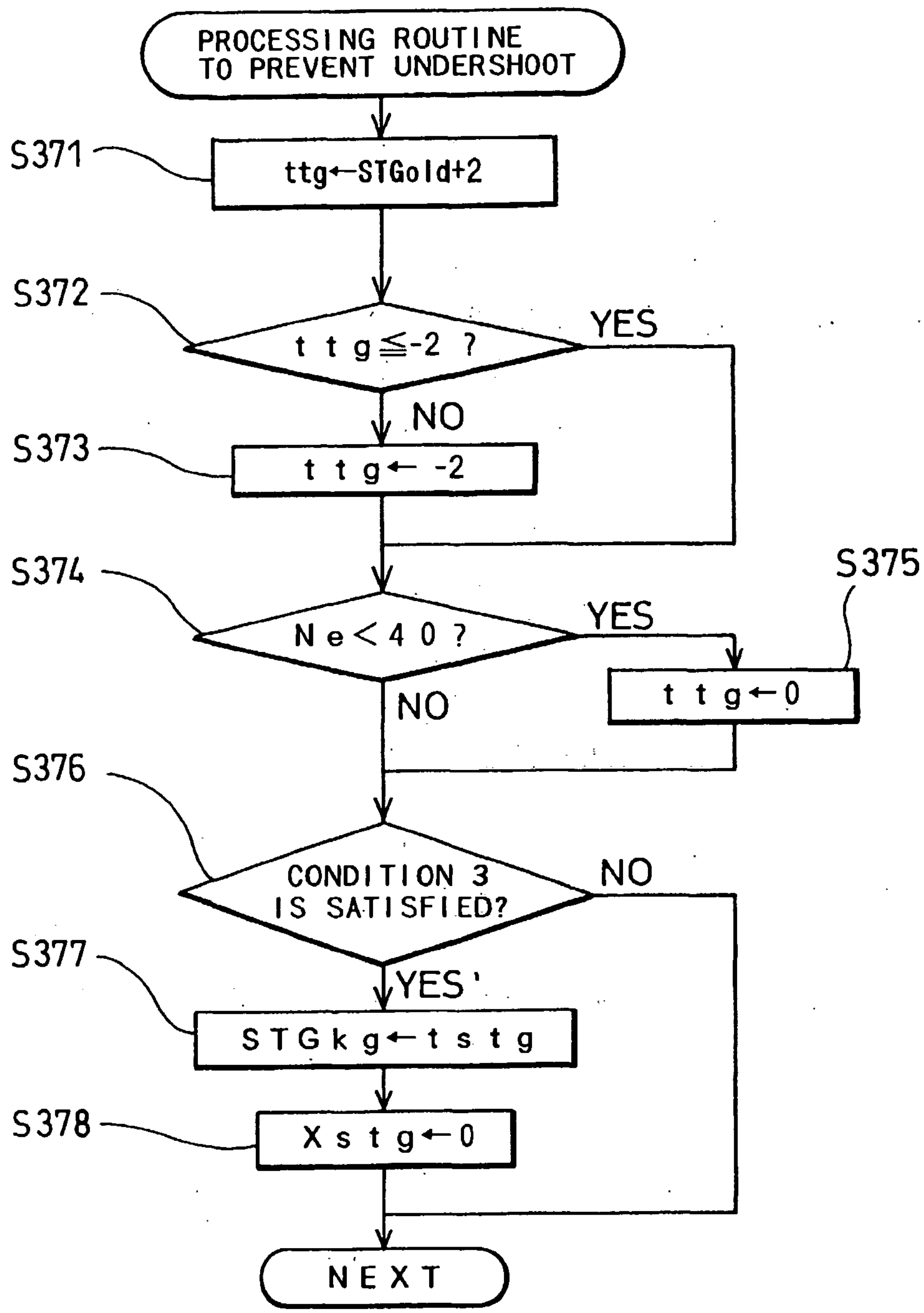

PROCESSING ROUTINE TO PREVENT UNDERSHOOT
S371
ttg←STGold+2
S372
ttg≦-2 ?
YES
NO
S373
ttg← -2
S374
Ne<40 ?
YES
S375
ttg←0
NO
S376
CONDITION 3 IS SATISFIED?
NO
YES
S377
STGkg←tstg
S378
Xstg←0
NEXT

Fig. 27

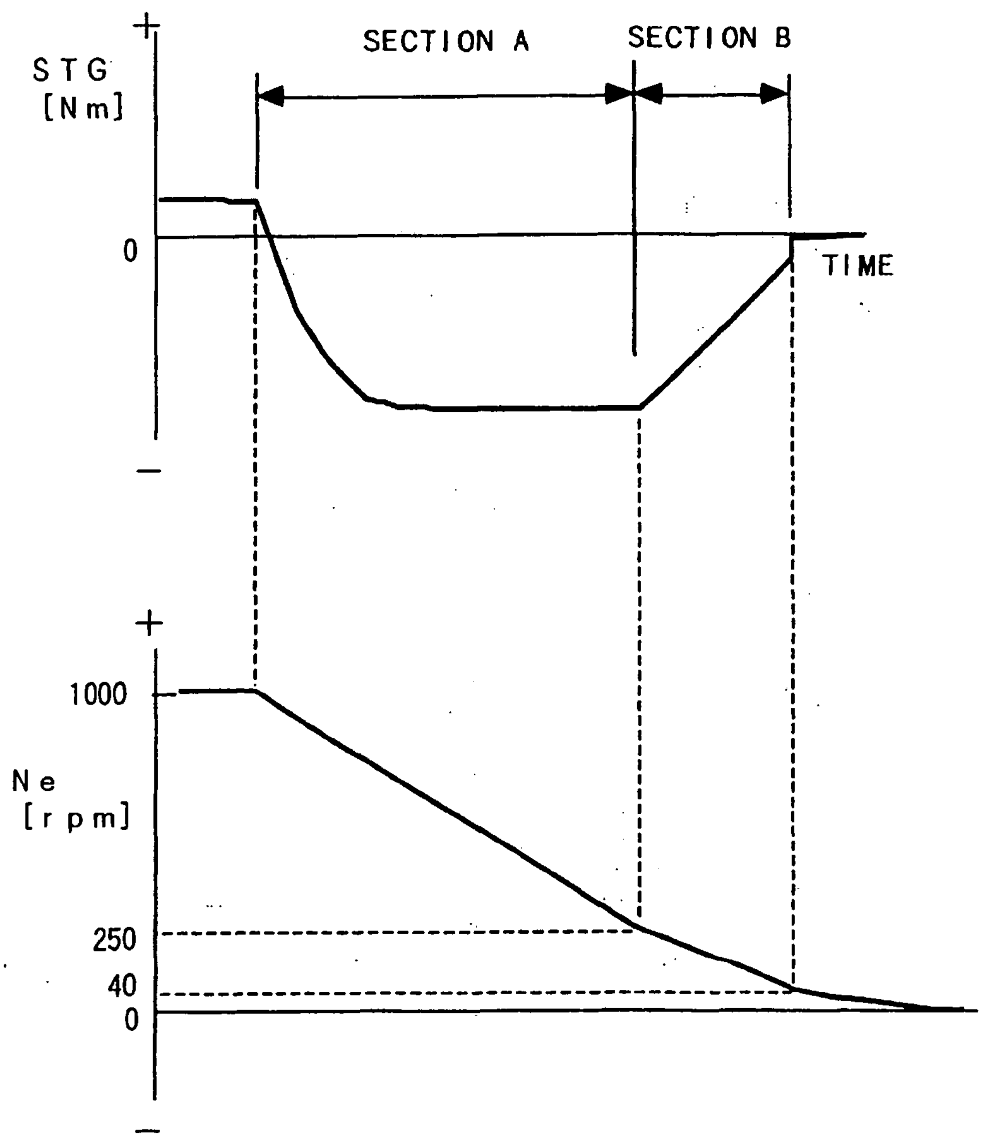


Fig. 28

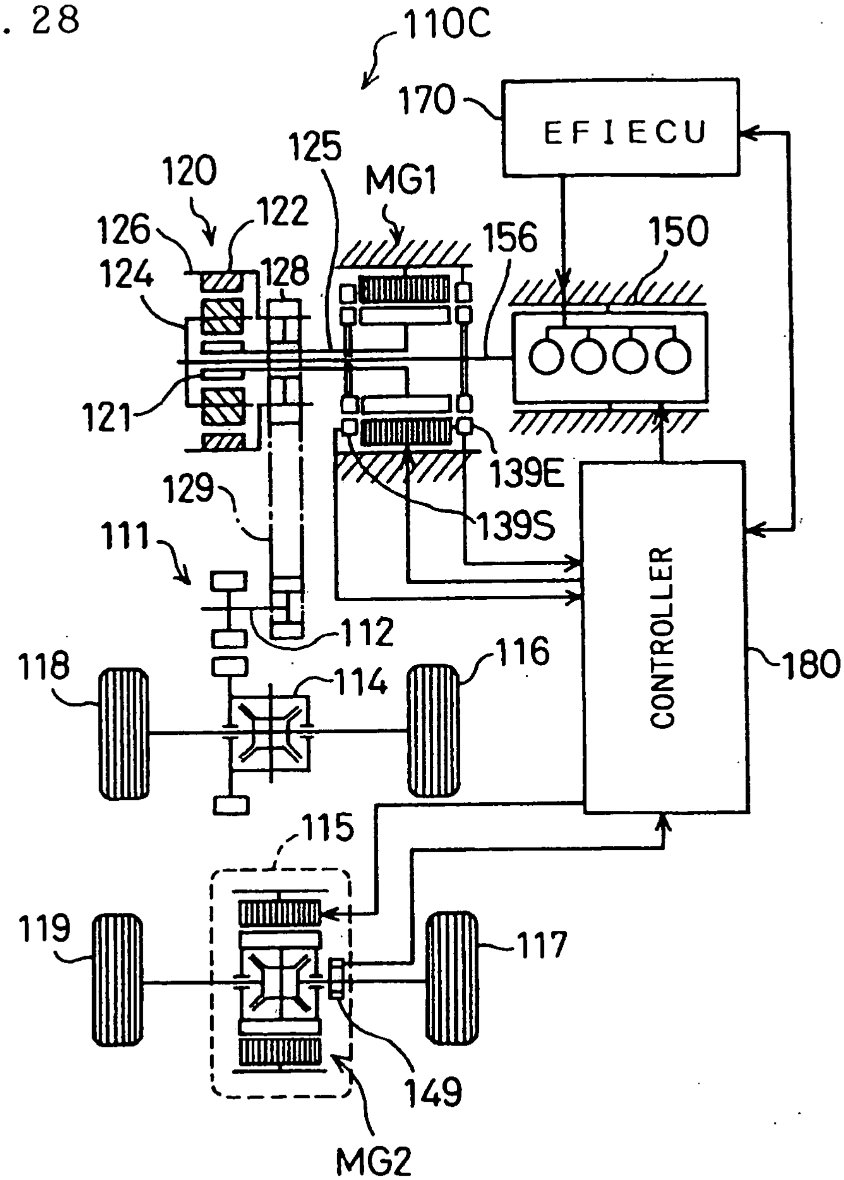
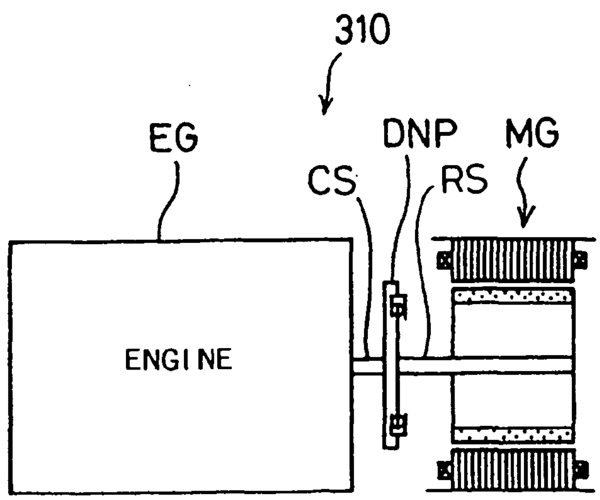

110C
170
EFIECU
125
120
MG1
122
126
156
150
124
128
121
139E
129
139S
111
CONTROLLER
112
118
116
180
114
115
119
117
149
MG2

Fig. 29



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 11 8748

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP 0 725 474 A (NIPPON DENSO CO) 7 August 1996 * column 6, line 44 - column 7, line 19; claims 1,18 *	1,11,19, 20	B60K41/00 B60K6/04
A	US 4 407 132 A (HONDA SHOJI ET AL) 4 October 1983 * column 13, line 57 - column 14, line 37; figure 12B *	1,11,19, 20	
P,A	JP 08 295140 A (AQUEOUS RES:KK) 12 November 1996 * figures 2,7-9 *	1,11,19, 20	
T	& US 5 788 006 A * claims 2,3 *		
P,A	DE 195 32 128 A (CLOUTH GUMMIWERKE AG) 6 March 1997 * claims 1,4,25; figures 7,8 *	1,11,19, 20	
P,A	EP 0 743 211 A (TOYOTA MOTOR CO LTD) 20 November 1996 * claims 2,4,7,10,12,14; figures 9,14 *	1,11,19, 20	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B60K B60L H02K F02D F16F F02B
P,A	EP 0 743 216 A (TOYOTA MOTOR CO LTD) 20 November 1996 * column 43, line 26 - line 35; claims 14,15 *	1,11,19, 20	
T	EP 0 830 969 A (TOYOTA MOTOR CO LTD) 25 March 1998 * page 11, line 49 - line 51 * * page 12, line 44 - line 51; claims 10,11 *	1,11,19, 20	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 April 1999	Bufacchi, B

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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T : theory or principle underlying the invention
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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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		EP 0743217 A	20-11-1996

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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PARIS

(11) N° de publication : **2 419 832**
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A1

DEMANDE DE BREVET D'INVENTION

(21) **N° 78 08080**

(54) **Moyens pour diminuer la consommation et la pollution des véhicules à moteur et pour augmenter temporairement leur puissance motrice.**

(51) Classification internationale (Int. Cl.²). B 60 K 1/00, 6/00, 17/00.

(22) Date de dépôt .... 16 mars 1978, à 17 h.

(33) (32) (31) Priorité revendiquée :

(41) Date de la mise à la disposition du public de la demande .... B.O.P.I. — «Listes» n. 41 du 12-10-1979.

(71) Déposant : BOCQUET Lucien Fernand François et DUPEYROL Alice Marie, résidant en France.

(72) Invention de : Lucien Fernand François Bocquet et Alice Marie Dupeyrol.

(73) Titulaire : *Idem* (71)

(74) Mandataire : Bocquet, Cidex 230 ter, Fréniches, 60840 Guiscard.

TPR 097563

D

Vente des fascicules à l'IMPRIMERIE NATIONALE, 27, rue de la Convention — 75732 PARIS *CEDEX 15*

On cherche à diminuer la consommation et la pollution des véhicules à moteur et les constructeurs souhaiteraient pouvoir réduire la puissance et l'importance des moteurs tout en conservant suffisamment de puissance pour les accélérations et la conduite.

La présente invention a pour objet de donner une solution à ce problème.

Elle consiste à utiliser le moteur du véhicule pendant le maximum de de temps dans les meilleures conditions de rendement et de puissance par l'ensemble des moyens suivants et de leurs diverses liaisons mécaniques et électriques : le moteur du véhicule est accouplé à un générateur électrique branché sur une batterie d'accumulateurs ; cette batterie et ce générateur sont connectés à des moteurs électriques qui assurent la propulsion, le freinage à récupération d'énergie et la marche arrière, par l'intermédiaire d'une boîte de vitesse et d'un pont ; un embrayage ou un dispositif équivalent permet d'accoupler mécaniquement ou autrement le groupe moteur-générateur à la transmission de propulsion ; tous ces organes étant commandés par un appareillage approprié, manuel, automatique ou mixte, permettant d'effectuer les liaisons, mécaniques, électriques ou autres, de ces organes entre eux et aux transmissions de propulsion afin de réaliser dans les conditions optima exposées précédemment les modes de fonctionnements suivants:

1 - exclusivement électrique, le groupe générateur étant arrêté.

2 - électrique normal, avec le groupe en marche non embrayé sur la transmission.

3 - électrique à surpuissance temporaire, approximativement doublée en embrayant sur la transmission de propulsion le groupe, générateur débranché; ou, susceptible d'être triplée, moyennement des aménagements appropriés, générateur branché.

4 - mixte de croisière, réalisé de préférence lorsque le véhicule roule régulièrement à une vitesse correspondant sensiblement au régime optima, par embrayage du groupe sur la transmission, moteurs de propulsion débranchés, générateur branché; ce dernier travaillant alors, suivant la vitesse de marche, en moteur ou en générateur pour régulariser la marche au régime optima.

5 - mixte accéléré, comme 4, mais en changeant le rapport de vitesse pour passer au rapport supérieur losque le régime optima est atteint. Dans ce mode de fonctionnement la surpuissance est automatiquement réalisée par le générateur au moment du changement de rapport.

6 - classique, avec le groupe embrayé, générateur et moteurs débranchés.

7 - marche arrière et freinage électrique à récupération d'énergie, par inversion du sens de marche des moteurs.

En faisant l'examen comparatif des bilans de fonctionnement d'un tel véhicule et d'un véhicule classique on constate que les pertes de rendement dûes à la transformation électrique sont très inférieures aux gains de l'invention. Plus particulièrement dans le cas d'une circulation très difficile, avec marche exclusivement électrique sans pollution, dans laquelle il est possible, avec une batterie de capacité peu élevée, d'obtenir une autonomie de parcours de 5 à 10 Km pendant 5 à 10 minutes. Les meilleures conditions de marche sont celles du fonctionnement mixte da ns lequel les pertes électriques sont réduites au minimum losque le débit du générateur est nul, sa tension à vide étant égale à la tension maxima de de la batterie. Le véhicule est alors propulsé avec la preque totalité de l'énergie mécanique du moteur et quand, par suite d'une augmentation des résistances à l'avancement, la vitesse de marche diminue, la puissance motrice s'accroît de la puissance fournie par le générateur.

Sur la planche unique annexéeont été représentées schématiquement deux réalisations non exclusives, des dispositions de l'invention : la Fig. 1 dans laquelle le moteur du véhicule, le générateur et les moteurs de propulsion ont des vitesse égales; la Fig. 2 dans laquelle, en vue d'un abaissements du poids et du prix, les organes électriques ont des vitesses plus élevées. Le moteur 1 du véhicule est accouplé au générateur électrique 2. Les moteurs électriques 3 assurent la propulsion par l'intermédiaire de l'arbre 4, la boîte de vitesse 5, le pont 6 et les transmissions 7. Les batteries sont figurées en 8, l'embrayage du moteur sur la propulsion en 9 et la capacité contenant l'appareillage de commande et de contrôle en 10. Sur la Fig. 2, le générateur 2 comporte deux enroulements égaux indépendants, chacun d'eux étant connecté à une demi-batterie 8; La propulsion est faite par deux moteurs 3, disposés sur un même axe. On pourra ainsi, sans interruption de charge, coupler en série ou en parallèle ces divers éléments au moyen d'un appareillage approprié et obtenir plusieurs vitesses électriques. Par exemple avec des demi-batteries de 12 volts et des moteurs de 24 volts il sera possible d'alimenter ceux-ci sous 6 , 12 ou 24 volts et obtenir 3 vitesses électriques qui, combinées à une boîte à 3 rapports donneront 9 allures de marche différentes.

Ces dispositions permettront de réaliser des véhicules économiques, de conduite agréable, ayant des couples de démarrage importants, de bonnes accélérations, une aptitude convenable en côte, des plafonds de vitesse plus élevés, capables de recharger leurs batteries pendant l'arrêt ou le stationnement et susceptibles de recevoir un équipement de marche semi-automatique peu coûteux. On peut, par exemple, concevoir 3 gammes: la première, de circulation urbaine ou encombrée à 11 , 22 et 44 Kmh; la seconde pour circulation banlieue ou promenade à 18 , 36 et 72 Kmh; la troisième

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pour les parcours routiers à 30 , 60 et 120 Kmh.

En principe seront utilisés, d'une part, des moteurs série et des génératrices shunt comportant éventuellement des dispositifs complémentaires d'excitation ou autres, couramment employés en commande électrique, et, d'autre part, les appareillages auxiliaires classiques nécessaires à leur fonctionnement.

Ces dispositions peuvent être appliquées à tous genres de véhicules à moteur , mais plus particulièrement à ceux de faible puissance ou de très petite cylindrée sans permis de conduire,auxquels elles apportent des améliorations modifiant totalement leurs performances en leur procurant ainsi des débouchés beaucoup plus importants.

Elles conviennent parfaitement aux véhicules de toutes puissances soumis à des arrêts fréquents de plus ou moins longue durée,comme les voitures de ramassage ou de livraison,de voyageurs de commerce,etc...

Elles s'appliquent également aux matériels,machines,appareils,dans lesquels on utilise diversement l'énergie d'un moteur et qui sont susceptibles d'exiger temporairement une puissance supérieure.

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REVENDICATIONS

1 - Invention ayant pour objet de réduire la consommation et la pollution des véhicules à moteur et d'augmenter temporairement leur puissance motrice, caractérisée par l'utilisation, pendant le maximum de temps, du moteur du véhicule fonctionnant dans les meilleures conditions de rendement et de puissance, en employant l'ensemble des moyens suivants et leurs diverses liaisons électriques et mécaniques : le moteur du véhicule est accouplé à un générateur électrique branché sur une batterie d'accumulateurs; cette batterie et ce générateur sont connectés à des moteurs électriques qui assurent la propulsion, le freinage à récupération d'énergie et la marche arrière, par l'intermédiaire d'une boîte de vitesse et d'un pont; un embrayage ou un dispositif équivalent permet d'accoupler, mécaniquement ou autrement, le groupe moteur-générateur à la transmission de propulsion ; tous ces organes étant commandés par un appareillage approprié, manuel, automatique ou mixte, permettant d'effectuer les liaisons électriques, mécaniques ou autres, de ces organes entre eux et aux transmissions de propulsion, afin de réaliser dans les conditions optima exposées précédemment les modes de fonctionnement suivants :

1 - exclusivement électrique, le groupe moteur-générateur étant arrêté.

2 - électrique normal, le groupe en marche, non embrayé sur la transmission.

3 - électrique à surpuissance temporaire, approximativement doublée, en embrayant le groupe, générateur débranché, sur la transmission; ou susceptible d'être triplée, en embrayant le groupe, générateur branché.

4 - mixte de croisière, par embrayage du groupe sur la transmission, moteurs de propulsion débranchés, générateur branché; ce dernier travaillant alors, suivant la vitesse de marche, en moteur ou en générateur, pour régulariser la marche au régime optima;

5 - mixte accéléré, réalisé comme 4, mais en changeant le rapport de vitesse pour passer au rapport supérieur lorsque le régime optima est atteint. Dans ce mode de fonctionnement la surpuissance est automatiquement réalisée par le générateur lors du changement de rapport.

6 - classique, avec le groupe embrayé, générateur et moteurs débranchés.

7 - freinage électrique à récupération et marche arrière par inversion du sens de marche des moteurs.

2 - Ensemble suivant la rev. 1 caractérisé par 2 générateurs, 2 moteurs et 2 demi-batteries, pour obtenir, sans interrompre la charge, par des connexions appropriées et le montage série-parallèle de ces éléments, plusieurs vitesses de marche des moteurs électriques.

3 - Ensemble suivant les rev. 1 et 2 caractérisé, en vue d'une ...

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amélioration du rendement et de l'encombrement, par le genre et la disposition des engrenages qu'il comporte, à savoir: pour la boite de vitesse, seuls tournent les engrenages du rapport utilisé, les autres étant à l'arrêt; pour le pont, couple réducteur dont le pignon est un engrenage droit, hélicoïdal ou à chevrons et la roue un engrenage intérieur.

4 - Ensemble suivant les rev. 1 et 2, caractérisé par un appareillage automatique de mise en marche et d'arrêt du moteur-générateur pour la charge de la batterie en fonction de la charge de celle-ci, susceptible de fonctionner pendant l'arrêt, la marche ou le stationnement du véhicule.

5 - Ensemble suivant les rev. 1 et 2, caractérisé, pour réduire l'encombrement, par des générateurs et des moteurs comportant deux enroulements distincts sur un même rotor et dans une même carcasse.

6 - Ensemble suivant les rev. 1 et 2, caractérisé, en vue d'une diminution de poids, d'encombrement et de pertes de rendement, par des moteurs électriques et des générateurs à grande vitesse, et l'accouplement de ces derniers au moteur du véhicule au moyen d'un multiplicateur de vitesse.

7 - Ensemble suivant les rev. 1 et 2 dans lequel les rapports de la boite de vitesse mécanique sont commandés manuellement, tandis que ceux de la combinaison électrique sont à commande automatique.

8 - Ensemble suivant la rev. 2, caractérisé, en vue d'une simplification, par un emploi partiel des dispositions de cette revendication, comme par exemple le montage série-parallèle de seulement les 2 moteurs de propulsion, ce qui réduit à 2 le nombre des régimes de marche obtenus.

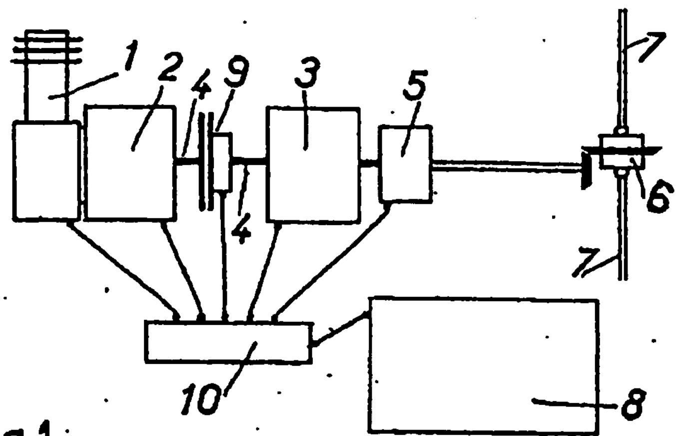

fig 1

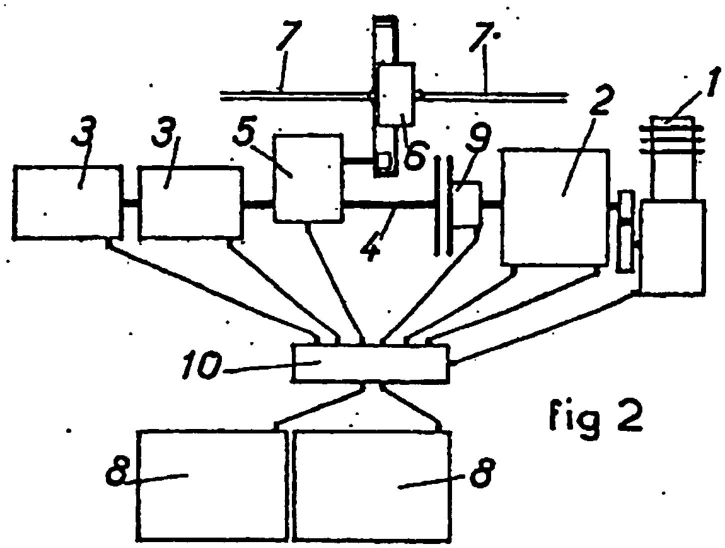

fig 2

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A1 **APPLICATION FOR A PATENT**

21 **No. 78 08080**

54 **Means of reducing the fuel consumption and pollution in motor vehicles and of temporarily increasing their engine power.**

51 International classification (Int. Cl.^{2}). **B 60 K 1/100, 5/00, 17/00**

22 Filing date .... **March 16, 1978, at 5 p.m.**

33 32 31 Priority claimed:

41 Date of availability of the application to the public...**Official Industrial Property Bulletin [B.O.P.I.] ("Lists") no. 41 of 10/12/1979**

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A search is underway to reduce fuel consumption and pollution by motor vehicles and manufacturers would like to be able to reduce the power and importance of engines, while retaining enough power for acceleration and driving.

The purpose of this invention is to provide a solution to this problem.

It consists of using the motor vehicle during the maximum time in the best conditions of fuel consumption and power by all of the following means and their various mechanical and electrical links: the vehicle's engine is directly connected to an electrical generator connected to a storage battery; this battery and the generator are connected to electric motors that provide the power, regenerative breaking, and moving in reverse gear, by means of a transmission and a bridge circuit; a clutch or an equivalent device to connect the motor-generator assembly to the power transmission, mechanically or otherwise; all of these units, being controlled by appropriate manual, automatic, or mixed equipment, allowing the manual, automatic, or other connections of these units to be carried out among themselves and to the transmission of power in order to carry out the following methods of operation in the optimum conditions as described above:

1 – exclusively electrical, the generator group being suppressed.

2 – normal electrical, with the group in operation, not engaged to the transmission.

3 – electrical with temporary emergency power, approximately doubled, by engaging the system on the transmission of power, with the generator disconnected; or, capable of being tripled by means of appropriate design with the generator connected.

4 – mixed at cruising speed, preferably done when the vehicle is moving steadily at a speed that corresponds closely to the optimal rate, by engaging the system on the transmission with the propulsion motors disconnected and the generator connected; the generator then operates according to the operating velocity, with the motor or the generator to stabilize the speed at the optimal level.

5 – mixed acceleration, like 4, but changing the velocity ratio in order to go to the higher ratio when the optimum rate is reached. In this method of operation, the emergency power is automatically achieved by the generator at the time when the ratio is changed.

6 – classic, with the system engaged and the generator and motors disconnected.

7 – reverse gear and regenerative electrical braking by reverse running of the motors.

In making a comparative examination in appraisal of the operation of such a vehicle and a classic vehicle, it

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is observed that the losses in efficiency due to the electrical transformation are much less than are the gains of the invention. In particular in the case of very difficult traffic, with exclusively electrical operation without pollution, in which it is possible with a low-capacity battery to make an autonomous trip of 5 to 10 kilometers in from 5 to 10 minutes. The best operating conditions are those with mixed functioning in which the electrical losses are reduced to a minimum when the output of the generator is nil, its empty voltage being equal to the maximum voltage of the battery. The vehicle is then powered with almost all of the mechanical energy of the engine and when, after an increase in resistance to the forward motion, the velocity decreases, the power of the engine increases from the energy provided by the generator.

In the only drawing attached, there is shown schematically two non-exclusive representations of the features of the invention: Fig. 1, in which the engine of the vehicle, the generator, and the propulsion motors have equal velocities; Fig. 2 in which, in view of a reduction in weight and in price, the electrical units have higher velocities. The engine 1 of the vehicle is connected to an electrical generator 2. The electrical motors 3 provide the power by means of the shaft 4, the gearbox 5, the bridge circuit 6, and the transmissions 7. The batteries are shown in 8, the clutch of the propulsion motor in 9 and the box containing the command and control instruments in 10. In Fig. 2, the generator 2 includes two equal and independent units, each of them connected to a half-battery 8; the power is achieved by two motors 3, arranged on the same axis. In this way, without interrupting the charge, these different units can be connected in series or in parallel, by means of appropriate instrumentation and achieve several electrical velocities. For example with 12 volt half-batteries and 24 volt motors it will be possible to supply them with 6, 12, or 24 volts and obtain 3 electrical velocities which, combined with 3-speed gearboxes velocities will give 9 different levels of performance.

These arrangements will allow the development of economical vehicles, easy to drive, with significant starting torque, a suitable response on inclines, higher velocity ceilings, able to recharge their batteries while stopped or parked, and able to receive inexpensive semi-automatic operating equipment. For example, three series appear possible: the first, in city or congested traffic at 11, 22, or 44 Kmh; the second for suburban or sightseeing traffic at 18, 36, and 72 Kmh; the third for highway trips at 30, 60, and 120 Kmh.

In principle, on the one hand, motors in series and generating shunts will be used possibly including excitation devices or other devices, currently used in electrical commands, and, on the other hand, the classic auxiliary instrumentation necessary for their operation.

These arrangements may be applied to all kinds of vehicles, but in particular to low-power vehicles or very few cylinders without a driver's license required, to which they will bring improvements that will completely change their performance, thereby providing them with much larger markets.

They are perfectly adapted to vehicles of any power that are subject to frequent long or short stops, such as pickup and delivery vehicles, traveling salespeople, etc.

They also apply to equipment, machines, and devices in which the energy of a motor is used in different ways and that are subject to a temporary need for greater power.

CLAIMS

1 – An invention whose purpose is to reduce fuel consumption and pollution of motor vehicles and to increase their engine power temporarily, characterized by the use, during the maximum period of time, of the engine of the vehicle operating in the best conditions of fuel consumption and power, using all of the following methods and their various electrical and mechanical links: the vehicle's engine is directly connected to an electrical generator connected to a storage battery; this battery and the generator are connected to electric motors that provide the power, regenerative breaking, and moving in reverse gear, by means of a transmission and a bridge circuit; a clutch or an equivalent device to connect the motor-generator assembly to the power transmission, mechanically or otherwise; all of these units, being controlled by appropriate manual, automatic, or mixed equipment, allowing the manual, automatic, or other connections of these units to be carried out among themselves and to the transmission of power in order to carry out the following methods of operation in the optimum conditions as described above:

1 – exclusively electrical, the engine-generator group being suppressed.

2 – normal electrical, with the group in operation, not engaged to the transmission.

3 – electrical with temporary emergency power, approximately doubled, by engaging the system on the transmission of power, with the generator disconnected; or, capable of being tripled by engaging the system with the generator connected.

4 – mixed at cruising speed, by engaging the system on transmission, with the propulsion motors disconnected and the generator connected; the generator then operates according to the operating velocity, with the motor or the generator to stabilize the speed at the optimal level.

5 – mixed acceleration, like 4, but changing the velocity ratio in order to go to the higher ratio when the optimum rate is reached. In this method of operation, the emergency power is automatically achieved by the generator at the time when the ratio is changed.

6 – classic, with the system engaged and the generator and motors disconnected.

7 – reverse gear and regenerative electrical braking by reverse running of the motors.

2 – A system according to claim 1, characterized by 2 generators, 2 motors, and 2 half-batteries in order to obtain by appropriate connections and the series-parallel assembly of these units several operating speeds from the electric motors, without interrupting the charge.

3 – A system according to claims 1 and 2, characterized in view

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of an increase in fuel efficiency and the size, by the kind and layout of the gears that are included, namely: for the gearbox, only gears of the ratio that are turning are used, the others are stopped; for the bridge circuit, a reduction torque whose cog is a straight, helicoidal, or double helicoidal gear and the wheel an interior gear.

4 – A system according to claims 1 and 2, characterized by an automatic device for starting and stopping the motor-generator for charging the battery according to its charge level, capable of operating during stops, running, or parking of the vehicle.

5 – A system according to claims 1 and 2, characterized, in order to reduce the size, by generators and motors including two different units on the same rotor and in the same casing.

6 – A system according to claims 1 and 2, characterized, in order to reduce weight, size, and loss of fuel economy, by electric motors and very high-speed generators, and their connection to the vehicle's engine by means of a velocity multiplier.

7 – A system according to claims 1 and 2 in which the ratios of the mechanical gearbox are commanded manually, while those of the electrical system are commanded automatically.

8 – A system according to claims 1 and 2, by simplification through a partial use of the provisions of this claim, as for example by the series-parallel assembly of the 2 propulsion motors only, which reduces the number of operating systems used to 2.

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Sole drawing

[see source for figures 1 and 2]

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⑤Int. Cl.⁵　識別記号　庁内整理番号　㊸公開　平成3年(1991)5月27日

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審査請求　未請求　請求項の数 1　（全7頁）

⑭発明の名称　電気自動車用補機電池充電装置

㉑特　願　平1－261588

㉒出　願　平1(1989)10月6日

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明　細　書

1．発明の名称

電気自動車用補機電池充電装置

2．特許請求の範囲

キースイッチがオンされたときのみモータを駆動する主電池から、所定の値の直流電圧を取込んで異なる値の直流電圧に変換し、この変換により得られた直流電圧で補機電池を充電し、かつキースイッチを介して負荷を駆動するDC－DCコンバータと、

補機電池の電圧値を検知する電圧検知部と、

キースイッチがオンされているときに、前記電圧検知部が検知した電圧値に基づき、前記DC－DCコンバータによる補機電池の充電動作を制御し、補機電池により駆動される充電制御部と、

を有する電気自動車用補機電池充電装置において、

前記電圧検知部により検知される補機電池の電圧値が、所定の基準電圧値以下に低下しており、かつキースイッチがオフされている所定の期間において、所定時間だけ、前記DC－DCコンバータによる補機電池の充電を行わしめるように、前記充電制御部を動作させる充電指令部を含み、

補機電池の電圧値を検知し、この電圧値が所定の基準電圧値以下に低下している場合には、所定時間だけ、補機電池の充電を行うことを特徴とする電気自動車用補機電池充電装置。

3．発明の詳細な説明

〔産業上の利用分野〕

本発明は、主電池から取込んだ直流電圧を異なる値の直流電圧に変換し、補機電池を充電する電気自動車用補機電池充電装置に関する。

〔従来の技術〕

一般に電気自動車においては、電気自動車の走行に係るモータを駆動するために、所定の直流電圧を出力する主電池が搭載されている。また、この電気自動車においては、車載の電気機器を駆動するために、前記主電池とは異なる値の直流電圧を出力する補機電池が搭載されている。

また、主電池及び補機電池が搭載された電気自

動車には、該補機電池を充電するために、電気自動車用補機電池充電装置が搭載される。

第３図には、従来における電気自動車用補機電池充電装置の一構成例が示されている。

この図においては、主電池１０にはメインコンタクタ１２を介してモータ制御回路１４が接続され、該モータ制御回路１４には、電気自動車の走行駆動に係るモータ１６が接続されている。また、前記モータ制御回路１４には、該モータ制御回路１４を制御するインバータ回路、チョッパ回路等のモータ制御部１８が接続されている。

すなわち、前記主電池１０からメインコンタクタ１２を介して前記モータ制御回路１４に所定の値の直流電圧が供給されると、該モータ制御回路１４は、前記モータ制御部１８によりＰＷＭ制御等の制御に基づき、主電池１０から供給された直流電圧を所定の電力に変換してモータ１６に供給する。このことにより、前記モータ１６が駆動され、電気自動車が走行可能な状態となる。

前記主電池１０と補機電池２０との間には、従

来例に係る電気自動車用補機電池充電装置２２が設けられている。この補機電池充電装置２２は、主電池１０から出力される直流電圧を補機電池２０を充電可能な直流電圧に変換するＤＣ～ＤＣコンバータ２４と、補機電池２０の出力電圧を検知し、この検知結果に基づきＤＣ－ＤＣコンバータ２４を制御するＤＣ－ＤＣコンバータ制御回路２６と、から構成されている。

前記ＤＣ－ＤＣコンバータ２４は、例えば実開昭４８－１１１８２７号公報に開示されたものと同様の構成を有しており、主電池１０から出力される直流電圧を交流化するインバータ部２８、該インバータ部２８から出力される電圧を変圧するトランス部３０、及び該トランス部３０から出力される電圧を整流して補機電池２０を充電可能な電圧を出力する整流部３２から構成されている。

すなわち、前記主電池１０から出力される直流電圧は、前述のようにメインコンタクタ１２を介してモータ制御回路１４に供給されると共に、ＤＣ－ＤＣコンバータ２４に内蔵されるインバータ

部２８に入力され、順次、トランス部３０及び整流部３２に供給され、前記補機電池２０を充電可能な異なる値の直流電圧に変換される。そして、補機電池２０は、このようにしてＤＣ－ＤＣコンバータ２４から出力される直流電圧により充電される。

一方、前記補機電池２０は、直接にあるいはキースイッチ３４を介して車載の負荷に接続されており、また、キースイッチ３４を介してモータ制御部１８に接続されている。

すなわち、前述のようにしてＤＣ－ＤＣコンバータ２４から出力された直流電圧は、補機電池２０を充電すると共に、直接あるいはキースイッチ３４を介して車載の負荷及びモータ制御部１８に供給される。ここで、メインコンタクタ１２は、前記キースイッチ３４と連動してオン／オフするように構成されており、キースイッチ３４がオンされている場合、ＤＣ－ＤＣコンバータ２４又は補機電池２０から出力される直流電圧により、モータ制御部１８が駆動され、主電池１０からモー

タ制御回路１４に所定の直流電圧が供給されるため、モータ１６が駆動されることとなる。

一方、前述のように、この従来例に係る補機電池充電装置２２は、前記ＤＣ－ＤＣコンバータ２４に加えＤＣ－ＤＣコンバータ制御部２６を含んでおり、このＤＣ－ＤＣコンバータ制御部２６は、補機電池２０の電圧及び電流をそれぞれ検知する電圧検出アンプ３６及び電流検出アンプ３８と、該電圧検出アンプ３６及び電流検出アンプ３８の出力に基づき、パルスのデューティを決めるフィードバック部４０と、該フィードバック４２において決められたデューティにより、前記インバータ部２８に制御パルスを供給するパルス化回路４２と、から構成されている。

すなわち、前記補機電池２０の電圧は、前記電圧検出アンプ３６により検出され、増幅されてフィードバック部４０に供給される。同様に、前記補機電池２０の直流電流は、前記電流検出アンプ３８により検出され、増幅される。

次に、前記フィードバック部４０において、前

記電圧検出アンプ３６及び電流検出アンプ３８によりそれぞれ検出された補機電池２０の電圧及び電流に基づき、パルスのデューティが決定される。例えば、前記電圧検出アンプ３６の検出結果に基づき、補機電池２０の過電圧充電が防止されるようにデューティが算定され、同時に、電流検出アンプ３８の検出結果に基づき、ＤＣ－ＤＣコンバータ２４の最大出力電流を越えないようにデューティが算定される。そして、これらの２種類のデューティ、すなわち電圧検出アンプ３６及び電流検出アンプ３８のそれぞれの検出結果に基づいて算定されたデューティのうち、小さい方、すなわち補機電池２０の充電における電圧的及び電流的要請を両方共満たすデューティが選択され、前記パルス化回路４２に出力される。

前記パルス化回路４２においては、前記フィードバック部４０から供給されたデューティに基づきパルスが発生し、このパルスにより前記インバータ部２８の動作がＰＷＭ制御される。

従って、この従来例においては、補機電池２０

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の電圧及び電流に基づいて、ＤＣ－ＤＣコンバータ制御部２６によってＤＣ－ＤＣコンバータ２４が制御され、補機電池２０が充電されると共に、車載の負荷に所定の電圧が供給される。

この従来例においては、車載の負荷において消費される電流量がＤＣ－ＤＣコンバータ２４の出力能力以上である場合等において、補機電池２０が放電され、この放電により車載の負荷に電流が供給される。このとき、前記キースイッチ３４をオフすると、前記補機電池２０は、放電された状態で保持されることとなる。

このような動作が繰返され、補機電池２０がいわゆる過放電状態となると、該補機電池２０の電圧は、例えばモータ制御部１８を駆動するために必要な電圧以下に低下する可能性がある。このような電圧低下が生じた場合には、キースイッチ３４をオンし、モータ１６を駆動しようとしても、補機電池２０によるモータ制御部１８の駆動が行われないため、モータ１６の駆動、従って電気自動車の走行が不能となってしまう。

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例えば、特開昭６４－８５５０２号公報には、「電気自動車の制御装置」として、キースイッチＯＮ後に補機電池の電圧を検出し、まずＤＣ－ＤＣコンバータを起動させ該補機電池を充電し、所定の電圧以上を確保してから車両駆動を指令するモータ制御部の電源を立ち上げる構成が示されている。

〔発明が解決しようとする課題〕

前述の特開昭６４－８５５０２号公報に開示された装置においては、ＤＣ－ＤＣコンバータは補機電池により作動に必要な電圧を供給されているため、該補機電池の電圧が停車中の電力消費など何らかの理由により著しく低下し、モータ制御部作動可能電圧はおろかＤＣ－ＤＣコンバータの起動に必要な電圧さえも確保されていない状態になったときに、目的とする車両起動を達成できないことがある。

本発明は補機電池電圧が常にＤＣ－ＤＣコンバータ及びモータ制御部の起動に必要な電圧を保てるように構成され、該補機電池電圧低下によるモ

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ータの駆動再開不能状態を防止する電気自動車用補機電池充電装置を提供することを目的とする。

〔課題を解決するための手段〕

前記目的を達成するために本発明は、電圧検知部により検知される補機電池の電圧値が、所定の基準電圧値以下に低下しており、かつキースイッチがオフされている所定の期間において、所定時間だけＤＣ－ＤＣコンバータによる補機電池の充電を行わしめるように、ＤＣ－ＤＣコンバータを制御する充電制御部を動作させる充電指令部を含み、補機電池の電圧値を検知し、この電圧が所定の基準電圧値以下に低下している場合には、所定時間だけ補機電池の充電を行うことを特徴とする。

〔作用〕

本発明の電気自動車用補機電池充電装置においては、電圧検出部により補機電池の電圧が検知される。さらに、電圧検知部により検知された補機電池の電圧値が、所定の基準電圧値以下に低下している期間であって、かつキースイッチがオフされている所定の期間において、所定時間だけ充電

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指令部が充電制御部に所定の動作を行わせる。この所定の動作とは、補機電池の充電を行わしめるよう、ＤＣ－ＤＣコンバータを制御する動作である。従って、キースイッチを再びオンした時確実にモータの駆動を再開することが可能となる。

〔実施例〕

以下、本発明の実施例を、図面に基づいて説明する。なお、第３図に示される従来例と同様の構成には同一の符号を付し、説明を省略する。

第１図には、本発明の第１実施例に係る電気自動車用補機電池充電装置の構成が示されている。

この実施例の電気自動車用補機電池充電装置４４は、第３図に示される従来例と同様のＤＣ－ＤＣコンバータ２４と、本発明の特徴的構成を含むＤＣ－ＤＣコンバータ制御部４６と、とから構成されている。

また、前記ＤＣ－ＤＣコンバータ制御部４６は、電圧検出アンプ３６の出力と所定の基準電圧とが入力されるヒステリシス特性を有するコンパレータ４８と、該コンパレータ４８のＨ／Ｌ２値の出

力によりオン／オフされるトランジスタ５０と、を含んでいる。更に、前記トランジスタ５０のコレクタは前記フィードバック回路４０に接続されており、ＤＣ－ＤＣコンバータ制御部４６には、補機電池２０から直接に駆動電力が供給されている。

次に、この実施例の動作を説明する。

まず、キースイッチ３４がオンされている場合には、第３図に示される従来例と同様に、モータ１６の駆動、ＤＣ－ＤＣコンバータ２０による補機電池２０及び車載の負荷への電圧出力が行われる。

また、キースイッチ３４がオフされ、従ってモータ１６が駆動されていないときには、補機電池２０の電圧が電圧検出アンプ３６により検出され、さらにコンパレータ４８に入力される。前記コンパレータ４８においては、電圧検出アンプ３６の検出値が所定のしきい値V_Lと比較され、この比較の結果しきい値V_Lよりも電圧検出アンプ３６の検出値が低いとされた場合には、該コンパレー

タ４８の出力が例えばＨ値となり、トランジスタ５０がオンされる。前記トランジスタ５０がオンされると、前記フィードバック回路４０が駆動され、従って、ＤＣ－ＤＣコンバータ２４による補機電池２０の充電が行われる。

この後に、補機電池２０が充電され、従って電圧検出アンプ３６の検出値が増加していく。このとき、前記コンパレータ４８においては、電圧検出アンプ３６の検出値が所定のしきい値V_Hと比較される。このしきい値V_Hは、前記しきい値V_Lよりも大である。すなわち、コンパレータ４８は、ヒステリシス特性を有している。電圧検出アンプ３６の検出値の方が大であるとされた場合には、コンパレータ４８の出力が例えばＬ値となり、前記トランジスタ５０がオフされ、フィードバック回路４０の動作が停止する。従って、前記ＤＣ－ＤＣコンバータ２４による補機電池２０の充電が停止される。

この実施例においては、キースイッチ３４がオフされ、従って電気自動車が停止している際に補

機電池２０の充電が行われるが、該補機電池２０の電圧を検知する電圧検出アンプ３６を含む構成に、モータ１６の停止中も電圧が供給され続けなければならない。第２図には、このような問題点について改良した、本発明の第２実施例に係る電気自動車用補機電池充電装置の構成が示されている。

この実施例においては、第１図の実施例と同様のトランジスタ５０には、補機電池２０にキースイッチ５２を介して接続されたリレー５４が接続されており、さらにこのリレー５４の一端は、該キースイッチ５２及びこれと連動するキースイッチ５６をバイパスするように、補機電池２０に接続されている。

まず、キースイッチ５２及びこれと連動するキースイッチ５６がオンされ、キースイッチ５２と連動するメインコンタクタ１２がオンされた場合には、主電池１０からモータ制御回路１４に所定の直流電圧が供給され、モータ制御部１８による制御に基づき、モータ１６が駆動される。

一方で、キースイッチ５２がオフされる場合には、それ以前に補機電池２０の電圧が電圧検出アンプ３６により検出され、該電圧が低下しているときは第１図に示される実施例と同様に、トランジスタ５０がオンされている。このとき、トランジスタ５０のコレクタは、リレー５４の駆動コイルに接続されており、該リレー５４の一端が補機電池２０と接続されているため、該リレー５４の駆動コイルに電流が流れ、リレー５４がオンされる。

さらに、これに伴い、キースイッチ５２がオフとなっても補機電池２０の電圧がリレー５４を介してＤＣ－ＤＣコンバータ制御部４６に供給され続けるため、該ＤＣ－ＤＣコンバータ４６によるＤＣ－ＤＣコンバータ２４の制御が行われ、補機電池２０が充電される。

また、前記コンパレータ４８は、ヒステリシス特性を有しているため、電圧検出アンプ３６の検出電圧値が所定のしきい値V_H以上になったときに、トランジスタ５０がオフされる。リレー５４

がオフされ、従って、補機電池２０からＤＣ－ＤＣコンバータ４６への電圧供給が停止され、前記ＤＣ－ＤＣコンバータ２４による補機電池２０の充電が停止される。

この実施例によれば、第１図に示される実施例に比べ、ＤＣ－ＤＣコンバータ制御部４６の少なくとも一部が駆動される時間が限定される。すなわち、この時間は、キースイッチ５２のオフ後の所定時間、すなわちコンパレータ４８のヒステリシス特性によって決定される時間に限定されるため無駄な電力消費が制御できる。

〔発明の効果〕

以上説明したように、本発明の電気自動車用補機電池充電装置によれば、補機電池の著しい電圧低下を未然に防ぐことが可能でタイムリーで効率的な、補機電池の充電が行われるため、補機電池の過放電によるモータの再駆動不能状態が回避され、かつ回路効率の良い電気自動車用補機電池充電装置を得ることができる。

４．図面の簡単な説明

第１図は、本発明の第１実施例に係る電気自動車用補機電池充電装置の構成を示す構成図、

第２図は、本発明の第２実施例に係る電気自動車用補機電池充電装置の構成を示す構成図、

第３図は、従来の電気自動車用補機電池充電装置の一構成例を示す構成図である。

１０ … 主電池
１６ … モータ
２０ … 補機電池
２４ … ＤＣ－ＤＣコンバータ
３４，５２，５６ … キースイッチ
３６ … 電圧検出アンプ
４０ … フィードバック回路
４２ … パルス化回路
４６ … ＤＣ－ＤＣコンバータ制御部
４８ … コンパレータ
５０ … トランジスタ

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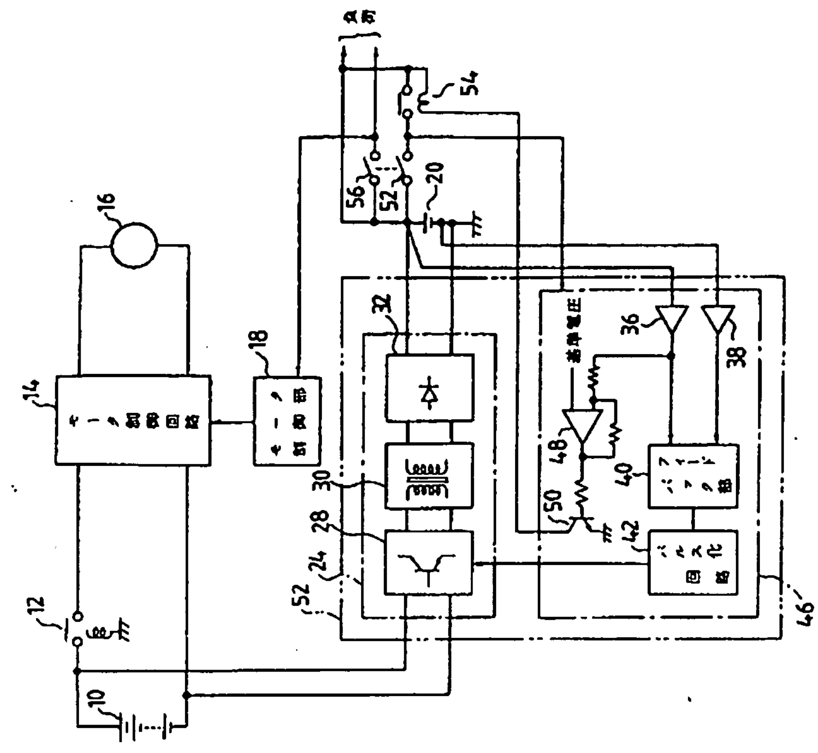
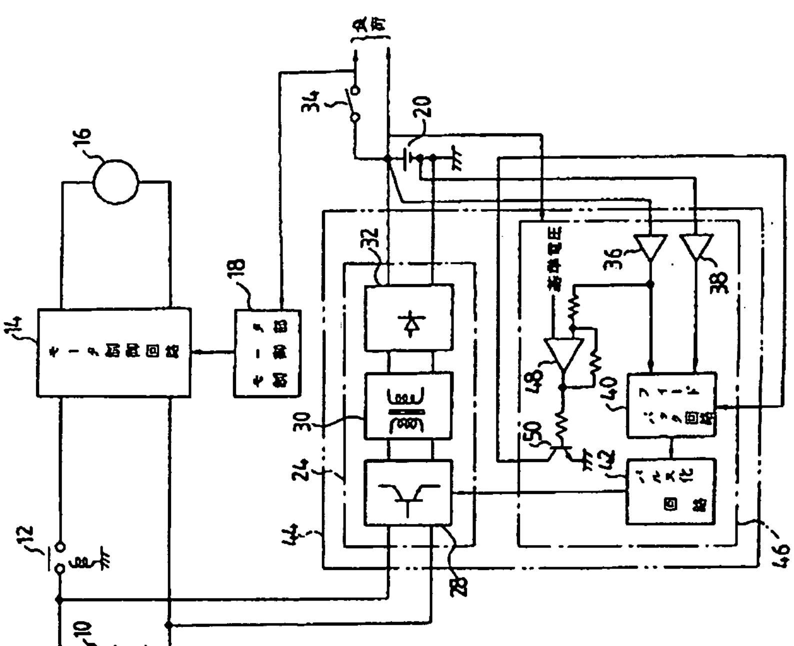
代理人　弁理士　吉田研二
（外２名）〔D-35〕



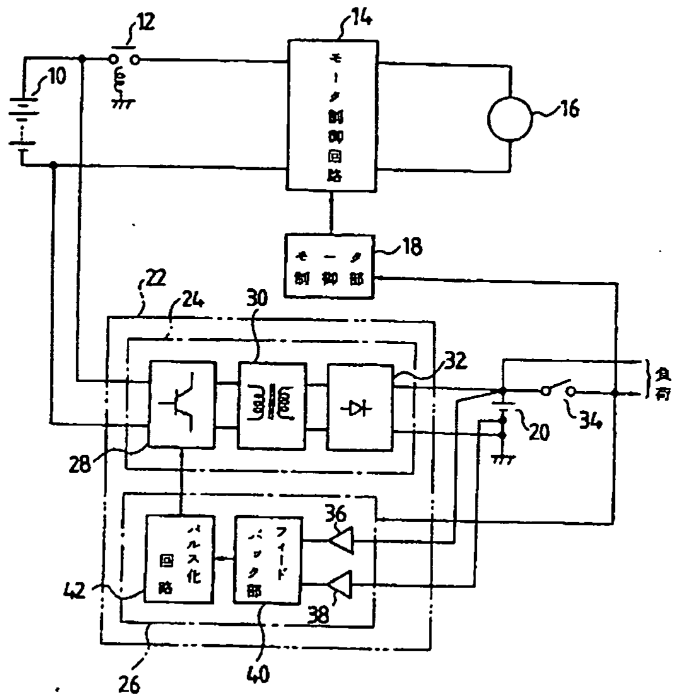
第2実施例の構成

第2図



第1実施例の構成

第1図


12
14
10
モータ制御回路
16
18
モータ制御部
22
24
30
32
負荷
28
20
34
36
フィードバック部
パルス化回路
42
38
26
40

従来例の構成

第 3 図

CERTIFICATION OF TRANSLATION

I, Christopher Field, a professional Japanese translator accredited by the American Translators Association, hereby attest that the attached translations from Japanese have been faithfully prepared to the best of my ability.

1. JP03-124201
2. JP51-103220
3. JP05-64531

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By: 5/13/04

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Japanese Laid-Open Patent Application 3-124201

Laid-Open: May 27, 1991

Filing Date: October 6, 1989

Applicant: Toyota Motor Corporation

Specification

1. Title of the Invention

AUXILIARY BATTERY CHARGING DEVICE FOR ELECTRIC AUTOMOBILE

2. Scope of the Claim

An auxiliary battery charging device for an electric automobile, comprising:

a DC-DC converter which intakes a direct current voltage of a predetermined value from a main battery driving a motor only when a keyswitch is turned on, converts it to a direct current voltage of a different value, charges an auxiliary battery by a direct current voltage which has been obtained by this conversion, and drives a load via the keyswitch;

a voltage detector which detects a voltage value of the auxiliary battery; and

a charging controller which, when the keyswitch is turned on, based on the voltage value detected by the voltage detector, controls a charging operation of the auxiliary battery by the DC-DC converter and is driven by the auxiliary battery; wherein there is included:

a charging instruction portion which operates the charging controller so as to, in a predetermined period in which the voltage value of the auxiliary battery to be detected by the voltage detector drops to a predetermined reference voltage value or less and the keyswitch is turned off, charge the auxiliary battery by the DC-DC converter for a predetermined time only;

wherein when the voltage value of the auxiliary battery is detected and this voltage value has deteriorated to a predetermined reference voltage value or less, charging of the auxiliary battery is performed for a predetermined time only.

3. Detailed Description of the Invention

[Industrial Use of the Invention]

This invention relates to an auxiliary battery charging device for an electric automobile which converts a direct current voltage taken from a main battery to a direct current voltage of a different value and charges an auxiliary battery.

[Prior Art]

In general, in order to drive a motor related to travel of an electric automobile, a main battery which outputs a predetermined direct current voltage is mounted on the electric automobile. Furthermore, in this electric automobile, in order to drive electric devices mounted on the automobile, an auxiliary battery is mounted, which outputs a direct current voltage of a value different from that of the main battery.

Additionally, in the electric automobile on which the main battery and the auxiliary battery are mounted, in order to charge the auxiliary battery, an electric automobile auxiliary battery charging device is mounted.

Fig. 3 shows a structural example of a conventional electric automobile auxiliary battery charging device.

In this diagram, a motor control circuit 14 is connected to a main battery 10 via a main contactor 12, and a motor 16 for driving the travel of an electric automobile is connected to the motor control circuit 14. Additionally, a motor controller 18 such as an inverter circuit, a chopper circuit or the like that controls the motor control circuit 14 is connected to the motor control circuit 14.

That is, when, based on control such as PWM control by the motor controller 18, a direct current voltage of a predetermined value is supplied to the motor control circuit 14 via the main contactor 12 from the main battery 10, the motor control circuit 14 converts the direct current voltage supplied from the main battery 10 to a predetermined voltage and supplies it to the motor 16. By so doing, the motor 16 is driven, and the electric automobile becomes mobile.

An auxiliary battery charging device 22 for an electric automobile related to a conventional example is disposed between the main battery 10 and the auxiliary battery 20. The auxiliary battery charging device 22 is constituted by a DC-DC converter 24, which converts a direct current voltage output from the main battery 10 to a direct current voltage which can charge the auxiliary battery 20, and a DC-DC converter control circuit 26, which detects an output voltage of the auxiliary voltage 20 and controls the DC-DC converter 24 based on this detection result.

The DC-DC converter 24 has the same structure as one disclosed in, for example, Japanese Laid-Open Utility Model Application 48-111827, and is constituted by an inverter 28 which converts a direct current voltage output from the main battery 10 into an alternating current voltage, a transformer 30 which changes a voltage that is output from the inverter 28, and a rectifier 32 which rectifies a voltage output from the transformer 30 and outputs a voltage which can charge the auxiliary battery 20.

That is, the direct current voltage output from the main battery 10 is supplied to the motor control circuit 14 via the main contactor 12 as mentioned above, and is input to the inverter 28 which is built into the DC-DC converter 24, is sequentially supplied to the transformer 30 and the rectifier 32, and is converted to a direct current voltage of a different value which can charge the auxiliary battery 20. The auxiliary battery 20 is then charged by a direct current voltage output from the DC-DC converter 24.

Meanwhile, the auxiliary battery 20 is connected to a load mounted on the automobile, directly or via a keyswitch 34, and is connected to the motor controller 18 via the keyswitch 34.

That is, as mentioned earlier, the direct current voltage output from the DC-DC converter 24 charges the auxiliary battery 20, and is supplied to a load mounted on the automobile and to the motor controller 18 directly or via the keyswitch. Here, the main contactor 12 is constituted so as to be turned on and off with the keyswitch 34. When the keyswitch 34 is turned on, the motor controller 18 is driven by direct current voltage output from the DC-DC converter 24 or the auxiliary battery 20, and a predetermined direct current voltage is supplied to the motor control circuit 14 from the main battery 10, so the motor 16 is driven.

Meanwhile, as mentioned above, the auxiliary battery charging device 22 of this conventional example includes the DC-DC converter controller 26 in addition to the DC-DC converter 24. The DC-DC converter controller 26 is constituted by a voltage detection amplifier 36 and an electric current detection amplifier 38 which detect a voltage and an electric current of the auxiliary battery 20, respectively, a feedback portion 40 which determines a pulse duty based on the output of the voltage detection amplifier 36 and the electric current detection amplifier 38, and a pulse circuit 42 which supplies a control pulse to the inverter 28 by a duty determined by the feedback 42 **[sic. "feedback portion 40"]**.

That is, the voltage of the auxiliary battery 20 is detected by the voltage detection amplifier 36, is amplified, and is supplied to the feedback portion 40. In the same manner, the direct current of the auxiliary battery 20 is detected by the electric current detection amplifier 38 and is amplified.

Next, in the feedback portion 40, based on the voltage and the electric current of the auxiliary battery 20 detected by the voltage detection amplifier 36 and the electric current detection amplifier 38, respectively, a pulse duty is determined. For example, based on the detection result of the voltage detection amplifier 36, a duty is calculated and determined so as to prevent excess voltage charging of the auxiliary battery 20. At the same time, based on the detection result of the electric current detection amplifier 38, a duty is calculated and determined so as to not exceed the maximum output electric current of the DC-DC converter 24. Additionally, the smaller duty, i.e., the duty which satisfies both the voltage and the electric current requirements for the charging of the auxiliary battery 20, is selected and output to the pulse circuit 42 from among the two types of duties, i.e., the duties calculated and determined based on the detection results of the voltage detection amplifier 36 and the electric current detection amplifier 38, respectively.

In this pulse circuit 42, a pulse is generated based on the duty supplied from the feedback portion 40, and the operation of the inverter 28 is PWM controlled by this pulse.

Therefore, in this conventional example, based on the voltage and the current of the auxiliary battery 20, the DC-DC converter 24 is controlled by the DC-DC converter controller 26, the auxiliary battery 20 is charged, and a predetermined voltage is supplied to a load mounted on the automobile.

In this conventional example, when an electric current amount to be consumed by the load mounted on the automobile is more than the output capability of the DC-DC converter 24, the auxiliary battery 20 is discharged, and electric current is supplied to a load mounted on the automobile by this discharging. At this time, when the keyswitch 34 is turned off, the auxiliary battery 20 is held in a discharged state.

When this operation is repeated, and the auxiliary battery 20 is in a so-called excess discharging state, the voltage of the auxiliary battery 20 can drop, e.g., to a voltage less than what is needed for driving the motor controller 18. When this type of voltage drop occurs, even if [a user] tries to turn on the keyswitch 34 and drive the motor 16, the driving of the motor controller 18 is not performed by the auxiliary battery 20, so driving of the motor 16, and hence, travel of the electric automobile, cannot be performed.

Japanese Laid-Open Patent Application 64-85502, for example, discloses a structure of a "electric automobile control device" which detects a voltage of an auxiliary battery after a keyswitch is turned on, and first activates a DC-DC converter, charges the auxiliary battery, ensures a predetermined voltage or more, and then turns on power of a motor controller which commands the driving of the automobile.

[Problems to be Resolved by the Invention]

In the device disclosed in the above-mentioned Japanese Laid-Open Patent Application 64-85502, the DC-DC converter is supplied with a voltage needed for an operation by an auxiliary battery, so when a voltage for the auxiliary battery significantly drops for some reason such as electricity consumption while the automobile is stopped such that not even a voltage needed for activation of the DC-DC converter or a voltage which can activate the motor controller are ensured, there are times that the goal of automobile activation cannot be accomplished.

An object of this invention is to provide an auxiliary battery charging device for an electric automobile in which an auxiliary battery voltage constantly maintains a voltage needed for activation of a DC-DC converter and a motor controller, and which prevents a state in which motor driving is impossible to restart due to the auxiliary battery voltage deterioration.

[Means of Solving the Problem]

In order to accomplish the above-mentioned objective, the present invention includes a charge command portion which operates a charging controller controlling the DC-DC converter so that, in a predetermined period in which a voltage value of an auxiliary battery to be detected by a voltage detector drops to a predetermined reference voltage value or less and a keyswitch is turned off, charging of an auxiliary battery by a DC-DC converter is performed for a predetermined time only, a voltage value of the auxiliary battery is detected, and when the voltage drops to a predetermined reference voltage value or less, charging of the auxiliary battery is performed for a predetermined time only.

[Operation]

In an auxiliary battery charging device for an electric automobile of this invention, a voltage of an auxiliary battery is detected by a voltage detector. Furthermore, in a predetermined period in which a voltage value of an auxiliary battery detected by a voltage detector drops to a predetermined reference voltage value or less, and in which a keyswitch is turned off, a charge command portion causes a charging controller to perform a predetermined operation for a predetermined time only. This predetermined operation is an operation which controls the DC-DC converter so as to charge the auxiliary battery. Therefore, it is possible to restart driving of the motor when the keyswitch is turned on again.

[Embodiments]

The following explains embodiments of this invention based on the drawings. Furthermore, the structure which is the same as in the conventional example shown in Fig. 3 uses the same symbols, so the explanation thereof is omitted.

Fig. 1 shows a structure of an auxiliary battery charging device for an electric automobile according to a first embodiment of this invention.

The auxiliary battery charging device for an electric automobile 44 of this embodiment is constituted by a DC-DC converter 24, which is the same as in the conventional example shown in Fig. 3, and a DC-DC converter controller 46, which includesthe characteristic structure of this invention.

Additionally, the above-mentioned DC-DC converter controller 46 includes a comparator 48, having a hysteresis characteristic, into which the output of a voltage detection amplifier 36 and a predetermined reference voltage are input, and a transistor 50 which is turned on and off by the output of an H/L2 value of the comparator 48. In addition, the collector of the transistor 50 is connected to the feedback circuit 40, and a driving electric power is directly supplied from the auxiliary battery 20 to the DC-DC converter controller 46.

The following explains the operation of this embodiment.

First, when the keyswitch 34 is turned on, the driving of the motor 16 and a voltage output to a load mounted on a vehicle and the auxiliary battery 20 by the DC-DC converter 20 **[sic. 24]** are performed in the same manner as in the conventional example shown in Fig. 3.

Additionally, when the keyswitch 34 is turned off, and hence the motor 16 is not driven, a voltage of the auxiliary battery 20 is detected by the voltage detection amplifier 36, and is input to the comparator 48. In the comparator 48, a detection value of the voltage detection amplifier 36 is compared with a predetermined threshold value V_L, and if the detection value of the voltage detection amplifier 36 is deemed to be lower than the threshold value V_L, the output of the comparator 48 becomes, for example, an H value, and the transistor 50 is turned on. When the transistor 50 is turned on, the feedback circuit 40 is driven, and charging of the auxiliary battery 20 is performed by the DC-DC converter 24.

After that, the auxiliary battery 20 is charged, and the detection value of the voltage detection amplifier 36 thus increases. At this time, in the comparator 48, a detection value of the voltage detection amplifier 36 is compared with a predetermined threshold value V_H. This threshold value V_H is larger than the threshold value V_L. That is, the comparator 48 has a hysteresis characteristic. If the detection value of the voltage detection amplifier 36 is deemed to be larger, the output of the comparator 48 becomes, for example, an L value, the transistor 50 is turned off, and the operation of the feedback circuit 40 stops. Charging of the auxiliary battery 20 by the DC-DC converter 24 is thus stopped.

In this embodiment, when the keyswitch 34 is turned off and the electric automobile thus stops, charging of the auxiliary battery 20 is performed. However, even during the stop of the motor 16, a voltage needs to be continuously supplied to the structure which includes the voltage detection amplifier 36 that detects a voltage of the auxiliary battery 20. Fig. 2 shows a structure of an auxiliary battery charging device for an electric automobile according to a second embodiment of this invention, which represents an improvement with respect to this type of problem.

In this embodiment, a relay 54 connected to the auxiliary battery 20 via the keyswitch 52 is connected to the transistor 50, which is the same as in the embodiment of Fig. 1, and one end of this relay 54 is connected to the auxiliary battery 20 so as to bypass the keyswitch 52 and a keyswitch 56 that operates in conjunction with the keyswitch 52.

First, when the keyswitch 52 and the keyswitch 56 that operates in conjunction with the keyswitch 52 are turned on, and the main contactor 12 that operates in conjunction with the keyswitch 52 is turned on, a predetermined direct current voltage is supplied to the motor control circuit 14 from the main battery 10 and the motor 16 is driven based on the control of the motor controller 18.

Meanwhile, when the keyswitch 52 is turned off, the voltage of the auxiliary battery 20 is detected by the voltage detection amplifier 36 in advance, and when the voltage drops the transistor 50 is turned on, in the same manner as in the embodiment shown in Fig. 1. At this time, the collector of the transistor 50 is connected to a driving coil of the relay 54, and one end of the relay 54 is connected to the auxiliary battery 20; therefore, an electric current flows to the driving coil of the relay 54, and the relay 54 is turned on.

Furthermore, along with this operation, even if the keyswitch 52 is turned off, the voltage of the auxiliary battery 20 continues to be supplied to the DC-DC converter controller 46 via the relay 54, so the DC-DC converter 24 is controlled by the DC-DC converter controller 46, and the auxiliary battery 20 is charged.

Furthermore, the comparator 48 has a hysteresis characteristic, so when a detection voltage value of the voltage detection amplifier 36 reaches a predetermined threshold value V_H or higher, the transistor 50 is turned off. The relay 54 is turned off; thus, a voltage supply to the DC-DC converter 46 from the auxiliary battery 20 stops, and charging of the auxiliary battery 20 by the DC-DC converter 24 stops.

According to this embodiment, compared to the embodiment shown in Fig. 1, the time in which at least part of the DC-DC converter controller 46 is driven is limited. That is, this time is limited to a predetermined time after the keyswitch 52 is turned off, i.e., the time which is determined by a hysteresis characteristic of the comparator 48, so wasteful electricity consumption can be controlled.

[Effects of the Invention]

As explained above, according to the auxiliary battery charging device of an electric automobile of this invention, it is possible to prevent significant voltage deterioration of the auxiliary battery in advance, and charging of the auxiliary battery is effectively performed in a timely manner; thus, a state in which it is impossible re-drive a motor due to excessive discharging of the auxiliary battery can be avoided, and an electric automobile auxiliary battery charging device with good circuit efficiency can be obtained.

4. Brief Description of the Drawings

Fig. 1 is a structural diagram showing the structure of an auxiliary battery charging device for an electric automobile according to a first embodiment of this invention.

Fig. 2 is a structural diagram showing the structure of an auxiliary battery charging device for an electric automobile according to a second embodiment of this invention.

Fig. 3 is a structural diagram showing a structural example of a conventional auxiliary battery charging device for an electric automobile.

10 Main battery

16 Motor

20 Auxiliary battery

24	DC-DC converter
34, 52, 56	Keyswitches
36	Voltage detection amplifier
40	Feedback circuit
42	Pulse circuit
46	DC-DC converter controller
48	Comparator
50	Transistor

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⑤発明の名称　電気自動車の補機バッテリー充電装置

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⑤特許請求の範囲

1　車両の補機系に接続される相互に並列な補機バッテリーおよびDC－DCコンバータと、

該DC－DCコンバータの上記補機バッテリー接続端とは反対端に接続される主バッテリーとを備える電気自動車の補機バッテリー充電装置において、

前記主バッテリーに充電が実行されていることを検出する充電時検出手段と、

該充電時検出手段が充電時であることを検出したとき、前記DC－DCコンバータの前記車両の補機系および補機バッテリーに接続される出力の電圧値を降下させる電圧降下手段と、

を備えたことを特徴とする電気自動車の補機バッテリー充電装置。

発明の詳細な説明

［産業上の利用分野］

本発明は、電力を利用して走行する電気自動車において、その動力源である電動機に電力を供給する主バッテリーから、該電気自動車のワイパー、前照燈やコントロール装置等の補機系へ電力を供給する補機バッテリーへの充電を行う電気自動車の補機バッテリー充電装置に関する。

［従来技術］

従来、電気自動車も通常の内燃機関を備えた自動車同様に、ワイパー、前照燈や各種のコントロール装置等の電源となる補機バッテリーを搭載しており、駆動力源となる電動機の電源である主バッテリーの高電圧直流源からDC－DCコンバータを介して充電されるように構成されている。これにより補機バッテリーは、自動車の補機系へ常に電力を供給するとともに、従来の内燃機を備えた自動車の補機バッテリーがオルタネータを介して充電されると同様の電力供給を受けることができるのである。

［発明が解決しようとする問題点］

しかしながら上記のごときDC－DCコンバータを有する電気自動車の補機バッテリー充電装置は、下記する点で未だに充分なものとはいえなかつた。

即ち、低電圧の補機バッテリーにう電力を供給するために、高電圧の主バッテリーはDC－DCコンバータを介することで補機バッテリーの端子電圧よりも僅かに高い電圧に変圧されてその電力を補機バッテリーに伝送するのである。これにより補機バッテリーは常に充電を受けることができ、補機バッテリーが同時に負荷へ電力を供給しているときにはこの状態で補機バッテリーの充・放電は平衡して所期目的が達成できる。

しかし、車両が停車中であるときなど補機バッテリーの負荷が軽い状態では、補機バッテリーへと充電電圧がその端子電圧よりも高いため過充電の可能性があつた。車両が一時的に停車するときなど補機バッテリーの軽負荷状態が短い時間であれば補機バッテリーが過充電にまで至ることはないのであるが、主バッテリーの充電時には通常数

時間以上の長い時間を要し、この状態が持続されると補機バッテリーは過充電によるエネルギー損失を生じ、またガス発生による液減り等補機バッテリーの性能の劣化を招来するのである。

［問題点を解決するための手段］

本発明は、上記問題を解決するためになされたものであり、主バッテリー充電中であつても補機バッテリーに過充電を発生することなく、エネルギーの有効利用を図り、かつ補機バッテリーの性能劣下の生じることのない優れた電気自動車の補機バッテリー充電装置を提供することをその目的としている。

この目的達成のための本発明の構成は、第1図の基本的構成図に示すごとく、

車両の補機系に接続される相互に並列な補機バッテリーⅡおよびDC−DCコンバータⅢと、

該DC−DCコンバータⅢの上記補機バッテリー接続端とは反対端に接続される主バッテリーⅣとを備える電気自動車の補機バッテリー充電装置において、

前記主バッテリーⅣに充電が実行されていることを検出する充電時検出手段Ⅴと、

該充電時検出手段Ⅴが充電時であることを検出したとき、前記DC−DCコンバータⅢの前記車両の補機系Ⅰおよび補機バッテリーⅡに接続される出力の電圧値を降下させる電圧降下手段Ⅳとを備えたことを特徴とする電気自動車の補機バッテリー充電装置をその要旨としている。

［作用］

本発明の充電時検出手段とは、主バッテリーに充電が施されていることを検出するものである。従つて、車両の充電用のコンセントに外部の電源からの接続端子が接続されたとき、機械的スイッチが開閉するようにして検出するもの、あるいは主バッテリーの電流の流出、流入の方向を電気的に検出するもの、どのような構成であつてもよい。

また、電圧降下手段とは、上記充電時検出手段の主バッテリーが充電中であるとの検出結果に基づき、補機バッテリーの両端子間へ印加される主バッテリーの電力変換手段であるDC−DCコンバータ出力の電圧を、補機バッテリーの開放端子電圧近くまで降下させるものである。電圧の降下方法としては、DC−DCコンバータとして使用される電気回路に応じて最適の方法とすればよく、例えばパルス幅制御（以下PWMという）インバータ式コンバータであれば電力を伝える期間のパルス幅を短くする等の方法で簡単に達成できる。

以下、本発明をより具体的に説明するため実施例を挙げて詳述する。

［実施例］

第2図は本発明の電気自動車の補機バッテリー充電装置を搭載した電気自動車の一実施例回路ブロック図である。

図において10が補機バッテリー充電装置を、20が主バッテリー充電装置を表わしている。

補機バッテリー充電装置10は、図示のごとく主バッテリー11と、その主バッテリー11の電力を補機バッテリー12および補機系負荷13へ変圧整流して供給するDC−DCコンバータ14とを備えている。また、15は充電コンセントで、後述する充電装置20の充電プラグ21が差し込まれると充電装置20と主バッテリー11とを電気的に接続するとともに内蔵する2接点型のスイッチ16を切換える。このスイッチ16とは、充電プラグ21が充電コンセント15に挿着された状態でb接点が閉成すると同時に他方の接点aを開放し、逆に充電プラグ21が引き抜かれると接点aを閉成して接点bを開放するように操作される。17はダイオード、18はオペレーショナル・アンプ（以下、OPアンプという）をそれぞれ表わしており、スイッチ16との組み合わせにより前述のDC−DCコンバータ14の出力をフイードバックしてその出力電圧VOを制御している。DC−DCコンバータ14のPWM制御部14Aは、このOPアンプ18の出力電圧VPとその内部に有する基準電圧VBとを比較して、DC−DCコンバータ主回路14Bを制御することによりDC−DCコンバータ14の出力電圧VOを制御するのである。

充電装置20は、商用電源22の電力を主バッテリー充電に適した電圧に変圧し、整流したものを充電プラグ21へ出力する充電器23とから構成されるものである。

以上のごとく構成される本実施例の補器バッテリー充電装置10は以下のように作動する。

まず、通常の作動状態にあり、充電装置20と補機バッテリー充電装置10とが分離されている

ときについて説明する。このとき、スイッチ16はa接点が閉成しており、OPアンプ18の非反転入力端子には実際のDC−DCコンバータ14の出力電圧VOよりもダイオード17の順方向電圧降下VD分だけ小さな電圧が入力されることになり、OPアンプ18の出力VPは電圧VD分だけ減少する。即ち、PWM制御部14Aの基準電圧VBと比較されるOPアンプ18の出力VPが減少するため、PWM制御部14AはDC−DCコンバータ主回路14Bをその出力電圧VOが上昇するべく作動させ、内部の基準電圧VBとDC−DCコンバータ14の出力電圧VOからダイオード17の電圧降下分VDを差し引いた値（VO−VD）とが一致するようにする。このときのDC−DCコンバータ14の出力電圧VO(＝VB＋VD）は補機バッテリー12の開放端子電圧より高く、通常状態の補機系負荷13の電力を充分に供給するとともに補機バッテリー12を充電できる程度の電位である。

一方、充電装置20と補機バッテリー充電装置10とが充電プラグ21、充電コンセント15によつて接続されるとき、即ち車両が停車中で補機系負荷13が軽いときには、スイッチ16のa接点が開放され、換つてb接点が閉成されるため補機バッテリー充電装置10は次のように作動する。

それまで、a接点を介して電圧VDだけ電圧降下したDC−DCコンバータ14の出力電圧VOを入力していたOPアンプ18の非反転入力端子は、一転してダイオード17を介さずして直接DC−DCコンバータ14の出力電圧VOを入力することとなる。従つて、OPアンプ18の出力も同様に電圧がVDだけ上昇するのである。これによりPWM制御部14Aはその内部の基準電圧VBよりもDC−DCコンバータ14の出力電圧VOが電圧VDだけ上昇したかのごとく作動し、DC−DCコンバータ14の出力電圧VOを電圧VDだけ降下させ、基準電圧VBと出力電圧VOとが等しくなるように、即ちVB＝VOとなるようにDC−DCコンバータ主回路14を制御する。

このときのDC−DCコンバータ14出力電圧VO(＝VB）が、主バッテリー11の充電中であり軽い状態の補機系負荷13に電力を供給するとともに、補機バッテリー12の端子電圧より僅かに高い電圧で補機バッテリー12を過充電にまで至らせることのない程度の電圧となるように予めPWM制御部の基準電圧VBが設定されるのである。

即ち、本実施例の補機バッテリー充電装置10は、補機系負荷13が重い状態である通常時には従来と同様に主バッテリー11からの電力を充分に補機系負荷13および補機バッテリー12へ供給するために補機バッテリー12の開放端子電圧よりも高い電圧に変圧している。これにより、補機バッテリー12は補機系負荷13が大電力を消費しているにも拘らず充電されることになる。

一方、車両が充電中になるとき、即ち補機系負荷13が軽くなり主バッテリー11の電力のほとんど全てが補機バッテリー12へ供給される状態になるときにはスイッチ16の切換えにより自動的にDC−DCコンバータ14の出力電圧VOはダイオードの順方向電圧降下分VDだけ降下される。その電圧VOは補機バッテリー12の開放端子電圧より僅かに高い状態にまで降下されることになり、補機バッテリー12は過充電されることなく、主バッテリー11の電力を有効利用するとともに補機バッテリー12の液減りや劣化を防止することができるのである。

また、第2図の回路ブロック図に示すごとく、本実施例の補機バッテリー充電装置10は、従来のDC−DCコンバータ14の出力電圧のフイードバック系にスイッチ16、ダイオード17およびOPアンプ18を中心とする簡単な比較回路を付加することだけでその目的を達成できる経済性、作業性に優れた装置となる。

〔発明の効果〕

以上実施例を挙げて詳述したごとく、本発明の電気自動車の補機バッテリー充電装置は、

車両の補機系に接続される相互に並列な補機バッテリーおよびDC−DCコンバータと、

該DC−DCコンバータの上記補機バッテリー接続端とは反対端に接続される主バッテリーとを備える電気自動車の補機バッテリー充電装置において、

前記主バッテリーに充電が実行されていることを検出する充電時検出手段と、

該充電時検出手段が充電時であることを検出したとき、前記DC−DCコンバータの前記車両の補

機系および補機バッテリーに接続される出力の電圧値を降下させる電圧降下手段と、
を備えたことをその要旨としている。

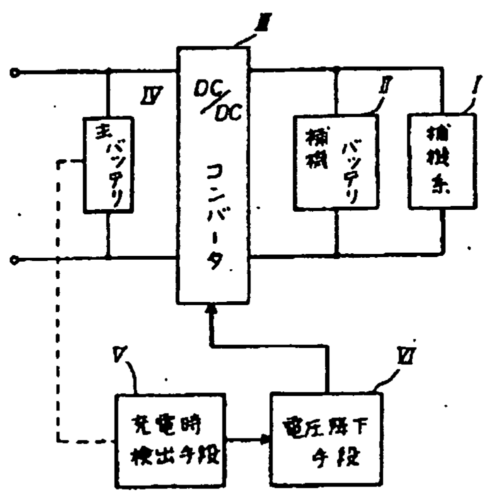
従つて、車両が走行中など通常の負荷状態であれば主バッテリーからの電力はDC−DCコンバータによつて補機バッテリーよりも高い電圧に変圧されて負荷および補機バッテリーに伝送されるので、補機バッテリーは充分に充電を受けることができるとともに高負荷に対処することができる。しかも、車両が充電中となり、負荷が軽い状態となつたことを充電時検出手段が検出すると、電圧降下手段によつて自動的に主バッテリーからの電力供給電圧は補機バッテリーよりも僅かに高い電圧にまで降下されて実行される。これにより、補機バッテリーは主バッテリーからの電力のほとんど全てを供給されるにも拘らず過充電に至ることはなく、主バッテリーの電力の有効利用が達成できることはもちろん、補機バッテリーの過充電による液減り等の性能の劣化を完全に回避できる優れた電気自動車の補機バッテリー充電装置となるのである。

図面の簡単な説明

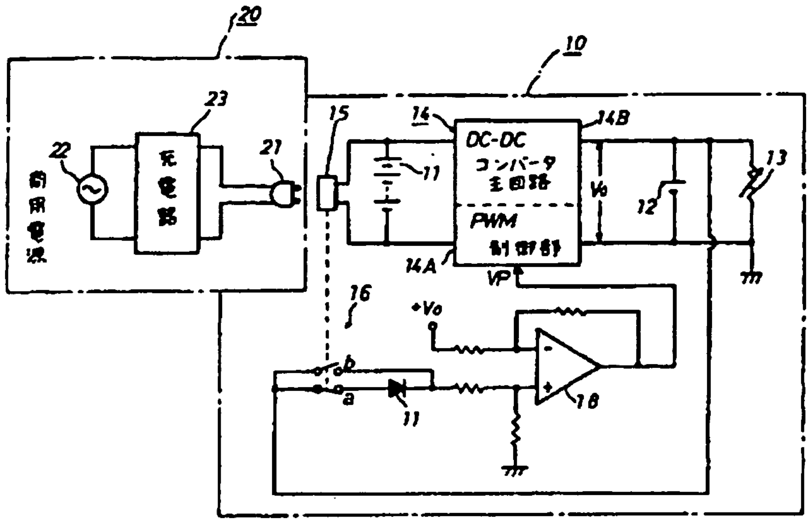
第1図は本発明の基本的構成図、第2図はその一実施例の回路ブロック図を示す。

I……補機系、II……補機バッテリー、III……DC−DCコンバータ、IV……主バッテリー、V……充電時検出手段、VI……電圧降下手段、10……補機バッテリー充電装置、11……主バッテリー、12……補機バッテリー、13……補機系負荷、14……DC−DCコンバータ、16……スイッチ、17……ダイオード、18……OPランプ、20……充電装置。

第1図



第2図



10…補機バッテリー充電装置
11…主バッテリー
12…補機バッテリー
13…補機負荷
14…DC-DCコンバータ
20…充電装置

CERTIFICATION OF TRANSLATION

I, Christopher Field, a professional Japanese translator accredited by the American Translators Association, hereby attest that the attached translations from Japanese have been faithfully prepared to the best of my ability.

1. JP03-124201
2. JP51-103220
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(54) Title of Invention Accessory Battery Charger for Electric Vehicle

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(57) **Scope of Claims**

1. An accessory battery charger for an electric vehicle having an accessory battery and a DC-DC converter connected to an accessory system of the vehicle and being parallel with each other, and a main battery connected to an end of the DC-DC converter opposite from the end to which the accessory battery is connected, comprising:

a charge detection means that detects that the main battery is being charged; and

a voltage reduction means which, when the charge detection means detects that charging is underway, reduces the voltage value of the DC-DC converter output connected to the vehicle accessory system and accessory battery.

Detailed Description of the Invention

[Industrial Field of the Invention]

This invention relates to an accessory battery charger for an electric vehicle driven by electric power, which charges electricity from a main battery that supplies electricity to a motor that is the source of motive force, to an accessory battery that supplies electricity to an accessory system, such as wipers, head lamps, and control devices, of the electric vehicle.

[Conventional Art]

Conventionally, like automobiles equipped with an internal combustion engine, electric vehicles have an accessory battery that becomes a power source for wipers, head lamps, various control devices, and the like, and is structured such that the accessory battery is charged through a DC-DC converter from the high voltage, direct current power supply of the main battery, which is the power supply for the motor which constitutes the drive source. As a result, the accessory battery can always supply power to the accessory systems of the vehicle while receiving a supply of power in the same way as a conventional accessory battery in a vehicle equipped with an internal combustion engine is charged via an alternator.

[Problem Solved by the Invention]

However, the accessory battery charger of an electric vehicle having the above-described DC-DC converter was still not sufficient with respect to the following points.

That is, to supply power for a low voltage accessory battery, the high voltage main battery transmits the power to the accessory battery by having the DC-DC converter convert the voltage to one slightly higher than the terminal voltage of the accessory battery. As a result, the accessory battery can be always charged, and when the accessory battery supplies power to the load at the same time, charging and discharging the accessory battery in this condition can be balanced, to achieve the desired operation.

However, when the load of the accessory battery is light, such as when the vehicle is at a stop, there is a possibility of overcharging because the charging voltage on the accessory battery is higher than its terminal voltage. The accessory battery would not be overcharged if the accessory battery light-load state is short in duration, such as when the vehicle is temporarily at a stop. However, charging the main battery normally requires more than a few hours, and if this state is continued, energy losses occur due to the overcharging of the accessory battery, or fluids are lost due to the generation of gases, leading to the deterioration of accessory battery performance.

[Problem Resolution Means]

The present invention was undertaken in order to resolve the above-described problems; its object is to provide a superior electric vehicle accessory battery charging device which achieves effective energy use without overcharging of the accessory battery even during charging of the main battery, and with which no degradation of the accessory battery occurs.

To achieve the object, the essence of the present invention, as shown in the basic structural diagram of Fig. 1, is an accessory battery charger for an electric vehicle having an accessory battery II and a DC-DC converter III connected to an accessory system of the vehicle in parallel with each other, and a main battery IV connected to an end of the DC-DC converter III opposite from the end to which the accessory battery is connected, comprising:

a charge detection means V that detects that the main battery IV is being charged; and

a voltage reduction means IV [sic, Fig. 1 says "VI"] that reduces the value of the voltage output on the DC-DC connector III to which the accessory system I and the accessory battery II are connected when the charge detection means V detects that [the main battery IV] is being charged.

[Operation]

The charge detection means of this invention detects that the main battery is being charged. Therefore it may be any structure, such as one that detects charging when a connection terminal from an external power source is connected to an outlet for charging the battery of the vehicle through the opening or closing of a mechanical switch, or by electrically detecting the direction of incoming or outgoing electric current at the main battery.

Moreover, the voltage reduction means reduces the output voltage of the DC-DC converter, which is the power conversion means for the main battery, that is applied to both terminals of the accessory battery, to a voltage near the open terminal voltage of the accessory battery. This voltage reduction is performed based on a detection result by the above-described charge detection means that the main battery is being charged. An optimal method in accordance with the electric circuit used as the DC-DC converter may be used as the method for decreasing the voltage. This can be easily achieved by a method such as by shortening the pulse width of a period during which electricity is transmitted, if a pulse width modulation (hereinafter called PWM) inverter-type converter is used, for example.

Below the we describe the invention by explaining a detailed embodiment.

[Embodiment]

Fig. 2 is a circuit block diagram showing one embodiment of an electric vehicle equipped with an accessory battery charger for an electric vehicle according to this invention.

In the figure, 10 indicates the accessory battery charger, and 20 indicates a main battery charger.

Below we discuss the present invention in detail, citing embodiments for a more concrete explanation.

The hub 10, as shown in the figure, comprises a main battery 11 and a DC-DC converter 14 which changes the voltage and rectifies power from that main battery 11 and supplies it to the accessory battery 12 and the accessory system load 13. 15 is a charging outlet which electrically connects the charging device 20 and the main battery 11 when the charging device 20 charging plug 21 (described below) is inserted therein, at the same time switching a two contact switch 16. The switch 16 closes contact "b" and simultaneously opens contact "a" when the charging plug 21 is inserted into the charging outlet 15, and conversely closes contact "a" and opens contact "b" when the charging plug 21 is removed. 17 shows a diode, 18 an operational amplifier ("op ampp" below); [these] feed back the output of the above-described DC-DC converter 14 according to their combination with the switch 16, controlling the output voltage V0 thereof. The DC-DC converter 14 PWM control portion 14A compares the output voltage VP from the op ampp 18 with a base voltage VB contained therein, and controls the DC-DC converter 14 output voltage VO by means of controlling the DC-DC converter main circuit 14B.

The charging device 20 comprises a charger 23 which converts and rectifies power from a commercial power supply 22 to a voltage appropriate for charging the main battery and outputs it to the charging plug 21.

The accessory battery charging device 10 comprised as described above operates in the following manner.

First we shall discuss the normal operating state, in which the charging device 20 and the accessory battery charging device 10 are isolated. At this point, contact "a" on the switch 16 is closed, and a voltage which is smaller than the output voltage VO from the actual DC-DC converter 14 by just the voltage drop VD in the forward direction on the diode 17 is input to the non-inverting input terminal of the op amp 18, and the op amp 18 output VP falls by just the voltage VD. That is, because of the reduction in the output voltage VP on the op amp 18, which is compared with the PWM control section 14A base voltage VB, the PWM control section 14A causes the DC-DC converter main circuit 14B to operate in such a way that the output voltage VO thereof rises, and the internal base voltage VB now matches the value (VO-VD), which is the diode 17 voltage decline VD subtracted from the DC-DC converter 14 output voltage VO. The output voltage VO (= VB + VD) from the DC-DC converter 14 at this point is higher than the accessory battery 12 open terminal voltage, and is of enough potential to adequately supply power to the normal state accessory system load 13 as well as charge the accessory battery 12.

At the same time, when the charging device 20 and the accessory battery charging device 10 are connected by the charging plug 21 and the charging outlet 15, which is to say when the accessory system load 13 is light during vehicle stoppage, the switch 16 "a" contact is open and the "b" contact is closed, so that the accessory battery charging device 10 operates as follows.

The op amp 18 non-inverting terminal, to which the DC-DC converter 14 output voltage VO, which had fallen by a voltage VD, was applied via contact "a," now changes, such that the DC-DC converter 14 output voltage VO is output thereto without passing through the diode 17. Therefore the op amp 18 output similarly rises in voltage by VD. As a result, the PWM control section 14A operates as if the output voltage of the DC-DC converter 14 had risen by a voltage VD above its internal base voltage VB, causing the DC-DC converter 14 output voltage VO to fall by the voltage VD, so that the base voltage VB and the output voltage VO are equal -- controlling the DC-DC converter 14, in other words, so that VB = VO.

The base voltage VB of the PWM controller is set in advance such that the output voltage VO (=VB) of the DC-DC converter 14 at this time is set to a voltage at a level wherein electricity is supplied to the accessory system load 13 that is lighter than that during the charging of the main battery 11, while it is slightly higher than the terminal voltage of the accessory battery 12 but does not cause the accessory battery 12 to be overcharged.

As in the past, at normal times when the accessory system load 13 is heavy, the accessory battery charging device 10 changes the power from the main battery 11 to a voltage which is higher than that of the accessory battery 12 open terminal voltage so as to sufficiently supply the accessory system load 13 and the accessory battery 12. By so doing, the accessory battery 12 is charged regardless of whether the accessory system load 13 is consuming a large amount of power.

On the other hand, when the vehicle is at a stop, that is, when the accessory system load 13 becomes light and almost all of the electricity from the main battery 11 is supplied to the accessory battery 12, the output voltage VO of the DC-DC converter automatically decreases by the forward voltage decrease VD of the diode due to the switching by the switch 16. Since the voltage VO is decreased to a state slightly higher than the open terminal voltage of the accessory battery 12, the electricity of the main battery 11 can be effectively utilized, and loss of fluid or deterioration of the accessory battery 12 can be prevented without overcharging the accessory battery 12.

As shown in the Fig. 2 circuit block diagram, the accessory battery charging device 10 of the present embodiment is an economically and operationally superior device which can be implemented by the addition of a simple comparator circuit consisting primarily of a switch 16 on a conventional DC-DC converter 14 feedback system, a diode 17, and an op amp 18.

[Efficacy of the Invention]

As described above with reference to the embodiment, the main point of this invention is that the accessory battery charger for an electric vehicle having an accessory battery and a DC-DC converter connected to an accessory system of the vehicle and being parallel with each other, and a main battery connected to an end of the DC-DC converter opposite from the end to which the accessory battery is connected, is comprised of:

a charge detection means that detects that the main battery is being charged; and

a voltage reduction means that reduces a voltage value of an output of the DC-DC connector to which the accessory system and the accessory battery are connected, when the charge detection means detects that [the main battery] is being charged.

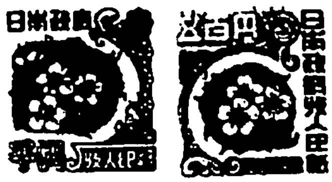
Accordingly, because the electricity from the main battery is changed to a voltage higher than the accessory battery by the DC-DC converter and transmitted to the load and the accessory battery under a condition with a normal load, such as when the vehicle is being driven, the accessory battery can be sufficiently charged, and can handle high loads. In addition, when the charge detection means detects that the vehicle is being charged and that the load is light, the voltage of electricity supplied from the main battery is automatically decreased by the voltage reduction means to a voltage slightly higher than the accessory battery. As a result, the accessory battery charger for an electric vehicle [according to this invention] is excellent in that the accessory battery is not overcharged although almost all of electricity from the main battery is supplied thereto, and in that not only the electricity from the main battery can be effectively utilized, but also the deterioration of the accessory battery performance, such as fluid loss, due to overcharging the accessory battery can be entirely avoided.

Brief Description of Drawings

Fig. 1 is a basic structural diagram of this invention, and Fig. 2 is a circuit block diagram of one embodiment.

I...Accessory system; II...Accessory battery, III...DC-DC convert, IV...Main battery, V...Charge detection means, VI...Voltage reduction means, 10...Accessory battery charger, 11...Main battery, 12...Accessory battery, 13...Accessory system load, 14...DC-DC converter, 16...Switch, 17...Diode, 18...OP amp, and 20...Charger.

公開実用 昭和51— 103220



(L 5000円)

実用新案登録願

昭和50年2月18日

特許庁長官 斎藤英雄 殿

1. 考案の名称

フクゴウデンキジドウシャノセイギョソウチ
複合電気自動車の制御装置

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(ほか1名)

50-021601

明　細　書

1. 考案の名称

複合電気自動車の制御装置

2. 実用新案登録請求の範囲

内燃機関の出力軸がクラッチを介して蓄電池の電力により動作する電動機の回転軸に連結され、前記内燃機関出力軸が発電機に連結されてそこで発電された電力を前記蓄電池に蓄電するようにされ、前記クラッチに油圧を導く油路に電気信号により切換動作するソレノイドバルブが挿入される複合電気自動車において、前記内燃機関出力軸と前記電動機回転軸にそれぞれその回転数を検出する検出器が設けられ、それらの検出器が両者の回転数を比較して電動機回転軸の方が内燃機関出力軸と等しいか、それより大

　

きい場合に電気信号を発生する比較器に接続され、該比較器の出力側が前記ソレノイドバルブのコイルにその電気信号により切換動作して前記油路を開くように接続され、前記比較器の出力側と前記油路に設けられて前記クラッチに供給される油圧がクラッチ係合油圧に達すると電気信号を発生する油圧スイッチとが、論理回路を介して前記発電機の界磁回路に、それらの比較器と油圧スイッチから共に電気信号が発生すると界磁回路を遮断するように接続されることを特徴とする複合電気自動車の制御装置。

3　考案の詳細な説明

本考案は内燃機関と直流電動機により車両を駆動する複合電気自動車において、特に走行モード切換時に発電機の界磁電流が遮断される場

令のタイミング制御に関するものである。

近年省資源、大気汚染という社会問題を改善するため提唱された複合電気自動車は、駆動用の内燃機関と電動機および蓄電池を充電する発電機から成り次のような3つの走行モードを有する。即ち第1のモードは車両を電動機のみにより駆動し内燃機関は発電機による発電に使用するもの、第2のモードは車両の駆動を内燃機関のみにより行い発電機による発電と電動機による駆動作用を共に停止するもの、第3のモードは高速走行等の高負荷時のように車両を内燃機関と電動機の両者で駆動し、しかも発電機による発電作用も行うものである。

またこのような走行モードにおいて第1のモードから第2のモードに切換える場合は、内燃

機関と電動機のそれぞれの出力軸回転数が一致したとき、発電機の界磁電流、電動機の駆動電流を遮断すると共に、クラッチを係合して内燃機関の動力を車両駆動軸に伝達するようになつている。しかるにこの場合のクラッチは解放時にピストン室が空の状態になつており、係合時に油圧が供給されてクラッチ板を圧着することにより一体的に結合した状態になる迄には多少時間がかゝる。従つてこのようなクラッチの作動遅れを考慮しないで早めに発電機の界磁電流が遮断されると、内燃機関は一時的に無負荷状態になつて吹き上げ、騒音を発生したり構成部品の耐久性を低下する等の不具合を生じる。また逆に発電機の界磁電流を遮断するタイミングが遅れると、内燃機関は一時的に過負荷の状態

になつて同じような不具合を生じる。

本考案はこのような不具合を解消するもので、内燃機関と電動機の出力軸回転数が一致し、しかもクラッチの油圧が係合を達成する高い値に達した場合に発電機の界磁電流を遮断させる複合電気自動車の制御装置を提供することにある。

以下に本考案を図面の実施例により説明する。第1図により複合電気自動車の駆動系について説明すると、内燃機関1の出力軸2が湿式多板クラッチ型のクラッチ3を介して直流電動機4の回転軸5に連結され、また出力軸2が増速機6を介して発電機7の回転軸8に連結され、発電機7のブラシ側が蓄電池9を介して電動機4の電機子や界磁コイルに電気的に接続され、これらの出力軸2と回転軸5にそれぞれその回転

数を電気的に検出する検出器10，11が設けられる。またクラッチ3のピストン室からの油路12にはソレノイドバルブ13が接続され、そのバルブ13からの油路14に油溜15からポンプ16により汲み上げた油圧を調圧する調圧弁17が接続され、油路12にクラッチ油圧が所定の値に達すると電気信号を発生する油圧スイッチ18が設けられる。

次いで第2図により制御装置について説明すると、前述の回転数検出器10，11が比較器19に接続されて、両回転数の比較により電動機回転軸5の方が内燃機関出力軸2と等しいか、それより大きい場合に電気信号を出力するようになつている。この比較器19の出力側はANDゲート20の一方の入力側、電気信号が入力されると負荷に応じた電動機3の電流制御を解除するモー

タコントローラ21、電気信号が入力されると負荷に応じて内燃機関1の出力を制御させるエンジンコントローラ22およびORゲート23の一方の入力側に接続され、ANDゲート20の他方の入力側に前述の油圧スイッチ18が接続され、ORゲート23の他方の入力側に内燃機関1の出力軸回転数がその始動回転数下限値以下の場合に電気信号を出力する検出器24が接続されている。ANDゲート20の出力側は信号を反転するインバータ25を介してスイッチ用トランジスタ26のベースに接続され、このトランジスタ26のエミッタとコレクタが発電機7の界磁コイル27、バッテリ28、イグニッションスイッチに連動してONになるスイッチ29を介して閉じた回路を形成するように接続されている。更にORゲート23の出力側

は同様にスイッチ用トランジスタ30のベースに接続され、このエミッタとコレクタがソレノイドバルブ13のコイル31、バッテリ32、イグニッションスイッチに連動してONになるスイッチ33を介して閉じた回路を形成するように接続されている。

このように構成されることにより、内燃機関1の始動時には検出器24からの信号によりトランジスタ30が導通してコイル31を励磁するようになり、このためソレノイドバルブ31が油路12と14を連通してクラッチ3に油圧を供給し係合した状態にする。そこで蓄電池9に蓄電された電力で電動機4が通常のガソリン自動車のスターターのように回転されると内燃機関1も動作しはじめ、それが完全にそれ自身で動作して所定

の回転数に達すると検出器24からは電気信号が出力しなくなる。そのためトランジスタ30は不導通しコイル31が消磁してソレノイドバルブ31は元の遮断状態に戻り、クラッチ3も排油により、解放状態になつて内燃機関出力軸2と電動機回転軸5を遮断する。従つて車両はモータコントローラ21で制御される電動機4の回転軸5のみにより駆動される。一方この場合に油圧スイッチ18からは電気信号が出力しないためインバータ25からの信号によりトランジスタ26は導通し、界磁コイル27に電流が流れて発電機7は発電可能な状態になつており、内燃機関1の出力軸2により増速機6を介して回転軸8と共に電機子が回転されるため、発電機7で発電され第1のモードになる。

次いでこのような第1のモードから第2のモードに切換えられる場合を第3図を用いて説明する。まず(a)の曲線n_5のように負荷に応じて増加する電動機回転軸5の回転数と、曲線n_2のように定速回転する内燃機関出力軸2の回転数が時間t_0で一致すると、比較器19から電気信号が出力する。そのため今度はモータコントローラ21により電動機4の動作は解除されてエンジンコントローラ22により内燃機関1の出力が負荷に応じて制御されるようになり、しかもORゲート23の出力信号で再びトランジスタ30が導通されて前述と同様にクラッチ3に油圧が供給される。しかるに時間t_0直後のようにクラッチ油圧が低く油圧スイッチ18から信号が出力されない場合は、引続いてANDゲート20からも信号が出

力されないため、トランジスタ26が導通状態を保つて内燃機関1により発電機7が発電作用を行つている。そして(c)のように時間t_1でクラッチ油圧が所定の係合油圧P_{00}に達して実質的にクラッチ板を係合するようになると、内燃機関出力軸2が電動機回転軸5と一体的に結合され、車両が内燃機関1によりのみ駆動される。またこのとき油圧スイッチ18から電気信号が出力されANDゲート20からも信号を出力するため、インバータ25によりトランジスタ26は不導通の状態になり(b)のように界磁コイル27へは界磁電流を流さなくなる。そこで発電機7は回転軸8が回転しても発電しなくなつて第2のモードになる。

以上説明したように本考案の制御装置による

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と、第1のモードから第2のモードへの切換時に油圧スイッチ18でクラッチ3が完全に係合作用したことを確認して発電機7の界磁電流を遮断し、しかもその遮断動作を電気的に迅速に行うため、既に述べたようなタイミング不良による種々の不具合を完全に除去することができる。

4 図面の簡単な説明

第1図は本考案が適用される複合電気自動車の一例を示す構成図、第2図は本考案の制御装置を示す回路図、第3図の(a)ないし(c)は本考案による第1のモードから第2のモードへの切換時の動作特性を示す線図である。

1−内燃機関、2−出力軸、3−クラッチ、4−電動機、5−回転軸、6−増速機、7−発電機、9−蓄電池、10，11−検出器、12−油路、

13－ソレノイドバルブ、18－油圧スイッチ、19－比較器、20－AND ゲート、25－インバータ、27－界磁コイル、31－コイル

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代理人　石山　博

同　中平　治

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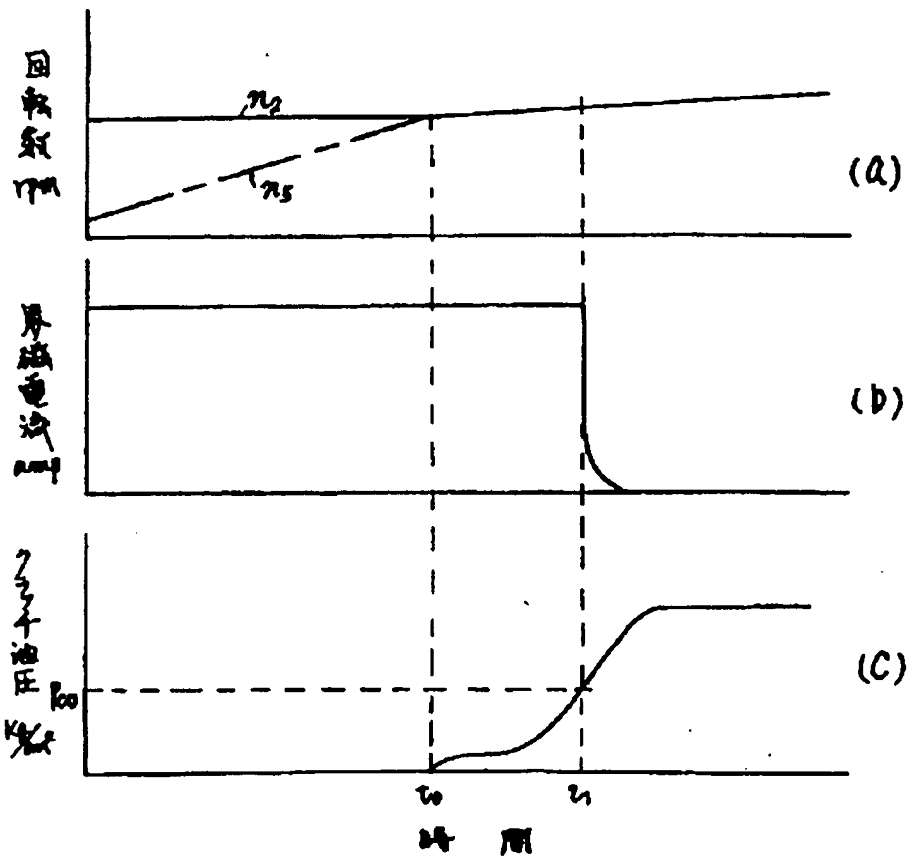
第3図



103220 2/2

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TPR 097896

5. 添附書類の目録

(1) 願書副本　　　　1通
~~( ) 出願審査請求書　　　　1通~~
(2) 明　細　書　　　　1通
(3) 図　　面　　　　1通
(4) 委　任　状　　　　1通
~~( ) 優先権主張書　　　　通~~
~~( ) 優先権証明書及び訳文　　　　各　通~~

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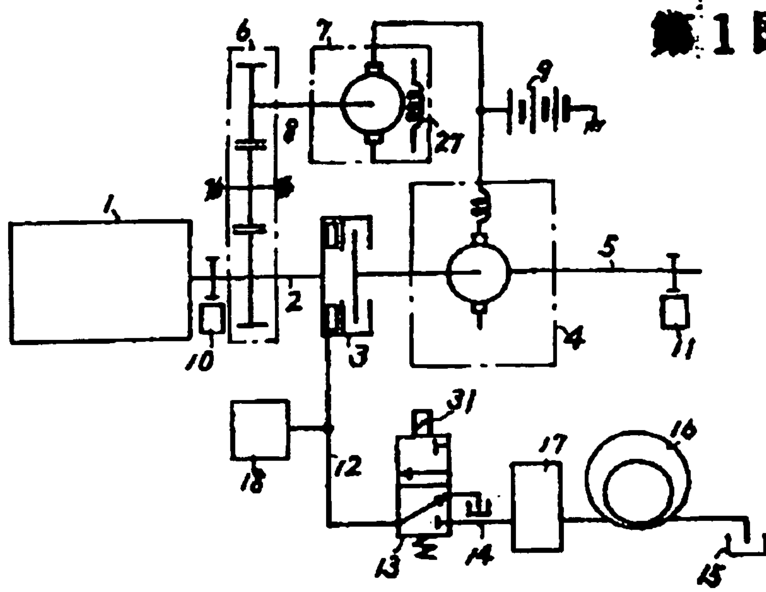
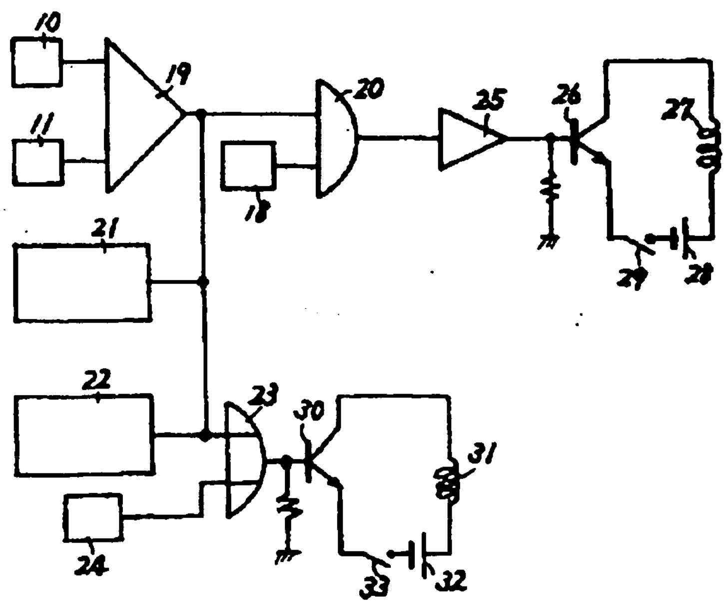
第1図



第2図



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CERTIFICATION OF TRANSLATION

I, Christopher Field, a professional Japanese translator accredited by the American Translators Association, hereby attest that the attached translations from Japanese have been faithfully prepared to the best of my ability.

1. JP03-124201
2. JP51-103220
3. JP05-64531

Date: May 13, 2004

By: 5/13/04

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 FORD EXHIBIT 1102

Japanese Laid-Open Utility Model Application 51-103220

Laid-Open: August 18, 1976

Filing Date: February 18, 1975

Applicant: Toyota Motor Corporation

SPECIFICATION

1. Title of the Invention

CONTROL DEVICE OF ELECTRIC HYBRID VEHICLE

2. Scope of the Claim

An electric hybrid vehicle in which an output shaft of an internal combustion engine is coupled to a rotation shaft of an electric motor which is operated by electric power of a battery via a clutch, the internal combustion engine output shaft is coupled to an electric generator, electricity generated by the generator is stored in the battery, and a solenoid valve which performs a switching operation in response to an electric signal is inserted in a hydraulic path which conducts hydraulic pressure to the clutch, wherein:

detectors which detect the respective rotation speeds of the internal combustion engine output shaft and the electric motor rotation shaft are respectively provided on the internal combustion engine output shaft and the electric motor rotation shaft, the detectors are coupled to a comparator which compares the respective rotation speeds and generates an electric signal when the rotation speed of the electric motor rotation shaft is equal to or larger than that of the internal combustion engine output shaft, an output side of the comparator is connected to a coil of the solenoid valve so as to open the hydraulic path by performing a switching operation in response to the electric signal, the output side of the comparator and a hydraulic pressure switch

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which generates an electric signal when a hydraulic pressure in the hydraulic path and supplied to the clutch reaches a clutch engagement hydraulic pressure are connected to a field circuit of the electric generator via a logic circuit so as to cut the field circuit when electric signals are generated from both the comparator and the hydraulic pressure switch.

3. Detailed Description of the Invention

This invention relates to an electric hybrid vehicle for driving a vehicle by an internal combustion engine and a direct current electric motor, and particularly to timing control when a field current of an electric generator is cut at the time of switching [between] travel modes.

Electric hybrid vehicles have been proposed in recent years in order to address the societal problems of diminishing fuel resources and air pollution, have an internal combustion engine and an electric motor for driving, and a generator for charging a battery, and have the following three modes. The first mode is a mode in which the vehicle is driven only by the electric motor, and the internal combustion engine is used for generating electricity via the generator. The second mode is a mode in which the vehicle is driven only by the internal combustion engine, and generation of electricity by the generator and driving by the electric motor are stopped. The third mode is a mode in which, at times of high load such as at high-speed travel of the vehicle, the vehicle is driven by both the internal combustion engine and the electric motor, and generation of electricity is also performed by the electric generator.

In these travel modes, when switching from the first mode to the second mode, when the output shaft rotation speed of the internal combustion engine and the output shaft rotation speed of the electric motor match, the field current of the generator and the drive current of the electric motor are cut, the clutch is engaged, and the motive force of the internal combustion engine is transmitted to the vehicle drive shaft. Therefore, in this case, when the clutch is released, the piston chamber is in an empty state, and at the time of engagement it takes some time before an integrated coupling state is accomplished by the supply of hydraulic pressure and pressure-engagement of the clutch plate.. Thus, if the field current of the electric generator is cut off early without considering this operational delay of the clutch, there are problems such as that the internal combustion engine will temporarily be in a non-load state and will rev up, generating noise, reducing component part durability, etc. Furthermore, if the timing of cutting the field current of the electric motor is delayed, the internal combustion engine will temporarily be in an excess load state, and the same type of problem will occur.

This invention is to solve this type of problem, and seeks to provide an electric hybrid vehicle control device which cuts the field current of an electric generator when an internal combustion engine rotation speed and an output shaft rotation speed of an electric motor match and the hydraulic pressure of the clutch has reached the high value at which engagement is achieved.

The following explains an embodiment of this invention with reference to the figures. According to Fig. 1, with respect to a drive system of an electric hybrid vehicle, an output shaft 2 of an internal combustion engine 1 is coupled to a rotation shaft 5 of a direct current electric motor 4 via a wet type multi-plate clutch 3. The output shaft 2 is coupled to a rotation shaft 8 of an electric generator 7 via a step-up gear 6. A brush side of the electric generator 7 is electrically connected to the armature, field coil, etc. of the electric motor 4 via a battery 9, and detectors 10, 11, which electrically detect the respective rotation speeds, are respectively disposed on the output shaft 2 and the rotation shaft 5. Furthermore, a solenoid valve 13 is connected to a hydraulic path 12 from a piston chamber of the clutch 3, and a pressure valve 17 which adjusts the hydraulic pressure [of hydraulic fluid] pumped by a pump 16 from a hydraulic fluid reservoir

15 is connected to a hydraulic path 14 from the valve 13. A hydraulic pressure switch 18 is provided which generates an electric signal when the clutch hydraulic pressure in the hydraulic path 12 reaches a predetermined value.

The following explains a control device with reference to Fig. 2. The rotation speed detectors 10, 11 are connected to a comparator 19, and an electric signal is output when the rotation speed of the electric generator rotation shaft 5 is equal to or larger than that of the internal combustion engine output shaft 2 according to the rotation speed comparison. The output side of this comparator 19 is connected to one input side of an AND gate 20, a motor controller 21 which releases an electric current control of the electric motor 3 according to load when an electric signal is input, an engine controller 22 which controls the output of the internal combustion engine 1 according to load when an electric signal is input, and one input side of an OR gate 23. The hydraulic pressure switch 18 is connected to the other input side of the AND gate 20. A detector 24 which outputs an electric signal when the output shaft rotation speed of the internal combustion engine 1 is a starting rotation speed minimum value or less is connected to the other input side of the OR gate 23. The output side of the AND gate 20 is connected to a base of a switching transistor 26 via an inverter 25 which inverts a signal. The emitter and collector of this transistor 26 are connected so that a closed circuit is formed via a field coil 27 of the electric generator 7, a battery 28, and a switch 29 which turns on together with the ignition switch. Additionally, the output side of the OR gate 23 is connected to the base of a switching transistor 30 in the same manner. The emitter and the collector of this transistor 30 are connected so that a closed circuit is formed via a coil 31 of the solenoid valve 13, a battery 32, and a switch 33 which turns on together with the ignition switch.

Thus, when the internal combustion engine 1 is started, the transistor 30 is made conductive by a signal from the detector 24, and the coil 31 is energized. Therefore, the solenoid valve 31 [sic. 13] connects the hydraulic paths 12 and 14, hydraulic pressure is supplied to the clutch 3, and the clutch 3 is engaged. Then, when the electric motor 4 is rotated by the electric power stored in the battery 9 as with a normal gasoline vehicle starter, the internal combustion engine 1 also begins to operate. When the internal combustion engine 1 is operates completely on its own and reaches a predetermined rotation speed, an electric signal is no longer output from the detector 24. Because of this, the transistor 30 becomes non-conductive, the coil 31 is de-energized, the solenoid valve 31 returns to the original cut-off state, the clutch 3 is placed in a released state due to evacuation of hydraulic fluid, and the internal combustion engine output shaft 2 and the electric motor rotation shaft 5 are disconnected. Therefore, the vehicle is driven by only the rotation shift 5 of the electric motor 4 controlled by the motor controller 21. Meanwhile, in this case, an electric signal is not output from the hydraulic pressure switch 18, so the transistor 26 is made conductive by a signal from the inverter 25, electric current flows through the field coil 27, and the electric generator 7 is in a state in which electricity can be generated. An armature is rotated by the output shaft 2 of the internal combustion engine 1 along with the rotation shaft 8 via the step-up gear 6, so the first mode is attained, in which electricity is generated by the electric generator 7.

Next, switching the mode from the first mode to the second mode is explained with reference to Fig. 3. First, if the rotation speed of the armature rotation shaft 5, which increases according to load as shown in curve n_5 of Fig. 3(a), and the rotation speed of the internal combustion engine output shaft 2, which is rotated at a constant speed as shown in curve n_2, match in a time t_0, an electric signal is output from the comparator 19. Because of this, the operation of the electric motor 4 is now released by the motor controller 21, and the output of the internal combustion engine 1 is becomes controlled by the engine controller 22 in accordance with load. Additionally, the transistor 30 is again made conductive by the output signal of the OR gate 23, and hydraulic pressure is supplied to the clutch 3 in the same manner as described before. Therefore, as at the time immediately after time t_0, if clutch hydraulic pressure is low and a signal is not output from the hydraulic pressure switch 18, a signal is also not output from the AND gate 20, so the transistor 26 keeps a conductive state, and the electric generator 7 generates electricity by means of the internal combustion engine 1. Additionally, as shown in Fig. 3(c), if the clutch hydraulic pressure reaches a predetermined engagement hydraulic pressure P_{C0} in a time t_1 and the clutch plate is substantially engaged, the internal combustion engine output shaft 2 is integrally coupled to the electric motor rotation shaft 5, and the vehicle is driven by only the internal combustion engine 1. In addition, at this time, an electric signal is output from the hydraulic pressure switch 18 and a signal is output from the AND gate 20, so the transistor 26 will be in a non-conductive state because of the inverter 25, and the field coil 27 ceases to conduct a field current, as shown in Fig. 3(b). Therefore, the electric generator 7 does not generate electricity even though the rotation shaft 8 is rotated, and the second mode is entered.

Thus, according to the control device of this invention, at the time of switching from the first mode to the second mode, it is confirmed by the hydraulic switch 18 that the clutch 3 is completely engaged, and the field current of the electric generator 7 is cut. Additionally, this cutting operation is electrically performed promptly, so it is possible to completely eliminate various problems due to the above-described timing failures.

4. Brief Description of the Drawings

Fig. 1 is a structural view showing an embodiment of an electric hybrid vehicle to which this invention is applied.

Fig. 2 is a circuit diagram showing a control device of this invention.

Figs. 3(a)-(c) are line diagrams showing operation characteristics at the time of switching from a first mode to a second mode according to this invention.

1. Internal combustion engine
2. Output shaft
3. Clutch
4. Electric motor
5. Rotation shaft
6. Step-up gear
7. Electric generator
9. Battery

10, 11 Detectors

12. Hydraulic path
13. Solenoid valve
18. Hydraulic pressure switch
19. Comparator
20. AND gate
25. Inverter
27. Field coil
31. Coil

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特　許　願　(特許法第38条ただし書の規定による特許願)

昭和46年10月20日

特許庁長官　井土武久殿

1. 発明の名称
複合電気自動車用ギヤトレーン

2. 特許請求の範囲に記載された発明の数　3

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⑲ 日本国特許庁

公開特許公報

⑪特開昭　48-49115

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㉑特願昭　46-82474

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審査請求　未請求　(全7頁)

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6477 36	80 A02
6477 36	80 A01
6477 36	79 A1
2126 31	54 A1

明　細　書

1　発明の名称

複合電気自動車用ギヤトレーン

2　特許請求の範囲

1　内燃機関からの入力軸、少くも3個の摩擦係合部材、結合可能な4個の要素を少くも有する遊星歯車装置及び出力軸から成るギヤトレーンに於て、前記遊星歯車装置の才1の要素が才1の摩擦係合部材を介して前記入力軸に連結され、才2の要素が前記出力軸に連結され、才3の要素が才2、才3の摩擦係合部材と発電機にもなり得る才1の直流電動機とに連結され、才4の要素が発電機にもなり得る才2の直流電動機に連結され、更に前記2個の直流電動機が電力の供給と受入れを可能に蓄電池と接続され、もつて内燃機関または直流電動機による単独の動力伝達と両者の組合わせによる動力伝達を可能に構成されたことを特徴とする複合電気自動車用ギヤトレーン。

2　前記2個の直流電動機が前記遊星歯車装置へ作用を及ぼさないように空転状態にされて、前記内燃機関の動力が前記摩擦係合部材の選択的な係合により前記遊星歯車装置へ与えられ、これにより前記出力軸に機関動力による少くも2段の変速比が得られることを特徴とする特許請求の範囲才1項記載の複合電気自動車用ギヤトレーン。

3　前記内燃機関の作動が停止されると共に、前記才3の摩擦係合部材の係合及び前記才1

の直流電動機の停止により前記遊星歯車装置の第3の要素の回転が拘束されて、前記第2の直流電動機の動力が前記第4の要素に与えられ、これにより前記出力軸に電気動力による定められた変速比の前進速と後進速が得られることを特徴とする特許請求の範囲第1項記載の複合電気自動車用ギヤトレーン。

4 前記内燃機関の動力がトルク制御されながら前記第 の摩擦係合部材の係合を介して前記遊星歯車装置に与えられると共に、前記2個の直流電動機の動力が減速または増速制御されながら前記遊星歯車装置に与えられ、これにより前記出力軸に零からオーバドライブにわたる範囲の連続的な無段変速が得られ、且つ車両走行中に於て一方の直流電動機により前記蓄電池が充電され、電気動力により機関動力の負担の一部分を軽減するように調整されることを特徴とする特許請求の範囲第1項記載の複合電気自動車用ギヤトレーン。

3 発明の詳細な説明

本発明は動力源にガソリン内燃機関と蓄電池を備えた電動機とを用いた複合電気自動車用ギヤトレーンに関するものである。

近年ガソリンエンジンを搭載した自動車の排気ガスによる大気汚染が、都市の稠密化とモータリゼーションの進展と共に大気中に拡散して無害化しきれずに蓄積し、直接人体に害になりまたは特殊な汚染物質が蓄積し易い地形や気象的に拡散を妨げる逆転層の現象条件と組合わさつて有害な作用をすることが明白な事実となつて現われ、現代文明の矛盾として問題化してきた。そこでこのような自動車排気ガスによる汚染防止対策として、行政上都市内の自動車の走行状態と一酸化炭素の排出量との関係により交通規制や立体交叉等の交通、道路対策がとられ、同時に排気ガス中の一酸化炭素、炭化水素、窒素酸化物、固体微粒子の有害成分の排出規制を強化する環境基準が制定されつゝある。このため自動車側に於ては、低汚染車と称してエンジンを改良し且つ排気ガスの浄化装置を開発して排気ガス中の有害成分の排出量を一定値以下に抑え、またはガスタービンエンジンや電池を備えた電動機等の無公害原動機を搭載した無公害車の開発が提案されているが、いずれもまだ一部の特殊用途車を除いて世界的に開発途上にあるのが現状と言える。

しかしこのような自動車の原動機に関する革命的な改革は優れた人間の英智と終りのない技術革新により順次その姿を現わすものと考えられるが、この究極の目的に向うワンステップとして少くもすでに人間の社会生活を脅かしている都市内での排気ガス公害を軽減する必要がある。

本発明の目的はガソリン内燃機関と蓄電池を備えた電動機とを搭載して複合電気自動車を構成し、これらの単独と両者の組合わせにより駆動して大気汚染の状態に応じて排気ガスの排出量を変化しながら走行可能なギヤトレーンを得ることにある。

以下に本発明を図面の実施例により説明する。

第1図に本発明の複合電気自動車用ギヤトレーンの一例が示され、第2図に第1図に於ける自動変速機構の具体的な実施例が示されており、これらの図に於てケース1は内部に変速機構を有し外部に電動機構を夫々有する。このようなケース1の内部に於て、ガソリン内燃機関2からの入力軸3は第1のクラッチ4のクラッチドラム5と第2のクラッチ6のクラッチハブ7に連結され、第1のクラッチ4のクラッチハブ8が第1の中間軸9を介して遊星歯車装置20の第1のサンギヤ21に連結され、第2のクラッチ6のクラッチドラム10が第2の中間軸11を介してその第2のサンギヤ22に連結され、更に第2のクラッチ6のクラッチドラム10とケース1との間にブレーキ12が設けられる。遊星歯車装置20は第1、第2のサンギヤ21,22と夫々一体化されて噛合うピニオンギヤ23,24を有し、これらのうちの第1のピニオンギヤ23にリングギヤ25が噛合い、両ピニオンギヤ23,24を支承するキャリヤ26が出力軸13に連結される。また入力軸3と出力軸13とに夫々オイルポンプ14,15が設けられ、これらのオイルポンプ14,15により生じた圧油が油圧制御回路（図示せず）を介してクラッチ4,6とブレーキ12とに選択的に供給され、第1のクラッチ4とブレーキ12に供給されて摩擦係合することにより第1のサンギヤ21の歯数Z_{21}と第2のサンギヤ22の歯数Z_{22}で定まる$1+\frac{Z_{22}}{Z_{21}}$の低速段の減速比が得られ、第1、第2のクラッチ4,6に供給されて摩擦係合することにより直結状態の高速段が得られるようになつている。

このような内燃機関用動力系路に電動機用動力系路が設けられるものであり、遊星歯車装置20の第2のサンギヤ22と一体的な第2の中間軸11及びリングギヤ25に夫々同じピッチ円径の伝達ギヤ30,31が設けられ、これらの伝達ギヤ30,31に回転方向を合せるため中間ギヤ32,33を介して夫々駆動ギヤ34,35が噛合つている。これらの駆動ギヤ34,35は夫々発電機にもなり得る直流電動機36,37を設けており、これらの直流電動機36,37と蓄電池38との間に電力の受渡しを可能に配線39,40が接続され、且つ励磁電流の増減と極性変更を行うコントローラ41,42を備える配線43,44が励磁側に接続されている。こうして第2の直流電動機37に蓄電池38から励磁電流が供給されて駆動ギヤ35を回転し、同時にブレーキ12に圧油が供給されて係合することにより遊星歯車装置20の第2のサンギヤ22の回転を拘束すると、第2のサンギヤ22の歯数Z_{22}、リングギヤ25の歯数Z_{25}、伝達ギヤ31の歯数Z_{31}及び駆動ギヤ35の歯数Z_{35}で定まる$(1+\frac{Z_{22}}{Z_{25}})\times\frac{Z_{31}}{Z_{35}}$の減速比が得られ、直流電動機37のトルクTに対して$(1+\frac{Z_{22}}{Z_{25}})\times\frac{Z_{31}}{Z_{35}}\times T$の出力トルクが取り出される。従つて減速比が一定の状態で、コントローラ42により励磁電流を変化することにより出力トルクの制御が行われ、且つコントローラ42により極性が反対にされることにより出力軸13は逆転して後進用になる。また直流電動機37の特性から、出力軸側より駆動されることにより直流電動機37は発電機として作

用し一種のエンジンブレーキの効果が得られると共に蓄電池38に充電することができるが、コントローラ42により励磁電流を切つてエンジンブレーキのない惰行が可能になる。

以上説明したように構成され且つ内燃機関及び電動機により夫々単独に駆動される本発明のギヤトレーンに於て、更に内燃機関2からの動力が才1のクラッチ4の作動により才1のサンギヤ21に与えられ、同時に直流電動機36または37からの動力が夫々才2のサンギヤ22または1ングギヤ23に与えられる複合駆動について説明する。このとき機関の絞り弁により機関動力の出力トルクが制御され、コントローラ41，42により直流電動機36，37はいずれも電動機または発電機として作動可能にされながらその回転速度を任意の傾きで減速または増速制御する。こうして出力トルク及び回転速度が制御された3個のギヤ21，22，23の組合わせにより、遊星歯車装置20はキヤリヤ26を介して出力軸13に広い変速域にわたる無段変速を出力するが、この場合才3図に示されるように才1の直流電動機36は入力軸3の回転速度の3倍から零に曲線aに沿つて直線的に減速され、才2の直流電動機37は入力軸3の回転速度の0.5倍で逆転した状態から、零を介して正転状態のその約2倍近くに曲線bに沿つて直線的に増加される。その結果出力軸13に入力軸3との回転数比である速度比が、零から才2の直流電動機37の回転が零の場合の0.3、両直流電動機36，37の回転速度が共に入力回転と等しい場合の1.0を経て才1の直流電動機36の回転が零の場合の1.5まで連続して取り出される。またこのような零からオーバドライブにわたる無段変速域に於て、速度比が0.3以下の場合は才2の直流電動機37が、0.3以上の場合は才1の直流電動機36が夫々発電機として動作し、この発電により得られた電気エネルギが蓄電池38に充電されることなくそのまま電動機動作に用いられる。

続く才4図にこの変速動作の速度比全域に於ける入力軸3と出力軸13との馬力の比で表わす効率が示されており、この図に於て機械部分の効率は100%にされ、電気部分の動力伝達効率をパラメータにしてその効率が80%の場合を曲線cで、50%の場合を曲線dで夫々示している。図から明らかのように速度比が約0.4になる迄は効率が急速に上昇し、その速度比以降になると電気部分の動力伝達効率が半分以下にならない限り80%以上確保し、曲線cの場合はほとんど100%に近い高効率を維持している。更に才5図に於ては電気部分の動力伝達効率に対し、出力軸13が停止している場合に得られるトルク比を表わすストールトルク比の関係が示されており、図から明白のように電気部分の動力伝達効率が0.6位い迄はトルク比の上昇が比較的緩慢であるが、その効率以降は急速に上昇し、車両発進時のような効率が零の場合は大きいトルク比を得ている。なおこのような複合駆動に於て、実施例は発電された電力を充電することなくそのまゝ電動機に用いているが、電気駆動に備えて発電された電力の一部分を車両走行中に於て

蓄電池38に貯えるようにすることも可能であり、急加速時の大トルクを内燃機関2からすべて供給することなくこの方式を用いて蓄電池38から補充することも可能であり、更にコントローラ41，42によりこの場合にも後進速が得られる。

このように通常の内燃機関駆動、電気駆動及び両者の複合駆動の3方式により駆動可能な本発明のギヤトレーンの夫々の使用態様を説明すると、都市内や大気汚染のひどい時間、場所に於ては勿論排気ガスの全く無い電気駆動方式が用いられ、このとき定められた一定の減速比で充分な駆動力を与えられながら走行される。次いで大気汚染が中程度の場合に於ては複合駆動方式が用いられることにより、内燃機関2の負担が蓄電池38からの電力の補充により軽減されて排気ガスの発生が改善され、無段変速により常時最も効率の良い状態で運転可能である。更に完全な郊外のように排気ガスが大気中に充分拡散される場所に於ては内燃機関駆動方式が用いられることにより、2段の変速比を有して充分な加速とレスポンスの良い走行が行われる。

また最後の才6図に於て遊星歯車装置20の他の実施例を前述と同一部分を省略して説明すると、図に於て別個に分割された2個のピニオンギヤ23'，24'が夫々サンギヤ21，22と噛合い、才2のピニオンギヤ23'がキャリヤ27を介して才1の中間軸9に連結され、才1のピニオンギヤ24'を支承するキャリヤ26が才2のピニオンギヤ23'と噛合する才2のリングギヤ28に連結され、2個のクラッチ4，6とブレーキ12の選択的動作により内燃機関駆動方式に於て、直結とオーバドライブの2種の変速比が得られる。

以上説明したように本発明の複合電気自動車用ギヤトレーンによると、通常の内燃機関駆動方式に加えて、排気ガスの全くない電気駆動方式と排気ガスの発生が著しく減じられる複合駆動方式とを備えており、大気汚染が生じ易い時間や場所を走行する場合のその汚染を排気ガスそのものゝ排出量を減じ、または零にして有効に防止することができ、このとき自動車としての機能が充分に確保されている。また遊星歯車装置20の構成により複合駆動方式に於て電気部分の効率が低くてもギヤトレーン全体の効率は比較的高く、変速域の広い無段変速が得られ、且つ発進時のトルク比が大きいという利点を有する。更に車両走行中に於て蓄電池38を充電できるため、電気自動車で最大の難問題にされている長い充電時間が解消され、且つ各方式に於ける制御動作及び各方式への切換も容易に行われ得る。

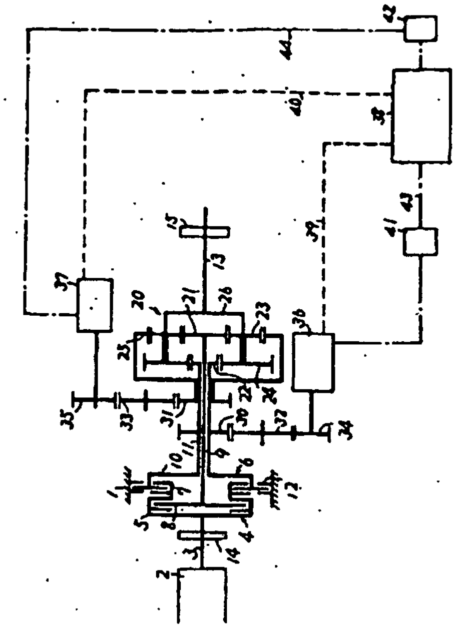
4 図面の簡単な説明

才1図は本発明のギヤトレーンの一例を示す構成図、才2図は才1図に於ける自動変速機構部分の構成を示す縦断面図、才3図は直流電動機の速度比とギヤトレーンの速度比との関係を示す線図、才4図はギヤトレーンの効率とその速度比の関係を電気部分の動力伝達効率をパラメータにして示す線図、才5図はストールトルク比と電気部分の動力伝達効率との関係を示す線図、才6図は本発明のギヤトレーンの他の例

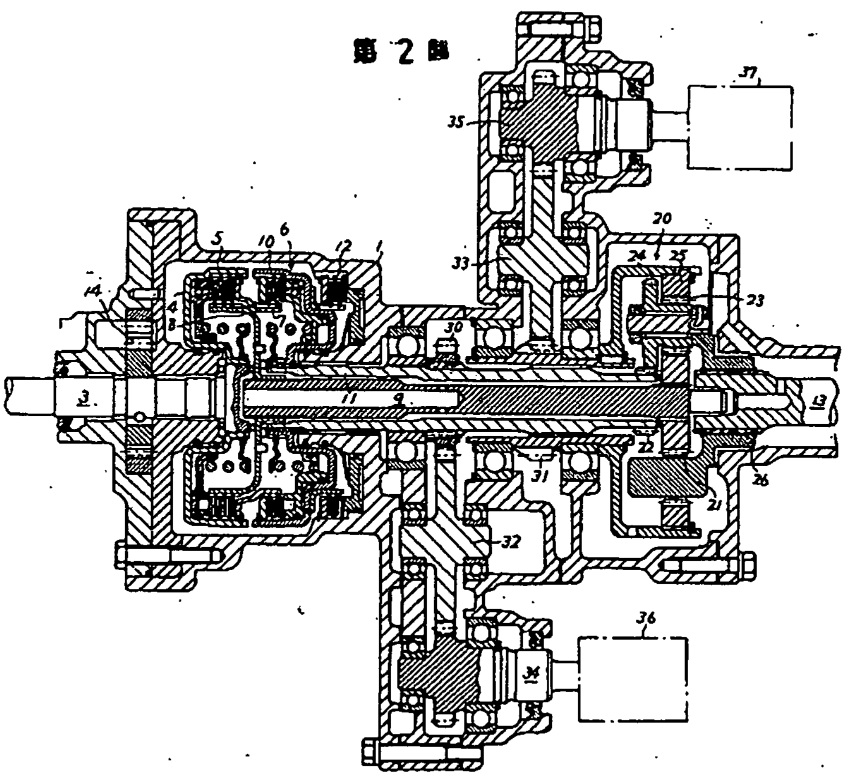
を示す構成図である。

2	内燃機関
3	入力軸
4	才1のクラッチ
6	才2のクラッチ
12	ブレーキ
13	出力軸
20	遊星歯車装置
21	才1のサンギヤ
22	才2のサンギヤ
23	リングギヤ
26	キャリヤ
36	才1の直流電動機
37	才2の直流電動機
38	蓄電池

第1図



第2図



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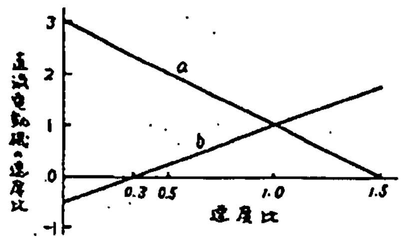
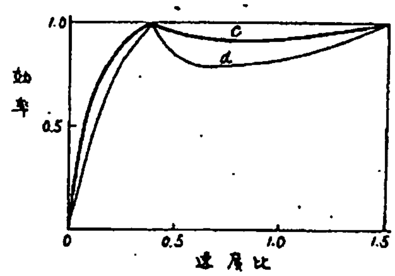
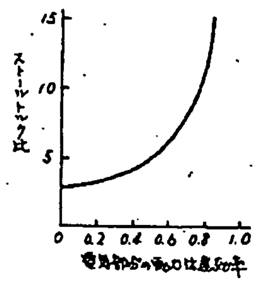
第3図



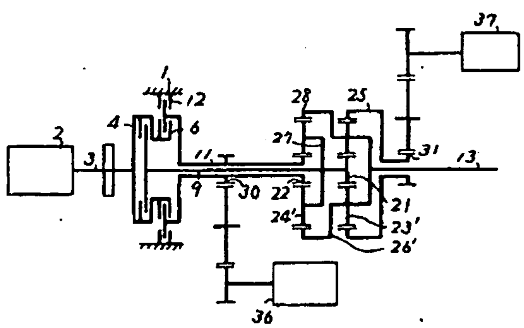
第4図



第5図



第6図



4. 添附書類の目録

(1)	願書副本	1通
~~( )~~	~~出願審査請求書~~	~~1通~~
(2)	明細書	1通
(3)	図面	1通
(4)	委任状	1通
~~( )~~	~~優先権主張書~~	~~1通~~
~~( )~~	~~優先権証明書及び訳文~~	~~各通~~

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FORD EXHIBIT 1102

CERTIFICATION OF TRANSLATION

I, Christopher Field, a professional Japanese translator accredited by the American Translators Association, hereby attest that the attached translations from Japanese have been faithfully prepared to the best of my ability.

1. JP 50-30223
2. JP 48-49115

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TPR 097982

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[revenue stamp] [stamp: corrected]
(2000 yen)

Patent Application

(Patent application in accordance with the regulation in the provision of Article 38 of the Patent Law)

October 20, 1971

Patent Examiner Takehisa Izuchi

1. Title of the invention
Gear Train for a Hybrid Electric Automobile

2. Number of invention stipulated in claims: 4

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6477 36	80 A01
6477 36	79 A1
2125 31	54 A1

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 FORD EXHIBIT 1102

Specification

1. Title of the invention

Gear Train For A Hybrid Electric Automobile

2. Claims

I. In a gear train for a hybrid electric automobile comprising an input shaft, at least three friction engaging parts, a planetary gear device having at least four connectable elements, and an output shaft, the gear train is characterized in that the planetary gear device first element is connected to the input shaft through the first friction engagement part, the second element is connected to the output shaft, the third element is connected to the second and third friction engagement parts and to a first DC motor, also capable of serving as a generator, the fourth element is connected to a second DC motor, also capable of serving as a generator, and, further, the two DC motors are connected to a storage battery so as to allow the supply and receiving of electrical power, thus enabling independent power transmission from an internal combustion engine or a DC motor, or combined power transmission from both [those sources].

II. The gear train for a hybrid electric automobile of Claim 1, characterized in that the second DC motor is placed an idle state so as not to affect the planetary gear device and the motive force of the internal combustion engine is imparted to the planetary gear through selective engagement of the friction engagement parts, thus obtaining at least two stages of gear shift ratio from the engine motive force to the output shaft.

III. The gear train for a hybrid electric automobile of Claim 1, characterized in that as the operation of the internal combustion engine is stopped, the engagement of the third friction engagement part and the stopping of the first DC motor restricts the rotation of the planetary gear third element, imparting the motive force of the second DC motor to the fourth element, thus achieving at the output shaft a forward and reverse speed having a pre-determined gear shift ratio based on the electric motive force.

IV. The gear train for a hybrid electric automobile of Claim 1, characterized in that internal combustion engine motive force, under torque control, is imparted to the planetary gear device through the __*[ordinal number left blank –tr.]* friction engagement part, while the second DC motor motive force is imparted to the planetary gear device under deceleration or acceleration control, thus obtaining a continuously variable speed to the output shaft starting from zero; the storage battery is charged by one of the DC motors while the vehicle is traveling, and adjustment is made so that a portion of the engine drive load is lightened by the electrical motive force.

3. Detailed Description of the Invention

The present invention relates to a gear train in a hybrid electric automobile using a gasoline internal combustion engine and a battery-equipped electric motor as power sources.

In recent years, atmospheric pollution caused by gasoline engine vehicle exhaust gases has been accumulating in the atmosphere, unable to be fully detoxified, as cities become denser and motoring increases. In areas where dispersion is topographically or meteorologically prevented, it is now clear that [such gases] or particular pollutants can accumulate and cause direct harm to the human body, thus raising a growing problem in conflict with modern civilization. Given the relationship between vehicle travel patterns and carbon monoxide exhaust levels, car-induced pollution has led to the adoption of transport and road policies such as transportation restrictions and flyovers, while at the same time environmental standards have been established which strengthen restrictions on damaging components in exhaust gas, such as carbon monoxide, hydrocarbons, NOx, and solid particulates. This has led to proposals on the vehicle side such as the development of improved engines and exhaust gas cleaning devices to hold the amount of harmful components in the exhaust gas to below a certain level – so called "low emissions vehicles." Development has also been proposed of no-pollution vehicles using non-polluting drive devices, such as gas turbines or battery-equipped electric motors, etc. In all cases, except for some special-use vehicles, these may still be said to be under development around the world.

It would seem that superb human intellect and ceaseless technological progress will gradually lead to a revolutionary improvement in the motors for such vehicles, but there is a need [now] to reduce the exhaust gas pollution which is threatening human social life in cities as one step toward that ultimate goal.

The object of the present invention is to provide a gear train for a hybrid electric vehicle with a gasoline internal combustion engine and a storage battery-equipped electric motor, whereby driving [the vehicle] with one or a combination of these [drive sources] allows the amount of output exhaust gases to be varied during travel in keeping with atmospheric pollution conditions.

The present invention is explained below using the diagrammed embodiments. Fig. 1 shows an example of the hybrid electric vehicle gear train of the present invention; Fig. 2 shows a specific embodiment of the automatic transmission mechanism of Fig. 1. In each of these figures, case 1 contains a transmission mechanism, and an externally located electric motor mechanism. Inside this case 1, the input shaft 3 from the internal combustion engine 2 is connected to a first clutch 3 clutch drum 5 and a second clutch 6 clutch hub 7. A first clutch 4 clutch hub 8 is connected to a planetary gear device 20 first sun gear 21 through a first intermediate shaft 9; a second device 6 clutch drum 10 is connected to a second sun gear 22 thereof through a second intermediary shaft 11, and a brake 12 is disposed between a second clutch 6 clutch drum 10 and the case 1.

The planetary gear device 20 is integrally formed with the first and second sun gears 21 and the 22 and has meshing pinion gears 23 and 24; of these, a ring gear 25 meshes with the first pinion gear 23 and a carrier 26, which supports both pinion gears 23, 24, is connected to the output shaft 13. Oil pumps 14, 15 are respectively disposed on input shaft 3 and output shaft 13; the pressurized oil produced by these oil pumps 14, 15 is selectively supplied to clutches 4, 6 and brake 12 through a hydraulic control circuit (not shown). A low speed stage speed reduction ratio of $1+\frac{Z_{22}}{Z_{21}}$, determined by the number of first sun gear 21 teeth Z_{21} and the number of second sun gear 22 teeth Z_{22}, is obtained by

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the supply [of hydraulic pressure] to the input shaft 3 and the brake 12 to engage [these] by friction, and a high speed stage direct linkage is obtained by supplying [hydraulic pressure] to the first and second clutches 4, 6 and [consequent] friction engagement thereof.

An electric motor drive system path is disposed on such an internal combustion engine drive system path. Transfer gears 30, 31, respectively having the same pitch circle diameters. are disposed on the second intermediate shaft 11 which is integral with the planetary gear device 20 second sun gear 22, and on the ring gear 25. Drive gears 34, 35 are respectively meshed with transfer gears 30, 31 through intermediate gears 32, 33 in order to adjust the rotational direction [of transfer gears 30, 31]. On each of the drive gears 34, 35 are disposed DC motors 36, 37 capable of also becoming electric generators, and wiring 39, 40, capable of transferring electrical power, is connected between these DC motors 36, 37 and a storage battery 38, and is further connected to the exciter side of wiring 43, 44, which is equipped with controllers 41, 42 which change vary and change the polarity of an excitation current. An excitation current is thus supplied to the second DC motor 37 from the storage battery 38 to turn the drive gear 35, while at the same time hydraulic pressure is supplied to the brake 12 to engage it, thus restricting the rotation of the planetary gear device 20 second sun gear 22 so as to obtain a reduction ratio of $(1+\frac{Z_{22}}{Z_{25}}) \times \frac{Z_{31}}{Z_{35}}$, determined by the second sun gear 22 tooth count Z_{22}, the ring gear 25 tooth count Z_{25}, the transfer gear 31 tooth count Z_{31} and the drive gear 35 tooth count Z_{35}, so that an output torque of $(1+\frac{Z_{22}}{Z_{25}}) \times \frac{Z_{31}}{Z_{35}}$ x T is obtained with respect to the DC motor 37 torque T. Therefore output torque control is controlled by holding the reduction ratio in a fixed state, and the output shaft 13 is reversed and movement caused to go backward by [using] the controller to reverse polarity. Given the DC motor 37 characteristics, the DC motor 37 acts as a generator by virtue of being driven from the output side, yielding an engine brake effect and the capacity to charge the storage battery 38, but using the controller 42, it is [also] possible to cut the excitation current and travel without the engine brake.

In the gear train of the present invention, driven independently using an internal combustion engine and an electric motor constituted as described above, we shall further explain the hybrid drive in which the motive force from the internal combustion engine 2 is imparted to the first sun gear 21 by the action of the first clutch 4, while at the same time the motive force from DC motors 36 or 37 is respectively imparted to the second sun gear 22 or the ring gear 25. At this point, engine motive force output torque is controlled by the engine throttle valve, and both of the DC motors 36, 37 are made able to [function] as either motors or generators by means of the controllers 41, 42, while their rotational speed can be decreased or increased by the freely selected inclination [thereof]. By the combination of the three gears 21, 22, 23, whose output torque and rotational speed is thus controlled, the planetary gear device 20 attains a continuously variable transmission over a wide speed shift range on the output shaft 13 through the carrier 26. In this case, as shown in Fig. 3, deceleration is linear along the curve a from three times the first DC motor 36 input shaft 3 rpm to zero, and increases linearly along the curve b from the state at which it reverses at 0.5 times the second DC motor 37 input shaft 3 through zero up to approximately twice that [speed] in the positive rotation state. As a result, the speed ratio obtained on the output shaft 13, which is the rpm ratio with respect to the input shaft 3, passes continuously from zero through 0.3, at which the second DC motor 37 rotation is zero, through 1.0, at which the second DC motor 37 is the same as the input rotation, up to 1.5, at which the first DC motor 36 rotation is zero. In this continuously variable speed regime from zero to overdrive, the second DC motor 37 functions as a generator when the speed ratio is below 0.3, as does the first DC motor 36 when the [speed ratio] is above 0.3. The electrical energy obtained from this generation is used as is to activate the motor, not for charging the storage battery 38.

Efficiency is indicated in Fig. 4 as a horsepower ratio between the input shaft 3 and the output shaft 13 over the entire speed shift operational speed ratio range. In this figure, efficiency in the mechanical portion is taken to be 100%. The power transfer rate for the electrical portion is used as a parameter; curve c shows the case in which that efficiency is 80%, and curve d shows the case in which it is 50%. As is clear from the figure, efficiency climbs rapidly until the speed ratio reaches approximately 0.4; past that speed ratio, efficiency is maintained above 80% so long as the electrical portion power transfer efficiency does not drop below one half; in curve c, a high efficiency close to 100% is maintained. Fig. 5 shows the relationship of the stall torque ratio, which expresses the torque ratio obtained when the output shaft 13 is stopped, with respect to the electrical portion power transfer efficiency. As is clear from the figure, the rise in torque ratio is comparatively gradual up to an electrical portion power transfer efficiency of about 0.6, rising rapidly at subsequent efficiencies; a high torque ratio is obtained when the efficiency is zero, such as when the vehicle is starting to advance. In a hybrid drive of this type, the embodiment uses the generated electrical power as is for the motor, with none being used for charging, but a portion of the electrical power generated as part of the electrical drive during vehicle travel may be stored in the storage battery 38. It is also possible to use this system to supplement [power] from the storage battery 38 so that not all of the large torque [needed] during rapid acceleration is supplied from the internal combustion engine 2. Furthermore, a reverse speed may be obtained in this case as well using the controllers 41, 42.

To explain the use of the gear train of the present invention, drivable by means of the above three systems of standard internal combustion engine drive, electrical drive, and a hybrid drive of the two, the electrical drive system, which is of course completely free of exhaust gases, would be used in cities or at times or places where atmospheric pollution was excessive, at which times travel would take place by imparting a sufficient drive force at a pre-determined fixed reduction ratio. Next, when atmospheric pollution was middling, the load on the internal combustion engine 2 would be lightened by electrical power supplementation from the storage battery 38 using the hybrid drive system; exhaust gas generation would be ameliorated, and driving could be accomplished at the best efficiency at all times using continuously variable transmission. Furthermore, in locations where the exhaust gases are sufficiently dispersed in the atmosphere, such as fully exurban areas, a sufficient acceleration using a two stage gear shift ratio and a good response could be achieved using the internal combustion engine drive system.

Finally, to explain another embodiment of the planetary gear device 20 in Fig. 6, omitting those portions which are the same as described above, the two pinion gears 23', 24', which are separated in the figure, mesh respectively with sun gears 21, 22; the second pinion gear 23' is connected to the first intermediate shaft 9, and the carrier 26' which supports the first pinion gear 25' is connected to the second ring gear 28 which meshes with the second pinion gear 23'; two gear ratios – direct and overdrive – are obtained in the internal combustion engine drive system by selective operation of the two clutches 4, 6 and the brake 12.

As explained above, according to the hybrid electric vehicle gear train of the present invention, an electrical drive system with no exhaust gas whatsoever and a hybrid drive system which significantly reduces exhaust gas are provided in addition to a normal internal combustion engine system. Exhaust gas volumes are effectively reduced or made zero when driving at times or locations prone to atmospheric pollution, and vehicle function is sufficiently assured. Due to the planetary gear device 20 structure, overall gear train efficiency is comparatively high in the hybrid drive system even when the electrical portion efficiency is low, offering the advantages of continuously variable speed over a wide speed change range and a high torque ratio at start up. Furthermore, because the storage battery 38 can be charged during vehicle travel, the long charging times which are the biggest difficulty with electric vehicles can be eliminated, and control operations and changeover between each of the systems can be easily effected.

4. Brief Description of Figures

Figure 1 is a block diagram showing an example of the gear train of the present invention. Figure 2 is a vertical cross-sectional view that shows the structure of the automatic transmission mechanism within Figure 1. Figure 3 is a graph showing the correlation between the speed ratio of the DC electric motor and the speed ratio of the gear train. Figure 4 is a graph showing the correlation between gear train efficiency and the speed ratio thereof using the power transfer efficiency of the electrical portion as a parameter. Figure 5 is a graph showing the correlation of the stall torque ratio and the power transfer efficiency of the electrical portion. Figure 6 is a block diagram showing another example of the gear train of the present invention.

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2. Internal combustion engine

3. Input shaft

4. First clutch

6. Second clutch

12. Brake

13. Output shaft

20. Planetary gear

21. First sun gear

22. Second sun gear

25. Ring gear

26. Carrier

36. First DC electric motor

37. Second DC electric motor

38. Battery

(19)

[see source for figures]

Figure 1

Figure 2

[see source for figures]

Figure 3

X axis: Speed ratio

Y axis: DC Electric Motor Speed Ratio

Figure 4

X axis: Speed Ratio

Y axis: Efficiency

Figure 5

X axis: Electrical Portion Power Transfer Efficiency

Y axis: Stall Torque Ratio

Figure 6

~~5~~6. List of Attachments 1 character corrected

(1) Application Copy 1

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12 characters corrected

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1. 発明の名称
複合電気自動車の歯車伝動装置

2. 特許請求の範囲に記載された発明の数

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明 細 書

1. 発明の名称

複合電気自動車の歯車伝動装置

2. 特許請求の範囲

太陽歯車、キャリヤおよびリング歯車の各回転要素から成る遊星歯車機構中の一軸を第1切替クラッチを介して原動機関の出力軸側に連結し、その第2軸を発電機軸に連動結合しその第3軸を車両の推進軸側に連結した構成において、上記第3軸側に歯車噛合伝動によって電動機軸を連結して電動機のみによるMモード運転系を形成し得ると共に上記発電機および電動機間に蓄電池とコントローラを配設してこれらを電気的に結合することによって原動機関と電動機による複合回転伝動を可能なM－Eモード運転系を形成させ、更に上記第2軸上か或は第1軸と第3軸間に第2切替クラッチを装着せしめることによって原動機関によるEモード運転系を形成するようにしたことを特徴とする複合電気自動車の歯車伝動装置。

3. 発明の詳細な説明

本発明は複合電気自動車の歯車伝動装置に関するものである。ガソリンエンジンやディーゼルエンジンによる自動車の排気ガスは大気汚染の一原因であるとしてマスキー法案にみられる如く排気ガス規制が厳しくなりつつある。そこで排気ガスを出さずに走行できる電気自動車が内外で注目されてきているが、一充電走行距離が短いとか重量が大きくなる等の欠点によりまだ従来の内燃機関にとってかわるまでに至っていない。そこで内燃機関と蓄電池を併用してあるときは蓄電池で電動機を駆動し(以後Mモードと呼ぶ)、あるときは内燃機関、電動機双方で駆動しそのとき内燃機関の動力の一部を発電機で電気エネルギーに変換して蓄電池を充電し(以後M－Eモードと呼ぶ)、またあるときには内燃機関のみで駆動(以後Eモードと呼ぶ)して走行できる複合電気自動車が注目を集めてきている。すなわちこのM，M－E，Eの各モードを都市内、郊外等で使い分けることによって排気ガスが特に問題となる場所ではそれを低減しようというものである。

この複合電気自動車に関する歯車伝動装置については、いくつかの公知技術が散見されるが比較的複雑な歯車伝動装置を用いているのでクラッチの数が多くなってしまうもの、あるいは全く単純な蓄電池と内燃機関の複合方式であるため電動機に大きな負担がかかるもの等に止まりまだ満足できるものは少い。

本発明は上記公知技術の欠点に鑑み、改良された複合電気自動車の歯車伝動装置を提供するものである。すなわち本発明の目的は歯車機構の連続構成が比較的簡単でありまたクラッチ等摩擦係合装置も比較的少く、簡単な構成でしかも良好に作動する複合電気自動車の歯車伝動装置を提供することである。本発明に係る歯車伝動装置を用いれば電動機は常に電動機として、発電機は常に発電機として作動するのでコントローラの負担が少く、また完全な無段変速が可能であり時に応じM，M－I，I各モードをそれぞれの運動態様に従って使いわけられる利益がある。そして動力伝達効率を上昇させるためにオーバドライブさせることも可能であり、走行速度が上昇するほど動力伝達効率は上昇ししかもIモードにしたときが最高の動力伝達効率となるので安定高速走行が可能である。

本発明に係る歯車伝動装置の構成について添附図面により詳細に説明する。各実施例を第1図から第4図に示したが、第2図以降の実施例の基本的な構成は第1図のそれと類似しているので主として第1図について説明し、その他に関しては若干の補足を加える。まず第1図を参照されたい。

内燃機関10のクランク軸に連結した歯車伝動装置の入力軸1があり、これは第1モード切替クラッチ60を介して中間軸4に連結される。この入力軸1には歯車ポンプ等の油圧供給源3があり、内燃機関10の動力の一部で油圧を発生させてクラッチ等の係合を為す動力源となる。内燃機関10の動力によらないで別の小型電動機により走行中常に一定油圧を得る方法もあり、この場合には内燃機関10が停止していても常に油圧を発生できる利点がある。

中間軸4は遊星歯車機構50の遊星歯車55を回転自在に軸支するキャリア51に一体的に結合されており、遊星歯車55と噛合う太陽歯車52は中空回転軸の後端に一体的に取付けられている。そしてこの中空回転軸の前端は多板式変速用ブレーキを構成する第2モード切替クラッチ70の回転可能な摩擦板72に結合され、一方クラッチ70の固定摩擦板71はケースに固着されている。従って油圧によって第2モード切替クラッチ70が係合されると中空回転軸5はケース73に対し固定状態となる。この中空回転軸5にはスプライン嵌合された歯車23があり、この歯車25に噛合う歯車22の回転軸21は発電機20の軸となっている。遊星歯車機構50のリング歯車54は出力軸2上に取付けられ、この出力軸2上には歯車33がスプライン嵌合し、これに噛合う歯車32を介して電動機30と連結している。一方において、電動機30と発電機20とはそれぞれ蓄電池40を介して電気的に関係づけられる。すなわち配線43，46は励磁側に接続されており、コントローラ41，42は励磁電流を制御する。一方配線44，45は蓄電池40、発電機20、電動機30間の電力の受け渡しをする。

次に第2図の実施例について説明する。なお、第1図の実施例と同一の部品に関しては同じ参照番号を用いている。（以下第6図まで同様である。）第1図と異る点は遊星歯車機構~~450~~が2列で構成されていることである。すなわち前列遊星歯車機構150のリング歯車154は後列遊星歯車機構の遊星歯車157を軸支するキャリヤ155と一体になっており、しかもこれは出力軸102と連結している。また後列遊星歯車機構150のリング歯車158は常にケース174に固着されている。そしてその太陽歯車156と一体に結合した歯車133に噛合う歯車132の軸は電動機130と一体的に結合している。

3字削除　3字加入　3字加入

次に第5図の実施例を説明する。第1図の実施例では発電機20と連結する遊星歯車機構の太陽歯車52は一端をケース75に固着した第2モード切替クラッチ70に連結されていたが、この実施例では第2モード切替クラッチ270は遊星歯

車機構のキャリア251とリング歯車254の間、言い換えれば中間軸204と出力軸202の間に設けた点が異っている。第2モード切替クラッチ270を係合させれば中間軸204と出力軸202は一体となる。

次に第4図について説明する。この実施例では中間軸304は遊星歯車機構350の遊星歯車を軸支するキャリア354と一体的に連結している。リング歯車353は中空回転軸305と連結されておりこれに歯車323がスプライン嵌合されている。さらに歯車322を介して発電機320と連結されている。また第2モード切替クラッチ370は遊星歯車機構350のリング歯車353に連結されており、太陽歯車351は出力軸302と連結されている。

次に第5図の実施例を説明する。この実施例では遊星歯車機構450が2重遊星歯車で構成されている点が前記各実施例と異っている。中間軸404はリング歯車454と連結しており、太陽歯車451は第2モード切替クラッチ470と連結していて、2重の遊星歯車452，453を軸支するキャリヤ455は出力軸402に連結されている。

最後の実施例である第6図でも第5図と同様に2重遊星歯車を使用している。中間軸504はリング歯車554を連結し、太陽歯車551は出力軸502と連結している。2重の遊星歯車552，553を軸支するキャリア555は中空軸505を介して第2モード切替クラッチ570に連結され、この中空軸505に歯車523，522を介して発電機520が連結している。

以上本発明の歯車伝動装置の構成について説明したが、次いでその作動態様を詳細に述べる。各実施例について基本的な動作は類似する点が多いので主として第1図の実施例を中心として説明し、他の実施例については異った作動をするものについてのみ記載する。

再び第1図を参照されたい。前述の如く本発明によってM，M－E，Eの各モードをとることが可能である。すなわち油圧供給源3から油圧を制御回路（図示せず）を通して第1モード切替クラッチ60，第2モード切替クラッチ70に選択的に供給し或は排出してそれらの係合，解放によって下表の如くM，M－E，E各モードをとることができる。

	Mモード	M－Eモード	Eモード
第1モード切替クラッチ60	×	○	○
第2モード切替クラッチ70	×	×	○

○ 係合

× 解放

上表のごとく、クラッチ60，クラッチ70をともに解放した状態ではMモードになる。内燃機関10は出力軸2と完全に切離されているので電動機30の駆動力のみで車両を駆動するわけである。また内燃機関10と発電機20の間も切離されているので、Mモードにおいては走行中発電機20によって蓄電池40を充電することは不可能である。しかし停車時に出力軸2を停止させておいてクラッチ60を係合させ内燃機関10の動力で発電機20を駆動し蓄電池を充電させることは可能である。

Mモードによる走行はコントローラ42による電動機30の回転数制御によって行なわれる。すなわち歯車32，33を介して出力軸に対しトルクを増大させて走行する。

第7図にMモードでの電動機回転数と車速の関係を示す。この関係は直線的でその傾きは歯車32と歯車33の歯数比に基づくものである。この歯数比を変化させることによって車速を上昇させることは可能であるが、実際上ある程度以上にするのは困難である。そこで歯車を2段にして歯数比を充分大きくとれるようにして電動機30を低トルクで高回転のものを使用可能にしたのが第2図の実施例である。前述の如くこの実施例では電動機130と出力軸102の間には歯車132，133に加えて遊星歯車機構180が一組設けられている。しかもリング歯車158は常にケースに固着され歯車133と太陽歯車156は一体であるから、

$$i=\frac{\text{歯車135の歯数}}{\text{歯車132の歯数}}$$

$$\rho=\frac{\text{太陽歯車156の歯数}}{\text{リング歯車158の歯数}}$$

とすれば電動機130の回転トルク T_M に対して出力軸の回転トルク T_O は

$$T_O=i\times\frac{1+\rho}{\rho}T_M$$

となり第1図の実施例に比して $(1+\rho)/\rho$ 倍だけ回転トルクを上昇させ得るわけである。また電動機の回転トルク T_M はコントローラ142により励磁電流を変化させれば変化させることができ、したがって T_O も T_M に応じて制御されることになる。

Mモードに関して第5図から第6図の各実施例の歯車伝動装置は第1図の実施例と類似の態様で作動する。

再び第1図を参照されたい。ここまで説明したMモードでは第1モード切替クラッチ60，第2モード切替クラッチ70共に解放状態であったが次に内燃機関10を回転させておいてクラッチ60のみ係合させクラッチ70を解放状態に保つ。このときには内燃機関10と出力軸2は遊星歯車機構50を介して連結されしかも電動機30の動力も出力軸2に加わるから、全体として内燃機関と電動機の動力は複合伝達される。この状態はM−Eモードであり、このM−Eモードでは内燃機関10の動力の一部が遊星歯車機構50の太陽歯車52から分流して歯車23，22を介して発電機20を駆動する。すなわち発電機20により電気的エネルギに変換されコントローラ41で制御され蓄電池を充電する。電動機30は蓄電池の電気エネルギによってコントローラ42で励磁電流を制御することによって駆動される。一方キャブレータ絞り弁の開度を一定にすることにより内燃機関10の出力を一定に保持しておいて、電動機30の回転速度のみの制御によって出力軸2の回転速度を変化させることが可能である。

M−Eモードにおいて内燃機関10の回転速度と出力軸2の回転速度の比 e に対する発電機20および電動機30の内燃機関10に対する各回転速度比 e_g，e_m との関係を第8図に示す。M−Eモードに移った時点（モード変換点と呼ぶ）の速度比を e^* とするとそのときの発電機20の回転速度比 e_g はB点で示される。一方電動機30の速度比 e_m はA点で示される。これら速度比は内燃機関10の回転速度に対する比であるから、前述の如くキャブレータの絞り弁によって内燃機関10の回転速度を一定にしておけば各速度比はそのまま電動機、発電機および出力軸の回転速度に対応する。

上記モード変換点よりコントローラ41，42を制御して e を徐々に大きくしてゆけば、第8図に示す如く電動機30の回転速度の増大にしたがって、リング歯車55とキャリア54の間の差動的回転によって太陽歯車52に連結した発電機20の回転速度は徐々に減少してゆく。すなわち e を増大させるにしたがって歯車伝動機構において駆動力に占める内燃機関10の占める割合は増大し、電動機30の占める割合は減少してゆく。$e=e_{max}$（最大速度比と称する）になると発電機20は全く回転を停止し、一方電動機30は最大の回転速度となる。ただしこの場合電動機30はその回転速度は大きくても駆動力としては殆んど零になり、内燃機関10のみによって駆動されていることに注意する必要がある。またこのとき後述する如く入力軸1と出力軸2の間でオーバドライブが達成さるべき歯車構成になっていることにも注意する必要がある。

$e=e_{max}$ の時点では前述の如く遊星歯車機構50の太陽歯車52は停止するのでこのとき第2モード切替クラッチ70に油圧を供給しこれを係合させる。クラッチ70のブレーキ作用によって発電機20は全く作動しなくなり、また蓄電池40から電動機30への電気エネルギの供給も断たれ、電動機30も自由回転しているだけなので内燃機関10によって純機械的に出力軸は連結され駆動される。すなわちこれがEモードである。このと

き前述の如く

$$\rho = \frac{\text{太陽歯車の歯数}}{\text{リング歯車の歯数}}$$

とすれば

$$\text{歯数比} = \frac{1}{1+\rho}$$

となり回転速度比としては$1+\rho$のオーバドライブが達成される。

ここでeと動力伝達効率の関係をとったものを第9図に示す。e^*の時点までは第1モード切替クラッチ60が係合していないので電動機20の駆動力の増大と共に動力伝達効率は上昇する。M−Eモードに移る時点e^*で動力伝達効率が不連続になるのはクラッチ60の係合によって発電機20へ駆動力が分流するからであり、その後はeの増大と共に発電機20へ分流する駆動力は減少し動力伝達効率は上昇する。e_{max}では発電機20の回転は全く停止し損失は純機械的なもののみとなり動力伝達率は最大となる。以上のことは第2図および第4図から第6図の各実施例においても第1図の実施例と類似である。

しかし第3図の実施例はそれらと若干異った作動をするので説明を加える。第3図の実施例では前述の如く第2モード切替クラッチ270はその一端でケースに対し固着されておらず、中間軸204と出力軸202の間にある。このクラッチ270は入力軸201と出力軸202の間を純機械的に直結させるためのものである。すなわちクラッチ270を係合させると遊星歯車機構250は入力軸201と一体になって回転し入力側の駆動力は出力軸へ直結される。ここで同時に電動機230への電気エネルギの供給を絶てばこれが第3図の実施例におけるEモードとなる。この場合クラッチ270にブレーキ作用はなくクラッチ270を係合させても発電機220は回転したままである。さらに車速を上昇させるためには、第2モード切替クラッチ270を解放し、遊星歯車機構250におけるリング歯車254とキャリア251の間の差動回転によって発電機220がさらに減少するように電動機230を回転させてオーバドライブ状態を達成させれば良い。

第3図の実施例での動力伝達効率を第9図に示す。$e=1$の時点で動力伝達効率が特異点となるのがこの実施例で特に変っている点である。

これまで本発明の歯車伝動装置についてその構成，作動態様を説明したが次に実際の走行中でのM，M−E，E各モードの使用，切替の態様を説明する。

Mモードは低速域すなわち車両のスタート時からある程度の車速になるまでに用いる。また内燃機関は完全に停止しており、排気ガスは全く発生しないから、都市内走行など低速で充分でしかも排気ガスの規制が厳しい場所で継続的に用いるのにも適している。また電動機の回転方向をコントローラで逆回転させれば後進可能になる。

都市内でMモードで走行し郊外に出てM−Eモードに切替えるときにはまず内燃機関を始動させる。内燃機関10の動力によって入力軸1が回転し、ポンプ5は油圧を発生する。この油圧によって第1モード切替クラッチを係合させる。このとき予め設定した内燃機関の回転速度まで一気に上昇させる。このモード切替時点を設定した速度比とするなら、その時の内燃機関の回転速度は一意的に決るから、そこまで上昇させるように制御系で制御する。これによって電動機に回転速度変化を与えることなく連続的にM−Eモードに移ることができる。一度M−Eモードに入ってしまったら、相当低速まではMモードに戻らないようにする制御系は実用上設ける必要がある。

M−Eモードでは、発電機はコントローラ41で制御されつつ発電作用を為すが、Mモードにおいても蓄電池を使用するのであるから発電機の性能は適切なものを選ぶ必要がある。また公害対策上内燃機関は最も排気ガスの少い回転速度で一定にしておくという方法は極めて有効である。

M−EモードからMモードの切替時には、まず第1モード切替クラッチに加わっている油圧を排出して解放状態にし、次に内燃機関を停止させれ

ば良い。

M－EモードからEモードへの切替時には、発電機が停止した時点を感知し第2モード切替クラッチを係合させれば良い。Eモードは高速道路等で高速，一定の走行に適している。このとき歯車伝動装置の動力伝達効率は最高であるから経済的走行が可能である。

その他本発明によれば、コントローラによって電動機の回転速度を連続的に変化させて完全な無段変速走行を為すことができるという利点もある。

4．図面の簡単な説明

第1図は本発明の第1の実施例を示す歯車伝動装置の概略図、第2図は第2の実施例を示す歯車伝動装置の概略図、第3図は第3の実施例を示す歯車伝動装置の概略図、第4図は第4の実施例を示す歯車伝動装置の概略図、第5図は第5の実施例を示す歯車伝動装置の概略図、第6図は第6の実施例を示す歯車伝動装置の概略図、第7図はMモード時の電動機回転速度と車速の関係、第8図は入，出力軸の回転速度比 e と、入力軸と電動機および発電機の回転速度比 e_m，e_g の関係図、第9図は第1図，第2図，第4図から第6図の各実施例の歯車伝動装置における入，出力軸回転速度比 e と動力伝達効率の関係図、第10図は第3図の実施例の歯車伝動装置における入，出力軸回転速度比 e と動力伝達効率の関係図。

1････入力軸、　2････出力軸、　3････油圧ポンプ、　4････中間軸、　5････中空回転軸、　10････内燃機関、　20････発電機、　30････電動機、　40････蓄電池、　41，42････コントローラ、　50････遊星歯車機構、　60････第1モード切替クラッチ、　70････　第2モード切替クラッチ。

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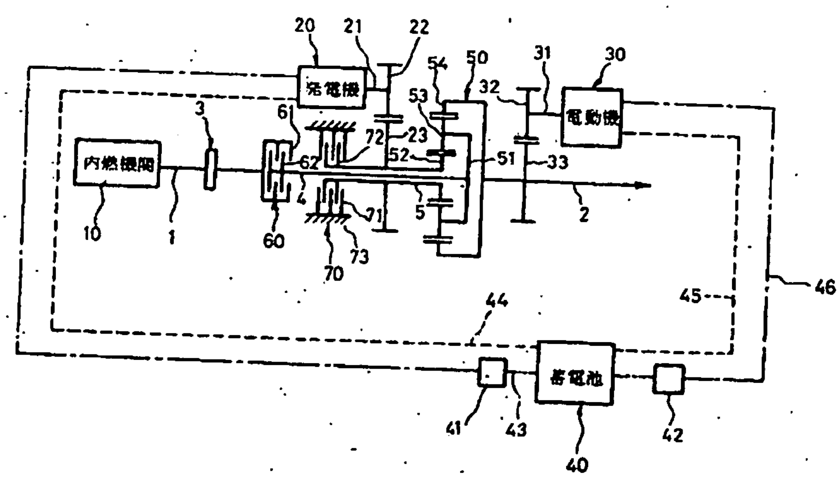
第1図



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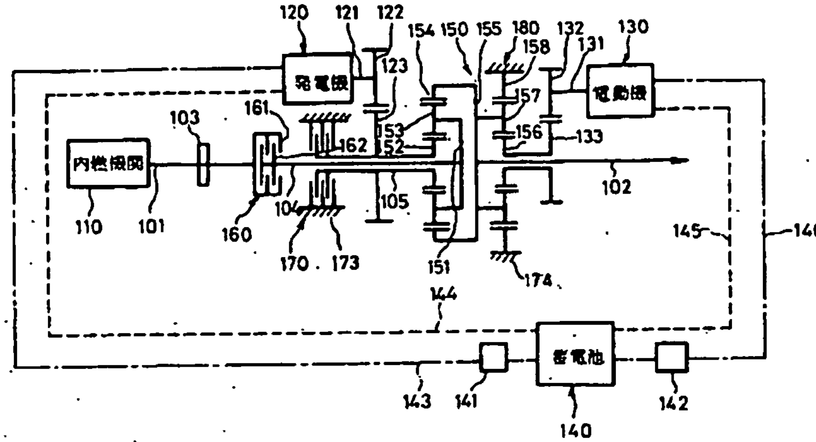
第 2 図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発電機
電動機
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152
内燃機関
102
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105
110 101
160
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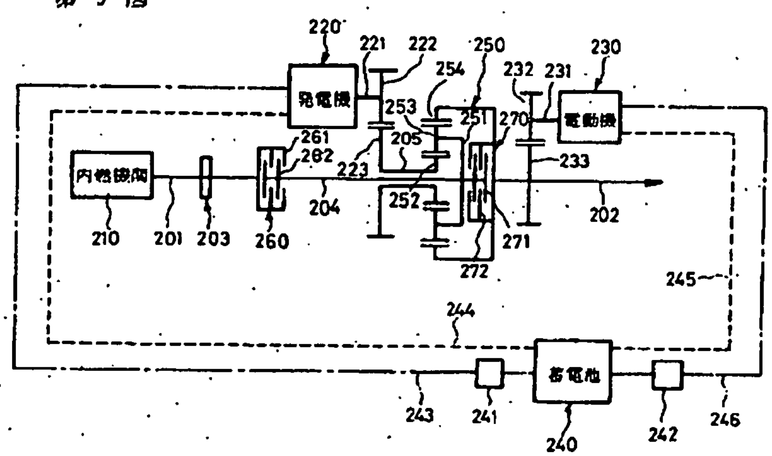
146
170 173
151
174
144
蓄電池
143 141
142
140

第 3 図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202
210 201 203 260
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245
244
蓄電池
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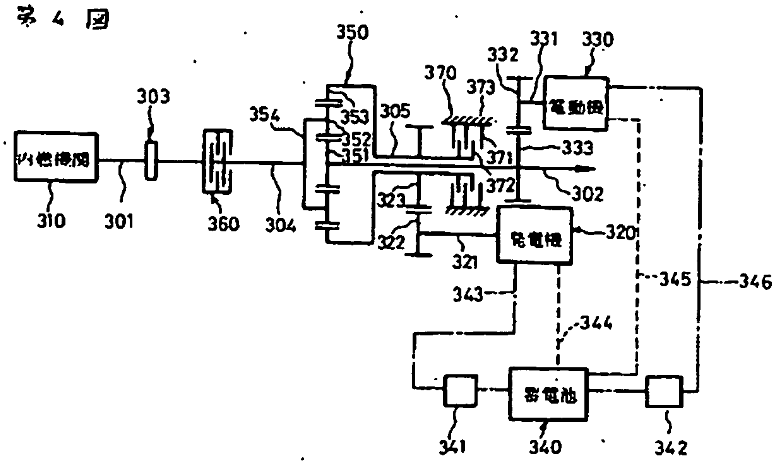
242 246
240

第 4 図



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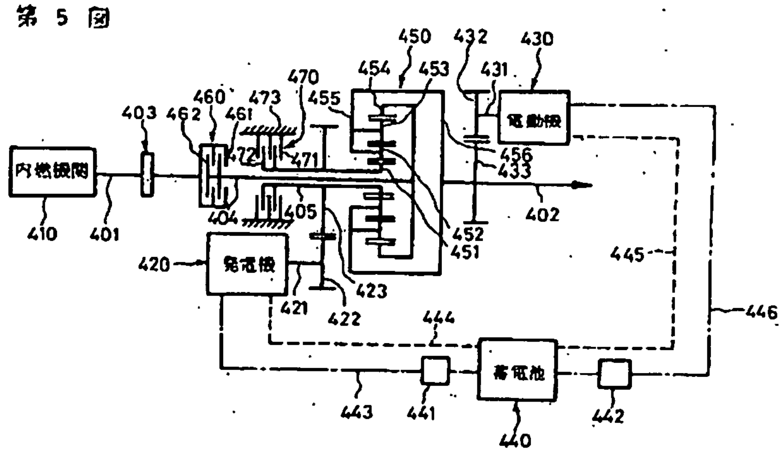

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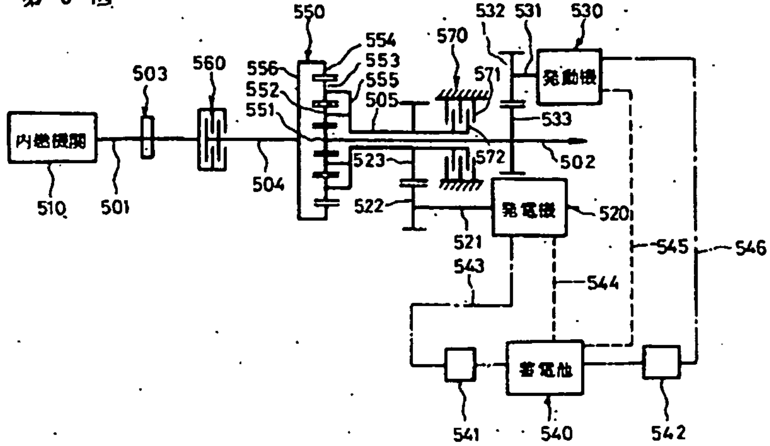
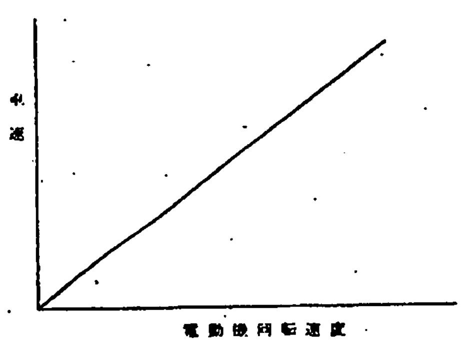
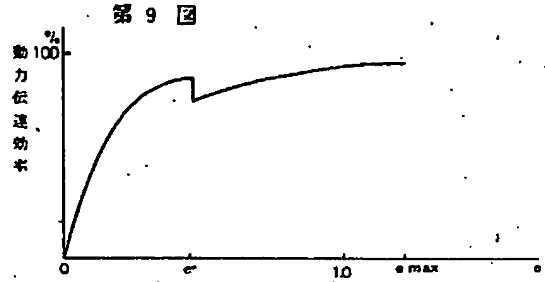
第 6 図



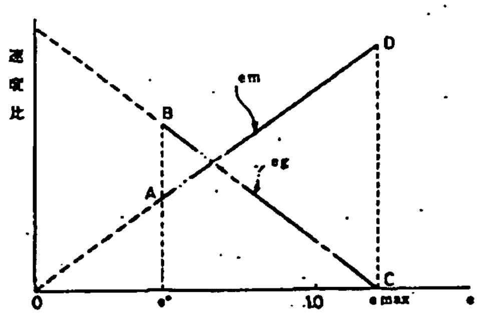
第 7 図



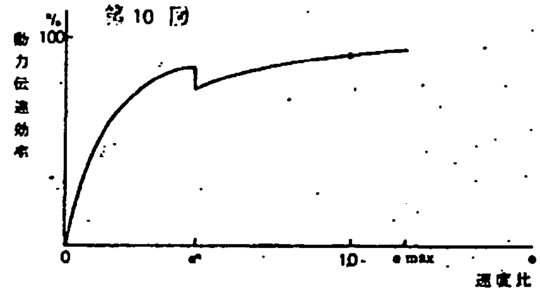
第 9 図



第 8 図



第 10 図



6.添附書類の目録

(1) 願 書 副 本　　1 通
(2) 明 細 書　　1 通
(3) 図 面　　1 通
(4) 委 任 状　　1 通

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CERTIFICATION OF TRANSLATION

I, Christopher Field, a professional Japanese translator accredited by the American Translators Association, hereby attest that the attached translations from Japanese have been faithfully prepared to the best of my ability.

1. JP 50-30223
2. JP 48-49115

Date: May 17, 2004

By: [signature]

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Patent Application

(¥ 2000)

7/20/1973

Patent examiner: Yukio Miyake

1. Name of Invention

   Hybrid Electric Vehicle Gear transmission device

2. Number of Inventions Described in the Range of Patent Claims:___

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(22) Application Date: 7/20/1973

Examination Request: Examination None (Total of 10 Pages)

File Number:

7052 51

(52) Japanese	(51) Int. Cl. ^{2}
Classification	B b0L 11/02
80 A 02	

Specification

1. Name of Invention

Hybrid Electric Vehicle Gear Transmission Device

2. Claim

A hybrid electric vehicle gear transmission device in which one shaft of a planetary gear mechanism comprising the rotational elements of a sun gear, a carrier, and a ring gear is connected to the output shaft side of an engine through a first switching clutch, a second shaft thereof is connected to an electric generator, and a third shaft thereof is connected to the vehicle propelling shaft side, an M-mode drive system based on only the electric motor can be formed, in which the electric motor shaft is linked by the gear engagement transmission on the above third shaft side, while an M-E mode drive system can be formed using a hybrid rotation drive based on an engine and an er and electric motor by disposing a storage battery and a controller between the above generator and electric motor and electrically linking these [elements]; furthermore by inserting a second switching clutch on the above second shaft, or between a first shaft and a second shaft, and E mode drive system based on an engine can be formed.

3. Detailed Explanation of Invention

The present invention relates to gear transmission devices for hybrid electric vehicles. Vehicle exhaust gases from gasoline engines and diesel engines are the primary sources of air pollution, and regulations pertaining to exhaust gases are becoming stricter, as seen in the Muskie Act. Given this, even though there is considerable interest, both in Japan and overseas, in electric vehicles that are able to travel without producing exhaust gases, weaknesses, such as the short distance that can be traveled on a single charge, and the increased weight [of the electric vehicles] have prevented electric vehicles from reaching the point wherein they can replace conventional internal combustion engines. Given this, attention has focused on hybrid electric vehicles that can travel in a so-called M mode wherein an electric motor is driven by a storage battery when a storage battery is used in parallel with an internal combustion engine, an M-E mode wherein, at some time, power is provided by both the internal combustion engine and the electric motor, where, at such times, a portion of the power from the internal combustion engine is converted into electrical energy in an electric generator and is stored in the storage battery, and can travel in an E mode wherein the propulsion is by the internal combustion engine alone. In other words, by using the M, M-E, and E modes selectively for urban driving or suburban driving it is possible to reduce exhaust gases in the places wherein the exhaust gases are particularly problematic.Although a variety of prior art can be found regarding gear transmission devices relating to these hybrid electric vehicles, these make use of relatively complex gear transmission devices, and therefore have large numbers of clutches, or use extremely simplistic battery and internal combustion engine hybrid methods, placing large loads on the electric motor; thus there are still few cases wherein [performance] is satisfactory.

In consideration of the weaknesses in the prior art, described above, the present invention provides an improved gear transmission device for a hybrid electric vehicle. In other words, the object of the present invention is to provide a gear transmission device for a hybrid electric vehicle that has excellent operation using relatively simple drive train, or with relatively few clutch or other friction engagement devices. When the gear transmission device according to the present invention is used, the electric motor always operates as an electric motor, and the electric generator always operates as an electric generator, so the load on the controller is reduced; fully infinitely variable transmission is possible, with the benefit that at different times the M, M-E, and E modes can be used selectively, depending on the driving conditions. Furthermore, it is also possible to engage an overdrive in order to increase the power transmission efficiency; power transmission efficiency increases as the driving speed increases, and the optimal power transmission efficiency will be in the E mode, thus providing stable high-speed travel.

The structure of the gear transmission device according to the present invention will be explained in detail using the attached drawings. Figures 1 through 6 show the various example embodiments, where the basic structure in the example embodiments in Figure 2 and above are similar to those in Figure 1, and are primarily explained using Figure 1, where minor changes have been made regarding the others. First, let us reference Figure 1.

There is an input shaft 1 for the gear transmission device connected to the crankshaft of an internal combustion engine 10, where this [input shaft 1] is connected to an intermediate shaft 4 through a first-mode switching clutch 60. This input shaft 1 has a lubrication supply source 3, such as a pump, where a portion of the power of the internal combustion engine 10 generates oil pressure to be the motor source for the meshing of the clutch, etc. There are also other methods, not using power from the internal combustion engine, for obtaining a constant oil pressure during travel using a small electric motor, in which case there is a benefit in that it is always possible to generate the oil pressure, even if the internal combustion engine 10 is stopped.

The intermediate shaft 4 is integrated with a carrier 51, which supports a planetary gear 53, in such a way that [said planetary gear 53] can rotate freely, in a planetary gear mechanism 50, where a sun gear 52, which meshes with [said] planetary gear 53, is affixed to the back end of a hollow rotating shaft. Furthermore, the front end of this hollow rotating shaft is connected to a rotating friction plate 72 in a second-mode switching clutch 70 which forms a multi-plate gear shift brake, while the stationary friction plate 71 of the clutch 70 is attached to the case. Therefore when the second mode switching clutch 70 is hydraulically engaged, the hollow rotating shaft 5 becomes fixed with respect to the case 73. The hollow rotating shaft 5 has a spline-engaged gear 23, and the rotating shaft 21 on the gear 22 which engages the gear 23 serves as the generator 20 shaft. The planetary gear mechanism 50 ring gear 54 is attached over the output shaft 2, and a gear 33 is spline-engaged on this output shaft 2, linked to an electric motor 30 via a gear 32 which engages thereto. At the same time, the electric motor 30 and the generator 20 are respectively electrically connected via the storage battery 40. In other words, wiring 43, 46 is connected on the exciter side, and controllers 41, 42 control the excitation current. Wiring 44, 45, meanwhile, hands off electrical power between the storage battery 40, the generator 20, and the electric motor 30.

We next explain the Fig. 2 embodiment. Those parts which are the same as Fig. 1 are referred to using the same reference numerals. (The same is true up to Fig. 6). Points which differ from Fig. 1 reflect the fact that the planetary gear mechanism has a double row configuration. In other words, the front-row planetary gear mechanism ring gear 154 is an integral piece with the carrier 155 which supports the rear-row planetary gear mechanism sun gear 157, and is further linked to an output shaft 102. The rear-row planetary gear mechanism 180 ring gear 158 is always affixed to a case 171, and the shaft of gear 132 which engages the gear 133, integral with the sun gear 157, is integrally linked to an electric motor 130.

We next explain the Fig. 3 embodiment. In the Fig. 1 embodiment, the solar gear 52 of the planetary gear mechanism which is linked to the generator 20 was linked to the second mode switching clutch 70, one end of which was affixed to the case; what is different in this embodiment is that the second mode switching clutch 270 is disposed between the planetary gear mechanism carrier 251 and the ring gear 254, which is to say between the intermediate shaft 204 and the output shaft 202. When the second mode switching clutch 270 is engaged, the intermediate shaft 204 and the output shaft 202 are made integral.

We next explain Fig. 4. In this embodiment, the intermediate shaft 304 is integrally linked with the carrier 354 which supports the planetary gear mechanism 350 planetary gear. The ring gear 353 is linked to the hollow rotating shaft 305; a gear 323 is spline-engaged thereto, and is further linked to the generator 320 via a gear 322. Also, the second mode switching clutch 370 is linked to the planetary gear mechanism 350 ring gear 353, and the sun gear 351 is linked to the output shaft 302.

We next explain the Fig. 5 embodiment. This embodiment differs from each of the previous ones in that the planetary gear mechanism 450 comprises a double planetary gear. The intermediate shaft 404 is linked to the ring gear 454, and the sun gear 451 is linked to the second mode switching clutch 470, while the carrier 455, which supports the double planetary gears 452, 453 is linked to the output shaft 402.

In the last embodiment, Fig. 6, a double planetary gear is used as in Fig. 5. The intermediate shaft 504 is linked to the ring gear 554, and the sun gear 551 is linked to the output shaft 502. The carrier 555 which supports the double planetary gears 552, 553 is linked to the second mode switching clutch 570 via the hollow shaft 505, and the generator 520 is linked to this hollow shaft 505 via the gears 523 and 522.

We have explained above the constitution of the gear transmission device of the present invention; next we shall explain the operation thereof in detail. There are many points of similarity in the operation of the various embodiments, so we shall primarily focus on the Fig. 1 embodiment, noting only the operations which differ from that of the other embodiments.

Again, please refer to Fig. 1. As previously discussed, it is possible with the present invention to adopt each of the M, M-E, and E modes. That is to say, it is possible by selectively supplying or removing hydraulic pressure from hydraulic supply source 3 through a control circuit (not shown) to the first mode switching clutch 60 [and] second mode switching clutch 70, and, by the engagement or release thereof, to adopt the M, M-E, or E modes according to the table shown below.

	M mode	M-E mode	E mode
First-mode switching clutch 60	X	O	O
Second-mode switching clutch 70	X	X	O

O: Engaged

X: Disengaged

As shown in the table above, the M mode occurs when the clutches 60 and 70 are both released. The internal combustion engine 10 is completely isolated from the output shaft 2, so the vehicle is driven by the drive force of the electric motor 30 only. There is also isolation between the internal combustion engine 10 and the generator 20, making it impossible to charge the storage battery 40 with the generator 20 in M mode. However, by stopping the output shaft 2 when halted and causing the clutch 60 to engage, the generator 20 can be driven by the motive force of the internal combustion engine 10 so as to charge the storage battery.

Running in M mode is accomplished by rpm control of the electric motor 30 using the controller 42. In other words, travel is brought about by increasing torque to the output shaft via the gears 32, 33.

Fig. 7 shows the relationship between the electric motor rpm and vehicle speed in the M mode. This relationship is linear, and the slope thereof is based on the gear ratio between gear 32 and gear 33. Vehicle speed can be increased by changing that gear ratio, but it is difficult in reality to push this above a certain level. A two-stage gear is therefore adopted so as to obtain a sufficiently large gear ratio, thus enabling high revolutions at low torque by the electric motor 30, as shown in the Fig. 2 embodiment. As described above, a pair of planetary gear mechanisms 180 is disposed in addition to the gears 132, 133 between the electric motor 130 and the output shaft 102. Moreover, the ring gear 158 is constantly affixed to the case, and the gear 133 and sun gear 156 are integral, so that assuming

i = (number of teeth in gear 133) / (number of teeth in gear 134)

and

p = (number of teeth in the sun gear 156) / (number of teeth in the ring gear 158),

the rotational torque To of the output shaft, relative to the rotational torque Tm of the electric motor 130 will be as follows:

$$T_O = i \times \frac{1+\rho}{\rho} T_M ,$$

and rotational torque can be increased by a power $(1+\rho)/\rho$ compared to the Fig. 1 embodiment. It is also possible to increase the electric motor rotational torque TM by changing the excitation current using the controller 142, and therefore TO is also controlled in accordance with TM.

In the M mode, the gear transmission devices in the embodiments of Figs. 3 through 6 operate in a similar way to that of the Fig. 1 embodiment.

Again, please refer to Fig. 1. In the M mode discussed thus far, both the first mode switching clutch 60 and the second mode switching clutch 70 were in a released state; next the internal combustion engine 10 is rotated and only the clutch 60 is engaged, leaving the clutch 70 in a released state. At this point, the internal combustion engine 10 and the output shaft 2 are linked via the planetary gear mechanism 50, and motive power is applied to the electric motor 30 output shaft 2, so in an overall sense motive power from the internal combustion engine and the electric motor is transferred in a hybrid manner. This state is the M-E mode; in this M-E mode a portion of the internal combustion engine 10 motive power is split off from the planetary gear mechanism 50 planetary gear 52 to drive the generator 20 via the gears 23, 22. In other words, the [motive force] is converted to electrical energy by the generator 20, controlled by the controller 41, and used to charge the storage battery. The electric motor 30 is driven using control of the excitation current from storage battery electrical energy using the controller 42. The internal combustion engine 10 output is held fixed by holding a fixed throttle opening on a carburetor, so that the rotational speed of the output shaft 2 can be varied by controlling only the electric motor 30 rotational speed.

In the M-E mode, the relationships between the ratio e of the internal combustion engine 10 rotational speed and the output shaft 2 rotational speed and each of the rotational speed ratios e_g, e_m of the internal combustion engine 10 with respect to the generator 20 and the electric motor 30 are shown in Fig. 8. Assuming that e* is the speed ratio at the point of transition to the M-E mode (called the "mode exchange point"), the rotational speed ratio e_g at that point for the generator 20 is shown by point B. The electric motor 30 speed ratio e_m is shown by point A. These speed ratios are ratios with respect to the internal combustion engine 10 rotational speed, and therefore by holding the internal combustion engine 10 rotational speed steady using the carburetor as described above, each speed ratio will correspond as is to the electric motor, the generator, and the output shaft rotational speeds.

By gradually increasing e from the above mode exchange point under the control of controllers 41, 42, a differential rotation between the ring gear 55 and the carrier 54 results in a gradual decrease in the rotational speed of the generator 20 linked to the sun gear 52 as the electric motor 30 rotational speed grows, as shown in Fig. 8. In other words, as e is increased, the proportion of motive force contributed by the internal combustion engine 10 in driving the gear transmission device increases, and the proportion of the electric motor 30 decreases. When e = Max (referred to as the maximum speed ratio), rotation of the generator 20 stops completely, while the electric motor 30 reaches maximum speed. However, it must be noted that while the rotational speed of the electric motor 30 is high, its drive force is virtually zero, and driving is done by the internal combustion engine 10 only. It must also be noted that the gear structure is arranged so that overdrive can be achieved between the input shaft 1 and the output shaft 2, as will be explained below.

At the point at which e = emax, the sun gear 52 on the planetary gear mechanism 50 stops, as explained above; it is here that hydraulic pressure is applied to the second mode switching clutch 70 and [the clutch] is caused to engage. The braking effect of the clutch 70 causes the generator 20 to stop operating completely, and the supply of electrical energy from the storage battery 40 to the electric motor 30 is interrupted; the electric motor 30 is simply freely rotating, so the output shaft is linked and driven in a purely mechanical way by the internal combustion engine 10. This is the E mode. At this point, as noted above, if we assume that

p = (number of teeth in the sun gear) / (number of teeth in the ring gear),

we have

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gear ratio = 1/1+p,

and a 1+p overdrive is achieved as the rotational speed ratio.

The relationship between e and drive transmission efficiency is shown in Fig. 9. Up until the point e*, the first mode switching clutch 60 is not engaged, so motive force transmission efficiency increases with the increase in the generator 20 drive force. The reason the motive force transmission efficiency becomes discontinuous at the point e* of transition to the M-E mode is that the drive force to the generator 20 is diverted by the engagement of the clutch 60; thereafter the drive force diverted to the generator 20 rises along with the increase in e. At emax, rotation of the generator 20 stops altogether, and losses are purely mechanical; drive force efficiency is at a maximum. The above elements are similar in each of the embodiments of Figs. 4 through 6 to the Fig. 1 embodiment.

However, the Fig. 3 embodiment operates slightly differently from those, as we shall now explain. In the Fig. 3 embodiment, the second mode switching clutch 270 is not fixed to the case at one end, as explained above; it is [disposed] between the intermediate shaft 204 and the output shaft 202. The purpose of this clutch 270 is to make a purely mechanical link between the input shaft 201 and the output shaft 202. In other words, when the second mode switching clutch 270 is engaged, the planetary gear mechanism 250 forms an integral piece with the shaft 201 and rotates, so that the input-side drive force is directly connected to the output shaft. The E mode of the Fig. 3 embodiment is here obtained by simultaneously stopping the supply of electrical energy to the electric motor 230. In this case there is no brake effect on the clutch 270, and even if the clutch 270 is engaged, the generator 220 will keep rotating. To further increase vehicle speed, the second mode switching clutch 270 should be released and the electric motor 230 further rotated and placed in an overdrive state so that [rotation of the] generator 220 is further reduced by the differential rotation between the ring gear 254 and the carrier 251 in the planetary gear mechanism 250.

The motive force transmission efficiency of the Fig. 3 embodiment is shown in Fig. 9. The aspect of particular difference in this embodiment is that the point of singularity in motive force transmission efficiency occurs at the point e = 1.

Up until now we have explained the constitution and operating states of the gear transmission device of the present invention. We shall now explain the use and switching states of the M, M-E, and E modes in actual travel.

M mode is used during low speeds, in other words, from the time the vehicle starts until it has reached a certain speed. In addition, the internal combustion engine is completely stopped and there are no emissions of exhaust gasses. The vehicle's low speed is sufficient for in-city driving and is suited for continual use in areas where exhaust gas regulations are strict. By controlling the rotating direction of the electric motor, traveling in reverse is also possible.

M mode is for in-city driving; the internal combustion engine starts when the engine switches to M-E mode when driving in the suburbs. The power of the internal combustion engine 10 rotates the input shaft 1 and the pump 3 generates hydraulic pressure. The hydraulic pressure engages the first mode switch clutch. At that time, the rotation of the internal combustion engine immediately increases to the velocity configured in advance. When switching modes at the configured speed, the rotational velocity of the internal combustion engine is uniquely determined, therefore, the control system controls the increase to that point. The transition to M-E mode is continuous as the rotational velocity of the electric motor does not change. Once in M-E mode, a control system is necessary to ensure that the motor does not return to M mode until reaching the proper low speed.

In M-E mode, the controller 41 controls and operates the generator. However, it is necessary to select a generator with proper capabilities as a battery is used in M mode. In addition, the method of constantly maintaining the rotation of the internal combustion engine at a velocity that keeps exhaust gases to a minimum is extremely effective as a measure for environmental pollution control.

When switching from M-E to M mode, the hydraulic pressure from the first mode switch clutch is firstly discharged and released. The internal combustion engine is then stopped.

Switching from M-E to E mode, the second mode switch clutch should be engaged when the generator is sensed as stopped. E mode is suited for constant high speed driving, such as on highways. As the drive train efficiency of the gear drive is maximized, driving becomes economical

This invention is beneficial as the controller continuously changes the rotational velocity of the electric motor and makes completely variable speed driving possible.

4 Brief Explanation of Figures

Figure 1 is the schematic diagram of the gear drive mechanism displaying the first example of this invention. Figure 2 is the schematic diagram of the gear drive mechanism displaying the second example of this invention. Figure 3 is the schematic diagram of the gear drive mechanism displaying the third example of this invention. Figure 4 is the schematic diagram of the gear drive mechanism displaying the fourth example of this invention. Figure 5 is the schematic diagram of the gear drive mechanism displaying the fifth example of this invention. Figure 6 is the schematic diagram of the gear drive mechanism displaying the sixth example of this invention. Figure 7 describes the relationship between the electric motor's rotational velocity and the speed of the vehicle during M mode. Figure 8 is the correlation diagram between the revolution velocity ratio of the input/output shafts and the revolution velocity ratio e_m and e_f of the input shaft, electric motor, and generator. Figure 9 is the correlation diagram between the input/output revolution velocity ratio e and drive train efficiency, for the gear drive mechanisms of each example in Figures 1, 2, 4, 5, and 6. Figure 10 is the correlation diagram between the input/output revolution velocity ratio e and drive train efficiency, for the gear drive mechanism of the example in Figure 3.

1: Input Shaft; 2: Output Shaft; 3: Hydraulic Pump; 4: Intermediate Shaft; 5: Hollow Rotating Shaft; 10: Internal Combustion Engine; 20: Generator; 30: Electric Motor; 40: Battery; 41 and 42: Controller; 50: Planet Gear Mechanism; 60: First Mode Switch Clutch; 70: Second Mode Switch Clutch

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Figure 1
[see source for figure]

Generator

Electric Motor

Internal Combustion Engine

Battery

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Figure 2

[see source for figure]

Generator

Electric Motor

Internal Combustion Engine

Battery

Figure 3

[see source for figure]

Generator

Electric Motor

Internal Combustion Engine

Battery

Figure 4
[see source for figure]

Electric Motor

Internal Combustion Engine

Generator

Battery

Figure 5
[see source for figure]

Electric Motor

Internal Combustion Engine

Generator

Battery

TPR 098019

Figure 6

[see source for figure]

Electric Motor

Internal Combustion Engine

Generator

Battery

Figure 7

[see source for figure]

[vertical axis] Vehicle's Speed

[horizontal axis] Rotational Velocity of Electric Motor

Figure 8

[see source for figure]

[vertical axis] Rate of Velocity

Figure 9

[see source for figure]

[vertical axis] Drive Train Efficiency

Figure 10

[see source for figure]

[vertical axis] Drive Train Efficiency

[horizontal axis] Rate of Velocity

6. Listing of Appendices

(1) Copy of Application 1

(2) Specifications 1

(3) Figures 1

(4) Power of Attorney 1

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Description

The present invention relates to a vehicle powerplant comprising thermal and electrical drive means variously connectable to the input shaft of the transmission as well as to a countershaft controlling accessory devices on the vehicle.

Vehicles of the aforementioned type are employed over mixed routes allowing of little or no emission, or over which normal emission is permitted. Over the first type, the vehicle is driven solely by the electrical drive means or in controlled manner by the thermal means, whereas, over the second, the thermal drive means are operated normally. Vehicles of this type invariably feature accessory devices (e.g. hydraulic power steering pump, brake and conditioner compressors, auxiliary alternators), and at times also special-purpose devices powered by the above drive means for performing special functions for which the vehicle is designed. Both the accessory and special-purpose devices frequently demand far greater power than that required for operating the vehicle under various driving conditions.

On one known powerplant of this type, the thermal drive means comprise a combustion engine connected mechanically to the transmission input shaft by a propeller shaft fitted with a clutch designed to assume a first and second position wherein the combustion engine is respectively connected to and disconnected from the transmission input shaft.

A countershaft for powering the vehicle accessory devices is connected by a system of gears to the propeller shaft, downstream from the clutch.

The electrical drive means normally consist of a unit designed to operate as both an electric motor and current generator. The rotor element of the unit is connected to the countershaft in such a manner as to be driven by it when the unit is operated as a current generator, and to drive it for rotating the transmission input shaft when the unit is operated as a motor.

Alternatively, the rotor element of the unit is connected directly to the propeller shaft to form a single drive line between the combustion engine and the transmission input shaft, in which case, the drive line is fitted with a second clutch downstream from the unit.

The powerplant also comprises a storage battery to which current is fed by the unit when operated as a generator, and from current is drawn when the unit is operated as a motor.

Powerplants of the type briefly described above provide for two operating modes. In a first, the combustion engine is operated and the clutch (or both clutches, in the case of the alternative configuration described above) is set to the first engaged position, so that both the transmission input shaft and the countershaft are driven by the combustion engine, while the rotor element of the unit, set to generator mode, is rotated by the countershaft for charging the batteries. In the second operating mode, the clutch is set to the second release position, and the unit alone is operated as an electric motor, the rotor element of which thus provides for powering both the transmission input shaft and the countershaft.

Powerplants of the aforementioned type present numerous drawbacks.

Firstly, in the second operating mode, i.e. when operated electrically, the accessory devices are driven solely by the power supplied by the battery, which, if of normal weight and size for the vehicle, provides for accumulating only a limited amount of energy.

Secondly, in the second operating mode, wherein the combustion engine is idle and disconnected from the drive line, current can only be generated for charging the battery when braking the vehicle, and if the unit is designed to operate as a brake, for recovering the energy produced during braking and converting it at least partially into electrical energy.

As a result, the operating range of the powerplant is fairly limited.

In FR-A-2415022 is described a vehicle powerplant comprising a combustion engine connected mechanically by a first clutch to a drive line transmitting the motion to the wheels of the vehicle and an electric motor connected to said drive line by a second clutch. Said electric motor is driven by the current supplied through an overhead connection to the public power supply. A powerplant of this type can be used only in the case in which an overhead connection is available and presents some of the drawbacks before exposed.

It is an object of the present invention to provide a powerplant of the aforementioned type designed to overcome the aforementioned drawbacks.

According to the present invention, there is provided a vehicle powerplant according to the features of claim 1, comprising first thermal drive means and second electrical drive means; said first and second means being activated for transmitting motion to the drive wheels of the vehicle via a transmission; said first drive means comprising a combustion engine connected mechanically to said wheels by a drive line fitted with said transmission and with a first clutch located between said engine and said transmission and which clutch may be set to a first and second position wherein said combustion engine is respectively connected to and disconnected from said transmission;

a current generator for supplying electric current to a storage battery, and the rotor element of which is connected to said drive line upstream from said first clutch;

said electrical drive means comprising an electric motor, the rotor element of which is connected by a first drive to said drive line downstream from said first clutch, said electric motor being driven by the current supplied by said battery,

a second clutch located between the rotor element of said electric motor and said drive line, and which may be set to a first and second position wherein said rotor element of said motor is respectively connected to and disconnected from said drive line;

a shaft connected to said drive line upstream from said first clutch by a second drive, and which provides for a power takeoff for operating the accessory devices of said vehicle in addition to the generator; the rotor element of said current generator being connected to said shaft;

said current generator being also arranged and installed to be operable as an electric motor; said second drive presenting a third clutch designed to assume a first position wherein said shaft connected to said rotor element of said current generator is also connected to said drive line, and a second position wherein said shaft is disconnected from said drive line; the arrangement being such that said accessory devices can be driven by said current generator when the current generator is disconnected from said drive line.

The design and operation of the powerplant according to the present invention will be described by way of example with reference to the accompanying drawings, in which:

Fig.1 shows a schematic view of a first configuration of the powerplant according to the present invention;

Fig.s 2 and 3 show a further two configurations of the Fig.1 powerplant.

The powerplant according to the present invention comprises a combustion engine 1, e.g. a diesel engine; and a transmission 2, the input shaft of which is connected mechanically to engine 1 by a propeller shaft 3 fitted with a clutch, e.g. a friction clutch, 4. Clutch 4, which is operable in any manner, e.g. directly by the driver and/or by means of any type of actuator, is designed to assume two positions: an engaged position (Fig.1) wherein the up- and downstream portions of shaft 3 are connected; and a release position (Fig.s 2 and 3) wherein said portions are disconnected.

As shown clearly in the accompanying drawings, the powerplant also comprises a countershaft 5 connected mechanically to shaft 3, upstream from clutch 4, by a drive consisting, for example, of gears 6.

A current generator 7 supplies electric current to a storage battery 8, and presents a rotor element (not shown) connected to and rotated by countershaft 5.

Countershaft 5 or another shaft upstream from clutch 4 also provides for a power takeoff 9 for operating the accessory devices on the vehicle. These, in addition to standard industrial vehicle devices, such as the power steering pump, brake and conditioner compressors and auxiliary alternators, may also consist of special-purpose devices, such as compactors, in the case of refuse collection and disposal vehicles.

The powerplant according to the present invention also comprises an electric motor 10 powered by the current supplied by battery 8, and the rotor element (not shown) of which is connected to propeller shaft 3, downstream from clutch 4, by a second drive consisting, for example, of gears 11. A second clutch 12, which may be the same type as clutch 4, is located between the rotor element of motor 10 and drive 11, and is designed to assume a first engaged position (Fig.3) wherein the rotor element of motor 10 is connected to drive 11, and a second release position (Fig.s 1 and 2) wherein the rotor element and drive 11 are disconnected.

For the reasons explained later on, current generator 7 may conveniently be designed to also operate as an electric motor powered by battery 8, in which case, drive 6 is provided with a clutch 5a of any type, designed to assume a first and second position wherein shaft 5 of generator-motor 7 is respectively connected to and disconnected from drive line 3 immediately downstream from engine 1. Clutch 5a may conveniently be housed in one of the gears of drive 6, as shown schematically in the accompanying drawings.

The powerplant may also comprise a further drive 2a forming part of and possibly comprising pairs of gears housed inside transmission 2, for transmitting motion from drive line 3 to shaft 5 connected to power takeoff 9. Drive 2a is activated exclusively, in known manner, with the gear lever in neutral, so that no motion is transmitted to the wheels of the vehicle.

According to a variation not shown, drive 11 may be driven from a point on drive line 3 downstream from transmission 2, as opposed to upstream as shown in the accompanying drawings, for reducing the size, particularly lengthwise, of the powerplant and so enabling troublefree installation on certain types of vehicle.

The powerplant according to the present invention operates as follows.

In a first operating mode (Fig.1), combustion engine 1 is operated with clutch 4 in the first (engaged) position and clutch 12 in the second (release) position, so that the vehicle is driven by engine 1 connected by shaft 3 to the input shaft of transmission 2. In this mode, clutch 4 is operated normally for shifting transmission 2.

At the same time, drive 6 rotates countershaft 5, which in turn rotates the rotor element of current generator 7 for charging battery 8, and operates the accessory devices on the vehicle connected to power takeoff 9.

This first operating mode therefore provides, thermally, for running the vehicle normally, operating the accessory devices, and charging the battery, and may conveniently be employed over routes involving no particular control of emission.

In a second operating mode, combustion engine 1 is again operated, but with clutch 4 in the second (release) position (Fig.2), so that only countershaft 5 and consequently generator 7 and the auxiliary devices are operated thermally. In this mode, means for controlling the speed and fuel supply of engine 1 may be provided for minimizing emission, thus enabling temporary stoppage of the vehicle for operating the accessory devices and/or charging battery 8.

In a third operating mode (Fig.3), combustion engine 1 is again operated, but with clutch 4 in the second (release) position, clutch 12 in the first (engaged) position, and electric motor 10 activated, so that shaft 3 is disconnected from engine 1 and drive 6, the input shaft of transmission 2 is powered by motor 10 via drive 11, and the vehicle is driven entirely electrically by the power drawn from battery 8. If combustion engine 1 is activated, current generator 7 is also operated simultaneously for charging battery 8, which thus acts as a flywheel for the power supplied by engine 1 and drawn off by electric motor 10.

In this third mode, operation of engine 1 is so controlled as to maintain substantially constant engine speed and output combined with a high degree of efficiency and minimum emission for driving along controlled-emission routes.

An important point to note is that, in all three configurations described, the accessory devices are operated thermally, that is, under high power conditions, with no limitation in terms of autonomy.

Nevertheless, when drive 11 is driven from a point along line 3 upstream from transmission 2, if the power required in said third mode for operating the accessory devices is not such as to limit autonomy, and/or peak power is demanded of takeoff 9 in excess of the average designed for effectively controlling combustion engine 1 (for achieving high efficiency and minimum emission), power takeoff 9 (and, hence, shaft 5) may be controlled by drive 2a transmitting motion from transmission 2 to shaft 5 and so electrically controlling power takeoff 9.

When absolutely no emission is permitted, a fourth operating mode may be employed, which consists in de-activating engine 1 and operating the powerplant as described with reference to Fig.3, in which case, the vehicle is operated entirely electrically by battery 8.

In fourth mode (with engine 1 de-activated), power takeoff 9 may still be controlled electrically, as required for at least operating the accessory devices governing the driveability of the vehicle, such as the power steering pump and brake system devices.

For this purpose, clutch 5a is released and generator 7 set to motor mode and supplied by battery 8 for electrically powering takeoff 9.

When electrically operating the vehicle (third and fourth mode), transmission 2 can only be operated normally by means of clutch 12 if drive 11 is located upstream from the transmission. Moreover, if also designed to function as a current generator, electric motor 10 may provide for electrically braking the vehicle and at least partially recovering and converting the energy produced when braking into electrical energy, which is stored in battery 8.

To those skilled in the art it will be clear that changes may be made to the powerplant as described and illustrated herein without, however, departing from the scope of the present invention.

The above further embodiment of the powerplant obviously operates in exactly the same way as described with reference to the accompanying drawings.

Claims

1. A vehicle powerplant comprising:
    - first thermal drive means and second electrical drive means; said first and second means being activated for transmitting motion to the drive wheels of the vehicle via a transmission (2); said first drive means comprising a combustion engine (1) connected mechanically to said wheels by a drive line (3) fitted with said transmission (2) and with a first clutch (4) located between said engine (1) and said transmission (2) and which clutch may be set to a first and second position wherein said combustion engine (1) is respectively connected to and disconnected from said transmission (2);
    - a current generator (7) for supplying electric current to a storage battery (8),

   said electrical drive means comprising an electric motor (10), the rotor element of which is connected by a first drive (11) to said drive line (3) downstream from said first clutch (4),
    - a second clutch (12) located between the rotor element of said electric motor (10) and said drive line (3), and which may be set to a first and second position wherein

said rotor element of said motor (10) is respectively connected to and disconnected from said drive line (3); characterized in that

the rotor element of said current generator is connected to said drive line (3) upstream from said first clutch (4); said electric motor (10) is driven by the current supplied by said battery (8); and

a shaft (5) connected to said drive line (3) upstream from said first clutch (4) by a second drive (6), and which provides for a power takeoff (9) for operating the accessory devices of said vehicle in addition to the generator; the rotor element of said current generator (7) being connected to said shaft (5);

said current generator (7) being also arranged and installed to be operable as an electric motor; said second drive (6) presenting a third clutch (5a) designed to assume a first position wherein said shaft (5) connected to said rotor element of said current generator (7) is also connected to said drive line (3), and a second position wherein said shaft (5) is disconnected from said drive line (3); the arrangement being such that said accessory devices can be driven by said current generator when the current generator is disconnected from said drive line.

2. A powerplant as claimed in one of the foregoing Claims, characterized by the fact that said first (11) and second (6) drives are gear drives.

3. A powerplant as claimed in one of the foregoing Claims, characterized by the fact that said first drive (11) is connected to said drive line (3) upstream from said transmission (2).

4. A powerplant as claimed in one of the foregoing Claims from 1 to 3, characterized by the fact that said first drive (11) is connected to said drive line (3) downstream from said transmission (2).

5. A powerplant as claimed in one of the foregoing Claims, characterized by the fact that said second clutch (12) is located between said rotor element of said electric motor (10) and said first gear drive (11).

6. A powerplant as claimed in one of the foregoing Claims, characterized by the fact that it comprises a third drive (2a) for connecting said transmission (2) to said shaft (5) providing for said power takeoff (9).

7. A powerplant as claimed in one of the foregoing Claims, characterized by the fact that said electric motor (10) is also designed to operate as a current generator, for electrically braking said vehicle and generating electric current which is supplied to said battery (8).

Patentansprüche

1. Fahrzeugantrieb der folgendes aufweist:
   - eine erste thermische Antriebseinrichtung und eine zweite elektrische Antriebseinrichtung; wobei die erste und die zweite Einrichtung zum Übertragen von Bewegung zu den Antriebsrädern des Fahrzeuges über ein Getriebe (2) aktiviert werden; wobei die erste Einrichtung einen Verbrennungsmotor (1) aufweist, der mechanisch mit den Rädern durch eine Transmission (3) verbunden ist, die mit dem Getriebe (2) und mit einer ersten Kupplung (4) eingerichtet ist, die zwischen dem Motor (1) und dem Getriebe (2) angeordnet ist, und wobei die Kupplung in eine erste und eine zweite Stellung gebracht werden kann, in welcher der Verbrennungsmotor (1) jeweils mit dem Getriebe (2) verbunden und von diesem getrennt wird;
   - einen Stromgenerator (7) zur elektrischen Stromversorgung einer Speicherbatterie (8), wobei die elektrische Antriebseinrichtung einen Elektromotor (10) aufweist, dessen Rotorelement durch einen ersten Antrieb (11) mit der Transmission (3) stromabwärts von der ersten Kupplung (4) verbunden ist, und
   - eine zweite Kupplung (12), die zwischen dem Rotorelement des Elektromotors (10) und der Transmission (3) angeordnet ist und welche in eine erste und eine zweite Stellung gebracht werden kann, wobei das Rotorelement des Motors (10) jeweils mit der Transmission (3) verbunden oder von dieser getrennt wird;

   dadurch **gekennzeichnet**, daß
   - das Rotorelemet des Stromgenerators mit der Transmission (3) stromaufwärts von der ersten Kupplung (4) verbunden ist;
   - der Elektromotor (10) von dem von der Batterie (8) zur Verfügung gestellten Strom angetrieben wird;
   - eine Welle (5), die mit der Transmission (3) stromaufwärts von der ersten Kupplung (4) durch einen zweiten Antrieb (6) verbunden ist, und die für einen Antrieb (9) zum Betreiben der

Nebeneinrichtung des Fahrzeuges zusätzlich zum Generator vorgesehen ist; wobei das Rotorelement des Stromgenerators (7) mit der Welle (5) verbunden ist; wobei der Stromgenerator (7) auch als ein Elektromotor betreibbar angeordnet und installiert ist; wobei der zweite Antrieb (6) eine dritte Kupplung (5a) aufweist, die so konstruiert ist, eine erste Position einzunehmen, bei der die Welle (5), die mit dem Rotorelement des Stromgenerators (7) verbunden ist, auch mit der Transmission (3) verbunden ist und eine zweite Stellung, bei der die Welle (5) von der Transmission (3) entkoppelt ist; wobei die Anordnung derart ist, daß die Nebeneinrichtungen von dem Stromgenerator angetrieben werden können, wenn der Stromgenerator von der Transmission entkoppelt ist.

2. Antrieb nach einem der vorhergehenden Ansprüche gekennzeichnet durch die Tatsache, daß die Erst-(11) und Zweit(12) -antriebe Getriebe-Antriebe sind.

3. Triebwerk nach einem der vorhergehenden Ansprüche, gekennzeichnet durch die Tatsache, daß der erste Antrieb (11) mit der Transmission (3) stromaufwärts von dem Getriebe (2) verbunden ist.

4. Triebwerk nach einem der vorhergehenden Ansprüche 1-3, gekennzeichnet durch die Tatsache, daß der erste Antrieb (11) mit der Transmission (3) stromabwärts von dem Getriebe (2) verbunden ist.

5. Triebwerk nach einem der vorangehenden Ansprüche gekennzeichnet durch die Tatsache, daß die zweite Kupplung (12) zwischen dem Rotorelement des Elektromotors (10) und dem ersten Getriebeantrieb (11) angeordnet ist.

6. Triebwerk nach einem der vorhergehenden Ansprüche gekennzeichnet durch die Tatsache, daß es einen dritten Antrieb (2a) zur Verbindung des Getriebes (2) mit der Welle (5), die den Antrieb (9) bereitstellt, umfaßt.

7. Triebwerk nach einem der vorhergehenden Ansprüche gekennzeichnet durch die Tatsache, daß der Elektromotor (10) auch so ausgelegt ist, daß er als ein Stromgenerator zum elektrischen Bremsen des Fahrzeuges und zum Erzeugen elektrischen Stromes, welcher der Batterie (8) zur Verfügung gestellt wird, arbeitet.

Revendications

1. Système de propulsion pour véhicule comprenant:
   - des premiers moyens thermiques d'entraînement et des deuxièmes moyens d'entraînement électriques; ces premiers et seconds moyens étant actionnés pour transmettre un mouvement aux roues motrices du véhicule par l'intermédiaire d'une boîte de vitesses (2); les premiers moyens d'entraînement comprenant un moteur à combustion (1) relié mécaniquement à ces roues par une ligne de transmission (3) équipée de ladite boîte de vitesses (2) et d'un premier embrayage (4) placé entre le moteur (1) et la boîte de vitesses (2), lequel embrayage peut être mis dans une première ou une seconde position dans laquelle le moteur à combustion (1) est respectivement relié à la boîte de vitesses (2) ou débrayé de celle-ci ;
   - une génératrice de courant (7) pour fournir du courant électrique à une batterie d'accumulateurs (8),

   les moyens électriques d'entraînement comprenant un moteur électrique (10), dont le rotor est connecté par une première boîte de transmission (11) à la ligne de transmision (3) en aval du premier embrayage (4) et
   - un second embrayage (12) placé entre le rotor du moteur électrique (10) et la ligne de transmission (3) et qui peut être mis dans une première et une seconde position dans lesquelles le rotor du moteur (10) est respectivement relié à la ligne de transmission (3) ou débrayé de celle-ci ;

   système de propulsion de véhicule caractérisé en ce que le rotor de la génératrice de courant est relié à la ligne de transmission (3) en amont du premier embrayage (4); le moteur électrique (10) est entraîné par le courant fourni par la batterie (8) et l'on prévoit un arbre (5) relié à la ligne de transmission (3) en amont du premier embrayage (4) par une seconde boîte de transmission (6) et qui comprend une prise de force (9) pour faire fonctionner les appareils accessoires du véhicule en plus de la génératrice; le rotor de la génératrice de courant (7) étant relié à l'arbre (5); la génératrice de courant (7) étant également agencée et installée de manière à pouvoir fonctionner en moteur électrique; la seconde boîte de transmission (6) présentant un troisième embrayage (5a) conçu pour prendre une première position dans laquelle l'arbre (5), relié au rotor de la génératrice de courant (7), est également relié à la ligne de transmision (3) et une seconde position dans laquelle l'arbre (5) est débrayé de la ligne de transmission (3); la disposition étant telle que les appareils accessoires puissent être entraînés par la génératrice de courant quand elle est débrayée de la ligne de transmission.

2. Système de propulsion tel que revendiqué dans la revendication 1, caractérisé par le fait que la première boîte de transmission (11) et la seconde boîte de transmission (6) sont des boîtes à engrenages.

3. Système de propulsion selon l'une des revendications précédentes, caractérisé par le fait que la première boîte de transmission (11) est reliée à la ligne de transmission (3) en amont de la boîte de vitesses (2)

4. Système de propulsion selon l'une des revendications précédentes, caractérisé par le fait que la première boîte de transmission (11) est reliée à la ligne de transmission (3) en aval de la boîte de vitesses (2)

5. Système de propulsion selon l'une des revendications précédentes, caractérisé par le fait que le second embrayage (12) est placé entre le rotor du moteur électrique (10) et la première boîte de transmission à engrenages (11).

6. Système de propulsion selon l'une des revendications précédentes, caractérisé par le fait qu'il comprend une troisième boîte de transmission (2a) servant à relier la boîte de vitesses (2) à l'arbre (5) prévu pour actionner la prise de force (9).

7. Système de propulsion selon l'une des revendications précédentes, caractérisé par le fait que le moteur électrique (10) est également conçu pour fonctionner en génératrice de courant, pour freiner électriquement le véhicule et produire du courant électrique qui est fourni à la batterie (8).

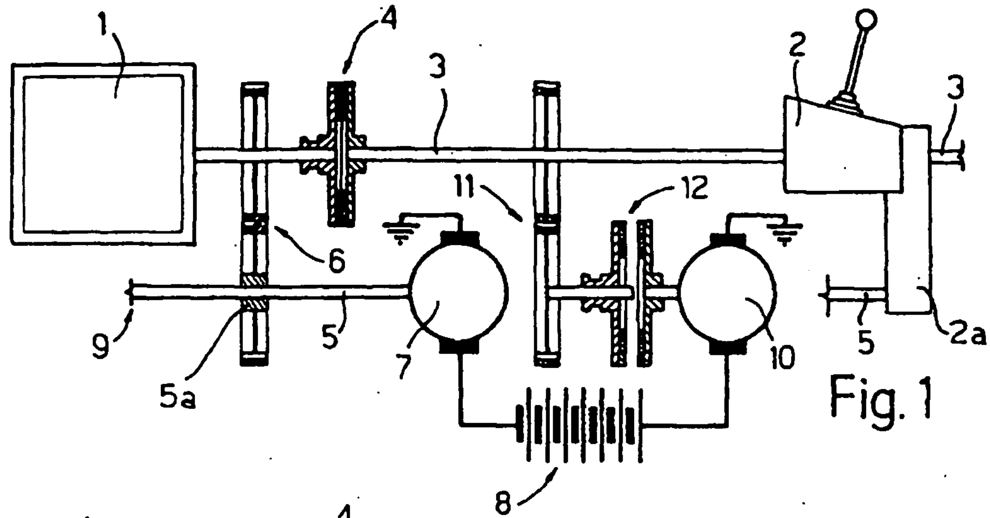

Fig. 1

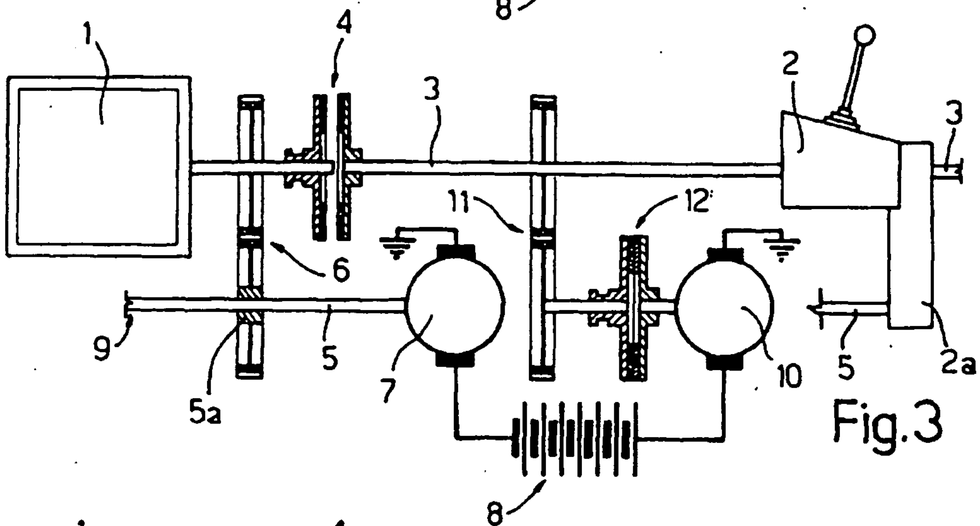

Fig.3

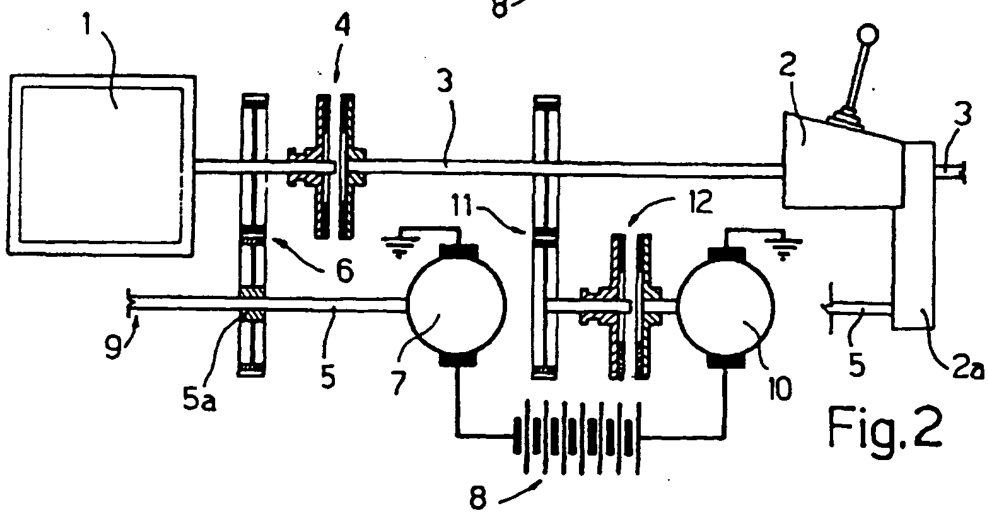

Fig.2

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(54)【発明の名称】　シリーズ、パラレル複合ハイブリッドカーシステム

(57)【要約】

【目的】回生制動時のモータの高回転側の回生制動トルク不足を解消し、低速回転から高速回転までほぼ一定の回生制動トルクを得ることができるシリーズ、パラレル複合ハイブリッドカーシステムを提供する。

【構成】エンジン1、発電機3、走行用のモータ9、バッテリ17を備え、かつ、エンジン1とモータ9との間に無段変速機5を設けるとともに、モータ9の高回転側の回生制動トルク不足分をエンジン1のフリクショントルクと発電機3の回生制動トルクとの合成トルクで補うように前記無段変速機5を制御する制御手段18を備えた。

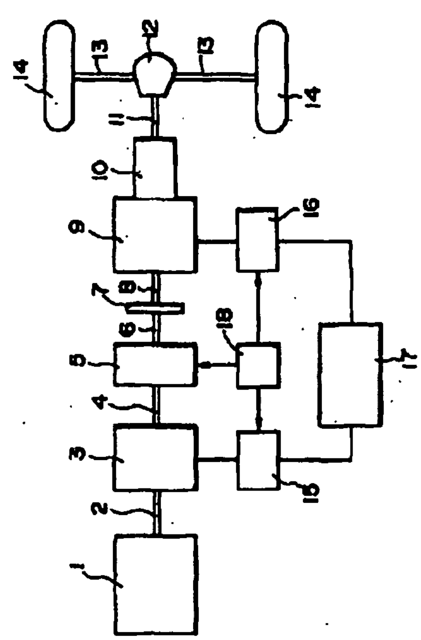

図1

1

【特許請求の範囲】

【請求項1】エンジンと、このエンジンにより駆動される発電機と、走行用のモータと、前記発電機とモータとの間で電力の授受を行うバッテリと、前記エンジンとモータとの間に設けられたクラッチと、前記エンジン、発電機、クラッチ及びモータとの間で互いにトルク伝達を行うトルク伝達手段と、前記モータの回転トルクを車輪に伝達するトルク伝達手段とを備えたシリーズ、パラレル複合ハイブリッドカーシステムにおいて、前記エンジンとモータとの間に無段変速機を設け、かつ、前記モータの高回転側の回生制動トルク不足分をエンジンのフリクショントルクと発電機の回生制動トルクとの合成トルクで補うように前記無段変速機を制御する制御手段を備えたことを特徴とするシリーズ、パラレル複合ハイブリッドカーシステム。

【発明の詳細な説明】

【0001】

【産業上の利用分野】この発明は、エンジンとモータにより駆動されるシリーズ、パラレル複合ハイブリッドカーシステム、特にモータの高回転側のトルク不足をエンジンのトルクで補うことができるシリーズ、パラレル複合ハイブリッドカーシステムに関するものである。

【0002】

【従来の技術】近年、省資源、大気汚染や騒音の防止に対する要求が社会的に益々高まりつつある。このような要求に応えるものとして、エンジンと、このエンジンにより駆動される発電機とともに、走行用のモータ及びこのモータに電力を供給するバッテリなどを備えたハイブリッドカーシステム、すなわち複合電気自動車が注目されている。このようなハイブリッドカーシステムとして、従来、実開昭51－103220号、実開平2－7702号、及び実開昭53－55105号公報などに開示された構成の装置が開発されている。上記各公報には、いずれも、走行用のモータとエンジンとがクラッチを介して回転軸で連結された電気自動車の構成が記載されている。

【0003】すなわち、実開昭51－103220号公報の第1図には、モータとエンジンとが回転軸とクラッチを介して連結され、かつ、増速機構を介してエンジンにより駆動される発電機と、この発電機により充電されるとともに、前記モータに電力を供給してこれを駆動する蓄電池を備えた構造の複合電気自動車が記載されている。この装置はクラッチを備えているので、クラッチを切り離したときにはシリーズ走行モード、すなわち、エンジンで駆動される発電機で発電した電力を一旦蓄電池に蓄え、この蓄電池から供給される電力により走行用のモータを回転させる走行モードをとることになる。また、クラッチを接続したときにはパラレル走行モード、すなわち車両をエンジンとモータの両方で駆動し、しかも発電機による発電作用も行う走行モードをとることが

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できるものである。

【0004】

【発明が解決しようとする課題】従来の課題

上記従来の装置においては，以上のように、クラッチの切り替えによりパラレル走行とシリーズ走行の切り替えが随時可能な構成になっているが、エンジンとモータの結合状態を負荷に応じて変化させ、モータのトルクに応じてエンジンのトルクを制御してエンジンの負荷領域を一定にするような装置は装着されていなかった。

【0005】確かに、パラレル走行モードでは、エンジンの出力とモータの出力とを同時に使用可能であり、加速時や登坂時などのように大きなトルクを必要とする場合に有利であるが、一般に回転数（回転速度）に対するエンジンとモータの最大効率点は等しくなく、モータが比較的高い回転数で高い効率を示すのに対し、エンジンは比較的低い回転数で高い効率が得られる。従って、モータとエンジンとを固定ギア比で連結した場合、エンジンの負荷領域がかならずしも最良な状態にならず、燃費向上の点で好ましくない。

【0006】また、シリーズ走行モードでは、エンジンを発電のためだけに用いるので、エンジンの負荷領域を燃費の良い領域に設定できる反面、車両の駆動用として走行用のモータの出力だけしか使えないので、加速性能が悪くなるという問題点があった。

【0007】更に、モータが、比較的高速回転をしている状態で制動をかける場合、図3（a）に示すように、走行用のモータによる回生制動トルクａが高回転側で大きく低下するので、理想トルク線ｂに対して図で斜線を施したトルク不足分ｃだけトルク不足を生じ、ブレーキの効きが悪くなるという問題点があった。従って、上記問題点を解消しなければならないという課題がある。

【0008】発明の目的

この発明は、上記課題を解決するためになされたもので、回生制動時のモータの高回転側の回生制動トルク不足を解消し、低速回転から高速回転までほぼ一定の回生制動トルクを得ることができるシリーズ、パラレル複合ハイブリッドカーシステムを提供することを目的とする。

【0009】

【課題を解決するための手段】本発明に係るシリーズ、パラレル複合ハイブリッドカーシステムは、エンジンと、このエンジンにより駆動される発電機と、走行用のモータと、前記発電機とモータとの間で電力の授受を行うバッテリと、前記エンジンとモータとの間に設けられたクラッチと、前記エンジン、発電機、クラッチ及びモータとの間で互いにトルク伝達を行うトルク伝達手段と、前記モータの回転トルクを車輪に伝達するトルク伝達手段とを備えている。また、前記エンジンとモータとの間に無段変速機を設け、かつ、前記モータの高回転側の回生制動トルク不足分をエンジンのフリクショントル

クと発電機の回生制動トルクとの合成トルクで補うように前記無段変速機を制御する制御手段を備えたものである。

【0010】

【作用】次に、本発明の作用を説明する。本発明によるシリーズ、パラレル複合ハイブリッドカーシステムは、まず、エンジンにより駆動される発電機により発電し、得られた電力を一時バッテリに蓄え、次いで、このバッテリに蓄えられた電力を走行用のモータに給電、駆動し、車両を走行させる。バッテリは、前記発電機とモータとの間で電力の授受を行う。前記エンジンとモータとの間に設けられたクラッチを接続すると、前記エンジン、発電機、クラッチ及びモータとの間で互いにトルク伝達が行われ、更に、前記モータの回転トルクを車輪に伝達することにより、エンジンとモータの両方の駆動トルクにより車両が駆動される。また、前記エンジンとモータとの間には無段変速機が設けられており、かつ、この無段変速機を、前記モータの高回転側の回生制動トルク不足分をエンジンのフリクショントルクと発電機の回生制動トルクとの合成トルクで補うように制御手段により制御し、回生制動トルクを一定にすることにより、回生制動時のモータの高回転側の回生制動トルク不足を解消することができる。

【0011】

【実施例】以下、この発明の一実施例を図面に基づいて説明する。図1は、この発明によるシリーズ、パラレル複合ハイブリッドカーシステムの一実施例の基本概念を示す構成図である。

【0012】同図において、1はエンジンであり、出力軸2を介して発電機3に連結され、さらに出力軸4、6、8などからなるトルク伝達手段を介して無段変速機（CVT）5、クラッチ7、走行用のモータ9が順次連結され、互いにトルク伝達されるように形成されている。また、モータ9の回転トルクは、変速機10、出力軸11、差動歯車装置12、アクセル軸13からなるトルク伝達手段を介して車輪14に伝えられる。

【0013】無段変速機5は、出力軸4と6の回転数の比を後述する制御手段により適宜連続的に変えることを可能にするCVT（Continuous Variable Transmission）である。また、出力軸6、8の間に設けられたクラッチ7は、出力軸6と8との間を接続したり、切り離したりする働きをするものである。更に、モータ9は、出力軸8と11との間に変速機10と共に組み込まれ、走行用の電動装置として車輪14を駆動する。

【0014】発電機3は、電力変換器15を介してバッテリ17に接続されて、エンジン1の回転エネルギや車輪14からトルク伝達手段を介して伝達される制動エネルギを電気エネルギに変換し、バッテリ17に貯蔵する。モータ9は、走行時、電力変換器16を介してバッテリ17から電力の供給を受けると共に、回生制動時、電力変換器16を介してバッテリ17に制動エネルギを回生する。18は無段変速機5と電力変換器15、16を制御する電子制御装置（ECU）である。

【0015】図2に示すように、エンジン1とモータ9とは効率最良領域が異なっており、パラレル走行をする場合にエンジン1とモータ9とを直結、または固定ギア比で結合していたのでは、必ずしもエンジン1をその燃費最良領域で動作させることができない。そこで、この発明では、エンジン1の負荷領域が燃費最良領域をとるように電子制御装置18で無段変速機5の変速比を最適に制御し、エンジン1を動力源として走行する場合にも常に最良の燃費で走行が可能な構成となっている。

【0016】つまり、図2（b）の動作点Aでモータ9が駆動されているときに、登坂や急加速などのためにパワーが必要になったとき、従来技術では図2（a）の動作点Aでそのままエンジン1を駆動することになり、燃料効率が悪くならざるを得なかった。しかし、この発明による上記実施例によれば、無段変速機5のギア比を電子制御装置18によって適正に制御することにより、エンジン1の動作点を図2（a）の点Bにずらすことが可能となり、最良の燃料効率が得られる。

【0017】従って、上記装置を使用する場合、通常はモータ9のみで走行するシリーズ走行モードをとり、また、比較的エンジン1の効率がよい定常走行時や、モータ9だけではパワーが不足する加速時及び登坂時にはクラッチ7を係合してパラレル走行モードとし、かつ、無段変速機5の変速比を適正に制御することにより、駆動力をエンジン1から効率的に供給することになる。

【0018】一方、回生制動時のモータ9のトルク特性は図3（a）の実線部aのようになるのに対し、制動力としての理想的な要求トルク特性は回転数にかかわらず破線部bのようになるから、結局、モータ9の高速回転側で図で斜線を施したトルク不足分cだけ制動力不足となる。そこで上記実施例では、図3（b）に示すエンジン1のフリクショントルクdと発電機3の回生トルクeとの合成トルクfを高回転側で大きなトルクが得られるように無段変速機5の変速比を電子制御装置18によって最適に制御し、前記モータ9の高回転側での制動力不足を補うことができる。

【0019】次に、電子制御装置18による無段変速機5の制御動作について図4、図5を参照して説明する。

【0020】まず、ステップ101でアクセル信号がOFFになると、ステップ102で、現在の車速に対応するモータ9の回転速度が定格回転速度Vnより大きいか否かを判断し、もしYESの場合、直ちにステップ103に進みクラッチ7をONする。続くステップ104では、ステップ103におけるクラッチON動作より時間的にやや遅れて無段変速機5のギヤ比を設定した後、ステップ105でブレーキ信号をONし、制動トルクを発

生させる（ステップ１０６）。一方、ステップ１０２でモータ９の回転速度が定格回転速度Ｖｎより小さい場合は直ちにステップ１０５にジャンプしてブレーキ信号をＯＮし、制動トルクを発生させる。

【００２１】他方、アクセル信号がＯＮになると、順次、クラッチ７、ブレーキ信号がＯＦＦとなり、モータ９の制動トルクの発生も停止される。

【００２２】以上説明したように、上記実施例は、回生制動時のモータの高回転側の回生制動トルク不足を解消し、低速回転から高速回転までほぼ一定の回生制動トルクを得ることができる。

【００２３】また，パラレル走行の場合には、エンジン１とモータ９の両方を効率最良領域で動作させることができるとともに、低速及び定常走行時にクラッチ７を切ってシリーズ走行をすることにより、回生制動時のエネルギ回収量をエンジンのフリクションの分だけ多くすることが可能である。

【００２４】更に、加速時以外は常にバッテリを充電する状態にしておくことが可能なので、深い放電が少なくなり、バッテリの寿命を向上させることができる。

【００２５】以上この発明の実施例について説明したが、この発明は上記実施例に何等限定されるものではなく、例えば、発電機３をエンジン１及びモータ９と同一軸上に設置せず、適当な増速歯車装置を介して出力軸２に対し並列的に配置するなど、この発明の要旨を逸脱しない範囲内において種々の態様で実施し得ることは勿論である。

【００２６】

【発明の効果】以上説明したように、本発明によるシリーズ、パラレル複合ハイブリッドカーシステムは、エンジンとモータとの間に無段変速機を設け、かつ、モータの高回転側の回生制動トルク不足分をエンジンのフリクショントルクと発電機の回生制動トルクとの合成トルクで補うように前記無段変速機を制御する制御手段を備えた構成により、回生制動時のモータの高回転側の回生制動トルク不足を解消し、低速回転から高速回転までほぼ一定の回生制動トルクを得ることができる効果を有する。

【図面の簡単な説明】

【図１】この発明のシリーズ、パラレル複合ハイブリッドカーシステムの一実施例の基本概念を示す構成図である。

【図２】（ａ）はエンジンの回転数とトルク及び等燃費率との関係を示す特性図、（ｂ）はモータの回転数とトルク及び効率との関係を示す特性図である。

【図３】（ａ）はモータの回転数と回生制動トルクとの関係を示す線図、（ｂ）はエンジンの回転数とフリクショントルク、発電機の回生トルク、及びそれらの合成トルクとの関係を示す線図である。

【図４】この発明によるシステムの動作を示すフローチャートである。

【図５】この発明によるシステムの動作タイミングを示すタイムチャートである。

【符号の説明】

1　エンジン

2，4，6，8，１１　出力軸

3　発電機

5　無段変速機（ＣＶＴ）

7　クラッチ

9　モータ

１０　変速機

１４　車輪

１５，１６　電力変換器

１７　バッテリ

１８　電子制御装置（ＥＣＵ）

【図５】

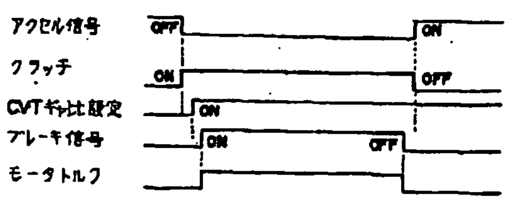

図5

【図1】

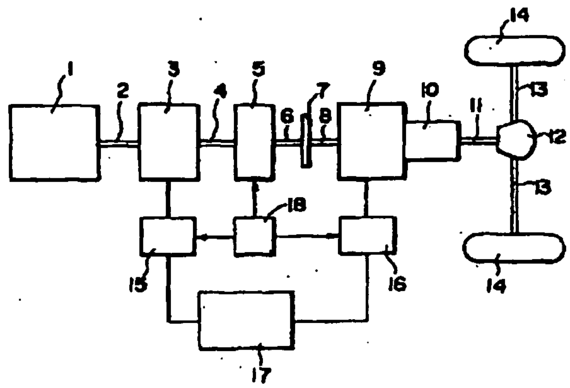

図1

【図2】

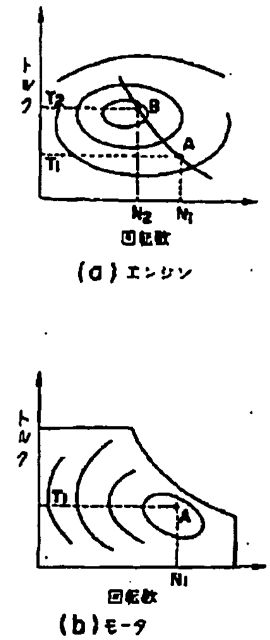

図2

【図3】

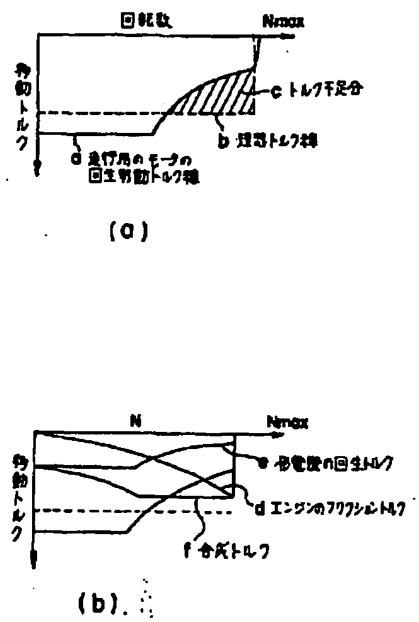

図3

【図4】

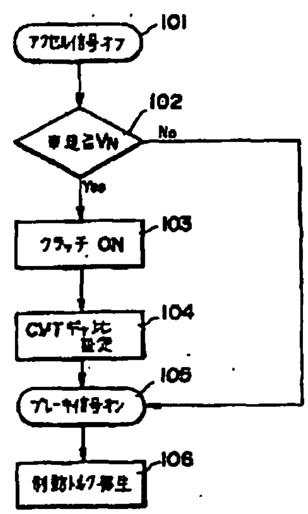

図4 フローチャート

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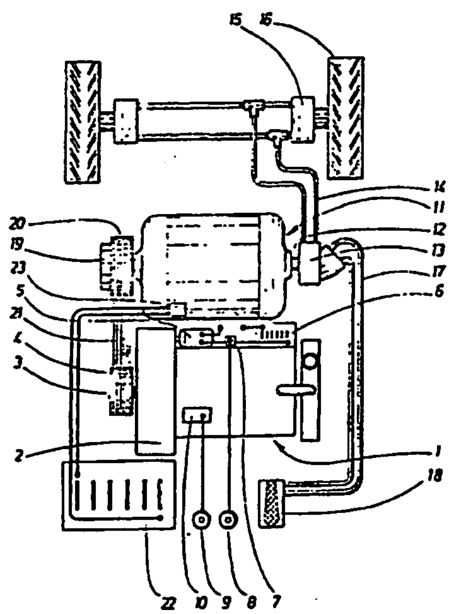

(57) Abstract

Propulsion arrangement for vehicles comprising a first machine (1) arranged as propulsion engine driven by combustion of a propellant and a second machine (11) arranged as alternative propulsion motor driven by means of electricity from a battery (22). The battery is arranged so as to be charged with current generated by the work of the first machine. The propulsion arrangement is designed to work alternatively in a first operational state with the first machine as drive source for vehicle operation and for generation of current for charging the battery and a second operational state in which the second machine functions as drive source for the vehicle with supply of current from the battery. The second machine (11) is so arranged that during the first operational state it acts as generator and is thereby driven by means of the first machine (1) during generation of the said current for charging up the battery (22).

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Propulsion arrangement for vehicles

Technical field:-

The present invention related to a propulsion arrangement for vehicles and comprises an initial machine in the form of a motor arranged to be driven by combustion of a propellant and a second machine arranged to be driven by means of electricity from a battery or to function as a generator. The object is preferably a propulsion arrangement for load trucks for handling goods both in the open air and inside buildings.

Background:

The propulsion of vehicles by an internal combustion engine has certain advantages. The main one appears to be that the operating time between refuelling operations can be long and that the actual fuel filling operation can take place rapidly, which taken together provide long operating times; if so required practically the entire day can be utilised for operation. Another important advantage is that the weight per horse-power for the motor and requisite fuel volume is low. Disadvantages which are linked with internal combustion engines are mainly that they give off harmful and dirty gases and have a relatively high sound level. In spite of these disadvantages, internal combustion engine operation for vehicles is accepted outdoors, whilst there is an ever increasing tendency to prohibit and depart from its use indoors. An alternative propulsion system in which the said disadvantages are practically eliminated is propulsion by means of one or more electric motors, which for vehicle operation must be battery-driven. This method is often employed for load carrying vehicles, e.g. trucks, which are employed indoors or in any case for the most part indoors. However the disadvantage does arise that with reasonable battery size energy extraction between charges must be restricted whilst at the same time a major part of the day has to be reserved for battery charging. Furthermore the costs for maintenance and replacement of the batteries if operations are conducted solely with these is relatively high. As such a high weight - and this is incurred because of the batteries - is not a direct disadvantage for load-carrying trucks such as fork-lift trucks, because in any event a counterweight is essential, but even so energy extraction during a working day between re-charging periods often has to be restricted below the desirable level.

The said disadvantages of electric motor-driven vehicles are generally not particularly accentuated if these are operated solely indoors, because the rolling resistance and differences in level are relatively slight, whilst at the same time the distance traversed during a working day is relatively short. Furthermore if operations are conducted solely indoors there is hardly any other alternative. In the case of vehicles for combined outdoor and indoor operation however the conditions become more difficult. As already mentioned there is a tendency no longer to accept internal combustion engine operation for indoor use, whilst at the same time the demand for energy and power are high as a result of outdoor operation. During outdoor runs it is often necessary to traverse longer distances on uneven surfaces and with load-carrying trucks the weight of the goods tends to be greater with outdoor operation than when operations are conducted solely inside buildings.

To solve the problem of being able to utilise the environmentally preferable method of electrical operation in doors, whilst at the same time having adequate energy and power available, the use has been proposed of hybrid machines for propulsion of vehicles. With these there is both an internal combustion engine and at least one electric motor, the said motors being capable of being used alternatively. The present invention relates to such a hybrid system and more particularly concerns a system in which the internal combustion engine is employed both for propulsion during certain operating periods and simultaneously for charging up the batteries which are provided for operation of the electric motor, which in turn are only employed for propulsion of the vehicle during limited periods, mainly during periods when the internal combustion engine is shut down. During outdoor operation the internal combustion engine is thus employed, whereby the batteries are charged at the same time, whilst during indoor operation solely the electric motor is used. When the power output is particularly high, possibly both machines can be employed.

On the other hand the invention does not relate to systems of the type "diesel-electric operation", i.e. constant propulsion, with electric motors which are supplied with electricity from a generator driven by an internal combustion engine and, in periods when this is shut down, from batteries.

Technical problem:

However, the fact has emerged that such hybrid systems are inflexible when changing over between the methods of drive, so that the vehicle has to be stopped when switching over and the purpose of the present invention is to provide a hybrid system of the above-mentioned type in which the changeover between operation with the electric motor to operation with the internal combustion engine and vice versa can take place in a very flexible manner and whilst the vehicle is in motion.

Another objective is to provide an arrangement for switching over between the two modes of operation which is simple and ensures reliable operation.

The solution:

The solution in accordance with the invention involves the second machine, as motor, operating within a lower speed range, the first machine operating as motor within a higher speed range located above the lower speed range, the first machine being arranged to drive the second machine, and whereby a speed sensing arrangement is provided to switch over the second machine from motor operation to generator operation when, as a result of the operation of the first machine, the speed rises to the higher speed range, and to switch in the second machine as motor within the lower speed range.

Brief description of drawings:

The appended diagrams illustrate an embodiment of the invention. Fig. 1 gives a schematic view of the driving machinery for a load-carrying truck and fig. 2 illustrates an electrical circuit diagram for the propulsion arrangement in accordance with the invention.

Best mode of carrying out the invention:

In accordance with fig. 1 the propulsion arrangement for a vehicle, preferably a load-carrying truck, comprises an internal combustion engine 1 with a flywheel casing 2, from which a drive shaft 3 proceeds on which a belt pulley 4 is fastened. A starting motor 5, which can be driven by the current from a battery 6, is provided to start the engine. A starting relay 7 is arranged in the battery lead for actuation of the starting motor 5, and this relay can be actuated from a starting controller 8, e.g. a press-button. Furthermore there is a stop button 9, by means of which the motor can be stopped by influencing its injection pump or ignition arrangement 10, in the case of diesel engines or Otto engines.

Furthermore the propulsion arrangement comprises an electric motor 11 with a drive shaft 12 which has shaft journals at both ends of the motor. One shaft journal is connected to an hydraulic pump 13 which by means of pipes 14 is connected to hydraulic motors 15, which are arranged to propel the propulsion wheels 16 of the truck. Furthermore, for regulating the flow from the hydraulic motor 13, there are actuation pipes 17 which extend up to an actuating valve 18 designed as a pedal. A free wheel 19 via which a belt pulley 20 which is connected by belts 21 with the belt pulley 4 can drive the shaft 12, is arranged at the other end of the shaft 12.

The shaft 12 which must always rotate during operation of the hydraulic pump 13 and thus during propulsion of the vehicle by means of the hydraulic motors 15 has a defined direction of rotation. The free wheel 19 is thereby so arranged that it is engaged when the internal combustion engine 1, which also has a certain drive direction on its output shaft 3, drives the belt pulley 20 in the same direction as the defined direction of rotation of the shaft 12. This signifies also that the free wheel free-wheels in the opposite relative direction of rotation, which means that for its part the shaft 12 cannot drive the belt pulley 20 and hence certainly not the internal combustion engine 1 during independent operation in the defined direction of rotation. In other words: if the internal combustion engine is in operation, but not the electric motor 11, the internal combustion engine drive the shaft 12 and thus the hydraulic pump 13, whilst on the other hand if the internal combustion engine 1 is not in operation, whilst the electric motor 11 is in operation, then the electric motor will run freely without entraining the internal combustion engine.

A battery 22 which can be connected by means of a relay 23 to the electric motor is provided for operation of the electric motor 11. The functioning of this relay will be explained later.

In what has been stated above the electrical machine provided has been designated as the electric motor 11. As such it is also envisaged to operate as a motor. However it is arranged to be able to function alternatively as generator, and it is then so connected to the battery 22 that the latter can be charged during operation of the generator. To draw attention to this point, in future the motor-generator will be designated as "the electrical machine 11". Such a changeover can be performed relatively simply, generally by certain windings of the electrical machine being magnetised by supplying a field current, whilst at the same time other windings are connected up for electricity output. The relay 23 is provided for this changeover. When the relay 23 is engaged for motor operation, electricity is thus taken from the battery 22 so that the machine 11 is driven, whilst during generator operation current is fed to the battery 22 to charge this up.

Characteristic of the invention is the fact that this changeover between motor and generator operation is controlled by a speed-sensing arrangement. This can consist of a special speed-sensing arrangement, e.g. on the shaft 12, and this has been designated as 24 in the circuit diagram in fig. 2. Alternatively, speed indication can be undertaken by recording the currents which flow through the windings of the electrical machine 11. Simultaneously with the fact that the relay is arranged to be controlled during its changeover of machine 11 between motor and generator operation as a function of speed, the actual machine is arranged to operate within a certain speed range as motor, and at another speed range which lies above this speed range as generator. Speed control of the relay is thereby so arranged that the changeover to generator takes place when the rotational speed of the shaft 12 of machine 11 passes from the lower speed range up to the higher speed range, whilst changeover to motor operation takes place when the speed drops from the higher speed range to the lower speed range. Furthermore motor operation is obtained during starting up and the supply of current to the machine from the battery 22, i.e. when starting from zero and passing to the lower speed range. Furthermore one of the characteristics of the invention is that the internal combustion engine 1 is arranged to drive the system within the higher speed range at the envisaged normal load range. In the embodiment illustrated thus the transmission ratio, via the belt pulleys 4 and 20, is so adapted to the speed of the internal combustion engine 1 that during operation of the internal combustion engine the shaft 12 is driven at a rotational speed located within the higher speed range.

In fig. 2 the arrangement is illustrated in the form of an electrical circuit diagram where the components described previously are reproduced with the same notation numbers. Furthermore, as mentioned, a speed sensing arrangement 24 is specified, which is shown in fig. 2 as being connected to the shaft 12. This can consist of some known arrangement of the centrifugal, eddy-current type or the like, which is capable of imparting a control signal in a conductor 25 to the changeover relay 23. In turn the relay 23 cannot have solely a changeover function, but must also function as charging relay, so as to provide suitable charging of the battery 22. It is not necessary to describe in greater detail the starting arrangement for the internal combustion engine 1. The method is already known of arranging a small electric motor for starting up internal combustion engines. In the embodiment shown the starting motor 5 is connected to a special battery 6 and a special generator is then provided for charging up this battery. Thus the internal combustion engine 1 is quite simply a standard engine with associated starting equipment of the standard type. As such it is possible, within the framework of the invention, to combine the two electrical installations illustrated in fig. 2, e.g. by connecting the starting motor 5 to the battery 22. It is also possible to allow the motor 11 to function as starting motor, although then the free-wheel 19 must be replaced by some controlled shaft coupling. During the development of the invention however the method illustrated was found to be the most suitable.

As shown by the foregoing the drive thus takes place from the shaft 12 either by means of the electrical machine or the internal combustion engine. The drive power output is transmitted to the hydraulic pump 13 for which flow control arrangements are provided. This can for example be of the type which has a swivelling plate by means of which the stroke length of the pistons can be controlled, whereby the outgoing flow can be varied infinitely even with constant speed of the input shaft. The pressure medium from the hydraulic pump is transmitted via pipes 14 to the two motors 15 and thus when the shaft rotates the wheels 16 are driven. Preferably the system is also provided with changeover valves so that reverse motion is possible. Such infinitely variable hydraulic systems form state of the art and do not need to be described in detail here. Flow regulation takes place by means of the said foot pedal via a remote actuation control arrangement which as shown in the diagram can be of the hydraulic type. The control range for pump 13 should be such that it should be possible to achieve the desired speed range during propulsion of the truck, regardless of whether the drive machinery, i.e. the shaft 12, operates within the previously mentioned lower speed range during electrical operation, or the higher speed range during internal combustion engine operation. In other words it must be possible, by regulating the pump within the control range provided for it, to compensate for differences in the speed of rotation of shaft 12 within both these speed ranges in such a manner that the speed of rotation of the wheels 16 can be maintained constant.

If we assume that the truck is to be started indoors, the battery 22 is connected to the electrical machine 11, which thereby rotates the shaft 12 and drives the pump 13. By means of control valve 18 the speed of wheels 16 can be controlled, so that it is possible to regulate the speed of the truck between zero up to the highest envisaged speed. During rotation of shaft 12 the free wheel 19 is disengaged, so that the belt pulley 20 remains stationary and the internal combustion engine 1 is not affected. During electric motor operation the speed control arrangement ensures that an adequate coupling is obtained so that current is supplied from the battery 22 to the machine 11 which functions as a motor. As shown by the foregoing this takes place at the lower speed range and, as long as this is complied with, the relay 23 ensures the said motor coupling.

If, for example, when driving out of the building internal combustion engine operation is required the engine is started in the conventional manner with its starting motor 5 by actuation of the starter control 8. As a result the engine 1 is started up and reaches its speed and the belt pulley 4 drives belt pulley 20. Since the belt pulley 20 is driven at a higher speed than the speed maintained by shaft 12 during electric motor operation, the free-wheel 19 is engaged and the shaft 12 increases its speeds to the higher speed range. As a result relay 23 is actuated by the said speed-sensing arrangement. This results in the machine 11 being switched over to generator operation. During this its field windings are energised and it starts to generate current which, via the relay 23 which functions as charging relay, is transmitted to the battery 22 to charge this up. At the same time the pump 13 also starts to be driven at higher speed and the wheels 16 also try to be driven at higher speed from the hydraulic motors 15. As soon as the driver senses this he can compensate for the increasing speed of shaft 12 by releasing pressure slightly on the pedal to the control valve 18. This reduces the flow of pump 13, so that the desired speed of rotation of wheels 16 is obtained. Very often however the situation is that a higher speed is required when driving outdoors and naturally actuation of the pedal takes place in accordance with the driver's required running speed. As indicated however there is a possibility of speed compensation and for maintaining a uniform speed.

If the internal combustion engine 1 is overloaded, either because the drive resistance on wheels 16 becomes excessive or because any ancillary equipment present in the form of load-handling arrangements such as lifting forks or cranes is heavily loaded, the speed of the engine will drop. If this occurs to such an extent that the speed of rotation of shaft 12 passes out of the specified higher speed range, then first of all generator operation of machine 11 will be disconnected, which signifies a lower loading. If the speed drops down to the lower speed range the relay 23 will change over machine 11 to motor operation and thus provides operation from both the internal combustion engine 1 and the electricalmachine 11. As indicated, the two speed ranges can be located one after the other with an intermediate range in which the machine 11 is completely disengaged. The two ranges can also occur directly one after the other so that the relay is switched over between generator and motor operation without any neutral position. Preference should be given to the latter.

If the vehicle is to be driven into a building once more the engine 1 is stopped using the stop control arrangement 9. As a result the speed drops to the lower speed range and the relay 23 now engages the machine 11 for motor operation with current being taken from the battery 22. As soon as the shaft 12 starts to rotate more rapidly than the belt pulley 20, the free-wheel 19 is disengaged and the shaft 12 can rotate freely without being affected by the engine1. The drive of pump 13 thus occurs by electric motor operation. The reduction in the flow from the pump which takes place during the transition to the lower speed range can thus be compensated, as described above, by means of the control valve 18 which is provided with a pedal, if so required.

Industrial applicability:

Within the framework of the invention, as defined in the following patent claims, the arrangement can be varied beyond what has been stated in the previous description. Thus the engine 1 does not need to be an internal combustion engine of the type most widely employed now, i.e. a piston engine of the diesel or Otto type. It is also feasible for it to be a Stirling engine, combustion turbine or a steam engine. The essential thing is that the one drive source has characteristics which are not appropriate for driving in enclosed premises, whilst on the other hand it can easily be provided with the necessary drive means. These circumstances prevail with all types of engines and machines which are driven by combustion of a fuel in some manner or other.

BAD ORIGINAL

The connection illustrated, via a through shaft to the electrical machine, is not essential to the invention. For example a connection is feasible where the two machines are connected in parallel with the power transmission. The latter also does not need to be of the hydraulic type, but some form of control of the transmission ratio should be provided to compensate for operation within the two speed ranges. It is also possible to provide the arrangement with an element which automatically changes over the transmission ratio on changing from one drive speed to another.

BAD ORIGINAL

Patent claims:

1. Propulsion arrangement for vehicles and comprising a first machine (1) arranged as propulsion motor and thereby driven by combustion of a propellant and a second machine (11) arranged partly as alternative propulsion motor, thereby driven by means of electricity from a battery (22) and partly as generator, thereby driven by means of the first machine (1) during generation of electricity to charge up the battery (22) whereby the propulsion arrangement is designed to alternatively function in a first operating state with the first machine as drive source for operating the vehicle and, if this be required, for generation of electricity for charging up the battery by operation of the second machine acting as generator, and a second operational state in which the second machine functions as drive source for the vehicle with supply of electricity from the battery, characterised in that the second machine (11) is so arranged that in the second operational state as motor it operates within a lower speed range, that the first machine (1) is so arranged that in the first operational state it functions as motor within a higher speed range which is located above the lower speed range, that the first machine is arranged to drive the second machine during its operation as propulsion motor and that a speed-sensing arrangement (23) is provided to change over the second machine from motor operation to generator operation when, as a result of the work of the first machine, the speed rises to the higher speed range, and to engage the second machine as motor when the speed is located within the lower speed range, so that of the two operational states the first can be achieved by bringing the first machine (1) into operation, whereby the higher speed range is normally reached and the second machine (11) functions as generator, or by shutting down the first machine whereby the second operational state involving the lower speed range is adopted and the second machine operates as motor.

2. Propulsion arrangement as in claim 1 characterised in that the first machine (1) is arranged so that at heavy loading it can operate in the lower speed range whereby when the lower speed is adopted under load the second machine (11) is caused by the speed-sensing arrangement (23) to change from generator operation to motor operation, by this means supporting the work of the first machine.

BAD ORIGINAL

3. Propulsion arrangement as in claims 1 or 2, characterised in that the first machine (1) and the second machine (11) are coupled in drive connection with the same output drive shaft (12) whereby the first machine is coupled to the drive shaft by means of a free-wheel coupling (19) in such a way that when the first machine is in operation this can drive the output shaft via the free-wheel coupling, whilst when it is not in operation the output shaft can rotate in the drive direction free-wheeling from the drive connection with the first machine.

4. Propulsion arrangement as in claims 1, 2 or 3 characterised in that the first machine (1) and the second machine (11) are arranged to drive the propulsion mechanism of the vehicle via an hydraulic power transmission (13,15) which is infinitely adjustable over at least a part of its speed range

5. Arrangement as in claim 4, characterised in that the hydraulic power transmission (13,15) is infinitely adjustable within a range such that the envisaged difference in speed between driving by means of the first machine (1) with its higher speed and driving by means of the second machine (11) with its lower speed can be compensated for by varying the transmission ratio in the hydraulic power transmission in such a way that the speed of propulsion of the vehicle can be maintained unchanged within the envisaged normal range of drive speed when changing over between the two machines as propulsion source.

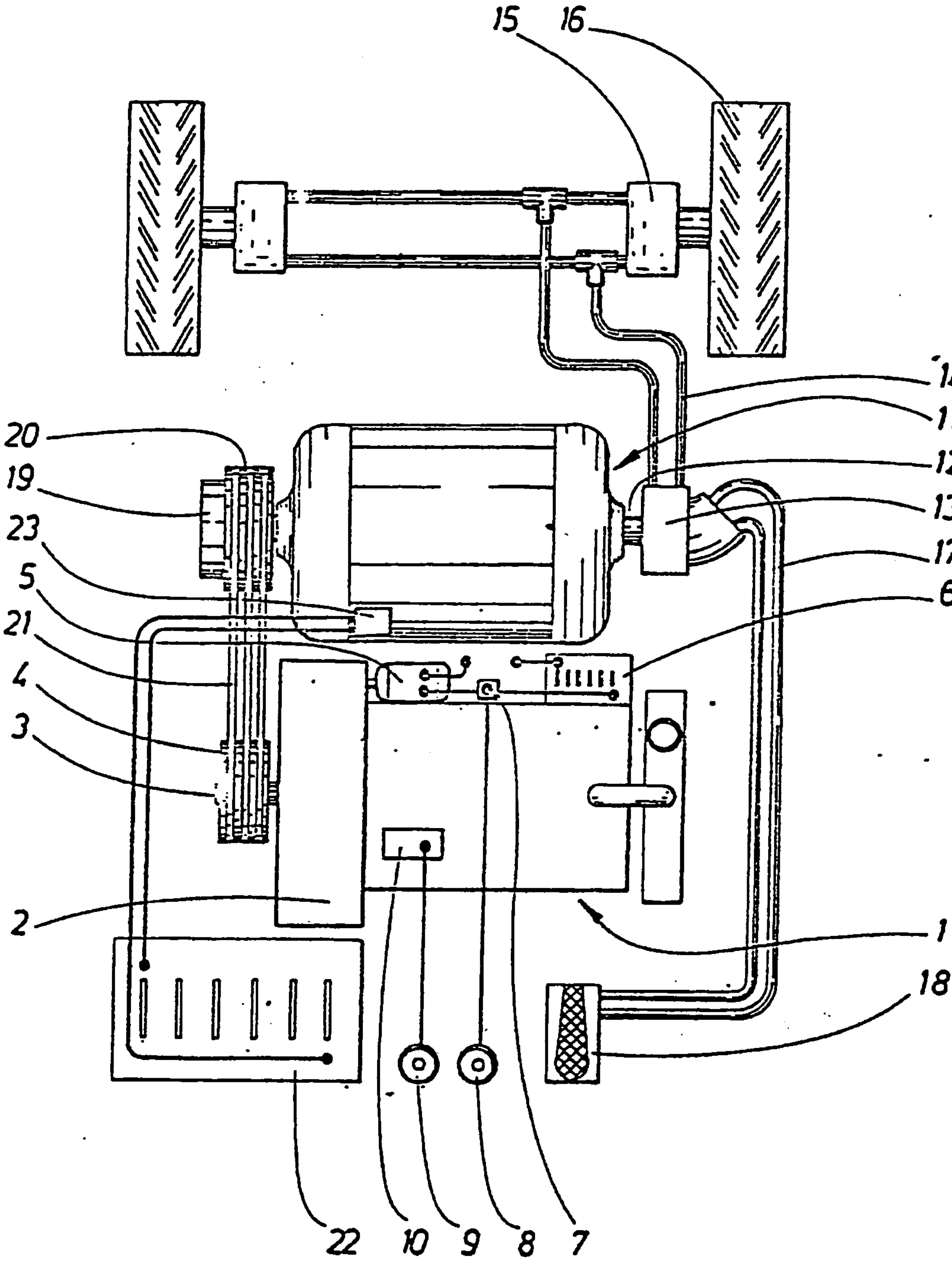

FIG. 1

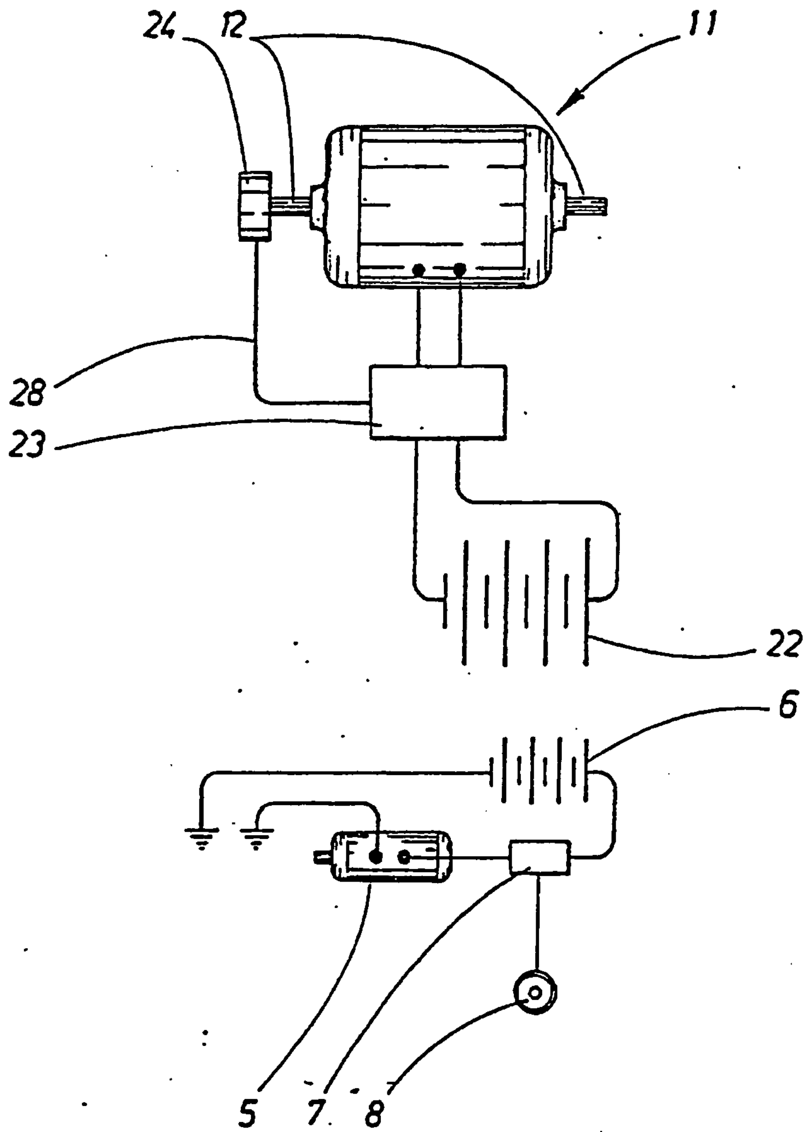

FIG. 2

BEST AVAILABLE COPY

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE81/0028[illegible]

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC 3

B 60 L 11/12

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC 3	B 60 L 11/00-18, B 63 H 23/12, 24
US Cl	180-65
National Cl	63c:1/06; 201:7/02, 10

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	US, A, 3 543 873 (LEWIS G HARMON) 1 December 1970 (01.12.70)	1-5
Y	US, A, 3 970 163 (NISSAN MOTOR CO LTD) 20 July 1976 (20.07.76)	1-5
Y	GB, A, 1 390 088 (ROBERT BOSCH GmbH) 9 April 1975 (19.04.75)	1-5
A	US, A, 4 165 795 (GOULD INC) 28 August 1979 (28.08.79)	
A	US, A, 3 791 473 (PETRO-ELECTRIC MOTORS LTD) 12 February 1974 (12.02.74)	

* Special categories of cited documents: [15]

"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

"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

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
1981-12-03	[illegible]
International Searching Authority [1]	**Signature of Authorized Officer** [20]
Swedish Patent Office	Håkan Sandh

Form PCT/ISA/210 (second sheet) (October 1981)

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/382,577	03/07/2003	Alex J. Severinsky	PAICE201.DIV	9389

7590 10/26/2005

Michael de Angeli
60 Intrepid Lane
Jamestown, RI 02835

EXAMINER	
DUNN, DAVID R	

ART UNIT	PAPER NUMBER
3616	

DATE MAILED: 10/26/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

Supplemental Notice of Allowability	Application No. 10/382,577	Applicant(s) SEVERINSKY ET AL.	
	Examiner David Dunn	Art Unit 3616	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to amendment filed 2/22/05 and telephone interview of 10/24/05.

2. ☒ The allowed claim(s) is/are 82-122.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date 7/01/05
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☒ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

David Dunn
Primary Examiner
Art Unit 3616

EXAMINER'S AMENDMENT

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Michael de Angeli on October 24, 2005.

The application has been amended as follows:

In claim 82, line 19, after "when torque", --required to be-- has been inserted.

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to David Dunn whose telephone number is 571-272-6670. The examiner can normally be reached on Mon-Fri, 8:30-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Paul Dickson can be reached on 571-272-6669. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

David Dunn
Primary Examiner
Art Unit 3616

OIPE JC135
JUL 0 1 2005
PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577
	APPLICANT: Severinsky et al	
	FILING DATE: 3/7/2003	GROUP ART UNIT: 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	5844342	12/1998	Miyatani et al			
DD	5804947	9/1998	Nii et al			
DD	5457363	10/1995	Yoshii et al			
DD	5907191	5/1999	Sasaki et al			
DD	5914575	6/1999	Sasaki			
DD	6005297	12/1999	Sasaki et al			
DD	6166499	12/2000	Kanamori et al			
DD	5801497	9/1998	Shamoto et al			
DD	5909720	6/1999	Yamaoka			
DD	5698955	12/1997	Nii			
DD	5428274	6/1995	Furutani et al			
DD	6077186	6/2000	Kojima et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	2419832	3/1978	France			X	
DD	3124201	10/1989	Japan			X	
DD	51103220	2/1975	Japan			X	
DD	H564531	9/1984	Japan			X	
DD	S48 49115	10/1971	Japan			X	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Winkelman et al, SAE paper 730511, "Computer Simulation...." (1973)
DD	Berman et al, IEEE VT-23, NO. 3, pp. 61-72 "Propulsion Systems...."(1974)
DD	Berman SPC-TUE-2 "Battery Powered Regenerative SCR Drive"(1970)
DD	Gelb et al "Performance Analyses..." ACS pub (1972), pp 977-988
DD	Berman SPC-TUE-1 "Design Considerations...." (1971)
DD	Berman SPC-TUE-2" All Solid State Method....." (1971)

EXAMINER	DATE CONSIDERED 10/12/05

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

OIPE JC139 JUL 01 2005 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577
	APPLICANT: Severinsky et al	
	FILING DATE: 3/7/2003	GROUP ART UNIT: 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	5991683	11/1999	Takaoka et al			
DD	5473228	12/1995	Nii			
DD	5927415	7/1999	Ibaraki et al			
DD	5928301	7/1999	Soga et al			
DD	6176807	1/2001	Oba et al			
DD	5904631	5/1999	Morisawa et al			
DD	5789877	8/1998	Yamada et al			
DD	6087734	7/2000	Maeda et al			
DD	5973460	10/1999	Taga et al			
DD	5988307	11/1999	Yamada et al			
DD	5991683	11/1999	Takaoka et al			
DD	5818116	10/1998	Nakae			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	S 50 3 0 2 2 3	7/1973	Japan			X	
DD	WO 82 0 11 7 0	4/1982	PCT				
DD	0 5 1 0 5 8 2	12/1995	EPO				
DD	4 2 9 7 3 3 0	3/1991	Japan				✓

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Minorikawa et al, "Current Status and Future Trends...." (Undated)
DD	Baum et al "Semiconductor Technologies..." (Undated)
DD	Chen "Automotive Electronics in the Year 2000..." (Apparently 1992)
DD	Brusaglino, SAE paper 910244 "Electric Vehicle Development..." (1991)
DD	Anderson et al, SAE paper 910246 "Integrated Electric..." (1991)
DD	Burke, SAE paper 911914 "Battery Availability for Near-Term..." (1991)

EXAMINER	[signature]	DATE CONSIDERED	10/12/05

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

.17

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD		Chang, IEEE AES Magazine (1993) "Recent Developments of Electric ..."
DD		Kamiyama et al, IEEE 0-7803-0582-5 (1992) "Application Trends...."
DD		Sen, IEEE Trans. Ind. Elec. (1990) "Electric Motor Drives..."
DD		Wang et al, PCSC '71 Record, "Analysis of SCR Chopper Drive" (1971)
DD		EPRI Report TR-101264 "Assessment of Electric Motor Technology (1992)
DD		Berman et al, SAE paper 720111 "Electric Car Drives...." (1972)

EXAMINER	DATE CONSIDERED
[signature]	10/12/05

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

OIPE JC138
JUL 0 1 2005
PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	WO 99 2 4 2 8 0	11/1997	PCT			X	
DD	EP 07 4 3 2 1 1	5/1996	EP				
DD	EP 08 3 9 6 8 3	10/1997	EP				

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Gelb et al, "The Application of Solid Electrolyte Batteries..." (Undated)
DD	Miller, "Integrated Power Module Requirements for Automotive..." (Undated)
DD	Vukosavic et al, IEEE Trans. Ind. App. "SRM Inverter Topologies..." (1991)

EXAMINER	DATE CONSIDERED 10/12/05

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

Issue Classification	Application/Control No. 10/382,577	Applicant(s)/Patent under Reexamination SEVERINSKY ET AL.	
	Examiner David Dunn	Art Unit 3616	

ISSUE CLASSIFICATION

ORIGINAL		CROSS REFERENCE(S)							
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)						
180	65.2	180	65.4						
INTERNATIONAL CLASSIFICATION		701	54						
B 6 0 K	6/02								
	/								
	/								
	/								
	/								

(Assistant Examiner) (Date)	David R. Dunn (Primary Examiner) (Date)	Total Claims Allowed: 41
(Legal Instruments Examiner) (Date)		O.G. Print Claim(s): 1 — O.G. Print Fig.: 4

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		31		61		91		121		151		181
	2		32		62		92		122		152		182
	3		33		63		93		123		153		183
	4		34		64		94		124		154		184
	5		35		65		95		125		155		185
	6		36		66		96		126		156		186
	7		37		67		97		127		157		187
	8		38		68		98		128		158		188
	9		39		69		99		129		159		189
	10		40		70		100		130		160		190
	11		41		71		101		131		161		191
	12		42		72		102		132		162		192
	13		43		73		103		133		163		193
	14		44		74		104		134		164		194
	15		45		75		105		135		165		195
	16		46		76		106		136		166		196
	17		47		77		107		137		167		197
	18		48		78		108		138		168		198
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	25		55		85		115		145		175		205
	26		56		86		116		146		176		206
	27		57		87		117		147		177		207
	28		58		88		118		148		178		208
	29		59		89		119		149		179		209
	30		60		90		120		150		180		210

Search Notes

Application No.	Applicant(s)
10/382,577	SEVERINSKY ET AL.
Examiner	**Art Unit**
David Dunn	3616

SEARCHED

Class	Subclass	Date	Examiner
180	65.2 65.3 65.4 65.8 165	11/29/2004	DD
60	706 711 716		
	718		
290	17 40R 40C		
322	16		
477	2 3		
UPDATE	SEARCH	3/16/05	DD
701	54	"	"
Updated		10/24/05	DD

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner
180	65.2	3/16/05	DD
	65.4		
Updated		10/24/05	DD

SEARCH NOTES (INCLUDING SEARCH STRATEGY)

	DATE	EXMR
EAST text search	11/29/2004	DD

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IFW

Application :	10/382577	**Examiner :**	Dunn	**GAU :**	3616
From:	TW	**Location:**	IDC FMF (FDC)	**Date:**	1-6-06

Tracking #: 6109169 Week Date: 5-23-05

DOC CODE	DOC DATE	MISCELLANEOUS
☐ 1449		☐ Continuing Data
☐ IDS		☐ Foreign Priority
☐ CLM		☐ Document Legibility
☐ IIFW		☐ Fees
☐ SRFW		☐ Other
☒ DRW	3-7-03	
☐ OATH		
☐ 312		
☐ SPEC		

Attn: Chief Draftsperson

[RUSH] **MESSAGE:**

In the Formal Drawings submitted on 3-7-03 the Figure 3 drawing has crossed out data, handwritten data and has data cut off at the bottom of the sheet.

Please supply a corrected drawing

Thank You
TW

[XRUSH] **RESPONSE:**

Dwg corrected

INITIALS: WJ

NOTE: This form will be included as part of the official USPTO record, with the Response document coded as XRUSH.
REV 10/04

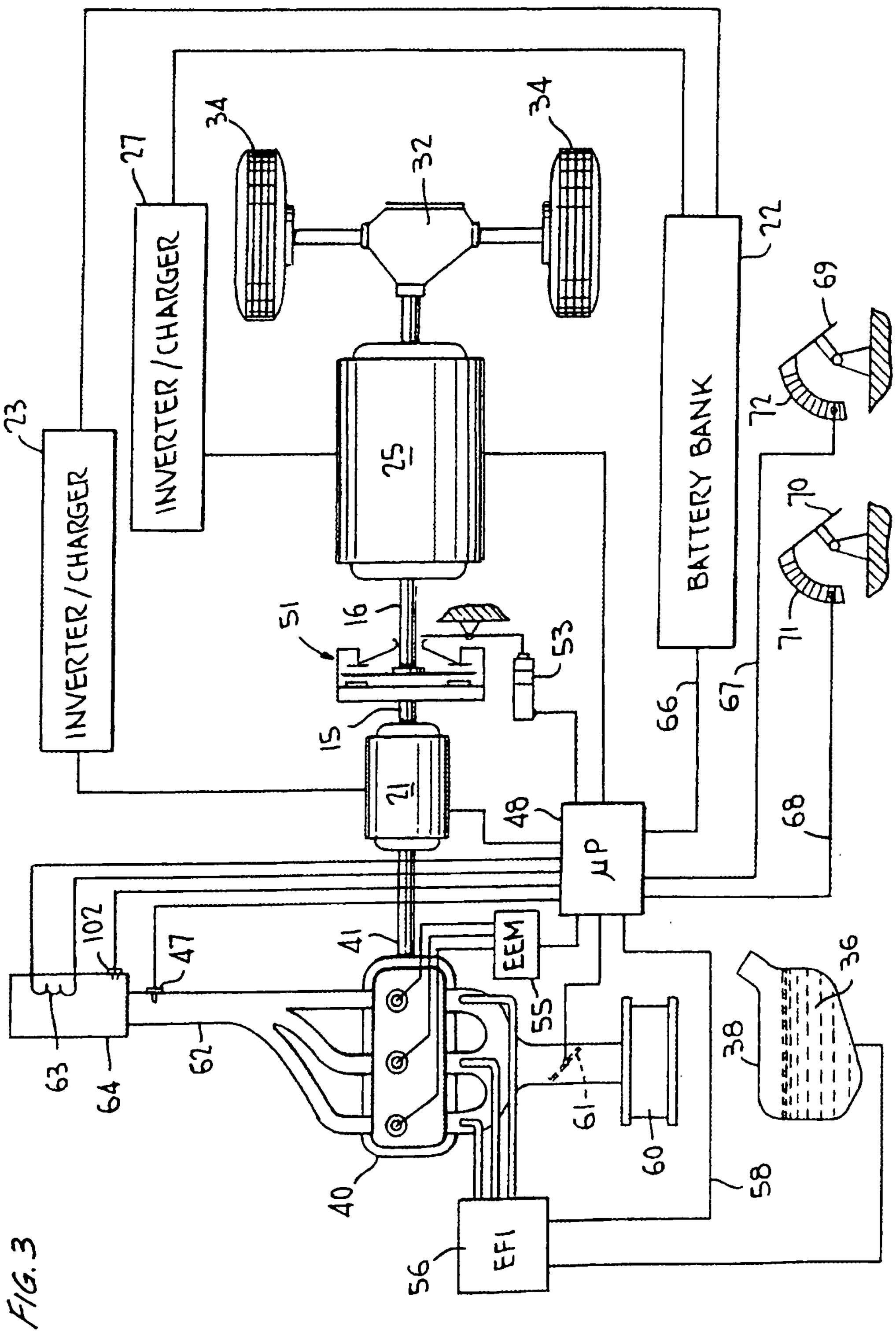
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FIG. 3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of	:	
Severinsky et al	:	Examiner: David Dunn
Serial No.: 10/382,577	:	Group Art Unit: 3616
Filed: March 7, 2003	:	Att.Dkt.:PAICE201.DIV
For: Hybrid Vehicles		

FAX RECEIVED
JAN 19 2006
OFFICE OF PETITIONS

PETITION UNDER 37 C.F.R § 1.313(c)(2)
TO WITHDRAW ALLOWED APPLICATION FROM ISSUE

Mail Stop Petition
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

This is a petition under 37 C.F.R. § 1.313(c)(2) for withdrawal from issue of an application in which the issue fee has been paid. Applicants respectfully request that the captioned application be withdrawn from issue to permit consideration of an Information Disclosure Statement under 37 C.F.R. § 1.97. The Information Disclosure Statement (IDS) contains materials from a recent jury trial, conducted December 6 - 20, 2005, involving the patents from which the present application claims priority. Concurrently with the present petition, Applicants have filed a Request for Continued Examination (RCE) under 37 C.F.R. § 1.114 along with the IDS mentioned above, copies of which are attached hereto. Applicants respectfully request the Office of Petitions to grant the present petition and hence allow for entry of the RCE and IDS in the present case.

The Commissioner is authorized to charge the petition fee of $130.00 (pursuant to 37 C.F.R. § 1.17(h)) to Deposit Account No. 04-0401 of the undersigned. If any extension of time (under 37 C.F.R. § 1.136) is necessary to prevent the above referenced application from becoming abandoned, Applicants hereby petition for such extension. The Commissioner is also authorized to charge any extension fee or other fees which may be necessary to the same account number.

As indicated above, enclosed herewith are the following items:

01/26/2006 CKHLOK 00000001 040401 10382577

01 FC:1464 130.00 DA

☒ Request for Continued Examination

☒ Information Disclosure Statement

The Information Disclosure Statement includes a PTO-1449 form listing materials that will be being submitted to the Examiner for consideration. The volume of these materials makes their submission with this Petition infeasible.

Should any questions remain, the Petitions Examiner is invited to telephone the undersigned at the number given below.

Grant of the above Petition, withdrawal of the application from issue, entry of the Request for Continued Examination, and return of the application to the Examiner for consideration of the Information Disclosure Statement are earnestly solicited.

Respectfully submitted,

Dated: Jan. 19, 2006

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

**** CERTIFICATE OF FACSIMILE TRANSMISSION ****

I hereby certify that this correspondence is being transmitted via facsimile to the United States Patent and Trademark Office (Fax No. 571-273-0025) on the date shown below:

Michael de Angeli
Name of Registered Representative

Signature — January 19, 2006
Date

MICHAEL M. DE ANGELI, P.C.
ATTORNEY AT LAW
60 INTREPID LANE
JAMESTOWN, RHODE ISLAND 02835
(401) 423-3190

FAX RECEIVED
JAN 19 2006
OFFICE OF PETITIONS

REGISTERED PATENT ATTORNEY

ADMITTED TO BARS OF PA & MD
NOT ADMITTED IN RI

FAX: (401) 423-3191
E-MAIL: MDEANGE@COX.NET

FACSIMILE TRANSMISSION

To: Petitions Examiner Wan Laymon
U.S. Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

Fax Number: 571 273-0025 Date: January 19, 2006

Re: Ser. No. 10/382,577

Total Pages (including this sheet): 8

Dear Ms. Laymon:

Attached pursuant to our conversation of yesterday are a Petition to Withdraw this application from issue, together with a Request for Continued Prosecution, and an Information Disclsoure Statement, with one sheet of PTO-1449.

Please contact me if there are any questions concerning this Petition or the supporting documents..

Very truly yours,

Michael de Angeli

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of	:	
Severinsky et al	:	Examiner: David Dunn
Serial No.: 10/382,577	:	Group Art Unit: 3616
Filed: March 7, 2003	:	Att.Dkt.:PAICE201.DIV

For: Hybrid Vehicles

REQUEST FOR CONTINUED EXAMINATION OF APPLICATION

Mail Stop Petition
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This is a request for continued examination of the above identified application, pursuant to 37 C.F.R. § 1.114. This request is being filed together with a Petition under 37 C.F.R. § 1.313(c)(2) for withdrawal from issue of an application in which the issue fee has been paid, in order to permit consideration of an Information Disclosure Statement under 37 C.F.R. § 1.97, both being filed concurrently herewith, as attached.

The following are the elements of the application enclosed:

1. Filing Fee:
   - ☐ A Fee Authorization is enclosed.
   - ☒ The Commissioner is hereby authorized to charge the RCE fee of $790.00 required under 37 C.F.R. § 1.17(e) to Deposit Account No. 04-0401 of the undersigned.
2. Submission under 37 C.F.R. § 1.114(c):
   - ☒ Information Disclosure Statement (IDS), with PTO-1449 listing materials to be subsequently provided
   - ☐ Copies of IDS Citations
3. Amendments
   - ☐ A preliminary amendment is enclosed.
   - ☐ Enter the unentered amendment previously filed on _____ under 37 C.F.R. § 1.116.
   - ☐ An amendment and response are attached hereto.
   - ☐ Please consider the arguments in the response filed on _____ under 37 C.F.R. § 1.116.
   - ☐ Please consider the arguments in the Appeal Brief or Reply

01/26/2006 CKHLOK 00000001 040401 10382577
02 FC:1801 790.00 DA

Brief filed on _____.

4. ☐ Please enter the enclosed affidavits or declarations.

5. ☐ Return Receipt Postcard

6. ☐ Other: ______________________________

If any extensions of time (under 37 C.F.R. § 1.136) are necessary to prevent the above referenced application(s) from becoming abandoned, Applicants hereby petition for such extensions.

The Commissioner is hereby authorized to charge any fees which may be required or credit any overpayment to Deposit Account No. 04-0401 of the undersigned.

Respectfully submitted,

Dated: Jan. 19, 2006

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of

Severinsky et al	Examiner: David Dunn
Serial No.: 10/382,577	Group Art Unit: 3616
Filed: March 7, 2003	Att.Dkt.:PAICE201.DIV
For: Hybrid Vehicles	

FAX RECEIVED

JAN 1 9 2006

OFFICE OF PETITIONS

Hon. Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

FOURTH SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Sir:

Applicant submits this Information Disclosure Statement for consideration by the Examiner. The issued patents from which this application claims priority have been asserted against Toyota Motor Corporation, Toyota Motor North America, Inc. and Toyota Motor Sales, USA, Inc. (collectively "Toyota") in civil action 2:04-CV-211 in the United States District Court for the Eastern District of Texas. A jury trial was recently conducted December 6 - 20, 2005, and a verdict holding the parent patents valid but not infringed was returned.

Applicants submit herewith materials from this litigation for the purpose of full disclosure. Applicants respectfully request the Examiner to fully review and consider these materials in determining patentability of the present application. The materials submitted include transcripts of the trial and deposition testimony of the witnesses on whom Toyota relied for prior art assertions, with any confidential material redacted therefrom, together with copies of the documentary evidence discussed therein.

The Examiner is respectfully requested to consider these materials, to indicate that he has done so in the file of this application, and to then issue a second Supplemental Notice of Allowance.

The materials also include a copy of the Court's *Markman* ruling construing the claims of the parent patents.

Should the Examiner have any questions concerning the materials submitted, he is invited to telephone the undersigned at the number given below.

A Supplemental Notice of Allowability is earnestly solicited.

Respectfully submitted,

Dated: 1/19/2006

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

FAX RECEIVED
JAN 1 9 2006
OFFICE OF PETITIONS

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER	PAICE201.DIV	APPLICATION NUMBER	10/382,577
	APPLICANT	Severinsky et al		
	FILING DATE	3/7/2003	GROUP ART UNIT	3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Trial and deposition transcripts of witnesses relied upon to assert invalidity of parent patents in Civil Docket No. 2:04-CV-211-DF (E.D. Texas), with documentary evidence made of record therein

Claim construction order entered September 28, 2005 in Civil Docket No. 2:04-CV-211-DF (E.D. Texas)

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

MICHAEL DE ANGELI
60 INTREPID LANE
JAMESTOWN, RI 02835

COPY MAILED

JAN 2 6 2006

OFFICE OF PETITIONS

In re Application of :
Alex J. Severinsky et al :
Application No. 10/382,577 : ON PETITION
Filed: March 7, 2003 :
Attorney Docket No. PAICE201.DIV :

This is a decision on the petition under 37 CFR 1.313(c)(2), filed January 19, 2006, to withdraw the above-identified application from issue after payment of the issue fee.

The petition is **GRANTED**.

The above-identified application is withdrawn from issue for consideration of a submission under 37 CFR 1.114 (request for continued examination). See 37 CFR 1.313(c)(2).

Petitioner is advised that the issue fee paid on July 1, 2005 in the above-identified application cannot be refunded. If, however, the above-identified application is again allowed, petitioner may request that it be applied towards the issue fee required by the new Notice of Allowance.[1]

Telephone inquiries should be directed to Wan Laymon at (571) 272-3220.

This matter is being referred to Technology Center AU 3616 for processing of the request for continued examination under 37 CFR 1.114.

Wan Laymon
Wan Laymon
Petitions Examiner
Office of Petitions

---

[1] The request to apply the issue fee to the new Notice may be satisfied by completing and returning the new Issue Fee Transmittal Form PTOL-85(b), which includes the following language thereon: "Commissioner for Patents is requested to apply the Issue Fee and Publication Fee (if any) or re-apply any previously paid issue fee to the application identified above." Petitioner is advised that, whether a fee is indicated as being due or not, the Issue Fee Transmittal Form **must** be completed and timely submitted to avoid abandonment. Note the language in bold text on the first page of the Notice of Allowance and Fee(s) Due (PTOL-85).

ZJW

OIPE IAP14 MAR 28 2006 PATENT & TRADEMARK OFFICE

MICHAEL M. DE ANGELI, P.C.
ATTORNEY AT LAW
60 INTREPID LANE
JAMESTOWN, RHODE ISLAND 02835
(401) 423-3190

REGISTERED PATENT ATTORNEY

ADMITTED TO BARS OF PA & MD

NOT ADMITTED IN RI

FAX: (401) 423-3191
E-MAIL: MDEANGE@COX.NET

March 27, 2006

Examiner David Dunn
United States Patent and Trademark Office
Group Art Unit 3616
P.O. Box 1450
Alexandria, VA 22313-1450

BY HAND

RE: Ser. No. 10/382,577

Dear Examiner Dunn:

Enclosed please find a Fourth Supplemental Information Disclosure Statement for this application. The documents being thus made of record are provided on a CD-ROM, for convenience, and are listed on eight sheets of PTO-1449 form. For your convenience, a second copy of the PTO-1449s is enclosed, showing the DTX (Defendants' trial exhibit) numbers, by which the documents (other than transcripts, and the Court's Claim Construction Order) are indexed on the CD-ROM.

Please feel free to call if there are any questions.

Very truly yours,

Michael de Angeli

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of	
Severinsky et al	Examiner: David Dunn
Serial No.: 10/382,577	Group Art Unit: 3616
Filed: March 7, 2003	Att.Dkt.:PAICE201.DIV
For: Hybrid Vehicles	

Hon. Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

FOURTH SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Sir:

Applicant submits this Information Disclosure Statement for consideration by the Examiner. The issued patents from which this application claims priority have been asserted against Toyota Motor Corporation, Toyota Motor North America, Inc. and Toyota Motor Sales, USA, Inc. (collectively "Toyota") in civil action 2:04-CV-211 in the United States District Court for the Eastern District of Texas. A jury trial was recently conducted December 6-20, 2005, and a verdict holding the parent patents as valid but not infringed was returned.

Applicants submit herewith materials from this litigation for the purpose of full disclosure. Applicants respectfully request the Examiner to fully review and consider these materials in determining patentability of the present application. The materials submitted include transcripts of the trial and deposition testimony of the witnesses on whom Toyota relied for prior art assertions, with any confidential material redacted therefrom, together with copies of the documentary evidence discussed therein.

The materials also include a copy of the Court's Markman ruling construing the claims of the parent patents.

The Examiner is respectfully requested to consider these materials and indicate that he has done so in the file of this application.

Should the Examiner have any questions concerning the materials submitted, he is invited to telephone the undersigned at the number given below.

A Supplemental Notice of Allowability is earnestly solicited.

Dated: March 27, 2006

Respectfully submitted,

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
	5371412	12/1994	Iwashita			
	5412251	5/1995	Furutani			
	5993169	11/1999	Adachi et al			
	6007451	12/1999	Matsui et al			
	6032753	3/2000	Yamazaki et al			
	6155364	12/2000	Nagano et al			
	5539318	7/1996	Sasaki			
	5680050	10/1997	Kawai et al			
	5964309	10/1999	Kimura et al			
	5883496	3/1999	Esaki et al			
	5905360	5/1999	Ukita			
	6158541	12/2000	Tabata et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Trial and deposition transcripts of witnesses relied upon to assert invalidity of parent patents in Civil Docket No. 2:04-CV-211-DF (E.D. Texas)

Claim construction order entered September 28, 2005 in Civil Docket No. 2:04-CV-211-DF (E.D. Texas)

Toyota Hybrid System, Toyota Press Information, Tokyo, 1997

Prius Hybrid EV, Toyota brochure, undated

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION		
DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577	
APPLICANT Severinsky et al		
FILING DATE 3/7/2003	GROUP ART UNIT 361	

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
	5 2 5 3 9 2 9	10/1993	Ohori			
	5 3 2 6 1 5 8	7/1994	Ohori			
	5 4 7 6 1 5 1	12/1995	Tsuchida et al			
	5 5 6 9 9 9 5	10/1996	Kusaka et al			
	5 6 3 7 9 7 7	6/1997	Saito et al			
	5 7 8 9 9 3 5	8/1998	Suga et al			
	5 8 9 5 1 0 0	4/1999	Ito et al			
	5 9 5 1 1 1 5	9/1999	Sakai et al			
	5 9 7 3 4 6 3	10/1999	Okuda et al			
	6 0 5 3 8 4 1	4/2000	Koide et al			
	5 9 2 9 5 9 4	7/1999	Nonobe et al			
	5 9 2 4 3 9 5	7/1999	Moriya et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
	0 1 3 6 0 5 5	03.04.85	European Patent Office				

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

	Miller et al, "Starter-Alternator for Hybrid Electric Vehicle.." (1996)
	Johnston et al, "The Design and Development of the [UC Davis].." (No date)
	Johnston et al, "The Design and Development of the [UC Davis].." (1997)
	Alexander et al, "A Mid-Sized Sedan Designed for High Fuel..." (No date)
	"PRIUS New Car Features", (Toyota manual) (1998)
	TRW Systems Group, "Analysis and Advanced Design Study..." (1971)

EXAMINER	DATE CONSIDERED

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
	4646896	3/1987	Hammond et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
	0769403	23.4.1997	European Patent Office				
	7172196	29.9.1994	Japan			X	
	9170533	9.5.1996	Japan			abst.	
	5319110	5.19.1992	Japan			abst.	
	3273933	12.5.1991	Japan			abst.	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

		Gelb, "An Electromechanical Transmission for Hybrid Vehicle..." (1971)
		Hirose et al, "The New High Expansion Ratio Engine..." (1997)
		Hong, "Toyota's Hybrid Program", *Road & Track*, August 1997
		Law, "Toyota Tech", *Car & Driver*, August 1997
		"Dual-Engine Fuel Saver", *Popular Mechanics*, July 1997
		"Toyota Launches Break-Through Hybrid EV", *Motor Trend*, September 1997

EXAMINER	DATE CONSIDERED

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER	PAICE201.DIV	APPLICATION NUMBER	10/382,577
	APPLICANT	Severinsky et al		
	FILING DATE	3/7/2003	GROUP ART UNIT	361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
	7268922	10.17.1995	Japan			abst.	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

	"Toyota touts advances in safety, emissions", *Automotive News*, 4/28/97
	"'96 North Wind Performance", undated
	Wakefield, "History of the Electric Automobile - Hybrid Electric Vehicles" (1998)
	"Escort 92-94", undated
	"Near-Term Hybrid Vehicle Program", General Electric Company (1979)

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

FORD EXHIBIT 1102

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

	"Guidelines for Electric Vehicle Safety", SAE J2344 (1998)
	"Intrepid", (undated)
	"COE's Team Paradigm challenged to build FutureCar" (1995)
	Butler et al, "A Versatile Computer Simulation Tool.." SAE 970199 (1997)
	Crumbley, "Hybrid vehicle designed", (1994)
	Brokaw, "Students Pick up the Challenge", (1997)

EXAMINER	DATE CONSIDERED

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	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
	5412293	5/1995	Minesawa et al			
	5883484	3/1999	Akao			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
	8214592	8.20.1996	Japan			abst.	
	10663833	3.6.1998	Japan			abst.	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Cuddy et al, "Analysis of the Fuel Economy Benefit..." SAE 970289 (1997)

"Team Paradigm Shines in FutureCar Competition" (1996)

Takaoka et al, "Study of the Engine Optimized for Hybrid System" (undated)

Gelb et al, "Cost and Emission Studies of a Heat Engine/Battery.." (1972)

Gelb et al, "Design and Performance Characteristics..." SAE 690169 (1969)

"Electric/Hybrid Vehicles: Alternative Powerplants..." SAE SP-1284 (1997)

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
	913846	3/1909	Pieper			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

	"Electric and Hybrid Vehicle Design Studies", SAE SP-1243 (1997)
	Gelb, "The case for Constant Speed Accessory Drives", (1975)
	Sasaki, "Toyota's Newly Developed Hybrid Powertrain", (1998)
	"Near-Term Hybrid Vehicle Program, Phase 1", General Electric Co. (1979)
	"Near-Term Hybrid Vehicle Program, Phase 1, App. A.", Gen'l Elec. (1979)
	"Joint Feasibility Study of Hybrid Vehicle, Final Report (1982)

EXAMINER	DATE CONSIDERED

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	APPLICANT Severinsky et al	
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U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

		North American Technology Seminar plans, April 1997
		Hermance, THS Technical Explanation (undated)
		"Toyota" brochure describing Prius (undated)
		Hermance, "Toyota Hybrid System" (undated)

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

ARTIFACT SHEET

Enter artifact number below. Artifact number is application number + artifact type code (see list below) + sequential letter (A, B, C ...). The first artifact folder for an artifact type receives the letter A, the second B, etc.. Examples: 59123456PA, 59123456PB, 59123456ZA, 59123456ZB

10/382 577 UA

Indicate quantity of a single type of artifact received but not scanned. Create individual artifact folder/box and artifact number for each Artifact Type.

[1] CD(s) containing:
- computer program listing [ ]
  Doc Code: Computer — Artifact Type Code: P
- pages of specification and/or sequence listing and/or table [ ]
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March 8, 2004

This form is to be used for application in IFW with a status of 20 and above.

Amended Compact Discs

EXAMINER NOTE: THIS PAPER IS AN INTERNAL WORKSHEET ONLY. DO NOT ENCLOSE WITH ANY COMMUNICATION TO THE APPLICANT. ITS PURPOSE IS ONLY THAT OF AN AID IN HIGHLIGHTING A PARTICULAR PROBLEM IN A COMPACT DISC.

THE ATTACHED CD (COPY 1) HAS BEEN REVIEWED BY OIPE FOR COMPLICANCE WITH 37 CFR 1.52(E).

Date: 5/2/06
Serial No./Control No. 10/382,577
Reviewed By: Kathy Nelson Phone: (703) 308-9210 ext 123

- ☐ The compact discs are readable and acceptable.
- ☐ Copy 1 and Copy 2 of the compact discs are not the same.
- ☐ The compact discs are unreadable.
- ☑ The files on the compact discs are not in ASCII.
- ☐ The compact discs contain at least one virus.
- ☑ The compact discs are not proper subject matter.
- ☐ Other:

1 CD

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 10/382577

CLAIMS AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE	SMALL ENTITY FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY FEE
BASIC FEE (37 CFR 1.16(a))				$	OR		$ 750
TOTAL CLAIMS (37 CFR 1.16(c))	7 minus 20 =	*	X $ =		OR	X $ 18. =	
INDEPENDENT CLAIMS (37 CFR 1.16(b))	3 minus 3 =	*	X $ =		OR	X $ 84. =	
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(d))			+ $ =		OR	+ $ =	
			TOTAL		OR	TOTAL	750

* If the difference in column 1 is less than zero, enter "0" in column 2.

CLAIMS AS AMENDED – PART II

2-22-05

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total (37 CFR 1.16(c))	* 41	Minus	** 126	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(b))	* 2	Minus	*** 11	=	X $ =		OR	X $ =	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(d))					+ $ =		OR	+ $ =	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

10/382577

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total (37 CFR 1.16(c))	* 421	Minus	** 126	= —	X $ =	—	OR	X $ =	—
Independent (37 CFR 1.16(b))	* 2	Minus	*** 3	= —	X $ =	—	OR	X $ =	—
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(d))					+ $ =		OR	+ $ =	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	—

AMENDMENT C

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total (37 CFR 1.16(c))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(b))	*	Minus	***	=	X $ =		OR	X $ =	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(d))					+ $ =		OR	+ $ =	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	5338	((180/65.2) or (180/65.3) or (180/65.4) or (180/65.8) or (180/165) or (60/706) or (60/711) or (60/716) or (60/718) or (290/17) or (290/40R) or (290/40C) or (322/16) or (477/2) or (477/3) or (701/54)).CCLS.	US-PGPUB; USPAT	OR	OFF	2006/07/07 10:45
L2	159115	electric adj motor$1	US-PGPUB; USPAT	OR	OFF	2006/07/07 10:46
L3	298597	battery	US-PGPUB; USPAT	OR	OFF	2006/07/07 10:46
L4	376092	engine	US-PGPUB; USPAT	OR	OFF	2006/07/07 10:46
L5	597317	controller	US-PGPUB; USPAT	OR	OFF	2006/07/07 10:46
L6	248375	torque	US-PGPUB; USPAT	OR	OFF	2006/07/07 10:47
L7	29	2 with 3 with 4 with 5 with 6	US-PGPUB; USPAT	OR	OFF	2006/07/07 10:47

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of :
Severinsky et al : Examiner: N/A
Serial No.: 10/382,577 : Group Art Unit: 3616
Filed: March 7, 2003 : Att. Dkt.: PAICE201.DIV
For: Hybrid Vehicles

Hon. Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Sir:

As discussed in the Preliminary Amendment dated August 11, 2003 in this application, applicants have performed additional searching for new patents possibly relevant to the subject matter of this application as amended, and other new patents and other documents have also come recently to applicants' attention. A number of patents and other documents thus located are listed on attached PTO-1449 forms, and are discussed below. Citation of a document herein should not be considered an admission that the disclosure thereof is indeed relevant to the invention defined by the claims, nor that the document thus made of record is indeed effective as prior art under 35 USC '102.

A correction is also desirable with respect to a statement made in an earlier Information Disclosure Statement (IDS). In the IDS filed on November 18, 1999 in grandparent application Ser. No. 09/264,817, which has been incorporated by reference to form part of the IDS for the present application, Taniguchi patent 5,846,155 was described as showing "a parallel hybrid of generally conventional topology, that is, comprising an ICE [internal combustion engine] and an electric motor connected to the road wheels of the vehicle through a continuously-variable transmission, but discloses a relatively sophisticated operational scheme, wherein the source of propulsive torque varies in accordance with the road load and the state of charge of the battery bank ('SOC')".

This could be misunderstood to suggest that Taniguchi suggests control of the hybrid vehicle's operating mode responsive to the road load and SOC. In fact, Taniguchi does not teach selection of the source of vehicle propulsive torque, much less the operating mode, in accordance with the road load and SOC, but in response to vehicle speed and accelerator pedal position. See col. 8, lines 13 - 40:

> Moreover, the individual engagement means, as shown in FIGS. 4 and 5, are operated as shown in the operation diagram of FIG. 6. *In the power split mode, the split drive unit 9 functions at the start and at a low/medium speed.* The output of the engine 2 is transmitted to the ring gear R through the input clutch Ci. On the other hand, the rotor 5a of the motor-generator 5 is connected to the sun gear S to charge the engine output partially or to output it as the motor so that the composed force is output from the carrier CR to the CVT input shaft 7a.
>
> On the other hand, *the parallel hybrid mode functions in a medium/high speed range*. In this state, the rotary elements of the planetary gear 6 are rotated together, and the output of the engine 2 is fed as it is to the CVT input shaft 7a. At the same time, the motor-generator 5 is connected to the input shaft 7a to assist the engine output or to charge the output partially.
>
> *The motor mode is in the state in which the accelerator opening is small and in which the revolution number is small, e.g., in which the engine 2 need not be used, such as in a traffic jam. Then, the motor-generator 5 is used as the motor to drive the vehicle*. In this state, the input clutch Ci is released to disconnect the engine 2 and the CVT input shaft 7a, and the direct-coupled clutch Cd is applied to output the revolution of the motor-generator rotor 5a directly to the input shaft 7a.
>
> *On the other hand, the engine mode functions during high speed cruising, and the vehicle is driven exclusively by the engine output without any participation of the motor-generator 5.* [Emphasis added].

The Examiner is respectfully requested to review the Taniguchi reference and confirm that in fact the road load is not used to determine the operating mode; in fact, Taniguchi controls the operation of the CVT, and the source of propulsive torque, in response to the vehicle speed and accelerator pedal position.

Turning now to new documents made of record hereby:

Abe 6,281,660 shows a battery charger for an electric vehicle.

Adler et al patent 5,515,937 claims a series hybrid where the power required by traction motors is drawn from either the batteries or directly from the engine/generator unit directly, depending on evaluation of their respective efficiencies and the batteries' state of charge, with respect to each new demand for power.

Barske patent 5,336,932 ties the operation of a generator used to charge a battery to specific fuel-consumption curves stored in ROM.

Bullock patent 6,170,587 shows a hybrid drive, all claims of which require at least three different types of energy storage, e.g., combustible fuel, battery, flywheel, or hydraulic accumulator.

Fattic et al patent 5,637,987 shows a hybrid vehicle in which an internal combustion engine and motor are coupled by controllable friction or electrical loading devices to control ratios.

Gray, Jr. patent 5,887,674 relates to a vehicle driven by a "fluidic motor", that is, having a hydraulic motor driving the wheels, in turn driven by a pump driven by an internal combustion engine.

Patent 4,762,191 to Hagin discloses a hybrid power train for a bus wherein multiple axles are driven via a driveshaft. Some of the dependent claims of the present application, recite connection of the combination of engine and first electric motor to a first set of wheels and connection of the second electric motor to a second set of wheels, which is quite different.

Hoshiya patent 6,315,068 shows a hybrid in which control of the torque provided by the motor is responsive to the torque provided by the engine, so that the engine can be operated at a target speed.

Ibaraki patent 5,856,709, discloses and claims a hybrid topology wherein an engine and a motor/generator are connected to different elements of a "synthesizing/distributing mechanism". A large number (nine or more) of operating modes are provided. The determination of the amount of torque required to propel the vehicle is apparently made in response to the position of the acclerator pedal; see col. 15, lines 59 - 61.

Patent 6,225,784 of Kinoshita claims a battery charge controller for a vehicle, wherein the level of charge above which further charging is permitted is varied based on the battery temperature. Patent 6,232,748 to the same inventor and assignee allows only discharge when the battery is above a specified temperature, and patent 6,204,636, again to the same inventor and assignee, controls the charging and discharge rate of the battery responsive to sensing of the "memory effect" of the battery. None of these expedients are claimed in the present application.

Four Lawrie and Lawrie et al patents, 5,993,350, 6,019,698, 5,979,257, and 6,006,620, and Reed et al 5,943,918 (et al here including Lawrie) are directed to transmissions for hybrids that combine the efficiency of manual transmissions with the convenience of automatic transmissions. Motors are used to operate the conventional "H"-pattern shifter, and a clutch, while the motor/generator present in a hybrid is employed to match the speeds of input and output shafts, to ensure smooth shifting. Finally, Reed, Jr. et al 6,332,257 claims a method of converting a manual transmission to automated operation.

Lovatt et al patent 6,291,953 shows an "electrical drive system", in some cases applied to a hybrid vehicle, requiring a lock-up torque converter.

Minowa et al patent 6,142,907 (Hitachi) claims a hybrid wherein either an engine or a motor is used to propel the vehicle. A generator is selectively connected to the wheels through a two-speed transmission. Patent 6,328,670 is a continuation.

Morisawa et al 5,984,034 discloses a hybrid wherein regenerative braking is used to oppose engine torque when idling to keep the vehicle stopped. Morisawa et al 6,119,799 issued on a continuation and discloses a hybrid offering control of braking responsive to "obstruction [e.g., a car ahead] detection". Another patent based on the same underlying document, no. 6,334,498, claims supplying power from a motor during upshifts of an automatic transmission being driven by an engine. None of these is a feature of the claimed invention.

Another Morisawa patent, no. 5,895,333, is limited to packaging details for a planetary gearbox for a hybrid vehicle. Still another Morisawa patent, no. 6,306,057, claims a complex planetary gearbox arranged so that the internal combustion engine is used to power the vehicle when reversing.

Nagano et al 6,344,008 discloses a hybrid wherein a transmission is coupled between an engine and a torque synthesizing device, which also accepts torque from a single motor.

Nakajima et al 6,090,007 shows a control scheme for a hybrid vehicle including a continuously variable transmission. Patent

6,328,671 to Nakajima et al is a continuation-in-part of the '007 patent and shows setting the "target drive power" based on the accelerator pedal position and vehicle speed.

Nekola patent 5,660,077 shows a variable-speed transmission stated to be useful in a hybrid vehicle, including a cone-shaped gear; the meshing gear slides along the conical gear to vary their relative speeds.

Nitta patent 6,321,150 shows an Aabnormality monitoring system@ that is responsive to faults in a very specific type of communication scheme that can be used for a hybrid vehicle. Another Nitta patent, no. 6,203,468, requires first and second motors on either side of a lock-up clutch, to smooth transitions between series and parallel operation.

Nogi et al patent application US 2001/0037905 is directed to lean-burn operation of a hybrid.

Omote patent 5,944,630 claims controlling torque applied by a motor during shifting operations, to smooth shift transitions.

Oyama patent 6,070,680 relates to prevention of stalling of the engine of a hybrid vehicle due to rapid deceleration; the traction motor provides torque to the engine in such cases.

Patent 6,123,642 to Saito claims a "speed change control apparatus" wherein a motor is connected to the wheels of a vehicle through a multispeed transmission; power to the transmission is cut during shifting.

Tabata et al patent 6,158,541 shows a hybrid vehicle wherein the battery is divided into several portions so that one or more can be completely discharged while the others remain partially charged.

A further Tabata et al patent, no. 5,847,469, is directed to a hybrid wherein the electric motor is employed for reversing if the battery is sufficiently charged, and the engine otherwise.

Another Tabata et al patent, no. 6,317,665, shows a hybrid in which a torque converter with lock-up clutch is disposed between the engine and motor and the wheels; the claims require the lock-up clutch to be released during mode switching to prevent rough running.

Another Tabata patent, no. 6,183,389, is directed to hybrids having "torque transmission systems" (i.e., torque converters; see col. 1, line 52) fitted with lock-up clutches; the invention has to do with the control system for the clutch.

Yet another Tabata et al patent, no. 5,873,426, claims a hybrid having an automatic transmission with differing shift patterns selected depending on the load; apparently, the engine is used as the only torque source in one mode and the engine and motor together in another.

Another Tabata et al patent, no. 5,923,093, recites in claim 1 that the automatic transmission is inhibited from shifting during regenerative braking, in claim 5 "braking shift control means" used when regenerative braking is not available, to downshift the transmission to increase engine braking, in claim 13 braking shift control means operated similarly prior to operation of regenerative braking, in claim 17 a clutch between transmission and engine that is engaged during regenerative braking, and in claim 23 means for preventing changing between engine and regenerative braking during a braking operation.

Still a further Tabata et al patent, no. 6,340,339, is limited to specific constructional details of a motor and transmission assembly for a hybrid.

In another Tabata et al patent, no. 5,935,040, claims 1, 5, 7, and 9 all require a manually-operated member for selecting drive modes, while claim 3 requires an automatic transmission operated so that the drive force remains constant in various drive modes as long as the required output remains constant.

Takaoka et al patent application US 2003/0085577 has claims drawn to control of gear selection in an automatic transmission for a hybrid based on engine efficiency; apparently, if the torque required cannot be supplied efficiently by the engine and motor working together, the transmission is downshifted.

Tuzuki et al patent 5,415,603 shows details of a hydraulic system for a hybrid vehicle in which the oil is used for cooling of a traction motor and lubrication of the transmission.

Wakuta et al patent 6,258,001 is directed to very narrow mechanical aspects of a motor and transmission assembly for a hybrid.

Woon et al patent 5,890,470 claims a method of controlling engine output power, evidently intended to improve on conventional governors as used on diesel engines to smooth throttle response and shifting. Claim 1 is typical and requires operating the engine at a constant horsepower value responsive to throttle position regardless of engine speed.

Yamada et al patent 6,328,122 discloses a series hybrid wherein the ICE can be used for vehicle propulsion only in the event of a failure in the charging system.

Nada patent 6,653,230 is also directed to operation of a hybrid after a particular failure.

Yamaguchi patent 5,915,489 shows a hybrid powertrain. It appears that the output torque is determined based on vehicle speed and accelerator pedal position; see col. 6, lines 17 - 21.

Yamaguchi et al patent 6,278,195 shows applying torque from the electric motor of a hybrid to quickly stop the engine.

Yamaguchi et al patent 6,247,437 claims control of the operation of a starter motor, e.g., for a hybrid, responsive to an engine parameter relevant to its startability. For example, if the engine is cold, fuel is supplied at a lower cranking RPM to limit the drain on the battery. A divisional application (not being supplied), Yamaguchi et al published patent application 2001/0022166, similarly claims a starting control for an engine, in which the rotating speed is limited when the engine is cold to avoid excessive use of battery power.

Yamaguchi patent 5,967,940 is directed to control of the power provided by the engine of a hybrid to prevent noise due to gear backlash.

Yamaguchi 6,135,914 discloses a method of control of a hybrid including an ICE and two motor/generators. The invention has to do with limiting the engine speed so that the first motor/generator is not rotated beyond its capability in the event of a failure The Yamaguchi system operates in engine-only, motor-only, and engine+motor modes (see col. 4, lines 46 - 54), but the method by which the choice between these is made is not explicit.

Field patent 5,081,365 discloses a hybrid vehicle wherein an engine is connected to road wheels through an electric motor, which is operated variously as traction motor or generator, depending on the batteries' state of charge and the vehicle operating mode; the operating mode is selected by the operator from an urban mode, a highway mode, an engine mode, and a cruise control mode. The selection is apparently to be made responsive to motor speed. Field acknowledges at col. 7, line 48 the desirability of operating the engine near its rated power to thus realize high efficiency; as discussed in detail below, Field suggest using an engine that is sized so that it operates at nearly maximum output during flat-highway, constant speed cruising. Such an engine would necessarily be too small to propel the vehicle up hills, so its performance would suffer under such circumstances.

Two additional patents to Field and Field et al, nos. 6,044,922 and 6,481,516, relate to developments of the system disclosed in the '365 Field patent above; the '516 patent is stated to be a continuation of the '922 patent, but their disclosures are not in fact identical. The vehicle described in these patents comprises two separate battery packs, a high-voltage battery pack for supplying power to the traction motor and a lower-powered accessory battery for operating usual vehicle ancillary components such as lights, radio, and the like.

Kubo patent 5,722,502 shows a hybrid vehicle comprising an ICE, a generator and a traction motor also operable as a generator. The vehicle can be operated in a variety of modes, include PEV ("pure electric vehicle", in which the ICE is not run at all; see col. 10, lines 18 - 28), SHV ("serial electric vehicle", wherein the ICE is run to drive the generator, which in turn supplies current to the traction motor to power the vehicle; see col. 5, lines 33 - 51), and "continuous-type PSHV" ("parallel-serial hybrid vehicle", where torque from the ICE is used to propel the vehicle and to drive the generator to power the traction motor to propel the vehicle if torque from the ICE is inadequate; see col. 5, lines 52 - 66). A distinction is drawn between this continuous-type PSHV and a "changeover-type PSHV", as exemplified by Japanese Laid-Open Publication 2-7702; see col. 3, lines 2 - 9 and col. 5, line 66 - col. 6, line 10.

The selection between the PEV mode and one or the other of the SHV and PSHV modes is made by the operator (see col. 10, line 47), while the selection between SHV and PHSV modes is made according to the battery's state of charge (SOC); see col. 6, lines 12 - 13. When the driver selects a mode other than the PEV mode, the engine is operated continuously (col. 11, lines 26 - 32), and may idle when not significantly loaded (col. 12, lines 31 - 32; col. 13, lines 51 - 52); if the battery is fully charged but braking is required, such that regenerative braking would be inappropriate, the engine can be operated as a mechanical brake (col. 11, lines 6 - 20).

In PSHV mode, an engine control unit (ECU) then determines whether torque is to be supplied from the traction motor, ICE, or both, depending on the accelerator pedal angle: "Further, if the change in accelerator pedal angle is too large for the torque to be supplied...by the ICE alone or...by the ICE alone because fuel consumption and emission are degraded, the ECU 20 controls the [inverter] to compensate by using the motor 10 for at least that part of the torque required at the driving wheels." (Col. 13, lines 32 - 39). At low speeds in PSHV mode, it appears that the ICE provides power to the traction motor through the first motor, being operated as a generator.

Tsukamoto et al 5,771,478 shows a hybrid vehicle in which the function of a clutch or torque converter, allowing slipping of an ICE with respect to the wheels of a vehicle, e.g., when accelerating from a stop, is provided by a gearbox connected between the ICE, wheels, and a motor-generator. Excess torque provided by the ICE at starting is absorbed by the motor-generator and stored in a battery; it can then be used to run accessories or propel the vehicle.

Tabata et al 5,833,570 relates to smoothing the shifting of an automatic transmission of a hybrid by application of torque from the traction motor. Tabata 5,951,614 is generally similar, but shows smoothing of shifting by reducing the torque supplied by either the motor/generator or ICE.

Hata et al 5,875,691 discloses and claims a specific arrangement of the components of a hybrid (ICE, motor, transmission) for packaging convenience.

Haka 5,931,271 shows a hybrid powertrain wherein one-way clutches are provided so that the same motor/generator can start an ICE and be disconnected therefrom for efficient regenerative braking.

Shibata et al patent 3,719,881 shows a battery charger arrangement especially for a serial hybrid vehicle, wherein an internal combustion engine is operated to drive a generator only above a minimum load, so as to reduce emissions, which increase at low loads.

Etienne patent 4,187,436 also shows a battery charging arrangement for a serial hybrid vehicle, which includes a first battery for powering the traction motor and a second battery for starting the ICE.

Lynch et al patent 4,165,795 shows a hybrid drive arrangement in which an ICE and a motor/generator are mechanically coupled to one another, and to the wheels of the vehicle, through a transmission. The engine is sized to provide the average power necessary for ordinary driving, and is operated near its optimal efficiency point at all times; the motor/generator is operated for load-leveling, that is, when the vehicle's torque requirements exceed the power provided by the engine the motor/generator adds torque, and when the engine's torque output exceeds the vehicle's torque requirement, the motor/generator operates as a battery charger. The difficulty with this approach is simply that the vehicle's torque requirements may vary by a factor of up to 1000%, or more, between city driving and highway driving, particularly when there are grades (using battery power to climb a grade of any length will quickly discharge any reasonably-sized battery bank) so this solution is not useful in "real-world" driving.

Hadley et al 5,283,470 shows an electric car, that is, without ICE, with regenerative braking. Hadley et al 5,406,126 is similar.

Schmidt 5,669,842 shows a hybrid drive in which either the ICE or one of several separate motors drive the accessories, depending on whether the engine is running. The engine and motors are arranged so that the engine and the mating member of the geartrain are driven at the same speed, allowing the clutch to be synchronously engaged.

Ibaraki et al 6,003,626 discloses a hybrid in which the engine normally propels the vehicle and charges the battery through a generator; if the generator fails, the engine propels the vehicle.

Takahara et al 6,009,365 discloses a hybrid with ICE and motor connected to the wheels through a continuously variable transmission (CVT). During coasting the actual torque being exerted is compared to a calculated desired torque and the actual torque adjusted accordingly.

Bower patent 6,231,135 relates to improvements in brake systems for hybrid vehicles. Although the present application is a division of an application which was a continuation-in-part of earlier applications, and which added disclosure of a new braking system to the disclosure of the parent application, no claims to that braking system are now being pursued in this application.

Soejima 5,951,118 discloses a vehicle braking system, not limited to hybrids, which includes a seating velocity reducing device for slowing the closing of a valve; this can be employed together with regenerative braking in a hybrid. Otomo et al 5,984,432 is similar. As above, no claims of the present application are directed to improvements in braking systems, although the parent was a C-I-P which added material relating thereto to the disclosure of the grandparent application.

Numazawa et al patent 5,497,941, Umebayahi et al patent 6,265,692, and Matsuda et al patent 6,357,541 all relate to improvements in HVAC systems. As in the case of the braking systems discussed above, no claims are currently being pursued to certain new material relating to HVAC systems that was added by the parent C-I-P application to the disclosure of the parent applications.

Takahara et al patent 6,064,161 shows operating a motor/generator of a hybrid to brake a slipping wheel. This is not a feature of the claimed invention. Takahara also shows that the vehicle operating mode can be controlled responsive to accelerator pedal position and vehicle velocity, in common with many other references. See Fig. 5.

Kaiser et al 5,979,158 suggests that emissions of an ICE on starting can be reduced by spinning the ICE to a speed approximating its idle speed, activating the ignition system for about a second, and only then activating the fuel supply. This is suggested to be useful in a hybrid. No claims of the present application are directed to high-rpm starting, although the advantages of doing so are discussed in the application. Kaiser also mentions preheating of the catalyst; this step is recited in claim 77, but is not solely relied upon for patentability. Claim 77 recites, *inter alia,* that the vehicle's operating mode is selected responsive to road load, which is not shown by Kaiser.

Salecker 5,983,740 discloses a system for controlling the engine speed during shifting of an automatic transmission to smooth transition between gears; there is a brief mention that this could be useful in a hybrid.

Salecker 6,006,149 has a closely related disclosure and claims continuing to monitor operating parameters, especially temperatures of various components, for a time (the example being one second) after the engine has been shut off.

Yang patent 5,562,566 is extremely difficult to understand, but appears to disclose a power unit combining an ICE and a motor, which is stated to be useful in vehicles, ships, aircraft, and in industrial and process equipment. The invention seems to be directed to a unit for combining the torque, but again the patent is extremely difficult to understand. Patents 5,547,433 and 5,549,524, also to Yang, appear to be directed to related inventions.

Origuchi patent 5,212,431 is directed to a serial electric hybrid vehicle wherein a generator, preferably to be driven by a gas turbine, is operated in response to monitoring of the battery's state of charge.

Antony et al 5,714,851 shows a serial hybrid with a bypass current path around the rectifiers and battery, to connect a generator driven by an ICE directly to a traction motor.

Horwinski patent 3,904,883 discloses a hybrid, wherein a single electric motor/generator is provided with separably rotatable armature and rotator, so that the unit can be operated as both motor and generator. An ICE is provided to drive the unit, and also to propel the vehicle under various conditions. Mode switching is apparently to be accomplished responsive to the battery's state of charge; see col. 5, lines 20 - 21 and col. 6, lines 64 - 66. The vehicle is intended to operate primarily as an electric car, with overnight charging from the power grid (see col. 6, lines 45 - 51) with the engine primarily provided as a range-extender, though, as noted, the engine can supply torque to the wheels; see col. 5, line 64 - col. 6 line 30.

Reichmann et al 5,851,698 and Venkatesan et al 5,856,047 are directed to nickel-metal hybride (NiMH) batteries optimized for hybrid vehicle applications.

Park 4,331,911 shows a method for equalizing the voltage across individual cells of storage batteries.

Miller et al 4,126,200 shows a vehicle having a flywheel for energy storage. Hagin et al 4,216,684 is similar. Matthews 4,591,016 shows recovering energy during regenerative braking by accelerating a flywheel. Michel 4,592,454 shows doing so employing a hydropneumatic accumulator.

Stuhr 4,674,280 shows an accumulator for the storage of energy in a hydraulic system.

Fiala 4,416,360 shows a vehicle powertrain in which a flywheel connected to the engine by a clutch is rotated by a starter motor, and then used to start the engine using rotational inertia stored in the flywheel; the "starter" motor can then be operated as a generator to recharge the battery.

Moore 4,090,577 shows a hybrid with a conventional engine/transmission assembly driving one pair of wheels, with a solar-charged battery and motor combination driving a second pair.

Walker 5,323,688 discloses hydraulic wheel motors stated to be capable of regenerative braking.

Coe 5,384,521 discloses flywheel energy storage for a vehicle, with electromagnetic couplers.

Boll et al 5,623,194 shows a charge information system for an electric or hybrid vehicle for monitoring battery status and advising the operator.

Weiss 5,947,855 shows a hybrid drive for a tractor or the like wherein torque from an ICE is combined with torque from an electric motor, driven by a generator powered by the ICE is combined individually at the drive wheels by a "Ravigneaux" summing gear set. This is stated to provide flexibility in control.

Smith 5,971,088 shows a battery charging apparatus for regenerative charging wherein the generator is built into the vehicle driveshaft and moves with it as the vehicle encounters bumps and the like.

Walker 5,971,092 shows a hybrid comprising two ICEs, sized to accomodate differing typical loads, plus a hydraulic accumulator. The engines are preferably two-strokes with "inertia pistons" sliding in bores in the main pistons.

Schulze et al 5,675,203 shows a motor/generator; the direction of rotation of the output shaft can be reversed by axial movement of a short-circuit winding.

Fliege 5,675,222 shows switchable winding motors for electric road vehicles.

Fliege 5,915,488 shows reducing the power supplied to switching components in a hybrid drive in response to detection of acceleration over a limiting value, e.g., to prevent sparking and erosion of switch contacts as they are jarred apart over bumps.

Lutz 5,679,087 and 5,685,798 disclose details of planetary gearboxes for vehicles.

Lutz 5,691,588 shows a clutch assembly for connecting motor and ICE of a hybrid, having separately-actuated friction plates on opposite sides of a hub forming part of the rotor.

Lutz et al patent 5,755,302 discloses a specific arrangement of a clutch connecting an engine, motor, and transmission of a hybrid - the rotor is attached to the transmission shaft and the stator to either the engine or the transmission housing, while the clutch also fits at least partially within the stator.

Fliege 5,678,646 discloses modular motors that can be stacked with interconnected coolant circuits to provide different power capacities, stated to be useful in hybrids.

Ruthlein et al 5,698,905 relates to emergency starting of a hybrid with a dead battery, by rearranging connections to allow starting by towing.

Lutz 5,713,427 shows a coupling structure for a hybrid comprising a deformable, resilient disc member.

Lutz 5,829,542 shows vehicles with separate motors on each wheel of at least one pair of wheels.

Welke patent 5,833,022 shows a specific constructional arrangement for a clutch and single traction motor of a hybrid vehicle. No operating scheme is discussed.

Adler et al 5,816,358 shows automatic disconnection of the current supply in the event of accident or the like in vehicles having relatively high current and voltage electric power supplies, e.g., hybrid vehicles.

Gardner 4,753,078 shows a hopelessly complicated hybrid vehicle design involving, among other impracticalities, "recovery of electricity from electromagnetic wind generators, gyrogenerators, and gravitational generators, and for the recovery of compressed air from air pumps...replacing the standard shock absorbers."

Wicks 5,000,003 shows a "combined cycle" engine wherein heat normally lost in the exhaust gases and rejected by heat exchange with cooling water from an ICE is recovered and used to drive a turbine or the like, and suggests that this might be especially suitable for use in a hybrid vehicle.

Lay 5,141,173 shows a vehicle capable of flight as well as travel along the ground. An ICE can propel the vehicle or drive a generator and thence electric motors, depending on the range and speed of intended travel.

Kutter 5,242,335 shows a drivetrain for a hybrid vehicle, shown in automobile and bicycle embodiments, wherein muscle power is combined with power from an auxiliary motor.

Kuang 5,264,764 shows use of an ICE as a power source to serve as a range extender for an electric car, that is, the ICE does not directly propel the vehicle.

Addie 3,699,351 shows a bi-modal vehicle, such as a rail car, which can be propelled by an external power source, such as a third rail, or by a prime mover, such as a gas turbine. A split torque device allows some of the turbine torque to be delivered to the output shaft and the remainder to a motor/generator combination.

Shibata et al 3,719,881 shows a series hybrid, that is, an electric car comprising an ICE arranged to charge a battery connected to a traction motor, wherein the battery's state of charge is monitored and used to control operation of the ICE; the load on the ICE is monitored and the ICE is shut off when the load drops below a predetermined value.

Berman patent 3,753,059 shows a control circuit for a motor operated in both propulsive and regenerative modes, as might be employed in the hybrid vehicle drive system of Berman patent 3,566,717, already of record. Berman 3,790,816 shows an "energy storage and transfer power processor" apparently intended for use with the same system.

Williams 4,099,589 shows a series hybrid wherein the preferred power path is from an ICE to an AC generator to an AC motor, to the wheels; a rectifier, battery and DC motor are also provided as an auxiliary or additional power source.

Rowlett 4,233,858 shows a vehicle propulsion system wherein two electric motors are provided. Torque from the two motors is combined; excess torque is stored in a flywheel, to provide load-leveling.

Dailey 4,287,792 shows a variable gear ratio transmission.

Fiala 4,411,171 shows a hybrid vehicle power train in which a single electric motor/generator and an ICE are coupled to the wheels of the vehicle. Various operating modes are described.

Tankersley et al patent 5,403,244 shows an electric vehicle with a planetary gearbox for reducing the shaft speed of an electric motor to a speed suitable for driving the wheels of the vehicle, and also providing a direct drive.

Hadley et al 5,406,126 shows another serial hybrid. The invention appears to have to do with the method of regenerative charging offered.

Westphal patent 5,570,615 shows a three-mass flywheel construction, with two of the masses connected by springs and the thrid by planetary gears for balancing of various moments and vibrations.

Nedungadi patent 6,110,066 shows a hybrid vehicle operating in four modes, as follows (col. 4, lines 25 - 38): "There are four modes of operation for the vehicle, namely: (a) electric; (b) charge; (c) assist; and, (d) regenerative. In the electric mode, only the motor is providing propulsion power to the vehicle. In the charge mode, part of the engine power drives the vehicle and the rest is absorbed by the motor (operating as a generator) to charge the batteries. In the assist mode, both the engine and the motor are providing power to propel the vehicle. In the regenerative mode, power from the decelerating wheels is diverted to the motor so that it can be used to charge the batteries. .... The controller selects the most appropriate mode depending upon the position of the accelerator pedal, the vehicle speed and the state of charge of the battery." Nedungadi makes it clear that the idea is to keep the engine "as loaded as possible" (col. 8, line 46). In assist mode, this is done by keeping the engine at maximum power; in the charge mode, the engine is maintained at its point of maximum fuel efficiency. See col. 5, lines 46 - 53.

Fini patent 6,387,007 shows several embodiments of hybrids. Mode control appears to be accomplished responsive to accelerator pedal position.

Tsai et al 6,592,484 shows a hybrid comprising an ICE and a single motor as prime movers. The invention is directed to a transmission including four clutches and two planetary gearsets. Some 13 operating modes are stated to be provided.

Horwinski patent 3,904,883 is essentially a predecessor of the Horwinski patent already of record.

Yamada patent 6,041,877 was recently cited in an Office Action issued against a Japanese application based on a PCT application with disclosure corresponding to the disclosures of the two parent applications. According to a non-certified translation of the Office Action, Yamada was cited because it shows "a hybrid vehicle in which a battery is configured as two separate battery sub-banks"; this was cited against a claim not corresponding to any now in this application, including a similar recitation. (Claim 29 of issued patent 6,209,672 includes a comparable limitation.) The disclosure of Yamada otherwise seems merely cumulative to numerous references of record. Japanese Utility Model Application No. 50-099456 (provided with a translated summary sheet only) was also cited in the same Office Action, the Japanese Examiner stating that "there is described a technology in which two battery groups in an electrically driven vehicle (B1 and B2, B4 and B3) are connected in series and the middle of the two battery groups is earthed to a vehicle chassis." Again, this is not relevant to any claim now being asserted herein.

Tabata patent 5,887,670 shows a single-motor hybrid. Mode determination is accomplished (see Fig. 7) responsive to a "currently required output Pd" which is determined responsive to pedal position, rate of change thereof, vehicle speed and trasnmission lever position (see col. 23, lines 20 - 26).

Otsu et al patent 6,123,163 shows a single-motor hybrid configured as a sort of city scooter. The vehicle operates in different modes depending on the "aimed" torque, which is determined responsive to accelerator opening and vehicle speed.

See Fig. 13, col. 10, lines 56 - 67 and col. 17, lines 11 - 33. Otsu 6,260,644 seems to have the same disclosure, and Suzuki 6,253,865 to relate to the same design.

Arai patent 6,435,296 shows a hybrid with an engine driving one set of wheels and a motor driving the other. In order that a DC motor can be used, avoiding the expense of an inverter, the motor is to be used as little as possible.

Sherman 5,789,823 shows both a torque converter and a friction clutch in a single motor hybrid. This is essentially an engine-assist arrangement; the engine can only be started when the vehicle transmission is in neutral (see col. 3, lines 30 - 38), so that it must be run at all times, and the motor/generator is stated to only assist the engine during times of peak power requirement (col. 4, lines 36 - 38). Another Sherman patent 5,258,651 is not directed to hybrid vehicles, but to a system for starting an ICE.

Onimaru 6,007,443 (Nippon Soken) shows a hybrid wherein an ICE is connected through a CVT and a clutch to a motor/generator, the output shaft of which drives the wheels. Above a minimum velocity, the engine is operated at a maximum speed. See col. 7, line 17. At lower vehicle speeds, the engine is permitted to idle; see col. 6, lines 9 - 23.

Ehsani et al, in "Propulsion System Design of Electric and Hybrid Vehicles", discuss determination of the sizes and capacities of an ICE and traction motor for a hybrid vehicle. This is generally relevant to the subject matter of claims 16 and 112. However, note that Ehsani fails entirely to address the relationship claimed between the voltage and current of the battery bank, as claimed. Ehsani et al, in "Parametric Design of the Drive Train of an Electrically Peaking Hybrid (ELPH) Vehicle", go into further detail, and indicate that the vehicle of concern is a single-motor hybrid wherein torque from the ICE and motor can be combined by a "matchgear", as in applicant's prior patent 5,343,970. Ehsani patent 5,586,613, apparently directed to the same work, is discussed in the application as filed.

Yamaguchi et al, "Development of a New Hybrid System - Dual System", SAE paper 960231 (1996) appears to be merely cumulative to numerous patents to the same inventors already of record. "Dual System - Newly Developed Hybrid System" (publication details not known), by some of the same authors, of which only a partial copy is available, is generally cumulative but does provide a diagram showing operation of the various components as a function of time

Takaoka et al, in "A High-Expansion-Ratio Gasoline Engine for the Toyota Hybrid System", discuss the details of an ICE designed for use in a hybrid vehicle. This paper states that "By using the supplementary drive power of the electric motor, the system eliminates the light-load range, where concentrations of hydrocarbons in the emissions are high and the exhaust temperature is low." (p. 57; a similar statement is made on p. 59) and "By allocating a portion of the load to the electric motor, the system is able to reduce engine load fluctuation under conditions such as rapid accleeration. This makes it possible to reduce quick transients in engine load so that the air-fuel ratio can be stabilized easily." (p. 58). The former statement simply emphasizes the fact that engines are operated more efficiently at higher loads, and the latter that stoichiometric combustion can be more nearly obtained if the engine's speed and/or load is varied as slowly as possible.

Sasaki et al, "Toyota's Newly Developed Electric-Gasoline Hybrid Powertrain System" (publication data not available) provides a mathematical analysis of the planetary gearbox.

PCT application PCT/SE81/00280, published as WO 82/01170, shows a hybrid vehicle wherein an ICE is used for propulsion under some circumstances and an electric motor under others, e.g., to provide a forklift truck that operates electrically when indoors and is driven by the ICE when outdoors. The change from one torque source to the other is made as a function of vehicle speed. See p. 3, lines 19 - 28.

Japanese utility model publication 53-55105 (of which only a partial translation is available) appears to show a hybrid vehicle having both an ICE and a motor as sources of propulsive torque, but the description provided is inadequate to understand how the two sources are to be operated. The disclosure of Japanese patent application publication 48-64626 (of which only a partial translation is available) seems to be similar.

Japanese unexamined patent application publication 4-67703 (of which only a partial translation is available) appears to relate to an electric vehicle.

Japanese patent application publication 4-297330 (of which only a partial translation is available) seems to relate to supplementing the regenerative braking available using a traction motor as the source of braking torque with regenerative braking from a generator attached to an ICE, and with friction from motoring the engine under braking.

Japanese patent application publication 55-110328 (of which only a partial translation is available) relate to a vehicle wherein a first pair of wheels is driven by a "main driving unit", a second pair being driven by an "auxiliary power unit", wherein the auxiliary power unit is controlled responsive to a difference in speed between the first and second pairs of wheels.

Japanese utility model publication 51-103220 (of which only a partial translation is available) describes a control system for a hybrid wherein the output shaft of an ICE is connected to that of an electric motor through a clutch, the clutch being controlled to operate when speed sensors on the shafts indicate that their rotational speeds are equal.

Japanese patent 49-29642 (of which only a partial translation is available) also shows a hybrid wherein the shaft of an ICE is connected by a clutch to that of an electric motor; in this case a one-way clutch is also provided.

Japanese patent publication 6-245317 (of which only a partial translation is available) relates to a device for preventing overcharging of the battery of an electric vehicle.

European patent application publication no. 510 582 shows a vehicle powerplant featuring both an ICE and an electric motor as sources of propulsion, and thus a hybrid of sorts, though the term is not mentioned. No suggestion is made that the control of operating mode is made other than by an operator; the determining factor seems to be whether emission must be completely prohibited, as in indoor operation.

European patent application publication no. 510 582 also shows a hybrid vehicle featuring both an ICE and an electric motor as sources of propulsion. Again there is no teaching of the specifics of switching operating mode; the invention has to do with loading the ICE by means of the generator so as to match the speed of the engine to the speed of a drive shaft driven by the traction motor before engaging a clutch connecting the two.

German OS 25 17 110, provided with an English-language abstract, is stated by the abstract to show a hybrid vehicle with a turbine engine. It appears that the vehicle is operated as an electric car until the current drawn exceeds a preset value, when the turbine is actuated; thereafter, the turbine is run at an "optimum setting", with the load split between battery charging and vehicle propulsion.

Mayrhofer et al, "A Hybrid Drive Based on a Structure Variable Arrangement" (1994), shows a hybrid vehicle design involving an ICE, two motor/generators, a planetary gearbox to enable combinations of sources of torque, and no less than four clutches, obviously much more complicated than would be desirable. Of interest with respect to the present invention is that in one operating strategy (see page 196) Mayrhofer et al suggest that the ICE should be activated only when the mean value of the power demanded exceeds a limit for more than a minimum time, 20 seconds being the example given. It is apparent that the ICE is thus to be used only for load-leveling and that mode changes are not being made based on the road load *per se*. In other strategies the engine operation appears to be even further afield from applicants' simple and direct strategy.

A December 1990 *Popular Science* article, "Diesel-Electric VW", describes a hybrid wherein an electric motor, also serving a generator and engine starter, is disposed between clutches connecting the motor to an ICE on one side and the vehicle wheels on the other. It is not clear what modes are provided, although some transitions are apparently made responsive to accelerator pedal position and vehicle velocity.

A May 1991 *Popular Science* article, "Electric Vehicles Only", addresses the then-current state of the art in electric vehicles and mentions hybrids only peripherally.

An April 1991 article appearing in *NASA Tech Briefs* discusses lead/acid batteries having woven electrodes.

As indicated, none of the newly-cited patents made of record hereby disclose or suggest the invention claimed herein. Early and favorable action on the merits of the application is earnestly solicited.

Respectfully submitted,

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
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	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER [signature] DATE CONSIDERED 11/24/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION

DOCKET NUMBER	PAICE201.DIV
APPLICATION NUMBER	10/382,577
APPLICANT	Severinsky et al
FILING DATE	3/7/2003
GROUP ART UNIT	3616

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	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 3616

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DD	Published application US 2001/0037905 ~~of~~, Nogi et al. 11/2001

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	APPLICANT: Severinsky et al	
	FILING DATE: 3/7/2003	GROUP ART UNIT: 3616

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OIPE IAP100 JUL 0 7 2006 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
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	FILING DATE 3/7/2003	GROUP ART UNIT 3616

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OIPE JC17 MAY 2 8 2004 PATENT & TRADEMARK OFFICE

OIPE IAP100 JUL 0 7 2006 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
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	FILING DATE 3/7/03	GROUP ART UNIT 3616

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U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	5675203	10/1997	Schulze et al			
DD	5675222	10/1997	Fliege			
DD	5679087	10/1997	Lutz			
DD	5685798	11/1997	Lutz			
DD	5691588	11/1997	Lutz			
DD	5698905	12/1997	Ruthlein et al			
DD	5713427	2/1998	Lutz			
DD	5714851	2/1998	Antony et al			
DD	5856047	1/1999	Venkatesan et al			
DD	5851698	12/1998	Reichmann et al			
DD	4216684	8/1980	Hagin et al			
DD	4331911	5/1982	Park			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER [signature]	DATE CONSIDERED 4/29/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP § 609: Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

1

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/03	GROUP ART UNIT 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	4416360	11/1983	Fiala			
DD	4591016	5/1986	Matthews			
DD	4592454	6/1986	Michel			
DD	4674280	6/1987	Stuhr			
DD	4753078	6/1988	Gardner			
DD	5000003	3/1991	Wicks			
DD	5141173	8/1992	Lay			
DD	5242335	9/1993	Kutter			
DD	5264764	11/1993	Kuang			
DD	5915488	6/1999	Fliege			
DD	5947855	9/1999	Weiss			
DD	5971088	10/1999	Smith			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER [signature] DATE CONSIDERED 11/29/04

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/03	GROUP ART UNIT 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	5971092	10/1999	Walker			
DD	5755302	5/1998	Lutz			
DD	5678646	10/1997	Fliege			
	~~5833022~~	~~11/1998~~	~~Welke~~			prev cited
DD	5816358	10/1998	Adler et al			
DD	3699351	10/1972	Addie			
DD	3719881	3/1973	Shibata et al			
DD	3753059	8/1973	Berman			
DD	3790816	2/1974	Berman			
DD	4099589	7/1978	Williams			
DD	4233858	11/1980	Rowlett			
DD	4287792	9/1981	Dailey			

FOREIGN PATENT DOCUMENTS

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OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER [signature]	DATE CONSIDERED 11/29/04

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577
	APPLICANT: Severinsky et al	
	FILING DATE: 3/7/03	GROUP ART UNIT: 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	4411171	10/1983	Fiala			
DD	5403244	4/1995	Tankersley			
	~~5406126~~	~~4/1995~~	~~Hadley et al~~			cited on pg 6
DD	5549524	8/1996	Yang			
DD	5547433	8/1996	Yang			
DD	5570615	11/1996	Westphal et al			
DD	5915489	6/1999	Yamaguchi			
DD	6110066	8/2000	Nedungadi et al			
DD	6135914	10/2000	Yamaguchi et al			
DD	6387007	5/2002	Fini			
DD	6563230	5/2003	Nada			
DD ✓	6592484	7/2003	Tsai			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Yamaguchi et al, "Dual System - Newly Developed Hybrid System" (incomplete)
DD	Takaoka et al "A High-Expansion-Ratio Gasoline Engine for the Toyota Hybrid System", *Toyota Technical Review* ~~47, 2, 1998~~ Vol. 47, No. 2, April 1998.
DD	Sasaki et al, "Toyota's Newly Developed Electric-Gasoline Hybrid Powertrain System" (publication data not available)

EXAMINER [signature] DATE CONSIDERED 11/24/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

2

INFORMATION DISCLOSURE CITATION IN AN APPLICATION		
DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577	
APPLICANT: Severinsky et al		
FILING DATE: 3/7/03	GROUP ART UNIT: 3616	

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	3904883	9/1975	Horwinski			
DD	6041877	3/2000	Yamada et al			prev. cited
	~~5887670~~	~~3/1999~~	~~Tabata et al~~			
DD	6123163	9/2000	Otsu et al			
DD	6260644	7/2001	Otsu			
DD	6253865	7/2001	Suzuki			
DD	6435296	8/2002	Arai			
DD	5258651	11/1993	Sherman			
DD	5789823	8/1998	Sherman			
DD	6007443	12/1999	Onimaru			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
	~~50099456~~	~~1/1977~~	~~Japan~~		NOT SUBMITTED		

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Ehsani et al "Propulsion System Design of Electric and Hybrid Vehicles", *IEEE Trans. Ind. Elec.*, **44** 1 (1997)
DD	Ehsani et al, "Parametric Design of the Drive Train of an Electrically Peaking Hybrid (ELPH) Vehicle", SAE paper 970294 (1997)
DD	Yamaguchi et al, "Development of a New Hybrid System - Dual System", SAE papers 960231 (1996)

EXAMINER: [signature] DATE CONSIDERED: 11/29/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of	
Severinsky et al	Examiner: N/A
Serial No.: 11/429,446	Group Art Unit: 3616
Filed: May 8, 2006	Att.Dkt:PAICE201.DIV.6
For: Hybrid Vehicles	

Hon. Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

INFORMATION DISCLOSURE STATEMENT

Sir:

This application is a divisional of Ser. No. 10/382,577. Incorporated herein by reference are the several Information Disclosure Statements (IDSs) that were filed in Ser. No. 10/382,577, and its predecessor, Ser. No. 09/822,866, now Patent 6,554,088. Copies of the IDSs thus incorporated are attached, together with the corresponding PTO-1449 forms. Where available the PTO-1449s attached are those returned by the Examiner, showing corrections that were noted in prosecution of the earlier applications. Copies of the documents thus cited were supplied in the parent and grandparent applications, or in earlier predecessor applications Ser. Nos. 09/264,817, now patent 6,209,672, and 09/392,743, now patent 6,338,391, and copies are accordingly not now being supplied herewith.

The Examiner is respectfully requested to consider the documents thus made of record, and to initial the PTO-1449 forms, indicating that he has done so.

Should there be any questions, the Examiner is invited to telephone the undersigned at the number given below.

Early and favorable action on the merits is earnestly solicited.

Dated: July 6, 2006

Respectfully submitted,

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown RI 02835
401-423-3190

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of	:	
Severinsky et al	:	Examiner: David Dunn
Serial No.: 10/382,577	:	Group Art Unit: 3616
Filed: March 7, 2003	:	Att.Dkt.:PAICE201.DIV
For: Hybrid Vehicles		

Hon. Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

FOURTH SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Sir:

Applicant submits this Information Disclosure Statement for consideration by the Examiner. The issued patents from which this application claims priority have been asserted against Toyota Motor Corporation, Toyota Motor North America, Inc. and Toyota Motor Sales, USA, Inc. (collectively "Toyota") in civil action 2:04-CV-211 in the United States District Court for the Eastern District of Texas. A jury trial was recently conducted December 6-20, 2005, and a verdict holding the parent patents as valid but not infringed was returned.

Applicants submit herewith materials from this litigation for the purpose of full disclosure. Applicants respectfully request the Examiner to fully review and consider these materials in determining patentability of the present application. The materials submitted include transcripts of the trial and deposition testimony of the witnesses on whom Toyota relied for prior art assertions, with any confidential material redacted therefrom, together with copies of the documentary evidence discussed therein.

The materials also include a copy of the Court's Markman ruling construing the claims of the parent patents.

The Examiner is respectfully requested to consider these materials and indicate that he has done so in the file of this application.

Should the Examiner have any questions concerning the materials submitted, he is invited to telephone the undersigned at the number given below.

A Supplemental Notice of Allowability is earnestly solicited.

Dated: March 27, 2006

Respectfully submitted,

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

INFORMATION DISCLOSURE CITATION IN AN APPLICATION		
DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577	
APPLICANT Severinsky et al		
FILING DATE 3/7/2003	GROUP ART UNIT 3616	

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
	5371412	12/1994	Iwashita			
	5412251	5/1995	Furutani			
	5993169	11/1999	Adachi et al			
	6007451	12/1999	Matsui et al			
	6032753	3/2000	Yamazaki et al			
	6155364	12/2000	Nagano et al			
	5539318	7/1996	Sasaki			
	5680050	10/1997	Kawai et al			
	5964309	10/1999	Kimura et al			
	5883496	3/1999	Esaki et al			
	5905360	5/1999	Ukita			
	6158541	12/2000	Tabata et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Trial and deposition transcripts of witnesses relied upon to assert invalidity of parent patents in Civil Docket No. 2:04-CV-211-DF (E.D. Texas)

Claim construction order entered September 28, 2005 in Civil Docket No. 2:04-CV-211-DF (E.D. Texas)

Toyota Hybrid System, Toyota Press Information, Tokyo, 1997

Prius Hybrid EV, Toyota brochure, undated

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
	5253929	10/1993	Ohori			
	5326158	7/1994	Ohori			
	5476151	12/1995	Tsuchida et al			
	5569995	10/1996	Kusaka et al			
	5637977	6/1997	Saito et al			
	5789935	8/1998	Suga et al			
	5895100	4/1999	Ito et al			
	5951115	9/1999	Sakai et al			
	5973463	10/1999	Okuda et al			
	6053841	4/2000	Koide et al			
	5929594	7/1999	Nonobe et al			
	5924395	7/1999	Moriya et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
	0136055	03.04.85	European Patent Office				

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

	Miller et al, "Starter-Alternator for Hybrid Electric Vehicle.." (1996)
	Johnston et al, "The Design and Development of the [UC Davis].." (No date)
	Johnston et al, "The Design and Development of the [UC Davis].." (1997)
	Alexander et al, "A Mid-Sized Sedan Designed for High Fuel..." (No date)
	"PRIUS New Car Features", (Toyota manual) (1998)
	TRW Systems Group, "Analysis and Advanced Design Study..." (1971)

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
	4 6 4 6 8 9 6	3/1987	Hammond et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
	0 7 6 9 4 0 3	23.4.1997	European Patent Office				
	7 1 7 2 1 9 6	29.9.1994	Japan			X	
	9 1 7 0 5 3 3	9.5.1996	Japan			abst.	
	5 3 1 9 1 1 0	5.19.1992	Japan			abst.	
	3 2 7 3 9 3 3	12.5.1991	Japan			abst.	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Gelb, "An Electromechanical Transmission for Hybrid Vehicle..." (1971)

Hirose et al, "The New High Expansion Ratio Engine..." (1997)

Hong, "Toyota's Hybrid Program", *Road & Track*, August 1997

Law, "Toyota Tech", *Car & Driver*, August 1997

"Dual-Engine Fuel Saver", *Popular Mechanics*, July 1997

"Toyota Launches Break-Through Hybrid EV", *Motor Trend*, September 1997

EXAMINER	DATE CONSIDERED

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577
	APPLICANT: Severinsky et al	
	FILING DATE: 3/7/2003	GROUP ART UNIT: 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
	7268922	10.17.1995	Japan			abst.	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

	"Toyota touts advances in safety, emissions", *Automotive News*, 4/28/97
	"'96 North Wind Performance", undated
	Wakefield, "History of the Electric Automobile - Hybrid Electric Vehicles" (1998)
	"Escort 92-94", undated
	"Near-Term Hybrid Vehicle Program", General Electric Company (1979)

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER	PAICE201.DIV	APPLICATION NUMBER	10/382,577
	APPLICANT	Severinsky et al		
	FILING DATE	3/7/2003	GROUP ART UNIT	361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
	913846	3/1909	Pieper			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

"Electric and Hybrid Vehicle Design Studies", SAE SP-1243 (1997)

Gelb, "The case for Constant Speed Accessory Drives", (1975)

Sasaki, "Toyota's Newly Developed Hybrid Powertrain", (1998)

"Near-Term Hybrid Vehicle Program, Phase 1", General Electric Co. (1979)

"Near-Term Hybrid Vehicle Program, Phase 1, App. A.", Gen'l Elec. (1979)

"Joint Feasibility Study of Hybrid Vehicle, Final Report (1982)

EXAMINER	DATE CONSIDERED

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	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

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FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

		North American Technology Seminar plans, April 1997
		Hermance, THS Technical Explanation (undated)
		"Toyota" brochure describing Prius (undated)
		Hermance, "Toyota Hybrid System" (undated)

EXAMINER	DATE CONSIDERED

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
	5 4 1 2 2 9 3	5/1995	Minesawa et al			
	5 8 8 3 4 8 4	3/1999	Akao			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
	8 2 1 4 5 9 2	8.20.1996	Japan			abst.	
	1 0 6 6 3 8 3	3.6.1998	Japan			abst.	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Cuddy et al, "Analysis of the Fuel Economy Benefit..." SAE 970289 (1997)

"Team Paradigm Shines in FutureCar Competition" (1996)

Takaoka et al, "Study of the Engine Optimized for Hybrid System" (undated)

Gelb et al, "Cost and Emission Studies of a Heat Engine/Battery.." (1972)

Gelb et al, "Design and Performance Characteristics..." SAE 690169 (1969)

"Electric/Hybrid Vehicles: Alternative Powerplants..." SAE SP-1284 (1997)

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of : Examiner: David Dunn

Severinsky et al

Serial No.: 10/382,577 : Group Art Unit: 3616

Filed: March 7, 2003 : Att.Dkt.:PAICE201.DIV

For: Hybrid Vehicles

Hon. Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

SECOND SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Listed on attached PTO-1449 forms are a number of documents that have come to applicants' attention since the filing of the Supplemental Information Disclosure Statement filed in this application on May 28, 2004. Applicants' thus making these documents of record should not be deemed a concession that they are necessarily available as prior art as defined by 35 USC Sect. 102. The Examiner is respectfully requested to consider these newly-cited documents and to indicate that he has done so in the file of this application.

The relevance of the newly-cited documents to the present invention is summarized as follows:

Japanese Patent Application Publication 7-54983 (Nakagawa et al) (provided with noncertified translation) shows controlling the shifting of an automatic transmission. The usual method is described as controlling the ratio based on detected engine load and vehicle speed, following a predetermined shift pattern. Prior art shows detecting increase in loading, e.g., "uphill running", if the speed drops below shift boundary line while the throttle opening is over a predetermined value. This is stated to be workable only under limited circumstances. This invention calculates a "running load coefficient KFUKA" which is then smoothed and used to correct the predtermined shift pattern.

From paragraph 10, "[T]he running load coefficient KFUKA is calculated according to an equation KFUKA=2-(b/a) when the detected vehicle speed 'b' is lower than the standard loaded-vehicle speed 'a', and according to an equation KFUFA=a/c when the detected vehicle speed 'c' is higher than the standard value 'a' ". This is mathematically inconsistent, since both "b" and "c" are the "detected vehicle speed". Further, it is clear that KFUKA is a running load coefficient, that is, a correction factor somehow responsive to variation in running load, not the running load itself.

Japanese Patent Application Publication 4-244568 (Onishi et al) (provided with noncertified translation) - Shifting of an automatic transmission is controlled responsive to a predictive program that calculates the torque to be available after shifting. Running load is employed in this calculation. It is stated to be determined as follows:

"(0022) The running load estimating means 101 now multiplies the torque converter output torque Tt by the gear ratio "r" to calculate the torque Tm generated at the wheels, and calculates the running load T_L based on the relational formula T_L = Tm − M · rw · α from the vehicle mass M, the effective wheel radius rw and the acceleration α. The flow of this calculation shown in FIG. 6.

"(0023) In FIG. 6,

Step 601: Reading of the respective data of vehicle speed V_{SP} and engine rotational speed N, gear ratio "r" an acceleration α is performed.

Step 602: the turbine rotational speed Nt is calculated by the following formula:

$Nt = V_{SP}/120\pi/rw \cdot r \times 1000$

Step 603: Torque converter or rotational ratio "e" is calculated and pump torque coefficient τ and torque ratio "t" are searched.

$e = Nt/N,\ \tau = f_1(e),\ t = f_2(e)$

Step 604: Pump torque Tp and turbine torque Tt are calculated.

$Tp = \tau \cdot (N/1000)^2.\ Tt = t \cdot Tp$

Step 605: Calculation of torque Tm.. $Tm = Tp \cdot r$

Step 606: Calculation of running load T_L. $T_L = Tm - M \cdot r \cdot \alpha$".

This makes no sense. In particular, it is clear that the idea is to correct the torque at the wheels Tm by the factor M · r · α to reach the running load, but calculating M · r · α does not yield a torque in units of kg-m, but a value in kg − m^2/sec^2.

In any event it is clear that neither reference refers remotely to hybrid vehicles, much less controlling operating modes thereof responsive to road load.

US Patent 6,067,801 (Harada) is based on Japanese application 9-329430. The disclosure is directed to reducing driveline shock occasioned upon shutting off the engine in a hybrid by loading it using one of the two motor/generators. Road load per se is not discussed; mode switching is discussed only inferentially, e.g., "..at the time when the engine is not required, for example, during a reduction of the speed or a downslope run, the hybrid vehicle stops operation of the engine 150 and runs only with the motor MG2" (col. 9, lines 40 - 43). Harada states nothing of relevance to operating the engine when loaded to above a setpoint SP.

However, this reference is generally relevant in that it acknowledges that the engine can be loaded by the battery charging load as well as the loading required for vehicle propulsion (col. 1, lines 15 - 17), that the engine can be shut off when not needed (as noted, col. 9, lines 40 - 43) and that it should be operated at an efficient operating point (same). The vehicle's power requirements, including power for acceleration, for charging, and for auxiliaries, is calculated, and a decision made whether the engine is required. Engine activation is based on vehicle speed, or the necessity of battery charging (col. 10, line 41 - col. 11, line 18). The engine is run at low power levels (col. 12, line 49), and idling is permitted (col. 11, line 65). The engine can be motored to warm it up prior to starting (col. 12, line 17). It is noted that for a given output power requirement it is more efficient to run the engine at lower RPM and higher torque than at higher RPM and lower torque output (col. 13, lines 34 - 45). The minimum RPM of the engine in the loaded state is maintained greater than in the non-loaded state, in order to allow gentle variation in torque applied to the motor MG1 during mode changes, avoiding rough operation (col. 16, lines 17 - 38), not so as only to operate the engine when loaded to the point of efficient operation. Most of the topologies shown involve the usual planetary gearset for combining the torque from the engine and two motors, but an embodiment is shown in Fig. 12 which avoids the planetary gearbox and first motor in favor of a "clutch motor MG3" which includes first and second rotors that function as an electromagnetic coupling (col. 18, lines 43 - 56). A series hybrid version, in which the engine never transmits torque directly to the wheels, is shown in Fig. 13.

Japanese Patent Application Publication 11-122712 (Morita et al) (provided with partial noncertified translation) shows a hybrid with a traction motor and engine propelling the vehicle; a second motor drives the ancillaries and starts the engine (there is no suggestion that this second motor is used to charge the battery), so the topology is effectively a single-motor hybrid with a separate starter. The invention is essentially to disengage a clutch connecting the engine and wheels upon braking, so that the engine can be shut off; when braking ends, the starter is used to motor the engine, and when the accelerator is then applied fuel is supplied and the engine started. Mode shifting is thus performed strictly in accordance with the operation of the accelerator and brake pedals.

Japanese Patent Application Publication 11-113956 (Hisamura) (provided with partial noncertified translation) shows a control device for a continuously variable transmission. The slope of the road being driven on is determined by a calculation employing the actual torque being supplied and the vehicle speed and acceleration. The "flatland" required torque is calculated and compared to the actual torque, to determine the slope of the road, and the transmission ratio adjusted accordingly.

Japanese Unexamined Patent Publication 11-82260 (Tsuzuki et al) (supplied without translation) - Topology includes engine, first clutch, motor/generator, second clutch, and automatic transmission, and wheels, in that order. In order to reduce shock upon engine starting, the second clutch is opened and left open until the engine and motor/generator are synchronized. This would be completely useless, since power flow to the wheels would be interrupted, seriously impacting drivability. Moreover, this would occur under acceleration, just when it would be most annoying and possibly even unsafe.

Japanese Unexamined Patent Publication 11-82261 (Tsuzuki et al) (supplied without translation) is closely related to the above Tsuzuki patent application. According to notes provided by our searcher, this simply adds the idea of providing a starter on the engine. This would suffer the same drivability problem.

According to our German searcher, German applications 198 38 853, 102 60 435, and 198 14 402, (all supplied without translations) describe methods for starting the engines of single motor hybrids.

Fiala US patent 4,411,171 shows a single-motor hybrid wherein the engine is connected through a first clutch to one side of a flywheel; a second clutch on the other side of the flywheel allows the flywheel to be locked to the output shaft, for direct drive, or to serve as the sun gear of a planetary gearbox. The planet carrier is connected to the output shaft, and the ring gear to a single motor/generator. The flywheel can also be locked, which provides an electric-car mode. The vehicle must be stopped to allow starting of the engine (col. 3, line 55), so clearly the vehicle must be operated in distinct low speed (electric car) and high-speed hybrid modes. The engine is to be used to start the vehicle from a standing stop by using some of the engine's torque to drive the motor/generator, i.e., the motor/generator acts as a brake (col. 5, lines 1 - 7), with the planetary gearbox thus decoupling the engine from the output shaft.

Maeda U.S. patent 3,620,323 shows a hybrid vehicle in which the engine is intended to be operated at full throttle at all times; see the abstract, col. 1, lines 37 - 38, col. 5, lines 13 - 15.

Tabata et al U. S. Patent 6,317,665 is directed to control of a lock-up clutch in a hybrid vehicle so as to smooth transitions between operation in motor-drive and engine-drive modes. Tabata et al patent 6,183,389 is also directed to control of operation of lock-up clutches. Finally, Tabata patent 5,887,670 is also directed to smoothing transitions.

Hagiwara patent 5,565,711 is the US equivalent to a Japanese patent document cited against a Japanese application claiming priority from the same basic application as the present application. The Hagiwara patent relates to specifics of the connection of the individual batteries in a battery bank. No claims are pending in this application which are drawn to this aspect of the invention.

Again, the Examiner is respectfully requested to consider these documents, and to indicate that he has done so in the file of the application.

Dated: 2/17/05

Respectfully submitted,

Michael de Angeli
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60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

OIPE JC98 FEB 2 2 2005 PATENT & TRADEMARK OFFICE

CANCELLED

OIPE IAP100 JUL 0 7 2006 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION 1/2	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	6067801	5/2000	Harada et al			
DD	4411171	10/1983	Fiala			
DD	3620323	5/1968	Maeda			
DD	6317665	11/2001	Tabata et al			
DD	6183389	2/2001	Tabata et al			
DD	5565711	10/1996	Hagiwara			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	754983	2/1995	Japan			X	
DD	4244658	9/1992	Japan			X	
DD	11082261	3/1999	Japan				X
DD	11122712	4/1999	Japan			Partial	
DD	62113956	5/1987	Japan			Partial	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER DD | DATE CONSIDERED 3/16/05

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION 2/2	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE

FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	11082260	3/1999	Japan				X
DD	19838853	8/1998	Germany				X
DD	19814402	3/1998	Germany				X

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER [signature]	DATE CONSIDERED 3/16/05

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of : Severinsky et al
Serial No.: 10/382,577
Filed: March 7, 2003
For: Hybrid Vehicles

Examiner: David Dunn
Group Art Unit: 3616
Att.Dkt.:PAICE201.DIV

Hon. Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Sir:

The issued patents from which this application claims priority are being asserted against an alleged infringer in civil litigation in the United States District Court for the Eastern District of Texas. The defendants in that case have brought a number of new patents and other documents to applicants' attention. New documents have also been cited in a Complete Search Report prepared by the European Patent Office, dated May 5, 2005 (copy enclosed) against a European application claiming priority from the same US applications. These newly-cited patents and other documents thus located are listed on attached PTO-1449 forms, and are discussed below. The Examiner is respectfully requested to consider these new documents and to indicate that he has done so in the file of this application, and to then re-issue the Notice of Allowance mailed April 21, 2005.

Citation of a document herein should not be considered an admission that the disclosure thereof is indeed relevant to the invention defined by the claims, nor that the document thus made of record is indeed effective as prior art under 35 USC 102.

It is respectfully submitted that although this Statement is being filed after issue of a Notice of Allowance, it is timely under 37 CFR 1.97 (e). The fee of $180.00 (per 37 CFR 1.17(p)) is enclosed.

It is respectfully submitted that none of the newly-cited patents or other documents made of record hereby disclose or suggest the invention claimed herein. Early and favorable action on the merits of the application - specifically, issue of the patent, the Issue Fee having been paid concurrently with submission of this Statement - is earnestly solicited.

Respectfully submitted,

Dated: 6/30/05

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1/5

OIPE JC135 JUL 0 1 2005 PATENT & TRADEMARK OFFICE

CANCELLED

OIPE IAP100 JUL 0 7 2006 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	5844342	12/1998	Miyatani et al			
DD	5804947	9/1998	Nii et al			
DD	5457363	10/1995	Yoshii et al			
DD	5907191	5/1999	Sasaki et al			
DD	5914575	6/1999	Sasaki			
DD	6005297	12/1999	Sasaki et al			
DD	6166499	12/2000	Kanamori et al			
DD	5801497	9/1998	Shamoto et al			
DD	5909720	6/1999	Yamaoka			
DD	5698955	12/1997	Nii			
DD	5428274	6/1995	Furutani et al			
DD	6077186	6/2000	Kojima et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	2419832	3/1978	France			X	
DD	3124201	10/1989	Japan			X	
DD	51103220	2/1975	Japan			X	
DD	H564531	9/1984	Japan			X	
DD	S48491115	10/1971	Japan			X	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Winkelman et al, SAE paper 730511, "Computer Simulation...." (1973)
DD	Berman et al, IEEE VT-23, NO. 3, pp. 61-72 "Propulsion Systems...."(1974)
DD	Berman SPC-TUE-2 "Battery Powered Regenerative SCR Drive"(1970)
DD	Gelb et al "Performance Analyses..." ACS pub (1972), pp 977-988
DD	Berman SPC-TUE-1 "Design Considerations...." (1971)
DD	Berman SPC-TUE-2" All Solid State Method....." (1971)

EXAMINER [signature] DATE CONSIDERED 10/12/05

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

OIPE JC139 CANCELLED 2005 PATENT & TRADEMARK OFFICE

OIPE IAP100 JUL 07 2006 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577
	APPLICANT: Severinsky et al	
	FILING DATE: 3/7/2003	GROUP ART UNIT: 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	5991683	11/1999	Takaoka et al			
DD	5473228	12/1995	Nii			
DD	5927415	7/1999	Ibaraki et al			
DD	5928301	7/1999	Soga et al			
DD	6176807	1/2001	Oba et al			
DD	5904631	5/1999	Morisawa et al			
DD	5789877	8/1998	Yamada et al			
DD	6087734	7/2000	Maeda et al			
DD	5973460	10/1999	Taga et al			
DD	5988307	11/1999	Yamada et al			
DD	5991683	11/1999	Takaoka et al			
DD	5818116	10/1998	Nakae			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	S 50 3 0 2 2 3	7/1973	Japan			X	
DD	W O 82 0 11 7 0	4/1982	PCT				
DD	0 5 1 0 5 8 2	12/1995	EPO				
DD	4 2 9 7 3 3 0	3/1991	Japan				✓

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Minorikawa et al, "Current Status and Future Trends...." (Undated)
DD	Baum et al "Semiconductor Technologies..." (Undated)
DD	Chen "Automotive Electronics in the Year 2000..." (Apparently 1992)
DD	Brusaglino, SAE paper 910244 "Electric Vehicle Development..." (1991)
DD	Anderson et al, SAE paper 910246 "Integrated Electric..." (1991)
DD	Burke, SAE paper 911914 "Battery Availability for Near-Term..." (1991)

EXAMINER [signature] DATE CONSIDERED 10/12/07

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

CANCELLED

OIPE JC133 JUL 8 2005 PATENT & TRADEMARK OFFICE

OIPE IAP100 JUL 07 2006 PATENT & TRADEMARK OFFICE

.17

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Chang, IEEE AES Magazine (1993) "Recent Developments of Electric ..."
DD	Kamiyama et al, IEEE 0-7803-0582-5 (1992) "Application Trends...."
DD	Sen, IEEE Trans. Ind. Elec. (1990) "Electric Motor Drives..."
DD	Wang et al, PCSC '71 Record, "Analysis of SCR Chopper Drive" (1971)
DD	EPRI Report TR-101264 "Assessment of Electric Motor Technology (1992)
DD	Berman et al, SAE paper 720111 "Electric Car Drives...." (1972)

EXAMINER [signature]	DATE CONSIDERED 10/12/05

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

,10

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	WO 99 2 4 2 8 0	11/1997	PCT			X	
DD	EP 07 4 3 2 1 1	5/1996	EP				
DD	EP 08 3 9 6 8 3	10/1997	EP				

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Gelb et al, "The Application of Solid Electrolyte Batteries..." (Undated)
DD	Miller, "Integrated Power Module Requirements for Automotive..." (Undated)
DD	Vukosavic et al, IEEE Trans. Ind. App. "SRM Inverter Topologies..." (1991)

EXAMINER [signature]	DATE CONSIDERED 10/12/05

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of : Examiner: N/A
Severinsky et al : Group Art Unit: 3619
Serial No.: 09/822,866 : Att. Dkt.: PAICE201
Filed: April 2, 2001
For: Hybrid Vehicles

Hon. Commissioner of Patents and Trademarks
Washington, DC 20231

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Dear Sir:

Listed on attached PTO-1449 forms are a number of new patents discovered after filing of the above application. Copies of the listed patents are enclosed. The Examiner is respectfully requested to consider these patents with respect to the claims of this application.

The relevance of the newly-listed patents may be summarized as follows:

US patent 6,307,276 to Bader shows a hybrid drive system comprising an engine, a traction motor coupled to the countershaft of a multispeed transmission, and a controller which determines a running average value for the vehicle's "required driving torque". The engine output power is then varied as the average required power changes. The specification and claims give examples of 15 and 50 seconds as the time period over which the average is calculated, and it is made clear that the engine power is varied accordingly slowly. Where the engine power is insufficient to satisfy the instantaneous torque requirement, the battery is used to supply power to a traction motor; conversely, when the engine is producing more power than is needed, the excess is used to charge the batteries.

Insofar as Fig. 2 of Bader suggests that the "required driving torque" can be negative (for example, a negative torque can be considered to be applied to the motor/generator(s) by the kinetic energy of the vehicle, i.e., under deceleration or descents, for regenerative braking), this parameter might be misunderstood to be generally comparable to the "road load" parameter, which is analyzed by the present system to make its mode switching determinations, as illustrated by Figs. 6, 7, and 9. However, Bader's "drive power P_o can be calculated from the torque M_o and the rotational speed n_o". Col. 4, lines 21-22. Hence the "drive power" is not in fact suggestive of applicants' road load, since the engine output, i.e., "the torque M_o at the gear input" (col. 4, line 18), cannot be negative.

In any event, there is no suggestion in Bader of changing operational modes of a hybrid vehicle responsive to the value of the "drive power P_o", whether or not this is fairly equivalent to the road load. As made explicit by the relevant claims 1 - 9 of this application, according to an important aspect of the invention the vehicle is operated in different modes according to the road load (among other variables), and so that the engine is operated only under sufficient load to make its operation efficient. For example, when the road load is low, e.g., at low speeds, the engine is run only as necessary to charge the batteries. By comparison, in Bader it appears the engine is to be run constantly, and its speed varied slowly in accordance with the then average value of drive power. Bader thus fails to teach an important aspect of the invention.

Nii patent 6,131,680 is directed to a hybrid vehicle wherein an internal combustion engine and first and second motors are all connected to one of the sun gear, the planet carrier, or the ring gear of a planetary gearbox. Nii adjusts the relative gear ratios according to the torque required, which is apparently derived directly from the position of the accelerator pedal - see col. 22, lines 27 - 30. The Nii hybrid is operated in different modes depending on the state of charge of the battery, and the torque required. See Fig. 9. Under certain circumstances the planetary gearbox may be locked-up to avoid inefficiency. See, e.g., col. 9 line 1 - 7, and Fig. 10. However, the modes shown by Nii are not the same as those used by applicants, although there are some similarities. For example, as stated at col. 37, lines 1 - 6, and in Fig. 26, Nii sets his engine speed to idle when the vehicle is being operated in "motor driving" (i.e., electric car) mode; this is highly inefficient, since the engine produces no useful power at idle. By comparison, applicants shut the engine off completely except when it is being operated at high efficiency.

Mikami patent 5,839,533 is discussed in the application as filed, but was apparently not listed on the PTO-1449 forms filed previously; this patent is acordingly listed on the PTO-1449 filed herewith. A copy of this patent is also provided herewith.

Stemler patent 6,300,735 relates to control of planetary gearboxes as might be used in hybrid vehicles to control the torque supplied by the internal combustion engien and electric motors. Such a gearbox is not a feature *per se* of the invention described by the claims of the present application.

Yanase et al patent 6,318,487 shows a scheme for braking a hybrid vehicle when the battery is fully charged, so that regenerative braking would be inappropriate, and whereby friction braking is avoided; specifically, the engine is motored, so that energy is consumed by compressing air in the engine. This is not a feature of the invention defined by the claims of this application.

Deguchi et al patent 6,278,915 shows a control system for a hybrid comprising a continuously-variable transmission, wherein the transmission ratio is set responsive to target values for the driving torque, the generated electrical power, and the engine speed. Such a transmission is not found in the system defined by the claims of this application, and the control scheme described by this patent is irrelevant to the present claims.

Deguchi et al patent 6,190,282 relates to controlling the engine, motor, and clutch of a hybrid so as to avoid shock to the passengers upon clutch engagement. This is not relevant to the claims of the present application. A similar Deguchi et al patent, 5,993,351, was made of record previously.

Obayashi et al patent 6,232,733 appears to be a further development of the invention described in Egami patents 5,789,881 and 6,018,694, previously made of record. All three of these patents relate to operating the electric motors of a hybrid to reduce vibration when the engine is started. This is not a feature of the claims of this application.

Friedmann et al patent 5,788,004 shows a control system for hybrid vehicles wherein the overall system efficiency is continuously optimized by adjustment of the operational parameters of the various system components.

Kashiwase patent 6,146,302 shows a drive system for a hybrid wherein an engine and first motor are connected to the ring gear of a planetary gearbox, a second motor is connected to its planet carrier, a transmission is connected between the planet carrier and the road wheels of the vehicle, and clutches are provided to engage two of the sun gear, planet carrier and ring gear. No such planetary gearbox is required by the system of the invention.

Frank patent 6,116,363 is stated to be a continuation-in-part of patent 5,842,534, already made of record and disucssed in this application as filed. Both of these Frank patents disclose a braking system for a hybrid vehicle wherein the first 30% of pedal travel initiates regenerative braking, while the latter 70% of pedal travel initiates mechanical braking. See also Frank patent 6,054,844, already of record, which limits the braking torque to be provided by regenerative braking as a function of vehicle speed.

Maeda et al patent 6,074,321 shows a transaxle for a hybrid vehicle having a specific construction that is not particularly relevant to any of the claims of this application.

Moroto reissue patent Re. 36,678 is a reissue of patent 5,513,719, already of record.

Finally, Severinsky et al patent 6,338,391 has recently issued on application Serial No. 09/392,743, that is, is one of the parent applications.

An early and favorable action on the merits of the application is earnestly solicited.

Respectfully submitted,

2/8/02

Dated

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401-423-3190

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER ~~ANA201~~	APPLICATION NUMBER ~~09/822,866~~ 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE April 2, 2001	GROUP ART UNIT ~~3619~~ 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	6307276	10/2001	Bader			
↓	6131680	10/2000	Nii et al			
↓	5839533	11/1998	Mikami et al			
↓	6300735	10/2001	Stemler			
↓	6318487	11/2001	Yanase et al			
↓	6278915	8/2001	Deguchi et al			
↓	6190282	2/2001	Deguchi et al			
↓	6232733	5/2001	Obayashi et al			
↓	5788004	8/1998	Friedmann et al			
↓	6146302	11/2000	Kashiwase			
↓	6116363	9/2000	Frank			
DD	6074321	6/2000	Maeda et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER [signature] DATE CONSIDERED 11/19/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201	APPLICATION NUMBER: ~~09/822,866~~ 10/382577
	APPLICANT: Severinsky et al	
	FILING DATE: 4/2/2001	GROUP ART UNIT: ~~3619~~

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	Re36678	5/2000	Moroto et al			
DD	6338391	1/2002	Severinsky et al			

FOREIGN PATENT DOCUMENTS

DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER [signature] DATE CONSIDERED 11/19/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of
Severinsky et al
Serial No.: 09/822,866
Filed: April 2, 2001
For: Hybrid Vehicles

Examiner: David Dunn
Group Art Unit: 3616
Att. Dkt.: PAICE201

Hon. Commissioner of Patents and Trademarks
Washington, DC 20231

SECOND SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Dear Sir:

Listed on accompanying PTO-1449 form(s) are a number of additional patents that may be considered relevant by the Examiner to the claims of this application. These patents were identified in supplemental searching conducted after the filing of the application. Copies of the newly-cited documents are provided herewith. The examiner is respectfully requested to consider these documents in connection with the patentability of the claims of this application. Citation of these documents should not be construed to admit they are necessarily statutory prior art effective against this application.

The relevance of the documents thus cited is as follows:

Goehring et al patent 6,394,209 discloses a hybrid vehicle in which the internal combustion engine is stated to be operated only at or near full load. To thus operate the engine of the vehicle of the invention is an object of the invention, and a limitation to that effect is present in claim 1 of the application as amended. However, the Goehring reference refers only to a serial hybrid, and therefore does not teach a hybrid vehicle operated in different modes responsive to the road load, as also required by claim 1.

Tabata et al patent 6,081,042, to be candid, is extrememly difficult to comprehend. It does appear that Tabata shows a hybrid vehicle which can be driven by a motor/generator, an engine, or both, the operation mode to be chosen based on "the currently required output Pd" and the battery state of charge. See Fig. 6 and cols. 17 - 20. Insofar as understood, the value Pd is not the same thing as applicants' instantaneous torque requirement or road load RL. Pd is defined as "an output of the hybrid drive system 210 required to drive the vehicle against a running resistance. This currently required output Pd is calculated according to a predetermined data map or equation, on the basis of the operation amount θ_{AC} of the accelerator pedal, a rate of change of this value θ_{AC}, running speed of the vehicle (speed N_o of the output shaft 19) or the currently established operating position of the automatic transmission." Col. 18, lines 34 - 42.

Another Tabata patent, 5982,045, is directed to control of mode shifting in a hybrid such that transmission ratios or torque distribution ratio changes are prevented from occurring concurrently with mode shifting, the goal evidently being to smooth mode shifting. No disclosure of control of mode shifting responsive to a quantity comparable to applicants' road load is apparent.

Lawrie et al patent 5,993,350 discloses an "automated manual transmission clutch controller" which purports to combine the advantages of conventional automatic and manual transmissions. Mode shifting is evidently carried out responsive to any or several of various "information..includ[ing] vehicle speed, RPM or the like..[or] other vehicle condition signals". Col. 8, lines 37 - 49. The disclosures of three further Lawrie and Lawrie et al patents, 6,006,620, 6,019,698, and 5,797,257 appear to be essentially identical.

Nagano et al patent 6,059,064 shows a hybrid vehicle and appears to be directed to improvements in the braking system employed; these include using a prime mover (e.g., an electric motor) on one axle and another, e.g., an IC engine on another axle. Hill-holding is also addressed, as is anti-lock. The improvements in brake "feel" addressed in the present application do not appear to be discussed by Nagano.

The Examiner is respectfully urged to consider these patents in connection with examination of this application, and to indicate that he has done so in the file of the case.

Respectfully submitted,

9/1/02

Dated

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401-423-3190

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201	APPLICATION NUMBER: 09/822,866 10/382577
	APPLICANT: Severinsky et al	
	FILING DATE: 4/2/2001	GROUP ART UNIT: 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	6394209	5/2002	Goehring et al			
	6081042	6/2000	Tabata et al			
	5982045	11/1999	Tabata et al			
	5993350	11/1999	Lawrie et al			
	6019698	02/2000	Lawrie et al			
	5979257	11/1999	Lawrie			
	6006620	12/1999	Lawrie et al			
DD	6059064	05/2000	Nagano et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER [signature] DATE CONSIDERED 11/19/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

Notice of References Cited	Application/Control No. 09/822,866	Applicant(s)/Patent Under Reexamination SEVERINSKY ET AL.	
	Examiner David Dunn	Art Unit 3616	Page 1 of 1

JC490 U.S. PTO 10/382577 03/07/03

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-6,315,068	11-2001	Hoshiya et al.	180/65.2
	B	US-6,330,498	12-2001	Tamagawa et al.	701/22
	C	US-6,359,404	03-2002	Sugiyama et al.	318/432
	D	US-6470983	10-2002	Amano et al.	180/65.2
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	11/19/04

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

U.S. Patent and Trademark Office
PTO-892 (Rev. 01-2001)

Notice of References Cited

Part of Paper No. 14

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of	
Severinsky et al	Examiner: David Dunn
Serial No.: 09/822,866	Group Art Unit: 3616
Filed: April 2, 2001	Att. Dkt.: PAICE201
For: Hybrid Vehicles	

Hon. Commissioner of Patents and Trademarks
Washington, DC 20231

THIRD SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Dear Sir:

Listed on accompanying PTO-1449 form(s) are five Japanese patent publications that may be considered relevant by the Examiner to the claims of this application. These publications were cited by the Japanese Patent Office in an office action dated September 2, 2002 in connection with prosecution of a Japanese patent application corresponding to the parent US applications, Ser. No. 09/264,817, now patent 6,209,672, and Ser. No. 09/392,743, now patent 6,338,391. A copy of a translation of this Japanese office action is attached, and copies of the newly-cited documents are provided herewith marked (1) - (5), in accordance with the Japanese Examiner's usage; copies of uncertified, partial translations of references 1 and 4 are also provided. The Examiner is respectfully requested to consider these documents in connection with the patentability of the claims of this application.

The relevance of the documents thus cited is as follows:

Japanese utility model registration 63-82283, published as "laid-open No. 2-7702", which was referred to in the Japanese office action as Reference 1 (a partial noncertified translation also being supplied), shows a hybrid vehicle comprising an internal combustion engine, an electric "traction" motor for providing additional torque to the wheels of the vehicle, and a second electric motor that can be operated to also supply additional torque to the wheels or operate as a generator to charge the battery during braking or hill descent. Typically, such hybrids are operated in different modes depending on whether the vehicle is sitting at a traffic light, accelerating, cruising on the highway, and so on. The same is true of the vehicle of the present invention.

In order that the hybrid vehicle can be made commercially acceptable, it is important that the "mode switching" decisions be made by a microprocessor or the like instead of the driver. Various references teach making this decision in different ways. Reference 1 does not address this question. Commonly, as in Japanese published application 06-080048, cited by the Japanese patent office as Reference 3 (which corresponds to US patent 5,697,466, already of record), the decision is made based on the degree to which the driver has depressed the accelerator pedal. By comparison, according to the present invention, as discussed extensively in the earlier prosecution of this and the parent applications, the mode switching decision is made based on the vehicle's instantaneous torque requirement or "road load" RL.

As previously, it is important to emphasize exactly what the terms "road load" RL means as used in the present claims, to distinguish over the art. "Road load" is a somewhat subtle concept, since during many phases of vehicle operation the road load quantitatively resembles, for example, the operator's foot pressure on the accelerator pedal, or simply the engine output power. However, the road load as used herein is neither of these. "Road load" as used herein is simply that amount of torque that must be supplied to the vehicle wheels in order to carry out the operator's current command.

Note that "road load" as thus defined can be positive, as during highway cruising, "highly" positive, as during acceleration or hill-climbing, negative, as during hill descent, and "heavily" negative, as during braking. Figs. 7 and 13 show this clearly, and it is explained in the specification of the application as well. The flowchart of Fig. 9 illustrates precisely how the mode switching decisions are made responsive to road load (with an additional variation possible based on the battery state of charge.)

The fact that according to the present invention the mode switching decisions are made responsive to road load, a quantity which can be positive or negative, distinguishes this invention from all prior art of which we are aware. It will be appreciated that making all of the mode switching decisions based essentially on monitoring this single variable (with subsidiary attention to the battery state of charge, as below) greatly simplifies the decision-making process, as compared, for example, to a system in which the operator's foot pressure on the throttle and brake pedals must be continually monitored.

The new references made of record hereby does not show this invention. Reference 1 does show a hybrid vehicle having components arranged comparably to those recited in claim 1, but there is no mention of the manner in which the mode-switching determinations are made. The Japanese Examiner made the comment that "the vehicle is operated in a plurality of operating modes in response to states of operation such as a load of the vehicle and the like", apparently based on the description in reference 1 of vehicle operation in different modes depending on the driving conditions. However, we find nothing in reference 1 that suggests mode switching based on road load as defined above.

None of the other references cited by the Japanese Examiner and made of record hereby (nor any of those previously made of record, of course) supply this deficiency of Reference 1. The Japanese Examiner cited published application 06-144020 (referred to as reference 2) against claim 1, for showing that the first motor also starts the engine, and cited reference 3 against claim 2, for showing that the state of charge of the battery can be considered in mode switching.

More specifically, in his remarks concerning claim 4, the Japanese Examiner asserted that reference 3 describes mode switching responsive to "road load (a press down amount of an accelerator pedal)(see [Fig. 3]) or the like". As above, "road load" as used in this application is something quite different than the degree to which the accelerator pedal is pressed down; for example, the latter cannot be negative, and road load as used herein can decidedly be negative. We have reviewed US patent 5,697,466 (which corresponds to Reference 3) in detail and it shows nothing comparable to mode switching based on road load as used in this application.

Claims 8 and 9 of this application are directed to the "turbocharger-on-demand" concept, which was an important aspect of the invention in parent application Ser. No. 09/392,743, now patent 6,338,391. Claims 15 - 20 of the Japanese application recite this concept, i.e., that of a turbocharger that is operated only when the road load exceeds a predetermined value for more than a minimum period of time. That is, the turbocharger is not operated continually, as in the usual prior art vehicles, but is only operated when needed, i.e., when road load exceeds the engine's normally aspirated torque capabilities (i.e., RL > MTO); moreover, the turbocharger is operated only when RL > MTO for more than some predetermined period of time T. This is an extremely powerful concept, and one which is only applicable to a hybrid vehicle. Providing the turbocharger on demand allows the engine to provide additional torque when needed, but to operate as a smaller, more efficient engine at other times.

More specifically, in a conventional turbocharged vehicle the turbocharger is spinning constantly, so that a turbine driven by the exhaust flow drives a compressor forcing air into the engine. The main problem with turbochargers as thus used is poor throttle response or "turbo lag", that is, a substantial time delay between the driver calling for more power by pressing on the accelerator pedal and the engine's response. While some progress has been made, mostly by use of smaller turbochargers, this problem is inevitable to some degree, since it takes some time for the turbocharger to "spool up" to its full speed.

The Japanese Examiner cited Japanese published application 55-069724 as reference 4; as noted, a partial noncertified translation of this reference is also provided. Reference 4 shows a turbocharger which is operated on demand, in response to a "load detecting means"; this is the first reference we have seen showing this concept. There is no suggestion of use of this turbocharger in a hybrid vehicle. A conventional (i.e., non-hybrid) vehicle fitted with a turbocharger of this type would have extremely poor throttle response if used to provide additional power for passing (i.e., overtaking) or hillclimbing; the "turbo lag" inherent in operation of a turbocharger starting from zero rpm would be on the order of tens of seconds, which would be totally unacceptable for a consumer vehicle. Possibly such a system would be useful in heavy truck operation or the like, where the load will vary significantly depending on whether the truck was loaded or not; in that case, the operator could be the "load detecting means", i.e., could throw a switch when he knew high power would be needed for an extended period of time.

By comparison, a turbocharger can be employed "on demand" in a hybrid vehicle according to the invention without poor throttle response caused by turbo lag, and without requiring any intervention by the operator. This is simply because the traction motor can be used to supply the vehicle's torque requirements in excess of MTO. Thus, when RL > MTO, the traction motor provides the additional torque required. If RL > MTO for longer than T, the turbocharger is activated and begins to spin. When it is up to operating speed, the traction motor can be deactivated. All this is shown clearly by Fig. 13, and would not be possible simply given the turbocharger-on-demand of Reference 4 in a conventional, non-hybrid vehicle. By comparison, in the present vehicle, at no point are the vehicle's torque requirements not met; therefore there is no "turbo lag".

It is apparent that this advantage can only be achieved by use of a turbocharger on demand in a hybrid vehicle. No combination of references can fairly be said to make this obvious. Specifically, the Japanese Examiner's comment as to claim 17, "it is a usual matter to control a turbocharger in response to a road load or the like" is not correct, for several reasons: no reference shows taking any kind of control action in response to road load as claimed; no reference suggests combining the turbocharger on demand of Reference 4 with a hybrid vehicle; and certainly no reference suggests the complete elimination of the turbo lag problem thus achieved, while at the same time the vehicle's useful load range is greatly broadened.

Finally, Japanese published application 04-274926 (Reference 5) was cited for a showing of preheating a catalyst before starting the associated engine, which is not a feature of the present claims.

The Examiner is respectfully urged to consider these patents in connection with examination of this application, and to indicate that he has done so in the file of the case.

Respectfully submitted,

Nov. 28, 2002
Dated

Michael de Angeli
Reg. No. 27,869
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Jamestown, RI 02835
401-423-3190

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201	APPLICATION NUMBER: ~~09/822,866~~ 10/382577
	APPLICANT: Severinsky et al	
	FILING DATE: 4/2/01	GROUP ART UNIT: 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	63 8 2 2 8 3	6/1988	Japan				
DD	06 1 4 4 0 2 0	11/1992	Japan				
DD	06 0 8 0 0 4 8	11/1992	Japan				
DD	55 0 6 9 7 2 4	11/1978	Japan				
DD	04 2 7 4 9 2 6	2/1991	Japan				

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER	DATE CONSIDERED
[signature]	11/19/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of :
: Examiner: N/A
Severinsky et al :
: Group Art Unit: N/A
Serial No.: N/A :
: Att. Dkt.: PAICE201.DIV
Filed: Herewith :

For: HYBRID VEHICLES

Hon. Commissioner of Patents and Trademarks
Washington, DC 20231

INFORMATION DISCLOSURE STATEMENT

Dear Sir:

This application is a divisional of Ser. No. 09/822,866. Incorporated herein by this reference are the original and three supplemental Information Disclosure Statements filed in the parent, copies of which are enclosed herewith. These, together with an Examiner's Notice of References Cited, a copy of which is also enclosed, collectively list all of the art deemed relevant to the claims of the application. Copies of the references were provided in the parent or in the applications from which it in turn claimed priority and thus are not being provided herewith. The Examiner is requested to indicate that all of the art thus listed has been considered.

Early and favorable action on the merits is earnestly solicited.

Respectfully submitted,

3/5/03
Dated

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JUL 0 7 2006 OIPE IAP100 PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of :
:
Severinsky et al : Examiner: N/A
:
Serial No.: 09/822,866 : Group Art Unit: N/A
:
Filed: April 2, 2001 : Att. Dkt.: PAICE201
:

For: Hybrid Vehicles

Hon. Commissioner of Patents and Trademarks
Washington, DC 20231

INFORMATION DISCLOSURE STATEMENT

Dear Sir:

Listed on attached PTO-1449 forms are the issued patents and literature references considered to be most relevant to the patentability of the claims of this application. Copies of the patents listed on page 15 of the PTO-1449 are attached for the convenience of the Examiner, as is a copy of German patent 1,905,641, with uncertified translation. Copies of the other listed references were provided to the Examiner in connection with one or both of patent applications 09/264,817 and 09/392,743, so additional copies are not being submitted herewith.

Comments on the relevance of the new references which are material to the claims of this continuation-in-part *per se* are found in the application as filed, while the comments on these references found in the prosecution files of the two parent applications are also incorporated by reference herein.

Early and favorable action on the merits is earnestly solicited.

5/21/01
Dated

Respectfully submitted,

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OIPE IAP100 JUL 0 7 2006 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201	APPLICATION NUMBER: ~~09/822,866~~ 10/382577
	APPLICANT: Severinsky et al	
	FILING DATE: 04/02/01	GROUP ART UNIT: ~~N/A~~ 3616

JC498 U.S. PTO 10/382577 03/07/03

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	5343970	9/94	Severinsky	180	65.2	
	5492192	2/96	Brooks et al			
	3566717	3/71	Berman et al			
	3732751	5/73 ~~5/93~~	Berman et al			
	4165795	8/79 ~~8/49~~	Lynch et al			
	5117931	6/92	Nishida			
	3923115	12/75	Helling			
	4588040	5/86	Albright, Jr., et al			
	5318142	6/94	Bates et al			
	5120282	6/92	Fjällström			
	4405029	9/83	Hunt			
	4470476	9/84	Hunt			
DD	4305254	12/81	Kawakatsu			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	1905641	6/76	Germany			X	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Simanaitis, "Electric Vehicles", *Road & Track*, May 1992, pp. 126-136
DD	Reynolds, "AC Propulsion CRX", *Road & Track*, Oct. 1992, pp. 126-129
DD	Kalberlah, "Electric Hybrid Drive Systems...", SAE Paper No. 910247, 1991
DD	Bullock, "The Technological Constraints of Mass, Volume, Dynamic Power Range and Energy Capacity..." SAE Paper No. 891659 1989
DD	Electric and Hybrid Vehicle Technology, vol. SP-915, SAE, Feb. 1992

EXAMINER [signature] DATE CONSIDERED 11/19/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION

DOCKET NUMBER	PAICE201
APPLICATION NUMBER	09/822,866
APPLICANT	Severinsky et al
FILING DATE	04/02/01
GROUP ART UNIT	N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	4407132	10/83	Kawakatsu			
	4335429	6/82	Kawakatsu			
	4180138	12/~~19~~ 79	Shea			
	4351405	9/82	Fields et al			
	4438342	3/84	Kenyon			
	4593779	6/86	Krohling			
	4923025	5/90	Ellers			
	3791473	2/74	Rosen			
	4269280	5/81	Rosen			
	4400997	8/83	Fiala			
	4697660	10/87	Wu et al			
	3970163	7/76	Kinoshita			
DD	4095664	6/78	Bray			

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DD	Wouk, "Hybrids: Then and Now", IEEE Spectrum, Vol. 32, 7, July 1995
DD	Bates, "Getting a Ford HEV on...", IEEE Spectrum, Vol. 32, 7, July 1995
DD	King et al, "Transit Bus takes...", IEEE Spectrum, Vol. 32, 7, July 1995
DD	Yamaguchi, "Toyota readies gasoline/electric hybrid system", Automotive Engineering, July 1997, pp. 55-58
DD	Wilson, "Not Electric, Not Gasoline..." Autoweek, June 2, 1997, pp. 17-18

EXAMINER [signature] DATE CONSIDERED 11/19/04

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION

DOCKET NUMBER	PAICE201
APPLICATION NUMBER	~~09/822,866~~ 10/382577
APPLICANT	Severinsky et al
FILING DATE	04/02/01
GROUP ART UNIT	N/A

U.S. PATENT DOCUMENTS

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	4306156	12/81	Monaco et al			
	4313080	11/82	Park			
	4354144	10/82	McCarthy			
	4533011	8/85	Heidemeyer			
	4951769	8/90	Kawamura			
	5053632	10/91	Suzuki et al			
	3525874	8/70	Toy			
	3650345	8/72	Yardney			
	3837419	9/74	Nakamura			
	3874472	4/75	Deane			
	4042056	8/77	Horwinski			
DD	4562894	1/86	Yang			

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	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Bulgin, "The Future Works, Quietly", Autoweek, Feb. 23, 1998 pp. 12-13
DD	"Toyota Electric and Hybrid Vehicles", a Toyota brochure
DD	Nagasaka et al, "Development of the Hybrid/Battery ECU...", SAE paper 981122, 1998, pp. 19-27

EXAMINER: [signature] DATE CONSIDERED: 1/19/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

Page 3 of 15

INFORMATION DISCLOSURE CITATION IN AN APPLICATION

DOCKET NUMBER	PAICE201
APPLICATION NUMBER	09/822,866
APPLICANT	Severinsky et al
FILING DATE	04/02/01
GROUP ART UNIT	N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	4611466	9/86	Keedy			
	4815334	3/89 ~~8/89~~	Lexen			
	3623568	11/71	Mori			
	3454122	7/69 ~~8/69~~	Grady, Jr.			
	3211249	10/65	Papst			
	2666492	1/54	Nims et al			
	3502165	3/70	Matsukata			
	1824014	9/31	Froelich			
	3888325	6/75 ~~10/75~~	Reinbeck			
	4578955	4/86	Medina			
	4765656	8/88	Weaver			
	4439989	4/84	Yamakawa			
DD	5301764	4/94	Gardner			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER	[signature]
DATE CONSIDERED	11/19/04

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Page 4 of 15

INFORMATION DISCLOSURE CITATION IN AN APPLICATION

DOCKET NUMBER	PAICE201
APPLICATION NUMBER	~~09/822,866~~
APPLICANT	Severinsky et al
FILING DATE	04/02/01
GROUP ART UNIT	N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DJ	5346031	9/94	Gardner			
	5667029	9/97	Urban et al			
	5704440	1/98	Urban et al			
	5495906	3/96	Furutani			
	5842534	12/98	Frank	180	65.2	
	5823280	10/98	Lateur	180	65.2	
	5826671	10/98	Nakae et al			
	5846155	12/98	Taniguchi et al			
	5845731	12/98	Buglione et al	180	65.2	
	5586613	12/96	Ehsani			
	5635805	6/97	Ibaraki et al			
	5249637	10/93	Heidl et al			
DJ	5558588	9/96	Schmidt			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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DOCKET NUMBER	PAICE201
APPLICATION NUMBER	09/822,866
APPLICANT	Severinsky et al
FILING DATE	04/02/01
GROUP ART UNIT	N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	5558595	9/96 ~~10/96~~	Schmidt et al			
	59~~80~~ 08 077	6/99	Moore			
	5722911	3/98	Ibaraki et al			
	5789882	8/98	Ibaraki et al			
	5550445	8/96	Nii			
	5650931	7/97	Nii			
	5865263	2/99	Yamaguchi et al			
	5788006	8/98	Yamaguchi et al			
	5791427	8/98	Yamaguchi et al			
	5799744	9/98	Yamaguchi et al			
	5806617	9/98	Yamaguchi et al			
	5899286	5/99	Yamaguchi et al			
DD	5433282	7/95	Moroto et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201	APPLICATION NUMBER: 09/~~822,8~~66
	APPLICANT: Severinsky et al	
	FILING DATE: 04/02/01	GROUP ART UNIT: N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	5778326	7/98	Moroto et al			
	5775449	7/98	Moroto et al			
	5697466	12/97	Moroto et al	180	65.2	
	5608308	3/97	Kiuchi et al			
	5614809	3/97	Kiuchi et al			
	5621304	4/97	Kiuchi et al			
	5893895	4/99	Ibaraki			
	5656921	8/97	Farrall			
	5773904	6/98	Schiebold et al			
	5515937	5/96	Adler et al			
	5650713	7/97	Takeuchi et al			
	5632352	5/97	~~Jeanneret~~ Jeanneret et al			
DD	5492189	2/96	Kreigler et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER [signature] DATE CONSIDERED 1/19/04

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201	APPLICATION NUMBER: ~~09/822,866~~
	APPLICANT: Severinsky et al	
	FILING DATE: 04/02/01	GROUP ART UNIT: N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DI	4354144	10/82	McCarthy			
	4697660	10/87	Wu et al			
	5831341	11/98	Selfors et al			
	5495907	3/96	Data			
	5672920	9/97	Donegan et al			
	5826671	10/98	Nakae et al			
	5757151	5/98	Donegan et al			
	6018694	1/00	Egami et al	701	102	
	5993351	11/99	Deguchi et al	477	5	
	5568023	10/96	Grayer et al			
	5890555	4/99	Miller			
	5172784	12/92	Varela, Jr.			
DI	4444285	4/84	Stewart et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER	DATE CONSIDERED 11/19/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201	APPLICATION NUMBER: ~~09/822,866~~
	APPLICANT: Severinsky et al	
	FILING DATE: 04/02/01	GROUP ART UNIT: N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	4562894	1/86	Yang			
	4495451	1/85	Barnard			
	4583505	4/86	Frank et al			
	4597463	7/86	Barnard			
	5789881	8/98	Egami et al			
	5786640	7/98	Sakai et al			
	5176213	1/93	Kawai et al			
	5839530	11/98	Dietzel			
	5898282	4/99	Drozdz et al			
	5327987	7/94	Abdelmalek			
	5415245	5/95	Hammond			
	5705859	1/98	Karg et al			
DD	5713425	2/98	Buschhaus et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER [signature]	DATE CONSIDERED 11/19/04

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201	APPLICATION NUMBER 09/822,866
	APPLICANT Severinsky et al	
	FILING DATE 04/02/01	GROUP ART UNIT N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DI	5820172	10/98	Brigham et al			
	5713426	2/98	Okamura			
	5713814	2/98	Hara et al			
	5823281	10/98	Yamaguchi et al			
	5427196	6/95	Yamaguchi et al			
	5839533	11/98	Mikami et al			
	5725064	3/98	Ibaraki et al			
	5755303	5/98	Yamamoto et al			
	5778997	7/98	Setaka et al			
	5785136	7/98	Falkenmayer et al			
	5785137	7/98	Reuyl			
	5785138	7/98	Yoshida			
DI	5566774	10/96	Yoshida			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

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Page 10 of 15

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201	APPLICATION NUMBER 09/822,866
	APPLICANT Severinsky et al	
	FILING DATE 04/02/01	GROUP ART UNIT N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	5492190	2/96	Yoshida			
	5441122	8/95	Yoshida			
	5558175	9/96	Sherman			
	5558173	9/96	Sherman			
	5788597	8/98	Boll et al			
	5788003	8/98	Spiers			
	5791426	8/98	Yamada			
	5323868	6/94	Kawashima			
	5545928	8/96	Kotani			
	5291960	3/94	Brandenburg et al			
	5255733	10/93	King			
	5664635	9/97	Koga et al			
DD	5463294	10/95	Valdivia			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER	DATE CONSIDERED
[signature]	11/19/04

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION		
DOCKET NUMBER: PAICE201	APPLICATION NUMBER: 09/~~822~~,866	
APPLICANT: Severinsky et al		
FILING DATE: 04/02/01	GROUP ART UNIT: N/A	

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	5562565	10/96	Moroto et al			
	5513719	5/~~8~~/96	Moroto et al			
	5513718	5/96	Suzuki et al			
	5833022	11/98	Welke			
	5841201	11/98	Tabata et al			
	5887670	3/99	Tabata et al			
	5862497	1/99	Yano et al			
	5637987	6/~~94~~ 97	Fattic et al			
	5643119	7/97 ~~4/94~~	Yamaguchi et al			
	5644200	7/97 ~~4/94~~	Yang			
	5489001	2/96	Yang			
	5653302	8/~~94~~ 97	Edye et al			
DD	5350031	9 ~~6~~/94	Sugiyama et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER

DATE CONSIDERED 11/19/04

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201	APPLICATION NUMBER ~~09/822,866~~
	APPLICANT Severinsky et al	
	FILING DATE 04/02/01	GROUP ART UNIT N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DV	5 3 4 5 7 6 1	9 ~~8~~/94	King et al			
	5 3 3 7 8 4 8	8/94	Bader			
	5 3 2 7 9 9 2	7 ~~6~~/94	Boll			
	5 5 8 9 7 4 3	12/96	King			
	5 3 4 5 1 5 4	9/94	King			
	4 8 6 2 0 0 9	8/89	King			
	5 3 7 2 2 1 3	12/94	Hasebe et al			
	5 4 9 5 9 1 2	3 ~~5~~/96	Gray, Jr., et al			
	5 5 8 8 4 9 8	12/96	Kitada			
	5 4 9 2 1 8 9	2/96	Kriegler			
	5 1 9 3 6 3 4	3/93	Masut			
	5 1 2 5 4 6 9	6/92	Scott			
DV	4 5 1 1 0 1 2	4/85	Rauneker			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER [signature]   DATE CONSIDERED 11/17/04

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION		
DOCKET NUMBER: PAICE201	APPLICATION NUMBER: 09/822,866	
APPLICANT: Severinsky et al		
FILING DATE: 04/02/01	GROUP ART UNIT: N/A	

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DN	4631456	12/86	Drescher et al			
	4680986	7/87	Elsner			
	4953646	9/90	Kim			
	5927417	7/99	Brunner et al	180	65.6	
	6048289	4/00	Hattori et al	477	15	
	6026921	2/00	Aoyama et al	180	65.2	
	6053842	4/00	Kitada et al	477	5	
	5767637	6/98	Lansberry	180	65.2	
	5934395	8/99	Koide et al	340	636	
	5969624	10/99	Sakai et al			
	5986376	11/99	Werson			
	6018198	1/00	Tsuzuki et al	322	16	
DN	6054844	4/00	Frank			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

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EXAMINER	DATE CONSIDERED
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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201	APPLICATION NUMBER: 09/822,866
	APPLICANT: Severinsky et al	
	FILING DATE: 04/02/01	GROUP ART UNIT: N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	6059059	~~9/94~~ 5/00	Schmidt-Brucken			
	6098733	8/00	Ibaraki et al			
	6161384	12/00	Reinbold et al			
	5996347	12/99	Nagae et al			
	6109025	8/00	Murata et al			
	6131538	10/00	Kanai			
	4774811	10/88	Kawamura			
DD	5327992	7/94	Boll			
	~~5249637~~	~~10/93~~	~~Heidt et al~~			DUPLICATE
	~~5495906~~	~~3/96~~	~~Furutani~~			//
	~~6018694~~	~~1/00~~	~~Egami et al~~			//
DD	6209672	4/01	Severinsky			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER	DATE CONSIDERED
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NOTICE OF ALLOWANCE AND FEE(S) DUE

7590 07/11/2006

Michael de Angeli
60 Intrepid Lane
Jamestown, RI 02835

EXAMINER	
DUNN, DAVID R	
ART UNIT	PAPER NUMBER
3616	

DATE MAILED: 07/11/2006

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/382,577	03/07/2003	Alex J. Severinsky	PAICE201.DIV	9389

TITLE OF INVENTION: HYBRID VEHICLES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$0	$1400	$1400	10/11/2006

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 07/11/2006

Michael de Angeli
60 Intrepid Lane
Jamestown, RI 02835

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/382,577	03/07/2003	Alex J. Severinsky	PAICE201.DIV	9389

TITLE OF INVENTION: HYBRID VEHICLES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$0	$1400	$1400	10/11/2006

EXAMINER	ART UNIT	CLASS-SUBCLASS
DUNN, DAVID R	3616	180-065100

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 ____________________

2 ____________________

3 ____________________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

☐ Issue Fee

☐ Publication Fee (No small entity discount permitted)

☐ Advance Order - # of Copies ____________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

☐ A check is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number ____________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ______________________________ Date ______________________________

Typed or printed name ______________________________ Registration No. ______________________________

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/382,577	03/07/2003	Alex J. Severinsky	PAICE201.DIV	9389

7590 07/11/2006

Michael de Angeli
60 Intrepid Lane
Jamestown, RI 02835

EXAMINER	
DUNN, DAVID R	
ART UNIT	PAPER NUMBER
3616	

DATE MAILED: 07/11/2006

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 263 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 263 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Notice of Allowability	Application No. 10/382,577	Applicant(s) SEVERINSKY ET AL.	
	Examiner David Dunn	Art Unit 3616	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to RCE filed1/19/2006.

2. ☒ The allowed claim(s) is/are 82-122.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date 3/28/06, 1/19/06
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

David Dunn
Primary Examiner
Art Unit: 3616

OIPE IAP14
MAR 28 2006
PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION		
DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577	
APPLICANT: Severinsky et al		
FILING DATE: 3/7/2003	GROUP ART UNIT: 3616	

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	5371412	12/1994	Iwashita			
DD	5412251	5/1995	Furutani			
DD	5993169	11/1999	Adachi et al			
DD	6007451	12/1999	Matsui et al			
DD	6032753	3/2000	Yamazaki et al			
DD	6155364	12/2000	Nagano et al			
DD	5539318	7/1996	Sasaki			
DD	5680050	10/1997	Kawai et al			
DD	5964309	10/1999	Kimura et al			
DD	5883496	3/1999	Esaki et al			
DD	5905360	5/1999	Ukita			
	~~6158541~~	~~12/2000~~	~~Tabata et al~~			previously cited

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Trial and deposition transcripts of witnesses relied upon to assert invalidity of parent patents in Civil Docket No. 2:04-CV-211-DF (E.D. Texas)
DD	Claim construction order entered September 28, 2005 in Civil Docket No. 2:04-CV-211-DF (E.D. Texas)
DD	Toyota Hybrid System, Toyota Press Information, Tokyo, 1997
DD	Prius Hybrid EV, Toyota brochure, undated

EXAMINER	DATE CONSIDERED
/David Dunn/	07/07/2006

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577
	APPLICANT: Severinsky et al	
	FILING DATE: 3/7/2003	GROUP ART UNIT: 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	5253929	10/1993	Ohori			
DD	5326158	7/1994	Ohori			
DD	5476151	12/1995	Tsuchida et al			
DD	5569995	10/1996	Kusaka et al			
DD	5637977	6/1997	Saito et al			
DD	5789935	8/1998	Suga et al			
DD	5895100	4/1999	Ito et al			
DD	5951115	9/1999	Sakai et al			
DD	5973463	10/1999	Okuda et al			
DD	6053841	4/2000	Koide et al			
DD	5929594	7/1999	Nonobe et al			
DD	5924395	7/1999	Moriya et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	0136055	03.04.85	European Patent Office				

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Miller et al, "Starter-Alternator for Hybrid Electric Vehicle.." (1996)
DD	Johnston et al, "The Design and Development of the [UC Davis].." (No date)
DD	Johnston et al, "The Design and Development of the [UC Davis].." (1997)
DD	Alexander et al, "A Mid-Sized Sedan Designed for High Fuel..." (No date)
DD	"PRIUS New Car Features", (Toyota manual) (1998)
DD	TRW Systems Group, "Analysis and Advanced Design Study..." (1971)

EXAMINER	DATE CONSIDERED
/David Dunn/	07/07/2006

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	4646896	3/1987	Hammond et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	0769403	23.4.1997	European Patent Office				
DD	7172196	29.9.1994	Japan			X	
DD	9170533	9.5.1996	Japan			abst.	
DD	5319110	5.19.1992	Japan			abst.	
DD	3273933	12.5.1991	Japan			abst.	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD		Gelb, "An Electromechanical Transmission for Hybrid Vehicle..." (1971)
DD		Hirose et al, "The New High Expansion Ratio Engine..." (1997)
DD		Hong, "Toyota's Hybrid Program", *Road & Track*, August 1997
DD		Law, "Toyota Tech", *Car & Driver*, August 1997
DD		"Dual-Engine Fuel Saver", *Popular Mechanics*, July 1997
DD		"Toyota Launches Break-Through Hybrid EV", *Motor Trend*, September 1997

EXAMINER /David Dunn/ DATE CONSIDERED 07/07/2006

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577
	APPLICANT: Severinsky et al	
	FILING DATE: 3/7/2003	GROUP ART UNIT: 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	7268922	10.17.1995	Japan			abst.	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	"Toyota touts advances in safety, emissions", *Automotive News*, 4/28/97
DD	"'96 North Wind Performance", undated
DD	Wakefield, "History of the Electric Automobile - Hybrid Electric Vehicles" (1998)
DD	"Escort 92-94", undated
DD	"Near-Term Hybrid Vehicle Program", General Electric Company (1979)

EXAMINER	DATE CONSIDERED
/David Dunn/	07/07/2006

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

O.I.P.E. IAP14
MAR 2 8 2006
PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577
	APPLICANT: Severinsky et al	
	FILING DATE: 3/7/2003	GROUP ART UNIT: 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD		"Guidelines for Electric Vehicle Safety", SAE J2344 (1998)
DD		"Intrepid", (undated)
DD		"COE's Team Paradigm challenged to build FutureCar" (1995)
DD		Butler et al, "A Versatile Computer Simulation Tool.." SAE 970199 (1997)
DD		Crumbley, "Hybrid vehicle designed", (1994)
DD		Brokaw, "Students Pick up the Challenge", (1997)

EXAMINER /David Dunn/ DATE CONSIDERED 07/07/2006

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	5412293	5/1995	Minesawa et al			
DD	5883484	3/1999	Akao			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	8214592	8.20.1996	Japan			abst.	
DD	10663833	3.6.1998	Japan			abst.	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Cuddy et al, "Analysis of the Fuel Economy Benefit..." SAE 970289 (1997)
DD	"Team Paradigm Shines in FutureCar Competition" (1996)
DD	Takaoka et al, "Study of the Engine Optimized for Hybrid System" (undated)
DD	Gelb et al, "Cost and Emission Studies of a Heat Engine/Battery.." (1972)
DD	Gelb et al, "Design and Performance Characteristics..." SAE 690169 (1969)
DD	"Electric/Hybrid Vehicles: Alternative Powerplants..." SAE SP-1284 (1997)

EXAMINER /David Dunn/ DATE CONSIDERED 07/07/2006

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	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	9 1 3 8 4 6	3/1909	Pieper			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	"Electric and Hybrid Vehicle Design Studies", SAE SP-1243 (1997)
DD	Gelb, "The case for Constant Speed Accessory Drives", (1975)
DD	Sasaki, "Toyota's Newly Developed Hybrid Powertrain", (1998)
DD	"Near-Term Hybrid Vehicle Program, Phase 1", General Electric Co. (1979)
DD	"Near-Term Hybrid Vehicle Program, Phase 1, App. A.", Gen'l Elec. (1979)
DD	"Joint Feasibility Study of Hybrid Vehicle, Final Report (1982)

EXAMINER /David Dunn/	DATE CONSIDERED 07/07/2006

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 361

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	North American Technology Seminar plans, April 1997
DD	Hermance, THS Technical Explanation (undated)
DD	"Toyota" brochure describing Prius (undated)
DD	Hermance, "Toyota Hybrid System" (undated)

EXAMINER /David Dunn/	DATE CONSIDERED 07/07/2006

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

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JAN 1 9 2006
OFFICE OF PETITIONS

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577
	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Trial and deposition transcripts of witnesses relied upon to assert invalidity of parent patents in Civil Docket No. 2:04-CV-211-DF (E.D. Texas), with documentary evidence made of record therein

Claim construction order entered September 28, 2005 in Civil Docket No. 2:04-CV-211-DF (E.D. Texas)

EXAMINER	DATE CONSIDERED

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

Duplicate (see IDS of 3/28/2006)

Issue Classification	Application/Control No.	Applicant(s)/Patent under Reexamination	
	10/382,577	SEVERINSKY ET AL.	
	Examiner	Art Unit	
	David Dunn	3616	

ISSUE CLASSIFICATION

ORIGINAL					CROSS REFERENCE(S)							
CLASS	SUBCLASS				CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)						
280	65.2				477	3						
INTERNATIONAL CLASSIFICATION					701	54						
B	6	0	K	6/04								
				/								
				/								
				/								
				/								

(Assistant Examiner) (Date)

7-7-06
(Legal Instruments Examiner) (Date)

7/7/06
David R. Dunn
(Primary Examiner) (Date)

Total Claims Allowed: 41

O.G. Print Claim(s)	O.G. Print Fig.
1	4

☒ **Claims renumbered in the same order as presented by applicant** ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		31		61		91		121		151		181
	2		32		62		92		122		152		182
	3		33		63		93		123		153		183
	4		34		64		94		124		154		184
	5		35		65		95		125		155		185
	6		36		66		96		126		156		186
	7		37		67		97		127		157		187
	8		38		68		98		128		158		188
	9		39		69		99		129		159		189
	10		40		70		100		130		160		190
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	29		59		89		119		149		179		209
	30		60		90		120		150		180		210

Search Notes	Application No. 10/382,577	Applicant(s) SEVERINSKY ET AL.
	Examiner David Dunn	Art Unit 3616

SEARCHED

Class	Subclass	Date	Examiner
180	65.2 65.3 65.4 65.8 165	11/29/2004	DD
60	706 711 716		
	718		
290	17 40R 40C		
322	16		
477	2 3		
UPDATE	SEARCH	3/16/05	DD
701	54	"	"
Updated		10/24/05	DD
Updated		7/7/06	DD

SEARCH NOTES (INCLUDING SEARCH STRATEGY)

	DATE	EXMR
EAST text search	11/29/2004	DD
Interference text search; see enclosed	7/7/06	DD

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner
180	65.2	3/1/05	DD
	65.4		
Updated		10/24/05	DD
Updated		7/7/06	DD

U.S. Patent and Trademark Office

Part of Paper No. 20041130

OIPE JUL 18 2006 PATENT & TRADEMARK OFFICE

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
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INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

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7590 07/11/2006

Michael de Angeli
60 Intrepid Lane
Jamestown, RI 02835

07/18/2006 HDEMESS2 00000098 040401 10382577

01 FC:1501 1400.00 DA
02 FC:8001 30.00 DA

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I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

Michael de Angeli (Depositor's name)
[signature] (Signature)
July 18, 2006 (Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/382,577	03/07/2003	Alex J. Severinsky	PAICE201.DIV	9389

TITLE OF INVENTION: HYBRID VEHICLES

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$0	$1400	$1400	10/11/2006

EXAMINER	ART UNIT	CLASS-SUBCLASS
DUNN, DAVID R	3616	180-065100

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. Use of a Customer Number is required.

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 Michael de Angeli
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: PAICE LLC
(B) RESIDENCE: (CITY and STATE OR COUNTRY): Boca Raton, Florida

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☒ Advance Order - # of Copies 10

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 04-0401 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature [signature] Date July 18, 2006

Typed or printed name Michael de Angeli Registration No. 27,869

MICHAEL M. DE ANGELI, P.C.
ATTORNEY AT LAW
60 INTREPID LANE
JAMESTOWN, RHODE ISLAND 02835
(401) 423-3190

REGISTERED PATENT ATTORNEY

ADMITTED TO BARS OF PA & MD
NOT ADMITTED IN RI

FAX: (401) 423-3191
E-MAIL: MDEANGE@COX.NET

FACSIMILE TRANSMISSION

To: Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450

Fax Number: 571-273-2885 Date: July 18, 2006

Re: Ser. No. 10/382,577

Total Pages (including this sheet): 2

Dear Sir:

Attached please find the completed PTOL-85 for this application. As noted thereon, the Issue Fee and related fees were paid previously, by a paper filed July 1, 2005. Any additional fees may be charged to my Deposit Account 04-0401. Please contact me at the number above if there are questions.

Early issue of the patent is respectfully requested.

Very truly yours,

Michael de Angeli

ATTENTION ATTENTION ATTENTION

withdrawn from issue

Method of Refund:

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- [ ] Credit Card
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Patent/TM/App/Serial # 10,382,579

Program Area Publishing

Date Processed 08-31-06

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MICHAEL M. DE ANGELI, P.C.
ATTORNEY AT LAW
60 INTREPID LANE
JAMESTOWN, RHODE ISLAND 02835
(401) 423-3190

REGISTERED PATENT ATTORNEY
ADMITTED TO BARS OF PA & MD
NOT ADMITTED IN RI

FAX: (401) 423-3191
E-MAIL: MDEANGE@COX.NET

FACSIMILE TRANSMISSION

To: Att: Refund Branch
U.S. Patent and Trademark Office
P.O. Box 1450
Alexandria, VA. 22313-1450

Fax Number: 571-273-6500 Date: August 18, 2006

Re: Request for Refund to Deposit Account

Total Pages (including this sheet): 9

Dear Sir:

Attached is a copy of the most recent Statement of my Deposit Account no. 04-0401. As indicated, my account was charged $1400 for the issue fee in Ser. No. 10/382,577, as well as $30 for ten copies of the issued patent; a $25 service charge was also assessed as these charges caused my account balance to fall below $1000.

However, the issue and copy fees in Ser. No. 10/382,577 had been paid previously, by a paper filed July 1, 2005. (Copy attached.) The application was subsequently withdrawn from issue, upon petition; in granting the Petition, the Petitions Examiner specifically noted (see enclosed Decision dated January 26, 2006) that the issue fee could not be refunded but could be applied if the application was again allowed, as subsequently occurred.

The new PTOL-85 mailed July 11, 2006 (attached) specifically noted that the issue fee had already been paid, and my cover letter(also attached) resubmitting the new PTOL-85 specifically noted that the issue and related fees had already been paid. I do apologize if my having checked the Issue Fee and Advance Order boxes under section 4a led to confusion.

Adjustment date: 09/05/2006 RCLEMONS
07/18/2006 ADEMESS2 00000098 040401 10382577
01 FC:1501 1400.00 CR

02 FC:8001 30.00 CR

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UNITED STATES PATENT AND TRADEMARK OFFICE

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Alexandria, VA 22313-1450
www.uspto.gov

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To replenish your deposit account, detach and return top portion with your check. Make checks payable to "Director of the USPTO."

Account No.
040401
Date
7-31-06
Page
1

MICHAEL DE ANGELI, P.C. FINA
MR. MICHAEL DE ANGELI
60 INTREPID LANE
JAMESTOWN RI 02835

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Pittsburgh, PA 15251-7279

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DATE POSTED MO.	DAY	YR.	CONTROL NO.	DESCRIPTION (Serial, Patent, TM, Order)	DOCKET NO.	FEE CODE	CHARGES/ CREDITS	BALANCE
7	18	06	196	10382577	PAICE201.DIV	1501	1400.00	1631.00
7	18	06	197	10382577	PAICE201.DIV	8001	30.00	1601.00
7	25	06	79	11404113	RLW-261	2011	150.00	1451.00
7	25	06	80	11404113	RLW-261	2111	250.00	1201.00
7	25	06	81	11404113	RLW-261	2311	100.00	1101.00
7	25	06	82	11404113	RLW-261	2051	65.00	1036.00
7	25	06	83	11404113	RLW-261	2251	60.00	976.00
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V - we need to send them money - just charged a $1000 filing fee -

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	3031.00	2080.00	0.00	951.00

PAGE 3/9 * RCVD AT 8/18/2006 11:12:20 AM [Eastern Daylight Time] * SVR:USPTO-EFXRF-6/36 * DNIS:2736500 * CSID:4014233191 * DURATION (mm-ss):03-10 OVERDRAWN

Att: Refund Branch
Page 2
August 18, 2006

1455.00

Therefore, it appears that a total refund of ~~$1465~~ is in order, and such is earnestly solicited. Please credit that amount to my deposit account no. 04-0401. If there are any questions, please contact me at the number above.

Very truly yours,

Michael de Angeli

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of	
Severinsky et al	Examiner: David Dunn
Serial No.: 10/382,577	Group Art Unit: 3616
Filed: March 7, 2003	Att. Dkt.: PAICE201.DIV
	Confirmation No. 5936

For: Hybrid Vehicles

Mail Stop ISSUE FEE
Hon. Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL OF ISSUE FEE

Sir:

Submitted herewith is Issue Fee Transmittal Form PTOL 85. Also enclosed is a check in the amount of $1730.00, including $1400.00 for the Issue Fee, $300.00 for the Publication Fee and $30.00 for 10 soft copies of the patent.

The Commissioner is hereby authorized to charge any underpayment (or to credit overpayment) to PTO Deposit Account No. 04-0401. A duplicate copy of this sheet is attached.

Respectfully submitted,

6/30/05
Dated

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

OIPE JC98 FEB 2 2 2005 PATENT & TRADEMARK OFFICE

INFORMATION DISCLOSURE CITATION IN AN APPLICATION 1/2	DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577
	APPLICANT: Severinsky et al	
	FILING DATE: 3/7/2003	GROUP ART UNIT: 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
DD	6067801	5/2000	Harada et al			
DD	4411171	10/1983	Fiala			
DD	3620323	~~5/1968~~ 11/1971	Maeda			
DD	6317665	11/2001	Tabata et al			
DD	6183389	2/2001	Tabata et al			
DD	5565711	10/1996	Hagiwara			

DD 2/18

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	754983	2/1995	Japan			X	
DD	4244658	9/1992	Japan			X	
DD	11082261	3/1999	Japan				X
DD	11122712	4/1999	Japan			Partial	
DD	62113956	5/1987	Japan			Partial	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER: DD [signature] DATE CONSIDERED: 3/16/05

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION

DOCKET NUMBER	PAICE201
APPLICATION NUMBER	~~09/822,866~~ 10/382577
APPLICANT	Severinsky et al
FILING DATE	04/02/01
GROUP ART UNIT	N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	4148192	4/79	Cummings			
	4306156	12/81	Monaco et al			
	4313080	11/82	Park			
	4354144	10/82	McCarthy			
	4533011	8/85	Heidemeyer			
	4951769	8/90	Kawamura			
	5053632	10/91	Suzuki et al			
	3525874	8/70	Toy			
	3650345	3 ~~8~~/72	Yardney			
	3837419	9/74	Nakamura			
	3874472	4/75	Deane			
	4042056	8/77	Horwinski			
DD	4562894	1/86	Yang			

DG 2/18

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Bulgin, "The Future Works, Quietly", Autoweek, Feb. 23, 1998 pp. 12-13
DD	"Toyota Electric and Hybrid Vehicles", a Toyota brochure
	Nagasaka et al, "Development of the Hybrid/Battery ECU...", SAE paper 981122, 1998, pp. 19-27

EXAMINER DMD DATE CONSIDERED 1/19/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION

DOCKET NUMBER	PAICE201.DIV
APPLICATION NUMBER	10/382,577
APPLICANT	Severinsky et al
FILING DATE	3/7/2003
GROUP ART UNIT	3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	6064161	5/2000	Takahara			
DD	5562566	10/1996	Yang			
DD	5212431	5/1993	Origuchi et al			
	~~4165795~~	~~8/1979~~	~~Lynch et al~~			Previously cited
DD	5283470	2/1994	Hadley et al			
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DD	5771478	6/1998	Tsukamoto			
DD	5833570	11/1998	Tabata			
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FOREIGN PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	510582	10/1992	European Patent Office				
DD	136055	3/1985	European Patent Office				
DD	2517110	10/1975	German				
DD	8201170	4/1982	PCT/SE81/00280				
DD	55110328	8/1980	Japan			part	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	"Diesel-Electric VW", *Popular Science*, December 1990, p. 30.
DD	"Electric Vehicles Only", *Popular Science*, May 1991, pp. 76-81 and 110.
DD	"Lightweight, High-Energy Lead/Acid Battery" *NASA Tech Briefs*, 4/91, 22-24.

EXAMINER [signature] DATE CONSIDERED 11/29/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201	APPLICATION NUMBER: ~~09/822,866~~ 10/382577
	APPLICANT: Severinsky et al	
	FILING DATE: 04/02/01	GROUP ART UNIT: N/A

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	4148192	4/79	Cummings			
	4306156	12/81	Monaco et al			
	4313080	~~1~~01/82	Park			
	4354144	10/82	McCarthy			
	4533011	8/85	Heidemeyer			
	4951769	8/90	Kawamura			
	5053632	10/91	Suzuki et al			
	3525874	8/70	Toy			
	3650345	8/72	Yardney			
	3837419	9/74	Nakamura			
	3874472	4/75	Deane			
	4042056	8/77	Horwinski			
DD	4562894	1/86	Yang			

DG 2/10

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Bulgin, "The Future Works, Quietly", Autoweek, Feb. 23, 1998 pp. 12-13
DD	"Toyota Electric and Hybrid Vehicles", a Toyota brochure
	Nagasaka et al, "Development of the Hybrid/Battery ECU...", SAE paper 981122, 1998, pp. 19-27

EXAMINER: DMD	DATE CONSIDERED: 1/19/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

Page 3 of 15

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER: PAICE201.DIV	APPLICATION NUMBER: 10/382,577
	APPLICANT: Severinsky et al	
	FILING DATE: 3/7/2003	GROUP ART UNIT: 3616

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	5847469	12/1998	Tabata			
DD	6317665	11/2001	Tabata			
DD	6183389	2/2001	Tabata			
DD	5873426	2/1999	Tabata			
DD	5923093	7/1999	Tabata			
DD	6340339	1/2002	Tabata			
DD	5935040	8/1999	Tabata et al			
DD	5415603	5/1995	Tuzuki et al			
DD	6258001	~~6/2001~~ 7/2001	Wakuta			
DD	5890470	4/1999	Woon			
DD	6328122	12/2001	Yamada			
DD	6278195	8/2001	Yamaguchi et al			

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GROUP 3600

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	48646266	9/1973	Japan			part	
DD	49296428	8/1974	Japan			"	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Published patent application US 2003/0085577 of Takaoka et al, May 8, 2003

EXAMINER: [signature] DATE CONSIDERED: 11/29/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP §609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to the applicant.

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IFW

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Severinsky et al	: Ser. No. 10/382,577
Patent No.: 7,104,347	: Filed March 7, 2003
Issued: September 12, 2006	: Atty. Dkt.: PAICE-201.DIV

For: Hybrid Vehicles

CHANGE OF CORRESPONDENCE ADDRESS

Hon. Commissioner for Patents
P. O. Box 1450
Alexandria VA 22313-1450

Sir:

Effective November 15, 2011, kindly change the address for correspondence concerning this patent to the following:

Michael de Angeli
34 Court Street
Jamestown RI 02835

Tel: 401-423-3190
Fax: 401-423-3191
Email: Mdeangeli20@gmail.com

Thank you for your attention to this matter.

Respectfully submitted,

Dated: 11/14/11

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown RI 02835
401-423-3190

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court for the District of Maryland Baltimore Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
1:14-cv-00492-WDQ	2/19/2014	for the District of Maryland Baltimore Division

PLAINTIFF	DEFENDANT
Paice LLC and The Abell Foundation, Inc.	Ford Motor Company

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 7,237,634	7/3/2007	Paice LLC and The Abell Foundation, Inc.
2 7,104,347	9/12/2006	Paice LLC and The Abell Foundation, Inc.
3 7,559,388	7/14/2009	Paice LLC and The Abell Foundation, Inc.
4 8,214,097	7/3/2012	Paice LLC and The Abell Foundation, Inc.
5 7,455,134	11/25/2008	Paice LLC and The Abell Foundation, Inc.

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	**DATE OF PATENT OR TRADEMARK**	**HOLDER OF PATENT OR TRADEMARK**
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy