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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

RULE 60 APPLICATION

Atty. Dkt. PAICE201.DIV

Hon. Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

This is a request for filing a **divisional** application under 37 CFR § 1.60 of pending prior application Serial No. 09/822,866 filed on April 2, 2001 entitled Hybrid Vehicles

Full Name of first joint inventor: Alex J. Severinsky

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X Enclosed is a copy of the prior application including the Declaration as originally filed. I hereby verify that the attached papers are a true copy of the prior application Serial No. 09/822,866, as originally filed on April 2, 2001.

X The filing fee is calculated below: Claims as filed, less any claims canceled:

								LARGE ENTITY
CLAIMS						Filing	Fee:	$750
Total	7	-	20	=	0	x	$18	$0
Indep.	3	-	3	=	0	x	$84	$0
								$750

X The Commissioner is hereby authorized to charge fees under 37 CFR § 1.16 and § 1.17 which may be required, or credit any overpayment of Deposit Account No. 04-0401. A duplicate copy of this sheet is enclosed.

___ Status as a "small entity" under 37 CFR 1.9 is claimed by way of the attached declaration.

___ A preliminary amendment is enclosed.

X An information disclosure statement is enclosed.

X Cancel the following claims before calculating filing the fee: 1 - 9.

X A check in the amount of $ 750.00 is enclosed.

___ Priority of application Serial No. __________ filed on ______ in (country) ____________ is claimed under 35 U.S.C. § 119.

a) _____ Certified copy is on file in prior application Serial No. __________ filed ______________________.

b) _____ Certified copy filed herewith.

X Amend the specification by rewriting lines 4 - 10 to read as follows:

This is a **divisional** application of application Serial No. 09/822,866 filed April 2, 2001, which was a continuation-in-part of Ser. No. 09/264,817, filed March 9, 1999, now U.S. patent 6,209,672, issued April 3, 2001, which in turn claims priority from provisional application Ser. No. 60/100,095, filed Spetember 14, 1998, and was also a continuation-in-part of Ser. No. 09/392,743, filed September 9, 1999, now U.S. patent 6,338,391 issued January 15, 2002, which in turn claims priority from provisional application Ser. No. 60/122,296, filed March 1, 1999.

___ Transfer the drawings for the prior application to this application, and abandon said prior application as of the filing date accorded this application. A duplicate copy of this sheet is enclosed for filing in the prior application file.

X New formal drawings are enclosed.

X The prior application is assigned of record to PAICE Corporation via a document dated May 18 and May 25, 2001 and recorded by the U.S. Patent and Trademark Office on June 26, 2001 at Reel 011932, Frame 0488.

X The power of attorney in the prior application is to Michael de Angeli, Reg. No. 27,869. The power was filed June 26, 2001.

X Address all future communications to:

Michael de Angeli
60 Intrepid Lane
Jamestown RI 02835
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X The undersigned declare further that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Respectfully submitted,

3/5/03
Dated

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10382577 .030703

HYBRID VEHICLES

Inventors: Alex J. Severinsky
Theodore N. Louckes

Cross-Reference to Related Applications

This application is a continuation-in-part of Ser. No. 09/264,817, filed March 9, 1999, now U. S. patent 6,209,672, issued April 3, 2001, which in turn claims priority from provisional application Ser. No. 60/100,095, filed September 14, 1998, and is also a continuation-in-part of Ser. No. 09/392,743, filed September 9, 1999, which in turn claims priority from provisional application Ser. No. 60/122,296, filed March 1, 1999.

Field of the Invention

This application relates to improvements in hybrid vehicles, that is, vehicles in which both an internal combustion engine and one or more electric motors are provided to supply torque to the driving wheels of the vehicle. More particularly, this invention relates to a hybrid electric vehicle that is fully competitive with presently conventional vehicles as regards performance, operating convenience, and cost, while achieving substantially improved fuel economy and reduced pollutant emissions.

Discussion of the Prior Art

For many years great attention has been given to the problem of reduction of fuel consumption of automobiles and other highway vehicles. Concomitantly very substantial attention has been paid to reduction of pollutants emitted by automobiles and other vehicles. To a degree, efforts to solve these problems conflict with one another. For example, increased thermodynamic efficiency and thus reduced fuel consumption can be realized if an engine is operated at higher temperatures. Thus there has been substantial interest in engines built of ceramic materials withstanding higher combustion temperatures than those now in use. However, higher combustion temperatures in gasoline-fueled engines lead to increase in certain undesirable pollutants, typically NO_x.

Another possibility for reducing emissions is to burn mixtures of gasoline and ethanol ("gasohol"), or straight ethanol. However, to date ethanol has not become economically competitive with gasoline, and consumers have not accepted ethanol to any great degree. Moreover, to make an alternate fuel such as ethanol available to the extent necessary to achieve appreciable improvements in nationwide air quality and fuel conservation would require immense costs for infrastructure improvements; not only the entire nation's motor fuel production and delivery system, but also the vehicle manufacture, distribution, and repair system, would have to be extensively revised or substantially duplicated.

One proposal for reducing pollution in cities is to limit the use of vehicles powered by internal combustion engines and instead employ electric vehicles powered by rechargeable batteries. To date, all such "straight electric" cars have had very limited range, typically no more than 150 miles, have insufficient power for acceleration and hill climbing except when the batteries are substantially fully charged, and require substantial time for battery recharging. Thus, while there are many circumstances in which the limited range and extended recharging time of the batteries would not be an inconvenience, such cars are not suitable for all the travel requirements of most individuals. Accordingly, an electric car would have to be an additional vehicle for most users, posing a substantial economic deterrent. Moreover, it will be appreciated that in the United States most electricity is generated in coal-fired power plants, so that using electric vehicles merely moves the source of the pollution, but does not eliminate it. Furthermore, comparing the respective net costs per mile of driving, electric vehicles are not competitive with ethanol-fueled vehicles, much less with conventional gasoline-fueled vehicles. See, generally, Simanaitis, "Electric Vehicles", *Road & Track*, May 1992, pp. 126-136; Reynolds, "AC Propulsion CRX", *Road & Track*, October 1992, pp. 126-129.

Brooks et al U.S. patent 5,492,192 shows such an electric vehicle; the invention appears to be directed to incorporation of antilock braking and traction control technologies into an otherwise conventional electric vehicle.

Much attention has also been paid over the years to development of electric vehicles including internal combustion engines powering generators, thus eliminating the defect of limited range exhibited by simple electric vehicles. The simplest such vehicles operate on the same general principle as diesel-electric locomotives used by most railroads. In such systems, an internal combustion engine drives a generator providing electric power to traction motors connected directly to the wheels of the vehicle. This system has the advantage that no variable gear ratio transmission is required between the engine and the wheels of the vehicle.

More particularly, an internal combustion engine produces zero torque at zero engine speed (RPM) and reaches its torque peak somewhere in the middle of its operating range. Accordingly, all vehicles driven directly by an internal combustion engine (other than certain single-speed vehicles using friction or centrifugal clutches, and not useful for normal driving) require a variable-ratio transmission between the engine and the wheels, so that the engine's torque can be matched to the road speeds and loads encountered. Further, some sort of clutch must be provided so that the engine can be mechanically decoupled from the wheels, allowing the vehicle to stop while the engine is still running, and to allow some slippage of the engine with respect to the drive train while starting from a stop. It would not be practical to provide a diesel locomotive, for example, with a multiple speed transmission, or a clutch. Accordingly, the additional complexity of the generator and electric traction motors is accepted. Electric traction motors produce full torque at zero RPM and thus can be connected directly to the wheels; when it is desired that the train should accelerate, the diesel engine is simply throttled to increase the generator output and the train begins to move.

The same drive system may be employed in a smaller vehicle such as an automobile or truck, but has several distinct disadvantages in this application. In particular, and as discussed in detail below in connection with Figs. 1 and 2, it is well known that a gasoline or other internal combustion engine is most efficient when producing near its maximum output torque. Typically, the number of diesel locomotives on a train is selected in accordance with the total tonnage to be moved and the grades to be overcome, so that all the locomotives can be operated at nearly full torque production. Moreover, such locomotives tend to be run at steady speeds for long periods of time. Reasonably efficient fuel use is thus achieved. However, such a direct drive vehicle would not achieve good fuel efficiency in typical automotive use, involving many short trips, frequent stops in traffic, extended low-speed operation and the like.

So-called "series hybrid" electric vehicles have been proposed for automotive use, wherein batteries are used as energy storage devices, so that an internal combustion engine provided to power a generator can be operated in its most fuel-efficient output power range while still allowing the electric traction motor(s) powering the vehicle to be operated as required. Thus the engine may be loaded by supplying torque to a generator charging the batteries while supplying electrical power to the traction motor(s) as required, so as to operate efficiently. This system overcomes the limitations of electric vehicles noted above with respect to limited range and long recharge times. Thus, as compared to a conventional vehicle, wherein the internal combustion engine delivers torque directly to the wheels, in a series hybrid electric vehicle, torque is delivered from the engine to the wheels via a serially connected generator used as a battery charger, the battery, and the traction motor. However, energy transfer between those components consumes at least approximately 25% of engine power. Further, such components add substantially to the cost and weight of the vehicle; in particular, an electric motor capable of providing sufficient torque to meet all expected demand, e.g., to allow reasonable performance under acceleration, during hill-climbing and the like, is rather heavy and expensive. Thus, series hybrid vehicles have not been immediately successful.

A more promising "parallel hybrid" approach is shown in U.S. Patent Nos. 3,566,717 and 3,732,751 to Berman et al. In Berman et al an internal combustion engine and an electric motor are matched through a complex gear train so that both can provide torque directly to the wheels, the vehicle being operated in several different modes. Where the output of the internal combustion engine is more than necessary to drive the vehicle ("first mode operation") the engine is run at constant speed and excess power is converted by a first motor/generator ("speeder") to electrical energy for storage in a battery. In "second mode operation", the internal combustion engine drives the wheels directly, and is throttled. When more power is needed than the engine can provide, a second motor/generator or "torquer" provides additional torque as needed.

Berman et al thus show two separate electric motor/generators separately powered by the internal combustion engine; the "speeder" charges the batteries, while the "torquer" propels the vehicle forward in traffic. This arrangement is a source of additional complexity, cost and difficulty, as two separate modes of engine control are required. Moreover, the operator must control the transition between the several modes of operation. Such a complex vehicle is unsuited for the automotive market. Automobiles intended for mass production can be no more complicated to operate than conventional vehicles, and must be essentially "foolproof", that is, resistant to damage that might be caused by operator error. Further, the gear train shown by Berman et al appears to be quite complex and difficult to manufacture economically. Berman et al also indicate that one or even two variable-speed transmissions may be required; see, e.g., col. 3, lines 19 - 22 and 36 - 38 of patent 3,566,717, and col. 2, lines 53 - 55 of patent 3,732,751.

Lynch et al patent 4,165,795 also shows an early parallel hybrid drive. Lynch argues that maximum fuel efficiency can be realized when a relatively small internal combustion engine is provided, such that when the engine is operated at an efficient speed, it produces approximately the average power required over a typical mission. The example given is of an engine producing 25 hp maximum and 17 hp at its most efficient speed, about 2500 rpm. This is to be combined with an electric motor-generator of about 30 peak hp. This vehicle requires a variable-ratio transmission to achieve reasonable performance. It appears that the engine is to be run continuously, at a steady speed, with additional torque provided by the motor when needed and excess torque produced by the engine being used to charge the batteries. In a first embodiment, torque provided by the motor is transmitted to the drive wheels through the engine, while in a second embodiment their respective positions are reversed.

Nishida U.S. patent 5,117,931 shows a parallel hybrid vehicle where torque from an electric motor may be combined with torque from an internal combustion engine in a "torque transmission unit" comprising paired bevel gears and means for controlling the relative rates of rotation of the motor and engine, so that the motor can be used to start the engine, absorb excess torque from the engine (by charging a battery), or provide additional propulsive torque. A variable-speed transmission is coupled between the torque transmission unit and the propelling wheels. Both the torque transmission unit and the variable-speed transmission are complex, heavy, and expensive components, the use of which would preferably be avoided.

Helling U.S. patent 3,923,115 also shows a hybrid vehicle having a torque transmission unit for combining torque from an electric motor and an internal combustion engine. However, in

Helling the relative rates of rotation of the motor and engine input shafts are fixed; a flywheel is provided to store excess mechanical energy as well as a battery to store excess electrical energy. Albright, Jr. et al patent 4,588,040 shows another hybrid drive scheme using a flywheel in addition to batteries to store excess energy; various complicated mechanical connections are provided between the various components. Capacitors have also been proposed for energy storage; see Bates et al U.S. patent 5,318,142.

Fjällström U.S. patent 5,120,282 shows a parallel hybrid drive train wherein torque from two electric motors is combined with torque produced by an internal combustion engine; the combination is performed by a complex arrangement of paired planetary gearsets, and unspecified control means are alleged to be able to allow variation of road speed without a variable-ratio transmission.

Hunt U.S. Patent Nos. 4,405,029 and 4,470,476 also disclose parallel hybrids requiring complex gearing arrangements, including multiple speed transmissions. More specifically, the Hunt patents disclose several embodiments of parallel hybrid vehicles. Hunt indicates (see col. 4, lines 6 - 20 of the '476 patent) that an electric motor may drive the vehicle at low speeds up to 20 mph, and an internal combustion engine used for speeds above 20 mph, while "in certain speed ranges, such as from 15 - 30 mph, both power sources may be energized... Additionally, both power sources could be utilized under heavy load conditions." Hunt also indicates that "the vehicle could be provided with an automatic changeover device which automatically shifts from the electrical power source to the internal combustion power source, depending on the speed of the vehicle" (col. 4, lines 12 - 16).

However, the Hunt vehicle does not meet the objects of the present invention, as discussed in detail below. Hunt's vehicle in each embodiment requires a conventional manual or automatic transmission. See col. 2, lines 6 - 7. Moreover, the internal combustion engine is connected to the transfer case (wherein torque from the internal combustion engine and electric motor is combined) by a "fluid coupling or torque converter of conventional construction". Col. 2, lines 16 - 17. Such transmissions and fluid couplings or torque converters are very inefficient, are heavy, bulky, and costly, and are to be eliminated according to one object of the present invention, again as discussed in detail below.

Furthermore, the primary means of battery charging disclosed by Hunt involves a further undesirable complexity, namely a turbine driving the electric motor in generator configuration. The turbine is fueled by waste heat from the internal combustion engine. See col. 3, lines 10 - 60. Hunt's internal combustion engine is also fitted with an alternator, for additional battery charging capability, adding yet further complexity. Thus it is clear that Hunt fails to teach a hybrid vehicle meeting the objects of the present invention - that is, a hybrid vehicle competitive with conventional vehicles with respect to performance, cost and complexity, while achieving substantially improved fuel efficiency.

Kawakatsu U.S. Patents Nos. 4,305,254 and 4,407,132 show a parallel hybrid involving a single internal combustion engine coupled to the drive wheels through a conventional variable-ratio transmission, an electric motor, and an alternator, to allow efficient use of the internal combustion engine. As in the Hunt disclosure, the engine is intended to be operated in a relatively efficient range of engine speeds; when it produces more torque than is needed to propel the vehicle, the excess is used to charge the batteries; where the engine provides insufficient torque, the motor is energized as well.

A further Kawakatsu patent, No. 4,335,429, shows a hybrid vehicle, in this case comprising an internal combustion engine and two motor/generator units. A first larger motor/generator, powered by a battery, is used to provide additional torque when that provided by the engine is insufficient; the larger motor-generator also converts excess torque provided by the engine into electrical energy, to be stored by the battery, and is used in a regenerative braking mode. The second smaller motor/generator is similarly used to provide additional torque and additional regenerative braking as needed.

More particularly, the latter Kawakatsu patent asserts that a single electric motor sized to provide sufficient torque to propel the vehicle would not be capable of providing sufficient regenerative braking force; see col. 1, line 50 - col. 2 line 8. Accordingly, Kawakatsu provides two separate motor/generators, as noted; a separate engine starting motor is also provided. See col. 6, lines 22 - 23. In the embodiment shown, the larger motor/generator is connected to the wheel drive shaft, while the engine and the smaller motor/generator are connected to the wheels through a complex mechanism comprising three separately-controllable clutches. See col. 5, lines 50 - 62.

Numerous patents disclose hybrid vehicle drives tending to fall into one or more of the categories discussed above. A number of patents disclose systems wherein an operator is required to select between electric and internal combustion operation; for example, an electric motor is provided for operation inside buildings where exhaust fumes would be dangerous, and an internal combustion engine provided for operation outdoors. It is also known to propose a hybrid vehicle comprising an electric motor for use at low speeds, and an internal combustion engine for use at higher speed. The art also suggests using both when maximum torque is required. In several cases the electric motor drives one set of wheels and the internal combustion engine drives a different set. See generally Shea (4,180,138); Fields et al (4,351,405); Kenyon (4,438,342); Krohling (4,593,779); and Ellers (4,923,025).

Many of these patents show hybrid vehicle drives wherein a variable speed transmission is required, as do numerous additional references. A transmission as noted above is typically required where the internal combustion engine and/or the electric motor are not capable of supplying sufficient torque at low speeds. See Rosen (3,791,473); Rosen (4,269,280); Fiala (4,400,997); and Wu et al (4,697,660). Kinoshita (3,970,163) shows a vehicle of this general type wherein a gas turbine engine is coupled to the road wheels through a three-speed transmission; an electric motor is provided to supply additional torque at low speeds.

For further examples of series hybrid vehicles generally as discussed above, see Bray (4,095,664); Cummings (4,148,192); Monaco et al (4,306,156); Park (4,313,080); McCarthy (4,354,144); Heidemeyer (4,533,011); Kawamura (4,951,769); and Suzuki et al (5,053,632). Various of these address specific problems arising in the manufacture or use of hybrid vehicles, or specific alleged design improvements. For example, Park addresses certain specifics of battery charging and discharge characteristics, while McCarthy shows a complex drive system involving an internal combustion engine driving two electric motors; the torque generated by the latter is combined in a complex differential providing continuously variable gear ratios. Heidemeyer shows connecting an internal combustion engine to an electric motor by a first friction clutch, and connecting the motor to a transmission by a second friction clutch.

Other patents of general relevance to this subject matter include Toy (3,525,874), showing a series hybrid using a gas turbine as internal combustion engine; Yardney (3,650,345), showing use of a compressed-air or similar mechanical starter for the internal combustion engine of a series hybrid, such that batteries of limited current capacity could be used; and Nakamura (3,837,419), addressing improvements in thyristor battery-charging and motor drive circuitry. Somewhat further afield but of general interest are the disclosures of Deane (3,874,472); Horwinski (4,042,056); Yang (4,562,894); Keedy (4,611,466); and Lexen (4,815,334); Mori (3,623,568); Grady, Jr. (3,454,122); Papst (3,211,249); Nims et al (2,666,492); and Matsukata (3,502,165). Additional references showing parallel hybrid vehicle drive systems include Froelich (1,824,014) and Reinbeck (3,888,325).U.S. Patent No. 4,578,955 to Medina shows a hybrid system wherein a gas turbine is used to drive a generator as needed to charge batteries. Of particular interest to certain aspects of the present invention is that Medina discloses that the battery pack should have a voltage in the range of 144, 168 or 216 volts and the generator should deliver current in the range of 400 to 500 amperes. Those of skill in the art will recognize that these high currents involve substantial resistance heating losses, and additionally require that all electrical connections be made by positive mechanical means such as bolts and nuts, or by welding. More specifically, for reasons of safety and in accordance with industry practice, currents in excess of about 50 amperes cannot be carried by the conventional plug-in connectors preferred for reasons of convenience and economy, but must be carried by much heavier, more expensive and less convenient fixed connectors (as used on conventional starter and battery cable connections). Accordingly, it would be desirable to operate the electric motor of a hybrid vehicle at lower currents.

U.S. patent 5,765,656 to Weaver also shows a series hybrid wherein a gas turbine is used as the internal combustion engine; hydrogen is the preferred fuel.

U.S. Patent No. 4,439,989 to Yamakawa shows a system wherein two different internal combustion engines are provided, so that only one need be run when the load is low. This arrangement would be complex and expensive to manufacture.

Detailed discussion of various aspects of hybrid vehicle drives may be found in Kalberlah, "Electric Hybrid Drive Systems for Passenger Cars and Taxis", SAE Paper No. 910247 (1991). Kalberlah first compares "straight" electric, series hybrid, and parallel hybrid drive trains, and concludes that parallel hybrids are preferable, at least when intended for general use (that is, straight electric vehicles may be useful under certain narrow conditions of low-speed, limited range urban driving). Kalberlah then compares various forms of parallel hybrids, with respect to his Fig. 4, and concludes that the most practical arrangement is one in which an internal combustion engine drives a first pair of wheels, and an electric motor the second; more particularly, Kalberlah indicates that mechanical combination of the torque from an internal combustion engine and an electric motor is impractical.

Gardner U.S. patents 5,301,764 and 5,346,031 follow Kalberlah's teachings, in that Gardner shows separately driving at least two pairs of wheels; one pair is driven by a first electric motor, and the second by a second electric motor or alternatively by a small internal combustion engine. Three different clutches are provided to allow various sources of drive torque to be connected to the wheels, and to a generator, depending on the vehicle's operation mode. The internal combustion engine is run continuously, and provides the driving torque when the vehicle is in a cruise mode; at other times it is used to charge the batteries powering the electric motors.

Bullock, "The Technological Constraints of Mass, Volume, Dynamic Power Range and Energy Capacity on the Viability of Hybrid and Electric Vehicles", SAE Paper No. 891659 (1989) provides a detailed theoretical analysis of electric vehicles in terms of the loads thereon, and a careful analysis of the various battery types then available. Bullock concludes that a vehicle having two electric motors of differing characteristics, driving the wheels through a variable-speed transmission, would be optimal for automotive use; see the discussion of Fig. 8. Bullock also suggests the use of an internal combustion engine to drive battery charging, but does not address combining the engine's torque with that from the motors; see pp. 24 - 25.

Further related papers are collected in Electric and Hybrid Vehicle Technology, volume SP-915, published by SAE in February 1992. See also Wouk, "Hybrids: Then and Now"; Bates, "On the road with a Ford HEV", and King et al, "Transit Bus takes the Hybrid Route", all in IEEE Spectrum, Vol. 32, 7, (July 1995).

Urban et al U.S. patent 5,667,029 shows two embodiments of parallel hybrids; a first embodiment is shown in Figs. 1 - 9 and 11, and a second in Figs. 12 - 17. Both embodiments have numerous common features, including similar operating modes. Referring to the first embodiment, an internal combustion engine provides torque to the road wheels or to a generator; two electric motors can provide torque to the road wheels, or charge batteries during regenerative braking. Torque from the engine and motors is combined at the input shaft to a variable-ratio transmission. Overrunning clutches are provided, e.g., to allow the engine's torque to be applied to the road wheels without also rotating the motors.

As indicated at col. 6, lines 25 - 54, certain transitions between various operating modes are made automatically, responsive to the position of the accelerator pedal; for example, if the operator does not depress the pedal beyond a given point, only the internal combustion engine is employed to propel the vehicle; if the operator depresses the pedal more fully, the electric motors are also energized. Other changes in the operational mode must be made by the operator directly; for example, the vehicle may be operated as a "straight electric" vehicle, e.g. for short duration trips, by the operator's making an appropriate control action. See col. 7, lines 49 - 56.

The Urban et al design appears to suffer from a number of significant defects. First, the internal combustion engine is stated to provide all torque needed to accelerate the vehicle to cruising speed under normal circumstances (see col. 5, lines 3 - 10), and also to propel the vehicle during cruising (see col. 6, lines 48 - 54). The electric motors are to be used only during rapid acceleration and hill-climbing; col. 5, lines 10 - 13. A 20 horsepower engine, operated through a continuously variable-ratio transmission and a torque converter, is stated to be adequate for this purpose. Such components are clearly complex and expensive; further, torque converters are notoriously inefficient. Moreover, using the internal combustion engine as the sole source of power for low-speed running would require it to be run at low speeds, e.g., at traffic lights, which is very inefficient and highly polluting. (Various additional references suggest that excess torque can be used to charge batteries; if this were incorporated in the Urban system, the engine might be run at a reasonably efficient output level while the vehicle was stationary, but this would lead to high levels of noise and vibration. In any event Urban does not appear to consider this possibility.)

On the other hand, Urban does suggest that the vehicle can be operated as a "straight electric" under low-speed conditions, but this requires the operator to provide an explicit control input; this complexity is unacceptable in a vehicle intended to be sold in quantity, as would be required in order to reach Urban's stated goals of reduction of atmospheric pollution and reduced energy consumption. As noted, hybrid vehicle operation must be essentially "foolproof", or "transparent" to the user, to have any chance of commercial success.

Urban's second embodiment is mechanically simpler, employing but a single "dynamotor", through which torque is transmitted from the engine to the variable-ratio transmission, but suffers from the same operational deficiencies.

A second Urban et al patent, 5,704,440, is directed to the method of operation of the vehicle of the '029 patent and suffers the same inadequacies.

Various articles describe several generations of Toyota Motor Company hybrid vehicles, believed to correspond to that available commercially as the "Prius". See, for example, Yamaguchi, "Toyota readies gasoline/electric hybrid system", Automotive Engineering, July 1997, pp. 55 - 58; Wilson, "Not Electric, Not Gasoline, But Both", Autoweek, June 2, 1997, pp. 17 - 18; Bulgin, "The Future Works, Quietly", Autoweek February 23, 1998, pp. 12 and 13; and "Toyota Electric and Hybrid Vehicles", a Toyota brochure. A more detailed discussion of the Toyota vehicle's powertrain is found in Nagasaka et al, "Development of the Hybrid/Battery ECU for the Toyota Hybrid System", SAE paper 981122 (1998), pp. 19 - 27. According to the Wilson article, Toyota describes this vehicle as a "series-parallel hybrid"; regardless of the label applied, its powertrain appears to be similar to that of the Berman patents described above, that is, torque from either or both of an internal combustion engine and an electric motor are controllably combined in a "power-split mechanism" and transmitted to the drive wheels through a planetary gearset providing the functionality of a variable-ratio transmission. See the Nagasaka article at pp. 19 - 20.

Furutani U.S. patent 5,495,906 describes a vehicle having an internal combustion engine driving a first set of wheels through a variable-ratio transmission and an electric motor driving a second set of wheels. The engine is apparently intended to be run continuously; at low speeds, it drives a generator to charge batteries providing energy to the motor, and at higher speeds the engine or both engine and motor propel the vehicle. In some circumstances the transmission may not be required; compare, for example, col. 3, lines 4 - 8 with col. 5, lines 59 - 64.

U.S. patent 5,842,534 to Frank shows a "charge depletion" control method for hybrid vehicles; in this scheme, the internal combustion engine is essentially used only when the state of the batteries is such that the vehicle cannot otherwise reach a recharging point. See col. 3, lines 50 - 55. In normal operation, the batteries are recharged from an external power source. Frank also discusses two-mode brake pedal operation, wherein mechanical brakes are engaged in addition to regenerative braking when the pedal is depressed beyond a preset point.

U.S. patent 5,823,280 to Lateur et al shows a parallel hybrid wherein the shafts of an internal combustion engine and first and second electric motors are all coaxial; the engine is connected to the first motor by a clutch, and the first motor to the second by a planetary gearset, allowing the speeds of the motors to be varied so as to operate them in their most efficient range. See col. 4, line 57 - col. 5, line 60.

U.S. patent 5,826,671 to Nakae et al shows a parallel hybrid wherein torque from an internal combustion engine is combined with that from a motor in a planetary gearset; a clutch is provided therebetween. The specific invention relates to sensing of engine warmup conditions, so as to limit emission of unburnt fuel and thus lower emissions.

U.S. patent 5,846,155 to Taniguchi et al shows a parallel hybrid wherein torque from an internal combustion engine and a motor is again combined in a planetary gearset; the specific improvement appears to be the use of a continuously-variable transmission.

It will be appreciated by those of skill in the art that there are significant limitations inherent in the use of planetary gearsets as a means for connecting different sources, e.g., an internal combustion engine and an electric motor, to the drive wheels of a vehicle, namely, that unless the planetary gearset is effectively locked (anathematic to its use as a continuously-variable transmission, e.g., in the Toyota vehicle) it is capable of additive combination of shaft speeds, but not of output torque. Hence, the principal advantage of the parallel hybrid drivetrain, additive combination of the output torque of both the electric motor and the internal combustion engine, is only available when the planetary gearset is locked. This fact is acknowledged by Lateur, for example, at col. 6, line 27.

Additional disclosures of possible interest include U.S. patent 5,845,731 to Buglione et al; this patent issued December 8, 1998, and therefore is not necessarily available as a reference against the claims of the present application. The basic powertrain shown by Buglione et al includes an internal combustion engine 12, coupled through a first clutch 18 to a first electric motor 20, coupled to a second electric motor 26 through a second clutch 24; the wheels are (apparently; see col. 3, line 8) driven by the second motor 26. The overall hybrid operational scheme provided by Buglione et al is illustrated in Fig. 4. At low speeds one or both motors may be used to propel the vehicle, with the engine off, idling, or running to drive one motor as a generator. During low-speed cruising the second motor propels the vehicle, while during high-speed cruising, the engine propels the vehicle. When acceleration is required at high speed, the engine and both motors may be used to propel the vehicle. Buglione et al also indicates that a variable-ratio transmission may be unnecessary, col. 3, line 9, and that the first motor can be used to start the engine, col. 4, lines 8 - 15.

U.S. patent 5,586,613 to Ehsani, showing an "electrically peaking hybrid" vehicle is also of interest. Ehsani's vehicle is shown in several embodiments; in each, an engine is apparently to be run continuously, with excess torque used to charge the batteries, and one or more motors used to provide additional propulsive torque when the engine's output torque is inadequate. A transmission is provided in some embodiments of the Ehsani vehicle. An embodiment involving two motors is shown in Fig. 7, and can be modified as discussed in the text at col. 9, lines 4 - 5. Fig. 7 itself shows driving a first set of wheels by a first "electric machine", i.e., a motor capable of operation as a generator. This drive arrangement is independent of a second drive arrangement, whereby a second set of wheels is driven by an engine connected through a first clutch to a second electric machine, connected to the second set of wheels by a second clutch. Ehsani suggests at col. 9, lines 4 - 5 that the drive shaft otherwise coupled to the first electric machine could also be driven by the engine. Although it is not made explicit that the first electric machine is to be retained, this seems likely; otherwise, the modified Fig. 7 embodiment would be the same as Ehsani's Fig. 1, modified to have all four wheels driven by a common driveshaft.

This application discloses a number of improvements over and enhancements to the hybrid vehicles disclosed in U.S. patent 5,343,970 (the "'970 patent"), to one of the present inventors, which is incorporated herein by this reference. Where differences are not mentioned, it is to be understood that the specifics of the vehicle design shown in the '970 patent are applicable to the vehicles shown herein as well. Discussion of the '970 patent herein is not to be construed to limit the scope of its claims.

Generally speaking, the '970 patent discloses hybrid vehicles wherein a controllable torque transfer unit is provided capable of transferring torque between an internal combustion engine, an electric motor, and the drive wheels of the vehicle. The direction of torque transfer is controlled by a microprocessor responsive to the mode of operation of the vehicle, to provide highly efficient operation over a wide variety of operating conditions, and while providing good performance. The flow of energy - either electrical energy stored in a substantial battery bank, or chemical energy stored as combustible fuel - is similarly controlled by the microprocessor.

For example, according to the operating scheme of the hybrid vehicle disclosed in the '970 patent, in low-speed city driving, the electric motor provides all torque needed responsive to energy flowing from the battery. In high-speed highway driving, where the internal-combustion engine can be operated efficiently, it typically provides all torque; additional torque may be provided by the electric motor as needed for acceleration, hill-climbing, or passing. The electric motor is also used to start the internal-combustion engine, and can be operated as a generator by appropriate connection of its windings by a solid-state, microprocessor-controlled inverter. For example, when the state of charge of the battery bank is relatively depleted, e.g., after a lengthy period of battery-only operation in city traffic, the internal combustion engine is started and drives the motor at between 50 and 100% of its maximum torque output, for efficient charging of the battery bank. Similarly, during braking or hill descent, the kinetic energy of the vehicle can be turned into stored electrical energy by regenerative braking.

The hybrid drive train shown in the '970 patent has many advantages with respect to the prior art which are retained by the present invention. For example, the electric drive motor is selected to be of relatively high power, specifically, equal to or greater than that of the internal combustion engine, and to have high torque output characteristics at low speeds; this allows the conventional multi-speed vehicle transmission to be eliminated. As compared to the prior art, the battery bank, motor/generator, and associated power circuitry are operated at relatively high voltage and relatively low current, reducing losses due to resistive heating and simplifying component selection and connection.

It can thus be seen that while the prior art, including the '970 patent, clearly discloses the desirability of operating an internal combustion engine in its most efficient operating range, and that a battery may be provided to store energy to be supplied to an electric motor in order to even out the load on the internal combustion engine, there remains substantial room for improvement. In particular, it is desired to obtain the operational flexibility of a parallel hybrid system, while optimizing the system's operational parameters and providing a substantially simplified parallel hybrid system as compared to those shown in the prior art, again as including the '970 patent.

As noted above, the present application is a continuation-in-part of Ser. No. 09/264,817, filed March 9, 1999 (the '817 application), which discloses and claims several distinct improvements over the hybrid vehicles shown in the '970 patent, as discussed in further detail below. Similarly, the present application is a continuation-in-part of Ser. No. 09/392,743, filed September 9, 1999 (the '743 application), which discloses and claims several distinct improvements over the hybrid vehicles shown in the '970 patent and the '817 application, as discussed in further detail below. The present application discloses and claims further improvements over the vehicles of the '817 and '743 applications.

As discussed in detail below, the '817 and '743 applications (which are not to be limited by this brief summary) disclose a new "topology" for a hybrid vehicle, wherein an internal combustion engine and a first electric "starting" motor, which can be operated as a starter, to start the engine, a generator, to charge the battery bank responsive to torque from the engine or the wheels (i.e., during regenerative braking) or as a source of torque, to propel the vehicle, are connected to the road wheels of the vehicle through a clutch, so that the engine can be decoupled from the wheels during starting and battery charging, but can be connected to the wheels to propel the vehicle. A second "traction" motor is directly connected to the road wheels to propel the vehicle. The vehicle operating mode is determined by a microprocessor responsive to the "road load", that is, the vehicle's instantaneous torque demands. The '743 application further discloses that a turbocharger may be provided, and operated when needed to increase the torque output of the engine when torque in excess of its normally-aspirated capacity is required for more than a minimum time. The present application builds further on these concepts.

Koide U.S. patent 5,934,395 and Schmidt-Brücken U.S. patent 6,059,059 were addressed during the prosecution of the '817 application. Tsuzuki 6,018,198 and Werson 5,986,376 were also each applied against one claim. As indicated, the '817 application discloses a hybrid vehicle comprising a controller, a battery bank, an internal combustion engine, and two electric motors, a starting motor and a traction motor. The starting motor and engine are connected to the road wheels through a clutch, while the traction motor is connected directly and permanently to the road wheels for torque transmission therebetween, i.e., without a clutch therebetween. Koide does not show this "topology" for a hybrid vehicle; although Koide does show a hybrid vehicle having first and second motors along with an engine, the components are not connected as described. Specifically, in Koide, both motors and the engine are connected to the road wheels by way of a variable-ratio transmission and a clutch, while, as noted, in the '817 application only the combination of the engine and starting motor is connected to the wheels through a clutch, while the traction motor is connected directly to the wheels for torque transmission therebetween, that is, without a clutch or variable-ratio transmission. More specifically, Koide's entire disclosure is premised on being able to vary the ratios between the torque-producing components of his system and the road wheels, in order that the engine can be smoothly started when needed. According to the '817 application, only the starter motor and engine need to be disconnectible from the wheels for smooth starting, while the traction motor can be connected to the road wheels at all times. This represents a substantial simplification with respect to the system shown by Koide.

The Schmidt-Brücken patent also fails to show the topology shown in the '817 application. Schmidt-Brücken shows an engine 1 in combination with a starting motor 7, connected to the road wheels through a first clutch 11, and a traction motor 19 connected to the road wheels through a second clutch 23.

The '817 and '743 applications also disclose that the vehicle operating mode is determined by a microprocessor responsive to the "road load", that is, the vehicle's instantaneous torque demands, i.e., that amount of torque required to propel the vehicle at a desired speed. The operator's input, by way of the accelerator or brake pedals, or a "cruise control" device, indicates that continuing at steady speed is desired, or that a change in vehicle speed is called for. For example, the operator's depressing the accelerator pedal signifies an increase in desired speed, i.e., an increase in road load, while reducing the pressure on the accelerator or depressing the brake pedal signifies a desired reduction in vehicle speed, indicating that the torque being supplied is to be reduced or should be negative. More particularly, it is important to note that the road load can vary between wide limits, independent of vehicle speed, and can be positive or negative, i.e., when decelerating or descending a hill, in which case the negative road load (that is, torque available at the wheels in excess of that required to propel the vehicle) is usually employed to charge the battery bank.

More particularly, it is important to recognize that road load is not the same thing as vehicle velocity. Indeed, as noted, road load can be negative while vehicle velocity is positive, as during deceleration or descent. Moreover, widely differing road loads may be encountered during operation at the same velocity; for example, operation at 50 mph on a flat road may involve a road load of only 30 - 40% of the engine's maximum output torque (MTO), while accelerating from the same speed while climbing a hill may involve a road load of well over 100% of MTO.

By the same token, control of the vehicle's operating mode in response to monitoring of road load is not the same as controlling its operating mode in response to vehicle speed. Numerous prior art references, including the Koide and Schmidt-Brücken patents, teach the latter, i.e., indicate the vehicle operating mode should be controlled in response to vehicle speed. See Koide at col. 12, lines 45 - 48, and Schmidt-Brücken at col. 5, line 56 - col. 6 line 29. Neither Koide nor Schmidt-Brücken, nor any other reference of which the inventors are aware, recognizes that the desired vehicle operational mode should preferably be controlled in response to the vehicle's actual torque requirements, i.e., the road load. Doing so according to the invention provides superior performance, in terms of both vehicle response to operator commands and fuel efficiency, under the widely-varying conditions encountered in "real world" driving situations, than is possible according to the prior art.

Moreover, as set forth in the '817 and '743 applications, in order to provide maximum efficiency in use of fuel, it is essential to operate the internal combustion engine of a hybrid vehicle only under circumstances where the engine will be loaded so as to require at least 30% of its maximum torque output ("MTO")(it being understood throughout this specification and the appended claims that this 30% figure is arbitrary and can be varied). If the vehicle is controlled to shift into an engine-only mode whenever it exceeds some arbitrary road speed, as in Koide and Schmidt-Brücken, it is apparent that the engine will be operated at various times when the road load is less than 30% of MTO, for example, during deceleration or during descents. Moreover, as noted above, the torque actually required can vary widely irrespective of vehicle speed. For example, 30% of MTO may be sufficient to maintain steady speed on a flat road, but 150% of MTO may be required for acceleration from the same speed. If the vehicle's operational mode is selected based solely on speed, as taught by Koide and Schmidt-Brücken, it will be incapable of responding to the operator's commands, and will ultimately be unsatisfactory.

By comparison, according to the invention of the '817 and '743 applications, and as further disclosed and claimed herein, the vehicle's operating mode -- that is, the selection of the source of torque needed to propel the vehicle -- is determined based on the amount of torque actually required. In this way the proper combination of engine, traction motor, and starting motor is always available. This apparently-simple point has evidently been missed entirely by the art.

Moreover, according to this aspect of the invention, the engine is used to propel the vehicle only when it is efficient to do so. This is in accordance with another aspect of the invention, wherein the engine is operated only at high efficiency, leading directly to improved fuel economy. For example, the engine is also used as needed to charge the battery bank, e.g., in low-speed city driving, where the battery bank may become depleted. The starter motor, which is operated as a generator in these circumstances, is accordingly sized so as be able to accept at least 30% of MTO as input torque; the battery bank is likewise sized so as to be able to accept a corresponding amount of charging current. Therefore the engine is never operated at less than 30% of MTO, and is thus never operated inefficiently. Koide and Schmidt-Brücken, because they teach switching the vehicle's operational mode based on vehicle speed and not its torque requirements, would inherently operate the engine under less efficient conditions.

Furutani patent 5,495,906 discloses selection of operating mode based on a combination of vehicle speed and "vehicle load"; see, e.g., col. 2, lines 39 - 47: "It is preferable that the running state detection means detects vehicle speed and vehicle load...[and] that the control means transfers the driving force generated by the engine to the power generator and changes the electric power generated by the power generator [i.e., more of the engine power is used to charge the batteries] in accordance with the vehicle load if the vehicle speed is the predetermined value or less. Moreover, it is preferable to change the predetermined value of the vehicle speed in accordance with the vehicle load." It thus appears that Furutani determines the vehicle operating state based on vehicle speed, although the change-over speed can be varied responsive to the vehicle load. Furutani's "vehicle load" thus apparently includes the torque required to charge the battery, as distinguished from applicants' "road load", i.e., the torque required to propel the vehicle. Even assuming that Furutani's "vehicle load", which is not defined, were suggestive of "road load" as used by applicants, Furutani clearly does not suggest determining the operating mode based on road load. More specifically, although Furutani recognizes a distinction between differing vehicle loads, and that the vehicle load can vary independent of vehicle speed, the vehicle operating mode is nonetheless selected based on vehicle speed; see col. 3, line 62 - col. 4, line 32. Instead of varying the operating mode of the vehicle based on road load, Furutani directs more or less of the engine's torque to battery charging; see col. 4, lines 24 - 32.

Frank 6,054,844 shows several embodiments of hybrid vehicles. In those where an engine is used to provide torque to the vehicle wheels, a continuously-variable transmission is employed, and the ratio R is considered in determining the response to be made to operator input, e.g., accelerator and brake pedal positions. Frank's control strategy is to operate the engine along a line of optimal efficiency and use an electric motor to add to or subtract from the engine's output torque as appropriate. See col. 6, line 49 - col. 7, line 7 and col. 10, line 33 - col. 11, line 22. Frank thus does not suggest control of the vehicle operating mode responsive to road load.

Patent 6,018,694 to Egami et al shows a controller for a hybrid vehicle comprising an internal combustion engine and first and second "rotary electric units". Although the question is not free from doubt, it appears from a detailed review of Egami's disclosure that torque from the engine is not supplied directly to the road wheels, but instead is used to drive one of the rotary electric units as a generator, in turn supplying the second with current to provide torque for propelling the vehicle. Hence Egami does not show selection of the operational mode of the vehicle (that is, the determination whether propulsive torque is to be provided from the engine, one or both of the motors, or all three) in response to the road load, since it does not appear that propulsive torque is ever supplied from the engine to the wheels. Moreover, despite making reference to a "vehicle driving torque demand Mv*", which might be misunderstood to be equivalent to applicant's road load, Egami in fact does not determine the road load. More specifically, Mv* is determined by consulting a "map", using "the vehicle speed V, the accelerator lift ACC, the brake state BRK, and the shift position SFT as the input parameters". See col. 22, lines 23 - 26. The same point, i.e., that the "vehicle driving torque demand Mv*" is not equivalent to applicant's claimed road load, is made throughout Egami's extensive specification; see, for example, col. 10, lines 28 - 32 and col. 27, lines 58 - 65.

Deguchi patent 5,993,351 refers to decision-making regarding the vehicle mode of operation "based on the vehicle speed detected value and the required motive force detected value" (Abstract; see also col. 1, line 41); the latter might be misunderstood to be equivalent to the road load. Deguchi also states (col. 2, lines 7

- 9) that the vehicle "runs on the motor at times of low load and runs on the internal combustion engine at times of high load". However, Deguchi makes it clear that in fact the operational-mode decision is made "based on the accelerator aperture detected value θ which represents the required driving force of the vehicle and the detected vehicle speed" (col. 5, lines 19 - 21). The accelerator position and vehicle speed signals are the only relevant inputs to the vehicle controller shown in Fig. 2. Hence Deguchi does not show controlling the vehicle operating mode responsive to road load as defined by applicants.

Along generally similar lines, Boll patent 5,327,992 teaches a hybrid vehicle comprising a diesel engine and a motor on a common shaft, and intended to be operated such that the engine is only operated efficiently, i.e., under relatively high load. The torque required to overcome the "instantaneous tractive resistance" is determined responsive to the deflection of the accelerator pedal, i.e., in response to operator command (see col. 3, line 13 and line 35); when this is less than the minimum amount of torque that can be produced efficently by the engine, the excess torque is used to power the motor as a generator. Boll also suggests that both the motor and engine can be used to propel the vehicle when needed, e.g., during acceleration, and that the vehicle can be operated in four different modes: (a) engine alone powering the vehicle; (b) motor only powering the vehicle, with the engine "generally switched off"; (c)engine and motor both powering the vehicle; and (d) engine powering vehicle, with excess torque powering motor in generator mode. Boll also teaches that a second motor can be provided, operable as a generator and then driven either by the engine directly or by exhaust gas, and that the resulting current can be used to charge the battery or to power the other motor.

Other references of interest are directed to the braking systems of hybrid vehicles, see for example German patent 19 05 641 to Strifler, discussing a method of control of a braking system providing both regenerative and mechanical braking, and the powering of ancillary systems, such as power steering pumps, see U.S. patent 5,249,637 to Heidl. These references are discussed in further detail below with reference to improvements provided in these areas by the present application.

Objects of the Invention

It is an object of the invention to provide an improved hybrid electric vehicle realizing substantially increased fuel economy and reduced pollutant emissions as compared to present day internal combustion and hybrid vehicles while suffering no significant penalty in performance, operating convenience, cost, complexity, or weight, which can be operated efficiently by an operator accustomed to conventional vehicles without special training, and which does not require modification of the existing infrastructure developed over the years to support conventional vehicles.

More specifically, it is an object of the invention to provide such an improved vehicle that operates on fuel now widely available and uses batteries already well understood and widely available, so that the operator need not learn new driving techniques, deal with new fuel supply arrangements, nor be obliged to be attentive to maintenance of batteries employing complex new technologies.

It is a more particular object of the present invention to provide an improved series-parallel hybrid electric vehicle wherein an internal combustion engine and two separately-controlled electric motors can separately or simultaneously apply torque to the driving wheels of the vehicle, controlled to realize maximum fuel efficiency at no penalty in convenience, performance, or cost.

It is a further object of the invention to provide a series-parallel hybrid electric vehicle comprising two electric motors together providing output power equal to at least 100 percent of the rated output power of the internal combustion engine, and more preferably up to about 150 - 200 percent thereof, so that the engine operates under substantially optimum conditions in order to realize substantial fuel economy and reduced emission of undesirable pollutants in operation.

More particularly, it is an object of the invention to provide a series-parallel hybrid electric vehicle wherein the internal combustion engine is sized to efficiently provide the average power required for operation at moderate and highway speeds, with two)or more) separately-controlled electric motors together sized to deliver the additional power needed for acceleration and hill climbing.

Still another object of the invention is to provide a series-parallel hybrid electric vehicle wherein the electric motor and battery charging circuits operate at no more than about 30 - 50 amperes continuous current (although significantly greater currents may flow for short periods, under peak load conditions), whereby resistance heating losses are greatly reduced, and whereby inexpensive and simple electrical manufacturing and connection techniques can be employed.

It is a more specific object of the present invention to provide a hybrid drive system for vehicles that does not require the controllable torque-transfer unit shown in the '970 patent, while providing the functional advantages of the hybrid vehicle shown in the '970 patent.

It is a more specific object of the invention to employ the control flexibility provided by the improved hybrid drive train of the invention to allow starting of the engine at comparatively high RPM, while controlling the fuel/air mixture supplied during starting, throttling the engine, and providing a preheated catalytic converter, minimizing emission of unburned fuel and further improving fuel economy.

It is a more specific object of the invention to employ the control flexibility provided by the improved hybrid drive train of the invention to allow employment of a motor producing substantially constant torque up to a base speed, and substantially constant power thereafter, as the engine starting motor, so that torque produced thereby can also be used to propel the vehicle.

In addition to the above objects of the invention, which are similar to those listed in the '817 and '743 applications, the invention of the present continuation-in-part application has as objects the broadening of the useful ranges of loading of vehicles according to the invention, e.g., to provide highly efficient hybrid operation for a vehicle that may weigh 7,000 pounds empty but which can be loaded to weigh 10,000 pounds or more, and may be expected to pull a trailer also weighing 10,000 pounds or more.

A further object of the present invention is to provide further improvements in methods of control of internal combustion engines for hybrid vehicles, to obtain very efficient use of fuel.

Another object of the present invention is to provide an optimal HVAC system for hybrid vehicles.

Still a further object of the invention is to provide a braking system for hybrid vehicles including regenerative braking that provides optimal operator feedback despite changes in operation responsive to the state of charge of the battery bank.

Other aspects and objects of the invention will become clear as the discussion below proceeds.

Summary of the Invention

As discussed above, the '970 patent discloses hybrid vehicles wherein a controllable torque transfer unit is provided capable of transferring torque between an internal combustion engine, an electric motor, and the drive wheels of the vehicle. See Figs. 3 - 11 thereof. The direction of torque transfer is controlled by a microprocessor responsive to the mode of operation of the vehicle, to provide highly efficient operation over a wide variety of operating conditions, and while providing good performance. The flow of energy - either electrical energy stored in a substantial battery bank, or chemical energy stored as combustible fuel - is similarly controlled by the microprocessor.

According to one aspect of the invention of the '817 and '743 applications, which is also employed according to the present continuation-in-part application, the controllable torque-transfer unit shown in the '970 patent is eliminated by replacing the single electric motor shown therein by two separate motors, both operable as generators and as traction motors when appropriate. See Figs. 3 and 4 hereof. As in the '970 patent, an internal combustion engine is provided, sized to provide sufficient torque to be adequate for the range of cruising speeds desired, and is used for battery charging as needed. The internal combustion engine is connected to the drive wheels by a clutch operated by the microprocessor responsive to its selection of the vehicle's mode of operation in response to evaluation of the road load, that is, the vehicle's instantaneous torque demands and input commands provided by the operator of the vehicle. A relatively high-powered "traction" motor is connected directly to the output shaft of the vehicle; the traction motor provides torque to propel the vehicle in low-speed situations, and provides additional torque when required, e.g., for acceleration, passing, or hill-climbing during high-speed driving.

According to the invention of the '817 and '743 applications, a relatively low-powered starting motor is also provided, and can be used to provide torque propelling the vehicle when needed. This second motor is connected directly to the internal combustion engine for starting the engine. Unlike a conventional starter motor, which rotates an internal combustion engine at low speed (e.g., 60 - 200 rpm) for starting, necessitating provision of a rich fuel/air mixture for starting, the starter motor according to the invention spins the engine at relatively high speeds, e.g., 300 - 600 rpm, for starting; this allows starting the engine with a much less fuel-rich fuel/air mixture than is conventional, significantly reducing undesirable emissions and improving fuel economy at start-up. A catalytic converter provided to catalytically combust unburnt fuel in the engine exhaust is preheated to an effective working temperature before starting the engine, further reducing emissions.

In the embodiment discussed in detail, the starting motor is connected directly to the engine, and this combination is connected to the traction motor by a clutch for transfer of torque; the output shaft of the traction motor is then connected to the road wheels of the vehicle. In other embodiments, the engine/starting motor combination may be connected to a first set of road wheels through a clutch, with the traction motor connected to another set of road wheels directly; in a further embodiment, plural traction motors may be provided. In each case, the engine is controllably disconnected from the road wheels by control of the clutch. Engagement of the clutch is controlled by the microprocessor, e.g., controlling an electrical or hydraulic actuator as part of controlling the state of operation of the vehicle in response to the road load.

For example, during low-speed operation, the clutch will be disengaged, so that the engine is disconnected from the wheels; the vehicle is then operated as a "straight" electric car, i.e., power is drawn from the battery bank and supplied to the traction motor. Should the batteries become relatively depleted (e.g., become discharged to 50% of full charge), the starter motor is used to start the internal combustion engine, which then runs at relatively high torque output (e.g., at least about 30% of its maximum torque), for efficient use of fuel, and the starting motor is operated as a high-output generator to recharge the battery bank.

Similarly, when the operator calls for more power than available from the traction motor alone, e.g., in accelerating onto a highway, the starter motor starts the internal combustion engine; when it reaches an engine speed at which it produces useful torque, the clutch is engaged, so that the engine and starter motor can provide additional torque. As noted above, the engine is rotated at relatively high speed for starting, so that the engine rapidly reaches a useful speed.

As in the '970 patent, the engine is sized so that it provides sufficient power to maintain the vehicle in a range of suitable highway cruising speeds, while being operated in a torque range providing good fuel efficiency; if additional power is then needed, e.g., for hill-climbing or passing, the traction and/or starter motors can be engaged as needed. Both motors can be operated as generators, e.g., to transform the vehicle's kinetic energy into electrical power during descent or deceleration. Also as in the '970 patent, the peak power of the two motors together at least equals the rated power of the engine, as is necessary to provide good performance without employment of a variable-speed transmission or the equivalent.

In each of these aspects of the operation of the vehicle, and as in the '970 patent, the operator of the vehicle need not consider the hybrid nature of the vehicle during its operation, but simply provides control inputs by operation of the accelerator and brake pedals. The microprocessor determines the appropriate state of operation of the vehicle based on these and other inputs and controls the various components of the hybrid drive train accordingly.

It is also within the scope of the invention to operate one or both of the motors at differing rotational speeds than the engine, so that each can be optimized for the demands thereon. More specifically, motors can in general be made smaller if they can be operated at relatively high RPM. Motors operating at up to 9000 - 18,000 RPM appear appropriate for the present application. However, operating the internal combustion engine at this speed would likely lead to undesirable levels of noise and vibration, and might constrain its performance characteristics in an undesirable manner. Accordingly, for example, the starter motor might drive the engine through a pinion geared to a larger toothed flywheel, as conventional. Similarly, it might be desirable to provide the traction motor as a relatively high-speed unit, driving the road wheels through a chain, belt, or gear reduction unit. The starter motor may be configured as a "faceplate" or "pancake" motor, essentially forming the flywheel of the engine, and rotating at engine speed, while the traction motor is a much higher speed induction motor connected to the vehicle driveshaft by a chain drive reduction unit. It is also within the scope of the invention, as noted above, to operate the engine and the two motors at the same speed when the clutch is engaged, avoiding intermediate gear trains or like mechanical components and the attendant cost, complexity, weight, audible noise, and frictional losses occasioned by their use.

Other improvements provided according to the invention include providing the batteries in two series-connected battery banks, with the vehicle chassis connected to the batteries at a central point, between the banks. This "center-point-chassis" connection reduces the voltage between various circuit components and the vehicle chassis by half, significantly reducing the electrical insulation required and simplifying such issues as heat-sinking of power semiconductors used in the inverter circuitry. Providing dual battery banks and dual electric motors, as above, also provides a degree of redundancy, permitting certain component failures without loss of vehicle function.

In the preferred embodiment, both the traction and starting motors are AC induction motors of four or more phases and the accompanying power circuitry provides current of more than three, preferably five, phases, allowing the vehicle to function even after failure of one or more components. These motors, and the inverter/chargers driving them, should be chosen and operated such that the motors have torque output characteristics varying as a function of rpm as illustrated in Fig. 14 of the '970 patent; that is, the motors should produce substantially constant torque up to a base speed and should produce substantially constant power at higher speeds. The ratio of the base to maximum speed can vary between about 3 to 1 and about 6 to 1. By comparison, the series-wound DC motors conventionally used as engine starting motors provide very high torque, but only at very low speeds; their torque output drops precipitously at higher speeds. Such conventional starter motors would be unsatisfactory in the present system.

During substantially steady-state operation, e.g., during highway cruising, the control system operates the engine at varying torque output levels, responsive to the operator's commands. The range of permissible engine torque output levels is constrained to the range in which the engine provides good fuel efficiency. Where the vehicle's torque requirements exceed the engine's maximum efficient torque output, e.g., during passing or hill-climbing, one or both of the electric motors are energized to provide additional torque; where the vehicle's torque requirements are less than the minimum torque efficiently provided by the engine, e.g., during coasting, on downhills or during braking, the excess engine torque is used to charge the batteries. Regenerative charging may be performed simultaneously, as torque from the engine and the vehicle's kinetic energy both drive either or both motors in generator mode. The rate of change of torque output by the engine may be controlled in accordance with the batteries' state of charge.

The vehicle is operated in different modes, depending on its instantaneous torque requirements, and the state of charge of the battery, and other operating parameters. The mode of operation is selected by the microprocessor in response to a control strategy discussed in detail below; the values of the sensed parameters in response to which the operating mode is selected may vary depending on recent history, or upon analysis by the microprocessor of trips repeated daily, and may also exhibit hysteresis, so that the operating mode is not repetitively switched simply because one of the sensed parameters fluctuates around a defined setpoint.

None of the implementations of the invention shown in the '970 patent or the '817 and '743 applications include a conventional multi-speed transmission between the motors and engine and the road wheels, and it was stated that a desirable aspect of the invention was to avoid such transmissions, so that the rotational speeds of the two motors and the engine were fixed with respect to one another, and to the speed of the road wheels. However, it now appears that in some circumstances a two-speed transmission may be desired in some cases to broaden the range of utility of the vehicles of the invention (principally to extend their load-carrying capabilities) while still providing highly efficient operation, and to include such a two-speed transmission is accordingly part of the invention of the present continuation-in-part application. Such a two-speed transmission could be operated infrequently as a two-speed "range selector", or could be operated essentially as a conventional automatic transmission, that is, be repetitively shifted during acceleration, upon "kick-down" and the like.

More specifically, it is of great present interest to optimize the hybrid power train of the invention for use with relatively heavy vehicles, such as vans, pickup trucks and "sport-utility vehicles" (SUVs). Such vehicles have become increasingly popular in recent years, despite their generally poor fuel mileage; it would be highly desirable to provide vehicles with generally similar load-carrying abilities and performance with better fuel economy. Still more particularly, heretofore large classes of such vehicles have not been subject to certain emission regulations; however, such regulations are expected to take effect shortly. Accordingly, it would be very desirable to provide such vehicles with hybrid power trains that will allow their owners to enjoy the load-carrying and performance abilities of the existing vehicles with improved fuel economy and reduced emissions.

One of the aspect of SUVs and similar vehicles that must be considered in design of a suitable hybrid powertrain is that their owners use them to carry and tow widely-varying loads. That is, a conventional SUV might weigh 5,500 pounds, and might typically be used during the week to transport a 140 pound person, up to 300 pounds of children, and 50 pounds of groceries. However, on the weekend the family might load the vehicle with half a ton of camping gear and the like and set off for the mountains towing a

7,500 pound trailer. The vehicle must provide adequate acceleration, passing, and hill-climbing performance in both uses. In order to have sufficient power at times of maximum loading, the vehicle is grossly overpowered under all different circumstances; that is, only when the vehicle is laden to near-maximum capacity and pulling up a long hill does the engine deliver near maximum torque for any length of time. Under all other circumstances, it is run very inefficiently, as noted in connection with Figs. 1 and 2 (reproduced herein from the '970 patent).

An important aspect of the invention as described by the present continuation-in-part application as well as the predecessor applications and the '970 patent lies in controlling the operation of the internal combustion engine of a hybrid vehicle so that it is only operated at high efficiency, that is, only when is it loaded to require a substantial fraction e.g., 30% of its maximum torque output. That is, the engine is never run at less than 30% of maximum torque output ("MTO"). As discussed in the '970 patent and the '817 application, this can be accomplished by sizing the engine so that it can efficiently propel the vehicle unassisted at highway speeds; if additional torque is required for passing or hill-climbing, the traction motor is operated. Application Ser. No. 392,743 further adds the idea of providing a turbocharger, controlled by the microprocessor only to operate when torque in excess of the engine's rated normally-aspirated maximum torque output (MTO) is needed for an extended period of time, for example in towing a trailer. By employing the turbocharger only when actually needed, many of the drawbacks inherent in conventional turbocharger uses are eliminated. Typically the turbocharger may be sized such that the engine provides up to 150% of MTO when turbocharged.

According to one aspect of the invention of the present continuation-in-part application, the range of efficient use of the hybrid vehicle of the invention is further broadened by providing a two-speed transmission between the engine and road wheels, so as to allow variation in the overall gear ratio and therefore vary the amount of torque available at the wheels. As noted above, this could be a manually- or automatically-operated "range shifting" gearbox akin to those presently provided on SUVs and the like, to allow shifting into a "low range", for example, when a heavy trailer is be towed, or could be operated similarly to a conventional multispeed transmission, that is, to provide a sequence of effective overall gear ratios each time the vehicle is accelerated.

A further improvement made according to the present continuation-in-part application has to do with the braking system. As noted above, the '970 patent (as well as numerous other prior art references) disclose regenerative braking, that is, employing the microprocessor to control the operation of inverter/chargers connected between the motor and battery bank so that when the operator desires to slow the vehicle, its momentum is used to drive the motor in generator mode, charging the battery. There are certain limitations on this as a method of vehicle braking, which must be addressed by any useful vehicle. In particular, a hydraulic braking system of generally conventional design must be provided for several reasons: first, for safety, in the event that the regenerative system fails for any reason; second, to provide braking in the event the battery bank is fully charged and cannot accept further charge (since overcharging is highly detrimental to battery life); and to provide braking when regenerative braking is not available, e.g., when at a standstill. The present application discloses certain improvements in hydraulic braking systems desired to optimize their design for use with hybrid vehicles, as well as a mechanism providing optimized brake "feel" to the driver, regardless whether conventional, regenerative, or both braking systems are in use.

The present application also discloses certain problems inherent in application of conventional vehicles' heating, ventilation and air conditioning systems to hybrid vehicles, and describes preferred solutions to these problems.

A further improvement according to the present invention includes the provision of an auxiliary 12 volt supply system, allowing the hybrid vehicle of the invention to "jumpstart" another vehicle, or likewise to be jumpstarted as might be necessary after a long hiatus, and to allow use of conventional 12 volt accessories, such as radios and other electronic items.

The present application also discloses further useful modifications and enhancements to the hybrid vehicles of the predecessor applications.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of a specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein like reference numerals in the various figures are utilized to designate like components.

Brief Description of the Drawings

The invention will be better understood if reference is made to the accompanying drawings, in which:

Fig. 1 is a plot of output power versus rotational speed (RPM) for a typical internal combustion engine, illustrating the relative fuel consumption of the engine as used in a conventional automobile in gallons/horsepower-hour;

Fig. 2 is a similar plot describing operation of a relatively small internal combustion engine used in the present invention under circumstances similar to those depicted in Fig. 1;

Fig. 3 shows a schematic diagram of the principal components of a first embodiment of the hybrid vehicle drive system according to the invention;

Fig. 4 shows a block diagram of the principal components of the drive system of the invention in a second embodiment, differing in certain mechanical arrangements from that of Fig. 3, and illustrating various control signals provided in both embodiments;

Fig. 5 shows a partial schematic diagram of the battery bank, inverter, and motor circuitry;

Fig. 6 is a diagram illustrating differing modes of vehicle powertrain operation, plotted on a three dimensional chart, illustrating that the mode of vehicle operation is a function of the state of charge of the battery bank, the instantaneous road load, and time;

Fig. 7, comprising Figs. 7 (a)-(c), and extending over two sheets, is a timing diagram showing road load, engine torque output, the state of charge of the battery bank, and engine operation as functions of time, thus illustrating a typical control strategy employed during low-speed city driving, highway cruising, and extended high-load driving;

Fig. 8, comprising Figs. 8 (a)-(d), are diagrams indicating the flow of torque and of energy among the components of the hybrid powertrain of the invention, in various modes of operation;

Fig. 9 is a simplified flow chart of the algorithm employed by the microprocessor to implement the control strategies provided by the vehicle according to the invention;

Fig. 9(a) is a flow chart of an engine starting subroutine employed in the flowchart of Fig. 9;

Fig. 9(b) is an alternate version of one of the steps of the flowchart of Fig. 9, implementing a modification to the vehicle control strategy;

Fig. 9(c) is an alternate version of another of the steps of the flowchart of Fig. 9, similarly implementing a modification to the vehicle control strategy;

Fig. 10 illustrates the preferred torque versus speed characteristics of the electric starting and traction motors, and of the internal combustion engine;

Fig. 11 is a schematic diagram similar to Fig. 3, illustrating an alternative embodiment of the hybrid vehicle powertrain according to the invention, wherein the engine is provided with a turbocharger which is controllably operable, so as to be employed only when needed;

Fig. 12 is a three-dimensional diagram comparable to Fig. 6, showing the modes of operation of the turbocharged hybrid vehicle of Fig. 11;

Fig. 13 is a timing diagram similar to Fig. 7, again comprising Figs. 13(a) - (c), extending over two sheets, and illustrating typical operation of the turbocharged hybrid vehicle of Fig. 11;

Fig. 14 is a schematic diagram similar to Figs. 3 and 11, illustrating a further alternative embodiment of the hybrid vehicle powertrain according to the invention, wherein a second traction motor is connected to a second set of road wheels, providing a particularly convenient way of providing four-wheel drive;

Fig. 15 is a schematic diagram of the preferred brake system of a hybrid vehicle according to the invention; and

Fig. 16 is a is a schematic diagram of the preferred heating, ventilation and air conditioning system of a hybrid vehicle according to the invention.

Description of the Preferred Embodiments

Referring specifically to Fig. 1, which is reproduced here from the '970 patent for convenience, curve 10 represents the output power versus engine speed (RPM) of a typical spark ignition gasoline-fueled internal combustion engine as used with an automatic transmission in a typical sedan of 3,300 pounds. As can be seen, the maximum engine power available is about 165 horsepower at about 5,000 RPM. Also shown in Fig. 1 by the curve labeled "Large Car Average Power Requirements" are the average power requirements of such a vehicle. Points C, S, and H on this curve show average fuel consumption in city, suburban, and highway driving, respectively; in particular, point C shows that the average power required in typical city driving is less than 5 hp. Point S shows that the average power consumed in suburban driving is 10 hp, and point H shows that the power needed for steady-speed highway driving is only about 30 hp. Thus, the vehicle is vastly overpowered at all times except during acceleration or hill-climbing.

Fig. 1 also includes dashed-line curves indicating the relative fuel consumption of the engine. As can be seen, reasonable fuel efficiency, that is, at least about 105 percent relative fuel consumption (100% being ideal), is reached only when the engine is operated at between about 2,000 and 4,000 RPM, and when producing between about 75 and 150 horsepower. Fig. 1 thus indicates that the typical internal combustion engine is operated with reasonable efficiency only when producing between about 50 and about 90% of its maximum output power. The typical automobile only requires such substantial power under conditions of extreme acceleration or hill climbing.

Accordingly, it will be appreciated that the typical engine is operated efficiently only during relatively brief intervals; more specifically, at lower power outputs, losses due to friction and pumping consume larger fractions of the engine's total torque, so that a lower fraction is available to propel the vehicle. As can be seen, during typical highway driving, shown by point H, the relative fuel consumption is on the order of 190 percent of that required during the most efficient operation of the engine. The situation is even worse in suburban driving, where the relative fuel consumption is nearly 300 percent of the most efficient value, and in city driving, where the relative fuel consumption is almost 350 percent of that required at most efficient operation.

Fig. 1 thus demonstrates that an internal combustion engine having sufficient horsepower for adequate acceleration and hill climbing capability must be so oversized with respect to the loads encountered during most normal driving that the engine is grossly inefficient in its consumption of fuel. As noted, Fig. 1 further shows that only about 30 horsepower is needed to cruise on the highway even in a relatively large car.

Fig. 2 (again reproduced from the '970 patent for convenience) is similar to Fig. 1, and illustrates the operational characteristics of the same 3,300 pound car if driven by a relatively small engine having a maximum horsepower rating of about 45 horsepower at 4,000 RPM. The power requirement of the vehicle during highway cruising, shown by point H on the curve marked "Large Car Average Power Requirements", is in the center of the most efficient region of operation of the engine. However, even with this small engine thus optimized for highway cruising, there is a substantial gap between the "Engine Operating Power" curve and the Average Power Requirement curve 14. That is, even this small engine produces substantially more power at low RPM than needed for city driving (point C) or for suburban driving (point S). Accordingly, even with a small engine sized appropriately for highway cruising, substantial inefficiencies persist at lower speeds. Moreover, of course, such a vehicle would have unsatisfactory acceleration and hill climbing ability. Therefore, the answer is not simply to replace large internal combustion engines with smaller internal combustion engines.

The prior art recognizes that there are substantial advantages to be gained by combining the virtues of a gasoline or other internal combustion engine with those of an electric motor running from a battery charged by the internal combustion engine. However, the prior art has failed to provide a solution which is directly price- and performance-competitive with vehicles now on the market; moreover, in order that such a vehicle can be commercially successful, it must also be no more complex to operate than existing vehicles.

As indicated above, "straight" electric vehicles, that is, vehicles having electric traction motors and batteries requiring recharge at the end of each day's use, do not have sufficient range and require too much time to recharge to fully replace conventional automobiles. Further, the operational costs of such vehicles are not competitive with internal combustion vehicles operated on fuels derived from renewable resources such as ethanol, and are even less competitive with gasoline-fueled automobiles.

A first type of series hybrid vehicles, involving a gasoline engine driving a generator charging a battery powering an electric traction motor, are limited in acceleration and hill climbing ability unless the electric motor is made very large, costly, and bulky. The alternative series hybrid approach, involving a transmission between a relatively smaller electric motor and the wheels to provide the torque needed to accelerate quickly, loses the virtue of simplicity obtained by elimination of a multi-speed transmission. These vehicles fail to realize the advantages provided by the parallel hybrid system in which both an internal combustion engine and an electric motor provide torque to the wheels as appropriate.

However (apart from the '970 patent) the prior art relating to parallel hybrid vehicles fails to disclose a system sufficiently simple for economical manufacture. The art further has failed to teach the optimum method of operation of a parallel hybrid vehicle. Moreover, the art relating to parallel hybrids (again, apart from the '970 patent) does not teach the appropriate operational parameters to be employed, relating to the relative power outputs of the internal combustion engine and the electric motor; the type of electric motor to be employed; the frequency, voltage, and current characteristics of the motor/battery system; the proper control strategy to be employed under various conditions of use; and combinations of these.

As shown in the '970 patent with reference to Figs. 1 and 2 thereof, and again above, typical modern automobiles operate at very low efficiency, due principally to the fact that internal combustion engines are very inefficient except when operating at near peak torque output; this condition is only rarely met. (The same is true, to greater or lesser degree, of other road vehicles powered by internal combustion engines.) According to an important aspect of the invention of the '970 patent, substantially improved efficiency is afforded by operating the internal combustion engine only at relatively high torque output levels, typically at least 35% and preferably at least 50% of peak torque. When the vehicle operating conditions require torque of this approximate magnitude, the engine is used to propel the vehicle; when less torque is required, an electric motor powered by electrical energy stored in a substantial battery bank drives the vehicle; when more power is required than provided by either the engine or the motor, both are operated simultaneously. The same advantages are provided by the system of the present invention, with further improvements and enhancements described in detail below.

According to one aspect of the invention of the '970 patent, the internal combustion engine of a hybrid vehicle is sized to supply adequate power for highway cruising, preferably with some additional power in reserve, so that the internal combustion engine operates only in its most efficient operating range. The electric motor, which is substantially equally efficient at all operating speeds, is used to supply additional power as needed for acceleration and hill climbing, and is used to supply all power at low speeds, where the internal combustion engine is particularly inefficient, e.g., in traffic.

As indicated above, this application discloses certain modifications, improvements, and enhancements of the hybrid vehicles shown in U.S. patent 5,343,970; where not otherwise stated, the design of the vehicle of the present invention is similar to that shown in the '970 patent. Components commonly numbered in this application and the '970 patent are functionally similar, with detail differences as noted. The advantages of the system shown in the '970 patent with respect to the prior art are provided by that of the present invention, with further improvements provided by the latter, as detailed herein.

In the system of the '970 patent, torque from either or both the engine and motor is transferred to the drive wheels of the vehicle by a controllable torque-transfer unit. This unit also allows torque to be transferred between the motor and engine, for starting the engine, and between the wheels and motor, for regenerative battery charging during deceleration of the vehicle. This unit, while entirely practical, comprises gears for power transfer, which are inevitably a source of audible noise and frictional losses. According to one aspect of the present invention, the controllable torque-transfer unit is eliminated. Instead, two electric motors are provided, each separately controlled by a microprocessor controller responsive to operator commands and sensed operating conditions.

In this connection, it will be understood that the terms "microprocessor" and "microprocessor controller" are used interchangeably throughout the present application, and it is to be further understood that these terms as used herein include various types of computerized control devices not always referred to as "microprocessors" per se, such as computers themselves incorporating microprocessors, digital signal processors, fuzzy logic controllers, analog computers, and combinations of these. In short, any controller capable of examining input parameters and signals and controlling the mode of operation of the vehicle according to a stored program, as discussed below in detail, is considered to be a "microprocessor" or "microprocessor controller" as used herein. Furthermore, the electronic fuel injection and electronic engine management devices shown in Figs. 3 and 4 as separate elements might also be integrated within the "microprocessor" or "microprocessor controller" as described herein.

Fig. 3 of the present application shows a first embodiment of the present invention, while Fig. 4, discussed below, shows a second embodiment illustrating certain alternative mechanical arrangements; overall the two embodiments are very similar, and functionally they are substantially identical. Fig. 11, also discussed below, illustrates a further embodiment, and Fig. 14 incorporates still further improvements.

In the Fig. 3 embodiment, a traction motor 25 is connected directly to the vehicle differential 32, and thence to the road wheels 34. A starting motor 21 is connected directly to the internal combustion engine 40. The motors 21 and 25 are functional as motors or generators by appropriate operation of corresponding inverter/charger units 23 and 27, respectively, connected between the motors and battery bank 22. At present, essentially conventional lead-acid batteries are preferred for battery bank 22, since these are widely available and well understood. More advanced batteries may be used if and when they become widely available and economically competitive.

Motors 21 and 25 are controllably connected for torque transfer by a clutch 51, mechanically interlocking the shafts 15 and 16 of motors 21 and 25 respectively. As discussed further below in connection with Fig. 4, microprocessor ("μP") 48 is provided with signals indicative of the rotational speeds of shafts 15 and 16, and controls operation of engine 40, motor 21, and motor 25 as necessary to ensure that the shafts are rotating at substantially the same speed before engaging clutch 51. Accordingly, clutch 51 need not necessarily be an ordinary automotive friction clutch (as illustrated schematically in Fig. 1), as conventionally provided to allow extensive relative slipping before the shafts are fully engaged. More particularly, as slipping of clutch 51 is not required to propel the vehicle initially from rest, as is the case in conventional vehicles, clutch 51 need not allow for extensive slipping when being engaged. In some cases it may be satisfactory to provide clutch 51 as a simple self-aligning mechanical interlock (as shown in Fig. 4), wherein positive mechanical connection is made between the shafts 15 and 16 upon engagement. Such a mechanical interlock is much simpler and less expensive than a friction clutch. In either case, clutch 51 is operated by microprocessor 48, e.g., through a known electric or hydraulic actuator 53, together with the other components of the system, in accordance with the operational state of the vehicle and the operator's input commands.

The respective positions of motor 21 and engine 40 with respect to clutch 51, motor 25, and wheels 34 could be reversed as compared to their positions in Figs. 3 and 4 without affecting the function of the system, although as engine 40 would then require torque transmitting connection at both ends of its crankshaft, some additional complexity would result.

As shown in Fig. 4, shaft encoders 18 and 19 may be mounted on the shafts 15 and 16 of starting motor 21 and traction motor 25, respectively, to provide signals to microprocessor 48 indicative of the relative rotational speeds of the shafts, and their respective rotational positions. Such shaft encoders are well-known and commercially available. Alternatively, signals indicative of the rotational speeds of the shafts may be derived from the inverter control signals, in accordance with well-known principles of control of "sensorless" motor drives (see, for example, Bose, "Power Electronics and Variable Frequency Drives", IEEE, 1996). However, provision of encoders 18 and 19 will allow better low-speed torque characteristics of motor 21 and 25, and thus reduction in cost.

Thus being provided with signals indicative of the rotational speeds of shafts 15 and 16, microprocessor 48 controls operation of engine 40, motor 21, and motor 25 as necessary to ensure that the shafts are rotating at substantially the same speed before engaging clutch 51; therefore, clutch 51 need not be an ordinary automotive friction clutch (as illustrated schematically in Fig. 3), as conventionally provided to allow extensive slipping before the shafts are fully engaged. According to this aspect of the invention, and particularly if microprocessor 48 is made capable of ensuring that shafts 15 and 16 bear a desired relative angular relationship, clutch 51 instead may be a simple, relatively inexpensive self-aligning mechanical interlock (as illustrated schematically in Fig. 4), wherein positive mechanical connection is made between the shafts 15 and 16 upon engagement.

Fig. 4 also shows additional signals provided to microprocessor 48 in both the Fig. 3 and the Fig. 4 embodiments. These include operator input commands, typically acceleration, direction, deceleration, and "cruise mode" commands, as shown. The acceleration and deceleration commands may be provided by position-sensing encoders 71 and 72 (Fig. 3)(which could be configured as rheostats, Hall-effect sensors, or otherwise) connected to microprocessor 48 by lines 67 and 68, to inform the microprocessor of the operator's commands responsive to motion of accelerator and brake pedals 69 and 70 respectively. The microprocessor monitors the rate at which the operator depresses pedals 69 and 70 as well as the degree to which pedals 69 and 70 are depressed. The operator may also provide a "cruise mode" signal, as indicated, when a desired cruising speed has been reached. The microprocessor uses this information, and other signals provided as discussed herein, in accordance with the operational strategy discussed in detail below in connection with Figs. 6 - 9, to properly control operation of the vehicle according to the invention by appropriate control signals provided to its various components.

For example, suppose the vehicle has been operated in city traffic for some time, that is, under battery power only. Typically the operator will only depress the accelerator pedal 69 slightly to drive in traffic. If the operator then depresses accelerator pedal 69 significantly farther than he or she had, for example, the prior few times acceleration was required, this may be taken as an indication that an amount of torque that can efficiently be provided by engine 40 will shortly be required; microprocessor will then initiate the sequence whereby starting motor 21 will be used to start engine 40.

Upon initiation of the engine starting sequence, a heater 63 (Fig. 3) will first be used to preheat a catalytic converter 64 provided in the engine exhaust system 62, so that any fuel that is not combusted during starting and subsequent running of the engine 40 will be catalytically combusted, reducing emission of undesirable pollutants. A temperature sensor 102 is preferably provided, so as to ensure the engine is not started until the catalytic material is heated to effective working temperature. As noted above, engine starting is preferably performed with the engine turning at a higher speed than is conventional, so that a the fuel/air ratio need only be slightly (e.g., 20%) richer than stoichiometric. As a result, only very limited amounts of pollutants are emitted during engine starting. By comparison, in conventional vehicles, a very significant fraction of the total pollutants emitted during any given trip are emitted during the first 30 - 60 seconds of operation, due to the extremely rich mixtures normally supplied during starting, and to the ineffectiveness of the catalyst until it has been heated by the exhaust.

If the operator depresses the pedal 69 rapidly, indicating an immediate need for full acceleration, the preheating step may be omitted; however, a preferable alternative may be to allow the traction and starting motors to be driven at or slightly beyond their rated power, providing adequate torque, for a short time sufficient to allow the catalyst to be warmed and the engine started.

Similarly, if the operator depresses the brake pedal 70 relatively gently, all braking may be provided by regenerative charging of the batteries; if the operator instead presses aggressively on brake pedal 70, and/or presses brake pedal 70 beyond a predetermined point, both mechanical and regenerative braking will be provided. Mechanical braking is also provided on long downhills when the batteries are fully charged, and in case of emergency. Further aspects of the preferred brake system of the hybrid vehicles of the invention are added by the present continuation-in-part application, and are discussed below.

In addition to engine and starting motor speed and traction motor speed, monitored by shaft encoders 18 and 19 as discussed above, battery voltage, battery charge level, and ambient temperature are also either monitored directly or derived from monitored variables. In response to these inputs, and the operator inputs, microprocessor controller 48 operates a control program (see the high-level flowchart of an exemplary control program provided as Fig. 9), and provides output control signals to engine 40, by commands provided to its electronic fuel injection unit (EFI) 56 and electronic engine management system (EEM) 55, and to starting motor 21, clutch 51, traction motor 25, inverter/charger units 23 and 27, and other components.

As indicated in Fig. 4, the control signals provided to inverter/chargers 23 and 27 by microprocessor 48 allow control of the current (represented as *I*), of the direction of rotation of the motor 25 (represented as +/-), allowing reversing of the vehicle, and of the frequency of switching (represented as *f*), as well as control of operation of the motors 21 and 25 in motor or generator mode. Inverter/chargers 23 and 27 are separately controlled to allow independent operation of motors 21 and 25. Inverter/charger operation is discussed further below in connection with Fig. 5.

As noted above, the Figs. 3 and 4 embodiments of the system of the invention differ in certain mechanical arrangements, intended to illustrate variations within the scope of the invention, and Fig. 4 also provides more detail concerning the specific control signals passing between various elements of the system.

Referring to the differing mechanical arrangements, it will be observed that in Fig. 3 the shafts of motors 21 and 25 are illustrated as coaxial with that of engine 40; this is the simplest arrangement, of course, but would require the engine 40 and starter motor 21 to rotate at the same speed at all times, and at the same speed as traction motor 25 when clutch 51 is engaged. As noted above, it may be preferable to design motors 21 and 25 to have maximum speeds of 9000 - 15,000 rpm, so that they could be made smaller, lighter, and less costly than slower-rotating motors. However, it is envisioned that a preferred maximum speed for engine 40 is 6000 rpm, as internal combustion engines running at substantially higher speeds wear rapidly and tend to have limited torque at low speed, and because higher frequency engine noise and vibration can also be difficult to absorb. It is within the scope of the invention to provide the motors coaxial with the engine shaft, as illustrated in Fig. 3, but to provide a planetary gearset(s) between the shafts of either or both of traction motor 25 and starting motor 21 and the output shaft to permit differing engine and motor speeds. Further alternatives to this aspect of the invention are again added by the present continuation-in-part application, and are discussed below.

Fig. 4 illustrates an alternative construction, also permitting differing engine and motor speeds. In this case, the output shaft of starting motor 21 is shown connected to that of engine 40 by spur gears 52, and traction motor 25 is connected to the output shaft 55 by chain drive indicated at 54. Numerous other arrangements will occur to those of skill in the art. However, in each case there is no variable-ratio transmission between the sources of torque -- that is, the motors 21 and 25, and the engine 40 -- and the road wheels 34. Again, further alternatives to this aspect of the invention are added by the present continuation-in-part application, and are discussed below.

It is also within the scope of the invention to connect the traction motor to one set of wheels, and to connect the combination of the engine 40 and starting motor 21 to another set of wheels through clutch 51, thus providing a four-wheel drive vehicle with differing power sources for the alternate pairs of wheels. In this embodiment, the torque from the traction motor 25 is effectively combined with that from engine 40 (and from starting motor 21, when used as a source of propulsive torque) by the road surface, rather than by mechanical connection, as in the Figs. 3 and 4 embodiment. A further alternative would be to provide a complete system as in Fig. 3 driving one pair of road wheels, and a separate traction motor driving a second pair of road wheels.

Both embodiments are within the scope of the invention, and the control strategy is essentially the same as to both. See Fig. 14 and the related text below for further discussion.

Other elements of the system as illustrated in Figs. 3 and 4 are generally as discussed in the '970 patent, including supply of fuel 36 from tank 38, air filter 60, and throttle 61.

Control of engine 40 by microprocessor 48 is accomplished by way of control signals provided to electronic fuel injection (EFI) unit 56 and electronic engine management (EEM) unit 55, responsive to throttle operation; preferably, the throttle in turn is operated electronically responsive to the opertor's depression of the accelerator pedal. Control of starting of engine 40, and using either or both of starting motor 21 and traction motor 25 as motors, providing propulsive torque, or as generators, providing recharging current to battery bank 22, is accomplished by microprocessor 48 by way of control signals provided to inverter/charger units 23 and 27.

Under deceleration, for example, during descents, or as needed for braking, or when the engine's instantaneous torque output exceeds the vehicle's current torque requirements, either or both of motors 21 and 25 are operated as generators, providing regenerative recharging of battery bank 22. Fig. 7, discussed below, illustrates this aspect of the operation of the vehicle of the invention in further detail.

Thus, as indicated above, when microprocessor 48 detects a continued operator requirement for additional power, such as during transition from slow-speed to highway operation, or by measuring the rate at which the operator depresses accelerator pedal 69, engine 40 is started using starter motor 21 and brought up to speed before clutch 51 is engaged, to ensure a smooth transition. As cruising speed is reached (as determined by monitoring the operator's commands), power to traction motor 25 (and to starter motor 21, if also used to accelerate the vehicle) is gradually reduced. Provision of the clutch 51 and separate starter motor 21, as compared to using the single traction motor to start engine 40 while simultaneously accelerating the vehicle, that is, as in the '970 patent, simplifies the control arrangements somewhat.

In one possibly preferred embodiment, both motors 21 and 25 and clutch 51 may be provided in a single sealed housing, possibly bathed in oil for cooling and protection from dust and the like. It is also known to control auxiliary motors, such as conventional starter motors, to absorb or add torque to that provided by an associated internal combustion engine, to damp out vibration caused by fluctuation of the torque provided by the engine; doing so herein using either or both of motors 21 and 25 is within the scope of the invention, and is simplified by virtue of the direct connection of the engine 40 to the drive wheels through motors 21 and 25 according to the invention.

Provision of the clutch 51 and separate starter motor 21 also allows another important improvement to be provided according to the present invention, namely starting engine 40 at high speed, e.g., about 300 -600 rpm, as compared to the 60 - 200 rpm starts conventionally provided. As is generally known in the art (see Simanaitis, "What goes around comes around", *Road & Track*, November 1998, p. 201) high-rpm starting allows substantial elimination of the usual necessity of providing a fuel-rich air/fuel mixture to start engine 40, reducing emission of unburned fuel and improving fuel economy at start-up, particularly from cold.

More particularly, in conventional low-rpm starts, a rich mixture comprising up to on the order of 6 to 7 times the stoichiometric amount of fuel is provided, to ensure that some fraction of the fuel is in the vapor phase, as only fuel in the vapor phase can be ignited by a spark. Most of the excess fuel condenses as liquid on the cold cylinder walls, and thus does not burn efficiently, if at all, and is immediately emitted unburned. By comparison, at high starting speeds according to the invention, turbulence in the combustion chamber is sufficient to ensure the presence of vapor, so that a near-stoichiometric mixture, typically including only 1.2 times the stoichiometric amount of fuel, can be provided to engine 40 during the starting phase. The avoidance of rich mixtures at starting significantly reduces emission of unburned fuel - since most of the fuel provided to a conventional engine at starting is immediately exhausted unburnt - and provides some improvement in overall fuel efficiency.

Furthermore, as noted above, whenever possible - that is, whenever the engine is started except when immediate full torque is required by the operator - a catalytic converter 64 is preheated to an effective working temperature of at least about 350° C before starting the engine, to prevent even this relatively small emission of unburned fuel.

Thus, the primary consideration in selecting the torque of starting motor 21 is that it be capable of rotating the engine 40 at about 300 - 600 rpm for starting, and that it be capable of accepting at least about 30% of the engine's maximum torque output when operated as a generator, so that the engine can be efficiently employed when charging the battery bank during extended low-speed operation; the main consideration in specification of the torque of engine 40 is that it provides sufficient power for highway cruising while being operated at high efficiency, i.e., that its maximum power output be sufficent to cruise in a range of desired cruising speeds; and the principal consideration defining the power required of the traction motor 25 is that it be sufficiently powerful to provide adequate acceleration in combination with the engine 40 and starting motor 21. Stated differently, the total power available provided by all of these torque-producing components should be at least equal to and preferably exceeds the peak power provided by the internal combustion engines of conventional vehicles of similar intended use, both as measured at the wheels. Moreover, as set forth in the '970 patent, the total torque provided by motors 21 and 25 should be at least equal to that produced by engine 40, in order to provide adequate low-speed performance under motor alone, and without necessity of a variable-ratio transmission.

At the same time, motors 21 and 25 are also sized to be capable of recovering almost all of the vehicle's kinetic energy when operated as generators in the regenerative braking mode. A particularly high fraction of the vehicle's kinetic energy can be recovered during low-speed operation; as compared to high-speed operation, where air resistance and road friction consume a relatively large fraction of the total energy required, in low speed operation much energy is lost by conventional vehicles as heat released during braking.

Given the above considerations, the following are typical power specifications for the engine 40, starting motor 21 and traction motor 25 of a 3000 pound vehicle having performance approximately equivalent to that of a "mid-size" sedan of United States manufacture. It should be understood that in these specifications, reference is made to the rated power produced continuously by the engine, not to the rated peak power of the motors, as is generally conventional in the art. Further, the motors are specified assuming the direct-drive embodiment of Fig. 3; if the motors run at higher speeds, their ratings would be determined accordingly.

Engine 40: 40 to 50 horsepower at 6000 rpm

Starting motor 21: 10 - 15 horsepower at approximately 1500 rpm and higher speeds

Traction motor 25: 50 - 75 horsepower from 1500 to 6000 rpm.

The same starting motor would be satisfactory for a larger, 4000 pound sedan, but the engine would typically provide 70 - 90 horsepower at 6000 rpm and the traction motor 75 - 100 horsepower.

In both cases, the total power available from the electric motors together should equal, and preferably exceeds, the maximum power available from the engine.

In the hybrid vehicle of the invention, which as noted does not require a complex, heavy, and costly variable-ratio transmission, these components would provide acceleration much superior to that of typical similarly-sized automobiles of United States manufacture, together with far better fuel economy and substantially reduced emission of pollutants. It will be apparent that these specifications may vary over relatively wide ranges depending on the intended use of the vehicle of the invention, and should not be construed to limit the scope of the invention.

As indicated above, in the preferred embodiment, both the starting and traction motors are AC induction motors, although other types may also be employed. These motors, and the inverter/chargers controlling them in response to control signals from the microprocessor (as discussed further below), should be chosen and operated such that the motors have torque output characteristics varying as a function of rpm as illustrated by curve A in Fig. 10. That is, the motors are operated by the inverter/chargers, in response to control signals from the microprocessor, so as produce constant torque up to a base speed C, typically 1500 rpm for a motor having a top speed of 6000 rpm, as employed in the direct-drive embodiment of Fig. 3, and should produce constant power at higher speeds; accordingly, the torque drops off at speeds above the base speed C, as shown. The ratio of the base to maximum speed, 4 : 1 in this example, can vary between about 3 to 1 and about 6 to 1. This torque output characteristic essentially allows the vehicle of the invention to provide quite acceptable performance, especially acceleration, without the weight, complexity and cost of a variable-ratio transmission.

By comparison, the series-wound DC motors conventionally used as automotive engine starting motors provide very high torque, but only at very low speeds; their torque output drops precipitously at higher speeds. Such conventional starter motors would be unsatisfactory in the present system.

Fig. 10 also shows the torque curve of a typical internal combustion engine at B; as noted, the torque is zero at zero rpm, so that a clutch allowing slippage is required to allow the engine to move the vehicle from rest. Fig. 10 shows at D typical curves for torque as measured at the wheels of a vehicle propelled by a typical internal combustion engine driving the vehicle through a four-speed transmission, used to provide additional torque at low speeds; the vertical spaces between sections of curve D represent changes in gear ratio, that is, the vehicle will be shifted to move between the sections of curve D. As shown by Fig. 10, the desired torque characteristics of the starting and traction motors discussed above allow the vehicle of the invention to provide low-speed performance comparable to or better than a conventional vehicle, while eliminating the necessity of a variable-ratio transmission. However, as discussed further below, it is within the invention of the present continuation-in-part application to extend the load-carrying capabilities of the hybrid vehicle of the invention by also providing a variable-ratio, e.g., two-speed, transmission, where not excluded by the appended claims. This should not be necessary with respect to passenger cars.

The ratio between the base speed and maximum speed of the motors as used according to the invention is thus comparable to the ratio between the lowest and highest gears of a conventional transmission; for passenger cars, the latter ratio is typically between 3 and 4 : 1, so that the engine's torque is relatively well matched to the road load over a reasonable range of road speeds.

As discussed above, while it is within the scope of the invention to operate the motors 21 and 25 and the internal combustion engine 40 at the same maximum speed, so that no gearing is required to couple these elements, it is presently preferred that at least traction motor 25 have a maximum speed substantially higher than that of the internal combustion engine 40; the output shaft of motor 25 can be connected to the road wheels by a chain-drive reduction unit, as indicated in Fig. 4. The maximum speed of the internal combustion engine is preferably limited to on the order of 6000 rpm to limit wear, noise and vibration, which increase with higher operating speeds, and because engines capable of higher-rpm operation tend to have narrow ranges of rpm within which they produce substantial torque; the latter characteristic would be undesirable in a vehicle not having a variable-ratio transmission and intended to cruise powered solely by the internal combustion engine, according to the invention.

By comparison, operating the motors 21 and 25 at maximum speeds of 9000 - 18,000 rpm allows them to be made smaller, lighter, and less costly; whether this advantage overcomes the added complexity of chain, gear, or belt drives, or other mechanical means allowing combination of torque from the motors with that from the engine, is a matter of engineering choice that may vary from one model of vehicle to the next. Both are accordingly within the present invention. If each of the torque-producing components (that is, engine 40 and starting and traction motors 21 and 25) is to be operated at the same speed, a maximum speed of approximately 6000 rpm is preferred, as this represents a good compromise between cost, weight, and size of the key components.

As discussed above, it is preferred that motors 21 and 25 have more than two poles, and be operated by current applied over more than three phases, so that failure of some components - such as the power semiconductors used in the inverter/charger units, as discussed below - can be tolerated without total failure of the vehicle. It is also desired that the battery bank be divided into two, with the vehicle chassis connected between them, halving the voltage between given components and the vehicle chassis, and thus simplifying their construction, insulation, and connection. Fig. 5 shows a partial schematic diagram of a circuit providing these attributes.

The functions of the inverter/chargers 23 and 27 (separate inverter/chargers being required to allow independent operation of motors 21 and 25) include control of motors 21 and 25 to operate as motors or as generators; operation of traction motor 25 in the opposite direction for reversing the vehicle; conversion of DC stored by the battery bank to AC for motor operation; and conversion of AC induced in the motors when operated as generators to DC for battery charging. Essentially similar functions were provided by the solid-state switching AC/DC converter 44 in the '970 patent; where not specified to the contrary, the discussion thereof is applicable to the inverter design shown in Fig. 5 hereof.

As illustrated in Fig. 5, traction motor 25 is embodied as a five-phase AC induction motor; starting motor 21, which is not fully illustrated, as indicated, can be but is not necessarily generally similar. Other motor types, such as permanent magnet brushless DC motors or synchronous motors, might also be employed. The motors are operated as multiphase devices, having three phases or more, permitting employment of smaller and overall less costly semiconductors, and allowing operation even if some of the semiconductors fail. Use of motors operated at relatively high frequency, e.g., more than 60 Hz, also permits motors of a given power output to be smaller. As shown in Fig. 5, it is currently preferred that at least traction motor 25 be wired in the "wye" arrangement shown, rather than the known "delta" arrangement; it is found that certain undesirable harmonics are reduced by the "wye" arrangement. Both are well known in the art, and within the scope of the invention.

As illustrated in Fig. 5, each of the windings 78 of motor 25 is connected to a pair of semiconductor switching elements 80 collectively making up inverter/charger 27. Inverter/charger 27 is correspondingly configured as a set of ten power semiconductors 80 controlled by switching signals A through J provided by a pulse generator 88 responsive to frequency, polarity and current signals received from microprocessor 48 (Figs. 3 and 4). Typical operating frequencies can be up to 200, 400 or 600 Hz; the transfer of power between the battery bank 22 and motors 21 and 25 is then controlled by pulse-width modulation, that is, by controlling the semiconductors 80 to conduct during portions of the power waveform, the duration of the conducting portions varying in accordance with the power required. Semiconductors 80 may be any type suitable for handling relatively high voltages and currents; satisfactory insulated-gate bipolar transistors (IGBTs) are currently available and are presently preferred. As conventional, each of the semiconductors 80 is paralleled by a freewheeling rectifier diode 82.

Design of the inverter/chargers 23 and 27 and of pulse generator 88 to provide suitable control signals A through T so that the inverter/chargers perform the functions listed above is within the skill of the art; again, see, for example, Bose, "Power Electronics and Variable Frequency Drives", IEEE, 1996.

The current drawn from the battery bank 22 during long-term operation of the traction and starting motor(s) to propel the vehicle should be limited to 30 - 50 amperes, to reduce the size of the conductors and other components required, as discussed in the '970 patent; these components are satisfactory to carry currents of up to 200 amperes, as may be encountered during full-power acceleration, as this condition will not persist for more than about 30 seconds.

As indicated, the battery bank 22 comprises two substantially similar battery assemblies 84; in one embodiment, each battery assembly will comprise eight 48-volt batteries, such that 384 volts is provided by each. The battery assemblies 84 are connected in series, so that 768 volts are provided across the circuit "rails" 86, 88. However, the vehicle chassis connection is taken from between the series-connected battery assemblies, so that only 384 volts is present between any given circuit component and the vehicle chassis; this "center-point-chassis" connection significantly reduces various insulation and heat-sinking requirements. More specifically, the conductors, connectors, relays, switches and like elements can be as approved by the National Electrical Manufacturers' Association (NEMA) for 600 volt service; such elements are widely available, and are much more easily employed and much less expensive than those needed for continuously carrying current at, for example, 300 volts and 300 amperes.

Preferably, as indicated by Fig. 5(a), illustrating a detail of a portion of one of the battery assemblies 84, the 48-volt batteries 85 are connected by normally-open relays 87, so that the batteries 85 are isolated from one another under fail-safe conditions; for example, if the vehicle is involved in an accident, power to the relays is cut off, so that the maximum open voltage anywhere in the vehicle is 48 volts, reducing the danger of fire. Similarly, the relays open when the vehicle's "ignition" is shut off by the operator.

The present continuation-in-part application adds to the above from the '817 application that an auxiliary 12-volt system may also be provided, as shown at 223 in Fig. 14, discussed further below. This would be a DC-to-DC converter, allowing the vehicle to provide "jumping" current to start other vehicles having conventional 12-volt electrical systems, and would also allow the vehicle of the invention to be jumpstarted similarly, if necessary. Provision of a 12-volt system also allows convenient employment of conventional automotive accessories, such as radios and the like. The 12-volt system could perhaps most conveniently be implemented by a separate semiconductor-implemented voltage conversion circuit, transforming the 48 volts from one of the batteries to 12 volts for jumping others, and providing the inverse 12 to 48 volt transformation as needed. It should also be understood that the individual batteries could be 42 volt units, conforming to the apparent trend toward 42 volt systems for new vehicles. Further preferably, the entire battery bank assembly, including the relays, is enclosed in a rugged container, significantly reducing the danger of electrical shock and the like.

Turning now to detailed discussion of the inventive control strategy according to which the hybrid vehicles of the invention are operated: as in the case of the hybrid vehicle system shown in the '970 patent, and as discussed in further detail below, the vehicle of the invention is operated in different modes depending on the torque required, the state of charge of the batteries, and other variables. Throughout, the object is to operate the internal combustion engine only under circumstances providing a significant load, thus ensuring efficient operation. In the following, the relationships between these modes are illustrated using several different techniques, to ensure the reader's full understanding of various aspects of the vehicle control strategy; some of these are seen more clearly in one form of illustration than another.

Fig. 6 illustrates the several modes of vehicle operation with respect to the relationship between the vehicle's instantaneous torque requirements or "road load", the state of charge of the battery bank 22, and time, while Fig. 7 shows variation in, and the relationship between, road load, engine torque output, and the state of charge of the battery bank over time, that is, during an exemplary trip. Figs. 8(a) - (d) show simplified schematic diagrams of the vehicle of the invention in its principal modes of operation, showing the flow of energy, in the form of electricity or combustible fuel, by dot-dash lines, and the flow of torque by dashed lines. Finally, Fig. 9 provides a high-level flowchart, showing the principal decision points in the algorithm according to which the microprocessor operates the various components of the hybrid vehicle drivetrain according to the invention, and Figs. 9 (a)-(c) show details and modifications thereof.

As noted, the preferred control strategy of the invention is illustrated in several different ways by Figs. 6 - 9. The same specific numerical examples for various significant control variables, data items, and the like are used throughout for clarity. It will be understood that these examples would normally be expressed as ranges; although ranges are not used in the following, to simplify the discussion, it should be understood throughout that these numerical examples are exemplary only, and that the invention is not to be limited to the exact values of the control variables mentioned herein.

Further, it should be realized that certain of these control variables need not be restricted to specific numbers; in some cases, the decision points may be "fuzzy", i.e., so-called "fuzzy logic" may be employed, so that while the operating scheme retains its overall characteristics, the specific values against which the control variables and data items are tested in implementation of the control strategy according to the invention may vary from time to time. Examples of this practice -- amounting in many circumstances to modifying certain specific values depending on other data items not discussed in detail, or by monitoring the vehicle's actual usage patterns over time -- are given below.

Given these several different explanations of the relationship between the various operating modes of the vehicle of the invention, and specifically these different illustrations of the combinations of conditions in response to which the microprocessor controls mode selection, one of ordinary skill in the art would have no difficulty in implementing the invention.

As noted, during low-speed operation, such as in city traffic, the vehicle is operated as a simple electric car, where all torque is provided to road wheels 34 by traction motor 25 operating on electrical energy supplied from battery bank 22. This is referred to as "mode I" operation (see Fig. 6), and is illustrated in Fig. 8(a). The same paths of energy and torque may also be employed under emergency circumstances, referred to as mode III operation, as discussed below.

While operating at low speeds, e.g., when the vehicle's torque requirements ("road load", or "RL") are less than 30% of the engine's maximum torque output ("MTO"), engine 40 is run only as needed to charge battery bank 22. Starting motor 21 is first used to start engine 40, and is then operated as a generator by appropriate operation of inverter/charger 23, so that charging current flows to battery bank 22. Accordingly, clutch 51 is disengaged, so that the road speed of the vehicle is independent of the speed of engine 40; engine 40 can thus be operated at relatively high output torque level, for fuel efficiency. This "mode II" operation is illustrated in Fig. 8(b); as indicated, clutch 51 is disengaged, so that engine operation to charge battery bank 22 through starting motor 21, and propulsion of the vehicle by traction motor 25, are completely independent of one another.

As in the '970 patent, engine 40 is sized so that its maximum torque is sufficient to drive the vehicle in a range of desired cruising speeds; this requirement ensures that the engine is operated at high efficiency during normal highway cruising. Therefore, when a sensed increase in the road load (e.g., by a continued operator request for more power) indicates that the preferred operating mode is changing from low-speed to highway cruising operation, the microprocessor controls starting motor 21 by way of inverter/charger 23 to start engine 40. When engine 40 is essentially up to speed, clutch 51 is engaged, so that engine 40 drives road wheels 34 through the shafts of motors 21 and 25. When the operator releases pressure on the accelerator pedal, indicating that a desired cruising speed has been reached, traction motor 25 is accordingly depowered. The highway cruising mode is referred to as "mode IV" operation, and the flow of energy and torque are as illustrated in Fig. 8(c).

If extra torque is needed during highway cruising, e.g., for acceleration or hill-climbing, either or both of motors 21 and 25 can be powered. This "mode V" operation is illustrated in Fig. 8(d); energy flows from tank 38 to engine 40, and from battery bank 22 to traction motor 25, and possibly also to starting motor 21; torque flows from either or both motors and engine to wheels 34.

The flow of energy during battery charging is not illustrated *per se* in Fig. 8, but will be understood by those of skill in the art, and is further described below. For example, when the engine's instantaneous output torque exceeds the road load, the starter motor 21 is operated as a charger, supplying recharging current to the battery bank. Similarly, when the road load is trending downwardly or is negative, either the traction motor or the starter motor, or both, can be operated as a regenerative battery charger, supplying recharging current to the battery bank; braking can be accomplished similarly in response to an appropriate operator command.

Fig. 6, as indicated above, is a diagram illustrating differing modes of operation of the hybrid vehicle powertrain of the invention; the modes of operation, indicated by numerals I - V, are plotted on a three dimensional chart, illustrating that the mode of vehicle operation as controlled by microprocessor 48 is a function of the state of charge of the battery bank, the instantaneous road load, and time. Fig. 7, discussed below, further illustrates the inventive mode of vehicle operation.

Fig. 6 shows on one axis the state of battery charge extending from 70% at the origin outwardly to a minimum value shown of 30%. Normally the batteries are maintained at least 30% of full charge. Preferably, the battery bank is not charged to more than 70% of its theoretical full capacity; if a number of series-connected batteries were all charged to 100% of their nominal full charge, some would likely be overcharged due to manufacturing variation, local temperature variation and the like, which would significantly shorten their service life. Moreover, frequently recharging any individual battery to 100% of its theoretical capacity is deleterious to battery life as well.

The road load is shown in Fig. 6 on a second axis as varying from 0 at the origin to 200% of the engine's maximum torque output. (Negative road load, occurring during descents or under braking, is not shown in Fig. 6 due to the difficulty of illustration. This circumstance is discussed in connection with Fig. 7, below.) Time is shown on the third axis extending from an arbitrary point at the origin; that is, Fig. 6 shows the mode of the vehicle's operation over the next short period of time (on the order of 30 - 60 seconds) from a present instant at the origin. Stated differently, according to one aspect of the invention, the microprocessor 48 controls the vehicle's mode of operation at any given time in dependence on "recent history," as well as on the instantaneous road load and battery charge state.

More specifically, Fig. 6 shows that during city driving (mode I), defined in this example as driving where the vehicle's instantaneous torque requirements, or "road load", is up to 30% of the engine's maximum torque, the vehicle is operated as a "straight electric" car, the clutch being disengaged and energy from the battery bank 22 being used to power traction motor 25 to propel the vehicle, as long as the battery remains charged to between 50 and 70% of its full charge. If the charge falls to below a given value, which may vary over time as indicated by the curved line defining the extent of mode II, mode II is entered as indicated, the engine is started, and the starter motor 21 is operated as a generator to charge the battery to substantially full charge. As indicated in mode III, operation of the vehicle as an electric car may also be permitted when the battery falls to below 40% of full charge, for example, if there is a fault in the engine or charging system, but only on an emergency basis; such deep discharge is harmful to battery life.

During highway cruising, region IV, where the road load is between about 30% and 100% of the engine's maximum torque output, the engine alone is used to propel the vehicle. Accordingly, when the microprocessor detects that transition between regions I and IV is required (e.g., the microprocessor can effectively determine the road load by monitoring the response of the vehicle to the operator's command for more power), it causes the starting motor 21 to spin the engine 40 to relatively high speed; when a desired starting speed, typically 300 rpm, is reached, the electronic engine management unit 55 and electronic fuel injection unit 56 are controlled to fire the spark plugs and supply fuel, respectively, starting the engine. Thus starting the engine at relatively high rpm allows a near-stoichiometric fuel/air mixture to be used, as compared to the much richer mixtures normally used for starting.

Emissions of unburned hydrocarbons are thus substantially reduced, and fuel economy improved.

When the speed of the engine output shaft substantially matches that of traction motor 25, clutch 51 is engaged; the power produced by motor 25 is reduced as that produced by engine 40 is increased, so that the transition between modes I and IV is smooth and essentially undetected by the operator. When the operator reduces pressure on the accelerator pedal 69, indicating that the desired cruising speed has been reached, power to motor 25 is reduced to zero.

If the operator then calls for additional power, e.g. for acceleration or passing, region V is entered; that is, when the microprocessor detects that the road load exceeds 100% of the engine's maximum torque output, it controls inverter/charger 27 so that energy flows from battery bank 22 to traction motor 25, providing torque propelling the vehicle in addition to that provided by engine 40. Starting motor 21 can similarly be controlled to provide propulsive torque.

As indicated above, during highway cruising, where the torque required to propel the vehicle varies as indicated by the operator's commands, the control system operates the engine at correspondingly varying torque output levels. The range of permissible engine torque output levels is constrained to the range in which the engine provides good fuel efficiency. Where the vehicle's instantaneous torque requirement exceeds the engine's maximum efficient torque output, e.g., during passing or hill-climbing, one or both of the electric motors are energized to provide additional torque; where the vehicle's torque requirements are less than the torque then being produced by the engine, e.g., during coasting, on downhills or during braking, the excess engine torque is used to charge the batteries. Regenerative charging may occur simultaneously, as torque from the engine and recovery of the vehicle's kinetic energy both drive one or both motors operated in generator mode. The rate of change of torque output by the engine may be controlled to reduce emissions, and in accordance with the state of charge of the battery bank. Fig. 7 illustrates these relationships.

As mentioned above, Fig. 7, comprising Figs. 7(a) - (c), and extending over two sheets, is a timing diagram showing the relationship between road load, engine torque output, the state of charge of the battery bank, and operation of the engine as these vary over time, during low-speed city driving, highway cruising, and extended high-load driving, thus further illustrating the control strategy employed according to the invention.

Fig. 7(a) shows the vehicle's instantaneous torque requirement, that is, the "road load", by a solid line, and the engine's instantaneous output torque by a dashed line, as these vary over time. (The engine's instantaneous output torque is repeated in Fig. 7(c), for clarity, and in order to clearly show certain additional aspects of the inventive control strategy.) The road load is expressed as a function of the engine's maximum torque output. Where the road load exceeds the engine's instantaneous output torque, the cross-hatched areas between these two lines represent torque provided by the traction and or starting motor(s); where the road load is less than the engine's instantaneous output torque, the cross-hatched areas represent charging of the batteries.

It will be appreciated that positive vehicle torque demands correspond to steady-state cruising, acceleration, hill-climbing, or the like, while negative vehicle torque requirements correspond to deceleration or descent. The engine's output torque is constrained to the range of efficient operation; as illustrated in Fig. 7 (a) and (c), this range is controlled to be between 30% and 100% of the engine's maximum torque output ("MTO"). As mentioned above, it will be appreciated that the 30% figure, as well as similar figures mentioned herein, may vary without departure from the scope of the invention.

In the example of vehicle operation shown in Fig. 7, initially the vehicle is operated only at road loads below 30% of MTO, that is, in traffic, as indicated at A. Accordingly, all the torque required is provided by the traction motor 25, and the state of charge of the battery bank 22 ("BSC"), as illustrated by Fig. 7(b), corresponds directly to the road load; when the road load is negative, BSC increases as the battery bank is charged by regenerative braking. (Changes in BSC are significantly exaggerated in order to clearly explain the events shown.)

At point B, the road load exceeds 30% of MTO for the first time on this particular trip. When this is detected by microprocessor 48, starting motor 21 spins the engine 40 at relatively high speed, and the catalytic converter 64 is preheated, causing a short drain on BSC, as shown at C. When the engine reaches the desired starting speed, e.g. 300 RPM, and the catalyst reaches a minimum effective operating temperature, e.g. at least about 350° C, the engine is started by supply of fuel and firing of its spark plugs, and the clutch is then engaged. As the engine is already rotating at relatively high speed, and will have been warmed by compression of air in its cylinders during the starting process, it begins to produce useful torque almost immediately, as indicated at D.

Thereafter, when the vehicle's torque requirement exceeds the instantaneous engine output torque, as at points E - G and P, one or both of the traction and starting motors 25 and 21 are powered to provide additional torque to the road wheels, that is, the vehicle is operated in mode V. While the road load RL remains within the engine's efficient operating range, e.g., while 30% MTO > RL > 100% of MTO, the vehicle is operated in mode IV. During mode IV operation, if the engine's instantaneous torque output exceeds the vehicle's torque requirement, but the battery is relatively fully charged, as at point H, the engine's torque output is reduced to match the road load; when MTO exceeds the road load, and BSC falls below a predetermined level (see Fig. 7(b)), as at I and J, the excess torque available from engine 40 is used to charge the batteries, as indicated at K and L (Fig. 7(c)). When the vehicle's torque requirement is less than the minimum permissible engine torque output, as at M, the engine is again used to charge the batteries, and regenerative braking is also performed, further charging the batteries. If the batteries become substantially fully charged, e.g., during a long descent, as at N, the engine may be shut off entirely, as seen at Q in Fig. 7(c).

More particularly, during deceleration or "coast-down", the engine may be "motored", that is, driven by torque from the wheels, with the clutch engaged, but with at least the fuel supply shut off. In addition to using no fuel, this has the advantage that when the operator next requires torque, e.g., when reaching the point at the bottom of a hill, the engine is rotating and can be immediately restarted by supply of fuel. The exhaust valves might be opened during the motoring of the engine to reduce pumping losses.

The rate of change of the engine's torque output is limited, e.g., to 2% or less per revolution, as indicated by noting that the dashed line in Fig. 7(a), indicating the instantaneous engine output torque, lags the solid line indicating the vehicle's instantaneous torque requirement. Thus limiting the rate of change of engine output torque is preferred to limit undesirable emissions and improve fuel economy; that is, as the stoichiometric fuel/air ratio varies somewhat as the load changes, simply opening the throttle and causing additional fuel to be injected (as is typically practiced) upon the operator's depressing the accelerator pedal would result in non-stoichiometric, inefficient combustion. According to this aspect of the invention, the rate of change of engine torque is limited; this provides sufficient time for the essentially conventional electronic engine management and electronic fuel injection systems, which comprise a "lambda sensor" 47 (Fig. 3) for monitoring the oxygen content of the exhaust gas stream as an indication of stoichiometric combustion, to respond as the load changes, preserving stoichiometric combustion and reducing emission of unburned fuel.

The maximum permissible rate of change of engine output torque also may be varied in accordance with the state of charge of the batteries; more specifically, if the batteries are relatively discharged, it may be preferable to allow the engine's output torque to ramp-up more quickly than otherwise, in order to limit the amount of electrical power drawn from the batteries in response to an acceleration command. More generally, it is preferred to operate the engine so as to limit the amount of power drawn from the batteries, as there are unavoidable losses attendant on conversion of energy stored in the batteries to motor output torque, and during the corresponding recharging period.

As mentioned above, Fig. 9 is a high-level flowchart of the principal decision points in the control program used to control the mode of vehicle operation. Broadly speaking, the microprocessor tests sensed and calculated values for system variables, such as the vehicle's instantaneous torque requirement, i.e., the "road load" RL, the engine's instantaneous torque output ITO, both being expressed as a percentage of the engine's maximum torque output MTO, and the state of charge of the battery bank BSC, expressed as a percentage of its full charge, against setpoints, and uses the results of the comparisons to control the mode of vehicle operation.

As noted above, certain control decisions involved in the inventive control strategy illustrated in Fig. 9, and described therein as being determined in response to precise criteria (in order to clearly present the main features of the inventive operating strategy), may instead be usefully somewhat "fuzzy"; in the present application, this term is intended to indicate that the value of a setpoint (for example) may vary somewhat in response to recent history, or in response to monitored variables not discussed above. As mentioned above, it is also to be understood that the values given above for various numerical quantities may vary somewhat without departing from the invention. Specific alternatives are provided below for steps set forth in Fig. 9 that implement certain of these alternatives.

For example, in the example of the inventive control strategy discussed above, it is repeatedly stated that the transition from low-speed operation to highway cruising occurs when road load is equal to 30% of MTO. This setpoint, referred to in the appended claims as "SP", and sometimes hereinafter as the transition point (i.e., between operation in modes I and IV) is obviously arbitrary and can vary substantially, e.g., between 30 - 50% of MTO, within the scope of the invention.

It is also within the scope of the invention for the microprocessor to monitor the vehicle's operation over a period of days or weeks and reset this important setpoint in response to a repetitive driving pattern. For example, suppose the operator drives the same route from a congested suburban development to a workplace about the same time every morning; typically the road load might remain under 20% of MTO for the first few minutes of each day, then vary between 0 and 50% of MTO for another few minutes as the operator passes through a few traffic lights, and then suddenly increase to 150% of MTO as the operator accelerates onto a highway. It is within the skill of the art to program a microprocessor to record and analyze such daily patterns, and to adapt the control strategy accordingly. For example, in response to recognition of a regular pattern as above, the transition point might be adjusted to 60% of MTO; this would prevent repetitive engine starts as the road load exceeded 30% of MTO for a few hundred yards at a time, as might often occur in suburban traffic. Similarly, the engine starting routine might be initiated after the same total distance had been covered each day.

It is also within the scope of the invention to make the setpoint SP to which the road load is compared to control the transition from mode I to mode IV somewhat "fuzzy", so that SP may vary from one comparison of road load to MTO to the next depending on other variables. For example, as discussed above, if during low-speed operation the operator depresses the accelerator pedal rapidly, this can be treated as an indication that full power will shortly be required, and the engine-starting operation begun before the road load reaches any particular setpoint SP.

The value of the transition point may also vary in dependence on the mode of operation in effect when the road load equals a given setpoint SP. For example, suppose the setpoint at which the mode of operation is controlled to change from the low-speed mode to the highway cruising mode is normally set to 30% of MTO, as in the examples discussed above. If traffic conditions were such that the road load fluctuated around this value, and engine operation were controlled solely in response to road load, the engine would be repeatedly started and shut off as the road load exceeded 30% of MTO for a few hundred yards at a time, and then fell back below 30% of MTO, as might often occur in suburban traffic. Repeated restarts might also occur if the road load averaged over 30% of MTO but occasionally dropped below this value, as might occur in moderate-speed, flat-road cruising.

By monitoring the road load over time, and comparing it to different setpoints accordingly, much of this undesirable repetitive sequence of engine starting and shut-off can be eliminated. It might be preferable to commence mode IV operation upon the occurrence of differing conditions; for example, mode IV might be entered from mode I only after the road load exceeded a first, lower setpoint SP for an extended period of time, so that the engine would be run for extended low-speed cruising, but to start the engine immediately if the road load exceeded a higher setpoint SP2, e.g. 50% of MTO, as during acceleration to highway speed. Similarly, the engine might preferably be shut down only if the road load was less than a minimum setpoint for mode IV operation for an extended period of time. Thus providing "hysteresis" in the mode-switching determination would limit repetitive engine starts in certain types of driving. These limits could be further adjusted as the driving pattern became clear, i.e., as discerned by the microprocessor.

In a further refinement, the setpoint at which the engine is shut off as the road load droppped below the usual minimum value for mode IV operation could vary dependent on BSC; if the batteries were substantially fully charged, the engine might be shut off as road load dropped below 30% of MTO, but if their charge was lower the engine might be controlled to continue to run, even at a stop, i.e., zero road load, to charge the batteries. Of course, the clutch would still have to be disengaged at when the road load fell below 20 - 30% of MTO, in order that the engine could run at an efficient speed for production of torque.

Fig. 9 thus shows the main decision points of the control program run by the microprocessor, with the transition point between mode I, low-speed operation, and mode IV highway cruising, set at a road load equal to 30% of MTO. Examples are then given for some of the various options discussed above, by substituting various of the decision points with alternatives indicated below. Other optional points not specifically shown but discussed herein are within the scope of the invention.

The control program is entered at step 100, where the microprocessor determines whether the road load RL is less than 30% of MTO. If the answer is yes ("Y"), the clutch is disengaged if necessary as indicated at steps 103 and 105. The state of charge of the battery bank BSC is then tested at step 110; if BSC is between 50 and 70% of full charge, the vehicle can operate for some time as a straight electric vehicle, and mode I is accordingly entered, as indicated at 115. A "mode I" loop is then established, including steps 100, 103, and 110; as long as all conditions tested in these steps remain stable, the vehicle continues to be operated in mode I.

However, if at step 110 it was determined that BSC was less than 50% of its maximum value ("N"), the engine should be run, if possible, to charge the battery bank, up to, for example, 75% of its maximum charge, as tested at step 120. If the engine is already running, as tested at step 125, the battery is charged as indicated at 130, and a stable "mode II" loop, as noted at 135, is established including steps 100, 103, 110, 120, 125, and 130. (Normal operation of step 110 would be bypassed or disabled in this mode to prevent battery charging from being stopped when BSC reaches 70%). If the engine is not running, an engine starting subroutine (shown separately, by Fig. 9(a), is entered, as indicated at step 140.

In the engine starting subroutine, beginning with the 'enter' block 141, the clutch is disengaged if necessary at steps 142 - 143, and the catalyst temperature is tested at 145, to determine whether it is at least about 350° C; the catalyst is heated as necessary, as indicated at 150. When the catalyst is heated suitably, the engine is then spun by the starter motor until a desired starting speed is reached, as indicated by the loop including blocks 155 and 160. When the engine reaches its desired starting speed, it is started at step 165, by supply of fuel and firing of its spark plugs, concluding the engine starting subroutine as indicated by 'return' block 170. If the engine starting subroutine was entered from the mode II loop, as above, the battery bank may then be charged as indicated at 130.

If in performance of step 120 it appeared that BSC was less than 40%, which would only occur upon failure of the engine or charging system, step 175 may be performed; thus, if 30% < BSC < 40%, the vehicle may be operated in mode III as an electric car, to provide emergency operation. However, this should be strictly limited to avoid deep discharge of the battery bank, tending to shorten its useful life. As indicated at 177, the vehicle is completely disabled if BSC falls below 30%.

If RL is determined to exceed 30% of MTO in step 100, the program goes to step 180, where the term 30% > RL > 100% is evaluated; that is, the microprocessor determines whether the road load is appropriate for highway cruising in mode IV. If so, and if the engine is running, as tested at step 190, a stable loop including steps 180 and 190 is established; the system remains in mode IV, as indicated at 185, until the state of one of these tests changes.

If in step 190 it is determined that the engine is not running, the engine start subroutine, starting with step 140 as discussed above, is entered as indicated at 195; upon return, at 200, the clutch is engaged at 210, and the loop including steps 180 and 190 is entered.

As noted, in step 180 it is determined whether RL is between 30 and 100% of MTO; if not, it is determined in step 220 whether RL is greater than 100% of MTO. If so, mode V is entered, and the traction motor (and optionally the starting motor) is powered to provide additional torque propelling the vehicle, as indicated at 230. A loop including steps 220 and 230 is thus established, so that mode V remains stable until the state of the test performed in step 220 changes.

When in performance of step 220, it appears that RL is now less than 100% of MTO, it is then determined in step 215 whether RL is less than 30% of MTO. If so, the engine is shut off, as indicated at 240, and the program returns to step 100; if not, the program is returned to step 180.

It will be appreciated that according to the Fig. 9 flowchart, it is possible for the system to proceed directly from mode I to mode V, that is, from step 100 to step 220, if the road load rapidly increases from less than 30% of MTO to more than 100% of MTO. Permitting the operator to thus operate the system is an important safety feature, for example when fast acceleration from a stop is required to merge into highway traffic. In these circumstances the engine would not be running during initial operation in mode V, necessitating a significant drain on the battery bank and overdriving the traction motor. Accordingly, steps equivalent to steps 190, 195, and 210 (including the engine starting subroutine) are to be understood to follow step 220 and precede step 230. That is, in the event mode IV was effectively omitted in passing directly from mode I to mode V, the engine is started and the clutch engaged as soon as possible; these duplicate steps are not shown, for clarity.

In the above discussion of Fig. 9, it was assumed that the transition point between low-speed and highway operation is set so that the transition occurs when the road load is equal to 30% of MTO under all circumstances. However, as discussed above, it may be desirable to operate the system so that the vehicle goes from the low-speed mode I to the highway-cruising mode IV at a higher road load, e.g., 50% of MTO, than the road load at which the low-speed mode is reentered, e.g., when road load in mode IV falls to below 20%. This "hysteresis" of the mode switching point -- for example, allowing the vehicle to accelerate in mode I up to road loads of up to 50% of MTO, but not shutting the engine off, ending mode IV operation, until road load falls below 20% of MTO -- avoids excessive mode-switching during periods of fluctuating road load.

For example, in typical suburban traffic, one might commonly accelerate past 30% of MTO, to what might otherwise be a normal cruising speed, but stop again shortly thereafter; it would be inefficient to thus repetitively stop and restart the engine as the load fluctuates around 30%. Hysteresis might similarly be useful in avoiding needless mode switching in moderate-speed, flat road cruising in mode IV, when the road load might well occasionally drop below 30%; again, it would be inefficient to repeatedly shut off and restart the engine.

Thus providing differing mode switching points depending on the direction of the change in road load can be accomplished readily by monitoring the road load RL as a function of time, and taking appropriate control action. For example, if the system is maintained in mode I until RL exceeds the "normal" 30% of MTO mode switching point for a period of, for example, 30 seconds, and without exceeding 50% of MTO, the excessive mode switching otherwise likely to be encountered in suburban traffic can be largely avoided. Fig. 9(b) shows a step 100' replacing step 100 in Fig. 9 and implementing this "low-speed hysteresis". As indicated, the system remains in the low-speed mode I as long as RL is less than 30% of MTO, or unless RL exceeds 30% of MTO for more than 30 seconds, or exceeds 50% of MTO; if either of the latter conditions occurs, the program goes to step 180, initiating mode IV operation.

Similarly, hysteresis in mode IV cruising, in order to implement excessive mode shifting that might otherwise occur if the road load fluctuates around a fixed mode switching point, can be implemented by simply providing that the system remains in mode IV as long as RL remains between 30 and 100% of MTO, unless RL is less than RL for more than 30 seconds, or exceeds 100% of MTO. This can be implemented as shown in Fig. 9(c); a revised step 215' replaces step 215 of Fig. 9, and provides that, if the system is in mode IV, unless RL is less than 30% of MTO for more than 30 seconds, step 180 is re-entered, thus preserving the "mode IV loop"; when RL is less than 30% of MTO for more than 30 seconds, the engine is shut down, at step 240, control is passed to step 100, and mode I re-entered.

Numerous further modifications to the detailed control strategy of the invention as illustrated in Figs. 6 - 9 will occur to those of skill in the art, and are within the scope of the invention. For example, it may be desirable to vary the operation of the system insofar as responsive to BSC in accordance with monitored variables indicative of battery temperature, ambient temperature, and the like; e.g., on a hot day it may be advisable to avoid charging the battery bank to more than 60% of full charge, as this may cause overheating. Further, as noted above the transition points between modes I, IV, and V in particular may vary in accordance with the operator's commands, so as to provide maximum vehicle responsiveness for safety and ease of consumer acceptance, and over periods of days or weeks, as the microprocessor builds up a detailed historical record of the vehicle's usage pattern, from which an optimized control strategy may be derived.

It may also be possible to provide the microprocessor with useful control information from the operator, without requiring the operator to understand the workings of the system in detail. For example, operators are now well-accustomed to set a "cruise control" when a desired cruising speed is reached; thereafter, existing engine management systems control the instantaneous engine torque output with respect to variation in the road load to maintain vehicle speed substantially constant. It would be a simple matter for the microprocessor to accept a desired cruising speed thus input by the operator, as indicated in Fig. 4. The operator would then be relieved of continuous throttle control, and the microprocessor would similarly control the instantaneous engine torque output with respect to variation in the road load to maintain vehicle speed substantially constant, both as conventional; however, according to the invention, the microprocessor would also reset the transition point so that the system would remain in cruising mode IV until the operator had indicated to the contrary, i.e., by exiting cruise mode.

As discussed above, according to a further embodiment of the invention, additional flexibility is provided to the hybrid vehicle as described above by providing a turbocharger 100, also controlled by the microprocessor 48, so as to be operated when useful in further improving vehicle efficiency and drivability and not at other times. Providing the "turbocharger-on-demand" allows the engine to function efficiently in different torque output ranges, as needed. Essentially, the turbocharger 100 is employed only when the vehicle's torque requirements, the "road load" as above, exceeds the engine's normally-aspirated maximum torque capacity for a relatively extended period T of time, for example, during extended high-speed driving, towing a trailer, or driving up a long hill. Where the road load exceeds the engine's maximum torque for a relatively short period less than T, the traction motor (and possibly also the starting motor) are used to provide additional torque, as in the '970 patent and above. According to a further aspect of the invention, the period T is controlled in response to the state of charge of the battery bank; when the battery bank is relatively depleted, the turbocharger is activated sooner than otherwise, so as to preserve the battery bank.

As is well known to those of skill in the art, a turbocharger 100 (see Fig. 11) typically comprises two turbine wheels 102 and 104 on a common shaft 106, referred to herein as the exhaust-side and air-side wheels respectively. The flow of exhaust gas from engine 40 causes exhaust-side wheel 102 to spin; air-side wheel 104 is driven by shaft 106, drawing air into the body of turbocharger 100 through air filter 110. Waste heat in the exhaust stream is thus effectively recovered by compressing the intake air, which is then ducted to the intake manifold 122 of engine 40. Additional fuel can be burned in the additional air thus provided, so that additional torque is produced. The compressed air may be cooled adiabatically by heat exchange with ambient air in intercooler 117 if desired, further improving thermal efficiency of engine 40.

In typical turbocharger operation, a "wastegate" 114 is provided to limit the exhaust pressure incident on exhaust-side wheel 102, thus limiting the speed of air-side wheel 104 and regulating the "boost" provided by the turbocharger. The waste gate may be spring-loaded to open at a fixed boost pressure (as typically provided to regulate the output of turbocharged racing engines) or may be controlled in a feedback loop using the pressure in the engine intake manifold as the control variable. See Automotive Handbook, 2nd Ed., Robert Bosch GmbH (1986), p. 356. Further, in conventional practice, the turbocharger is used at all times, and the engine's design is optimized accordingly. For example, turbocharged gasoline engines typically have compression ratios of 7 or 8 to 1, as compared to 9 - 11 to 1 for normally-aspirated engines. Neither practice is employed according to the present invention; the turbocharger is controlled by the microprocessor to operate only when needed, and the engine's compression ratio, and other design parameters, are selected based on design criteria relevant when operated in the normally-aspirated mode.

According to the present invention, the waste gate 114 is controlled by the microprocessor 48; except under circumstances when the extra power provided by turbocharging is needed, the waste gate 114 is open (as shown in Fig. 1), so that the engine exhaust essentially bypasses the turbocharger 100. A valve 120, also controlled by microprocessor 48, may also be provided in the duct connecting the air side of the turbocharger 100 and the intake manifold 122 of the engine, so that the engine 40 draws air through the turbocharger only when in use; a second air filter 124 is then also provided.

Commonly, turbocharging for automotive use is employed in order that relatively small-displacement engines will produce high horsepower at the upper end of their operating range; the other design parameters of such engines (e.g., camshaft profiles) are chosen similarly. Engines thus optimized for high-rpm horsepower produce reduced low-speed torque, that is, are "peaky" compared to normally-aspirated engines. A variable-ratio transmission is essential to obtain reasonable acceleration from low speeds. Stated differently, turbocharging as usually implemented for automotive use provides relatively high torque at the upper end of the engine's speed range, but relatively poor torque at lower speeds; such an engine would be unsuitable in practice of the present invention. Moreover, turbocharged engines typically suffer "turbo lag", that is, slow response to sudden increase in torque required. As discussed further below, this particular problem is overcome by use of the turbocharger in a hybrid vehicle according to the invention.

Those of skill in the art will recognize that turbocharged engines are also used in heavy-load road vehicle applications, such as trucks and the like, but these vehicles demand transmissions having 12, 16, or more ratios, so that the engine's narrow power peak can be matched to the load, and exhibit extremely poor acceleration, as well as excessive gear-changing and cost, all of which would be unacceptable to the ordinary motorist. Thus, normally-turbocharged engines, of both the low-speed truck type, or the high-speed automotive type, are not satisfactory in implementation of the present invention.

As also noted above, as conventionally employed, a turbocharger is used at all times. By comparison, according to the present invention, the turbocharger is controlled by the microprocessor 48 to be used only under specified driving conditions, allowing the engine to be operated efficiently in other modes.

Fig. 12, as indicated above, is a diagram comparable to Fig. 6. The differing modes of operation of the hybrid vehicle powertrain of the invention shown thereon are identical to those of the Figs. 3 and 4 vehicle illustrated in Fig. 6, with the addition of turbocharged mode VI. Similarly, Fig. 13 is similar to Fig. 7, but illustrates the operation of a vehicle including a "turbocharger-on-demand" according to this aspect of the invention.

As shown in Fig. 12, according to this aspect of the present invention, a further region VI is provided, wherein the turbocharger 100 is activated by the microprocessor 48 when it detects that the road load has exceeded the engine's maximum output for more than a period of time T. Typically these events will occur when the vehicle is towing a trailer or is otherwise heavily laden, is climbing a long hill, or is operated at high speed for a long period of time.

More specifically, when the road load only exceeds the engine's maximum power for a short time, less than T, as during acceleration onto a highway or during passing, the traction motor is employed to provide the additional torque required, as described above. When the road load exceeds the engine's maximum power for a time greater than T, the turbocharger is energized by closing waste gate 114, and operating valve 120, if provided, to open the duct between the air-side of turbocharger 100 and the intake manifold 122 of engine 40. As the turbocharger "spools up" to its operating speed range, the maximum torque produced by engine 40 increases, and the torque produced by traction motor 25 is gradually reduced. This sequence of events is discussed further below in connection with Fig. 13.

Fig. 12 also shows, by the angle of the line separating regions V and VI with respect to the t = 0 plane, that T can vary with the state of charge of the battery bank 22; when the battery bank is fully charged, T is longer -- that is, energy from the battery bank is used to satisfy road load in excess of the engine's maximum torque output for a longer period -- than when the battery bank is relatively less fully charged. The turbocharger can also be operated to provide additional engine power when full acceleration is needed, e.g., upon detection of the operator's aggressively pressing the accelerator pedal down completely.

As mentioned above, Fig. 13, comprising Figs. 13(a) - (c), and extending over two sheets, is a timing diagram showing the relationship between road load, engine torque output, the state of charge of the battery bank, and operation of the engine in electric car, normally-aspirated and turbocharged modes as these vary over time, during low-speed city driving, highway cruising, and extended high-load driving, thus further illustrating the control strategy employed according to the invention. Fig. 13 is essentially identical to Fig. 7, with the addition of illustration of the operation of turbocharger 100 when the road load exceeds 100% of MTO for more than a period of time T.

Thus, as shown in Fig. 13(a) at t_1, t_2, t_3, and t_4, the microprocessor monitors the length of time t during which road load exceeds 100% of MTO, and compares t continually to a value T preferably varied in accordance with BSC; this is shown by the relative lengths of the arrows marked T on Fig. 13(b). While $t < T$, as at E, F, and G in Fig. 13(a), the excess torque required by the road load is provided by either or both of the traction and starting motors, drawing power from the battery bank. Note that the motors together are rated to be capable of continuously providing torque up to at least 100% of MTO, in accordance with the '970 patent; this allows the motors to provide adequate torque for good vehicle performance without a variable-ratio transmission. The motors may also be overdriven to provide more than their rated torque, well over 100% of MTO, for short periods of time, $t < T$, as at F; as noted, according to an important aspect of the invention, where torque in excess of MTO is needed for a longer period of time, $t > T$, the turbocharger is activated.

Thus, when $t_4 \geq T$, as at P, the microprocessor activates the turbocharger essentially as discussed above, that is, by closing waste gate 114 and valve 120 (if provided). As the turbocharger "spools up", which may take some seconds, and the boost it provides increases, as indicated at Q, the torque provided by the traction motor (and possibly also by the starting motor) is decreased accordingly, as indicated at R. The operator need not be aware of or take any action to initiate the turbocharger's activation; this is controlled by the microprocessor in response to monitoring the road load over time and the state of charge of the battery bank.

As discussed in connection with both Figs. 12 and 13, T is preferably varied in accordance with BSC, so that the turbocharger is activated relatively sooner when BSC is relatively low; this limits the amount of energy drained from the battery during operation of the engine and the traction motor (or both motors) when the road load exceeds 100% of MTO, so that BSC does not fall to an undesirably low value.

Those of skill in the art will recognize that provision of a microprocessor-controlled turbocharger in a hybrid vehicle according to the invention permits operation in an additional mode, providing increased flexibility in the operational scheme provided; essentially the turbocharger provides a larger engine only when needed, at no cost in efficiency at other times. This is particularly significant in meeting the goals of the hybrid vehicle of the invention. More specifically, in addition to the operational advantages noted, provision of a "turbocharger-on-demand" in the hybrid vehicle according to the invention allows the engine to be smaller than otherwise, that is, to provide adequate highway performance in a vehicle of a given weight. As the starting motor/generator must be sized such that when it is operated to charge the batteries (e.g., in extended city driving) it loads the engine adequately that the engine is operated efficiently, employment of a smaller engine allows use of a smaller generator motor. For similar reasons, provision of a smaller engine allows it to be used to efficiently propel the vehicle in highway driving commencing at lower average speeds, resulting in turn in better fuel economy. By providing the "turbocharger-on-demand" according to the invention, all these advantages can be realized without sacrifice in the ultimate performance of the vehicle.

As noted above, one convenient implementation of the "turbocharger-on-demand" according to the invention is to operate the wastegate by a solenoid or the like controlled by the microprocessor, that is, to employ the wastegate as a bypass valve except when turbocharged operations are desired. A separate bypass valve might also or alternatively be provided. The wastegate is still preferably implemented as a spring-loaded relief valve, as illustrated in Fig. 11, and as generally conventional, to limit the "boost" provided. It is also within the invention to operate the waste gate to take intermediate positions, that is, between fully-open and closed positions, so as to limit the torque to limit wheelspin as detected, and to keep the turbocharger wheels spinning at an intermediate speed, to reduce the time necessary to "spool up" to full speed. It is also within the invention to adjust the wastegate responsive to an atmospheric-pressure signal provided by a suitable sensor 107 (Fig. 11) to ensure that adequate boost is provided at higher altitudes to ensure vehicle performance.

It will also be appreciated that a supercharger, that is, a positive-displacement air pump driven by the engine, could be used to implement the differing modes of vehicle operation illustrated in Figs. 12 and 13; for example, the supercharger's operation could be controlled by the microprocessor by driving it through an electrically-controlled clutch, and this is accordingly within the invention. However, this would be less efficient than turbocharger operation, as turbocharging effectively recovers some of the waste heat in the engine exhaust by compressing the air reaching the inlet manifold, while supercharging consumes engine torque. Turbocharging, as discussed in detail, is accordingly preferred.

It will therefore be appreciated that by providing the internal-combustion engine of a hybrid vehicle with a turbocharger controlled by the vehicle's controller to operate only during extended periods of high torque requirements, a number of important advantages are realized, both as compared to a conventional system wherein the turbocharger is continually activated, or as compared to a large engine having the same maximum torque as the smaller turbocharged engine. As to the latter, as explained above all internal combustion engines are extremely inefficient, except when operated at near peak torque output; the larger the engine, the less frequently this will occur. As to the former, employing a conventionally-turbocharged engine, having the typical "peaky" torque curve, would not allow the engine to be used to propel the vehicle during highway driving without a variable-speed transmission. Instead, by providing a "turbocharger-on-demand", that is, which is only employed when it is actually needed, the vehicle of the invention can employ a small engine optimized for its main function of propelling the vehicle efficiently during highway cruising, and which is operable as a much larger engine when needed.

Other advantages provided by the invention include the fact that as the wastegate is normally open, the exhaust temperature will stay high, optimizing catalytic converter performance; as conventionally implemented, cooling of the exhaust gases as their energy is removed in spinning the turbocharger rotor can prevent good catalytic converter performance, especially at low speeds. Further, because the traction motor provides additional torque when needed, the "turbo lag" experienced in conventional turbocharged vehicles as the turbocharger "spools up" when the operator calls for more power is eliminated.

When constructed and operated according to the invention, that is, as a hybrid vehicle having an internal-combustion engine with a turbocharger controlled by the vehicle's controller to operate only during extended periods of high torque requirements, even a heavy vehicle having poor aerodynamic characteristics, such as a sport-utility vehicle or van, can offer good acceleration and hill-climbing and towing ability, while still providing extremely good fuel economy and extremely low emissions.

Another aspect of the invention concerns the method of sizing the various components of the system. Examples were given above of component selection for a vehicle not including a turbocharger according to this aspect of the present invention. Using as a further example a 5,500 pound "sport-utility vehicle" ("SUV") required to have reasonable acceleration and passing performance even while towing a 6,000 pound trailer, sizing of the components of the hybrid drive system of the present invention is preferably accomplished as follows:

1. An internal combustion engine is selected which has sufficient torque to drive the SUV without trailer at medium to high speed along a moderate grade. More specifically, a typical specification will require that the engine be sufficiently powerful to proceed up a 6% grade of unlimited extent at 50 mph. An engine of 100 hp at 6,000 maximum RPM is appropriate to meet this requirement for the SUV described above.

2. If a trailer is to be towed, a turbocharger, operated as above, is added. The turbocharger is sized so that when it is operated the engine provides up to 140 hp.

3. The charger motor is sized so as to provide an engine load

equal to approximately 70% of the engine's maximum torque at a suitable engine speed. In this way fuel is used efficiently during battery charging, as discussed above. In the example, the charger motor is preferably an induction motor of 15 - 30 hp capacity, possibly configured as a "faceplate" or "pancake" type, essentially forming the flywheel of the engine. Such a motor can be operated as a generator requiring 20 - 22 hp, which is 70% of the maximum torque produced by the engine specified above when operated at 1200 - 1500 rpm; battery charging can thus be accomplished in a very fuel-efficient manner. This is essentially equivalent to specifying the starter/generator based on its ability to accept at least about 30% of the engine's maximum torque output (MTO, as above); in this way the engine is operated at a fuel-efficient power level during charging.

4. The traction motor is sized to provide adequate torque at zero speed to overcome the maximum grade specified from rest, with the starter motor assisting as needed. In the example the traction motor may be an induction motor of 100 hp, with a maximum speed of 16,000 rpm, and be connected to the drive wheels through a chain drive providing the appropriate reduction ratio. It will be appreciated that in this example the total torque available from the starting and traction motors combined exceeds that provided by the engine, in accordance with an aspect of the invention of the '970 patent.

5. The torque vs. speed profile of the traction motor is selected to allow city driving, in particular, to provide acceleration sufficient to conform to the Federal urban driving fuel mileage test ("FUDS"), without use of torque from the engine.

6. The battery capacity is then selected to provide sufficient cycle life, i.e., so as not to be overstressed by deep discharge over many repetitive driving cycles. In the example, an 800 v, 8.5 KAH battery pack is provided. The battery bank should be sized and arranged so that the maximum current to be absorbed with the starter/generator being driven at 30% of MTO is no more than 50

amperes.

7. Finally, the controller is provided with software to implement the control scheme described in detail above, that is, to use the traction motor as the only source of drive torque at low speed, to start the engine when the road load increases beyond a setpoint, to operate the turbocharger when the road load exceeds the engine's maximum torque for more than a prescribed time T, which may be varied in accordance with the state of charge of the batteries, and otherwise as described above. Essentially, the controller is operated so that the engine is only operated in a fuel-efficient range, e.g., driving a load at least equal to 30% of MTO.

Simulations show that vehicles configured as above will generally be capable of 80 - 100% improvement in fuel economy with respect to conventional vehicles of similar size, weight and performance characteristics.

Further Improvements according to the Continuation-in-Part

Component Specification

In addition to the methods of sizing the components of the powertrain and ancillary components set forth above, another method of doing so is generally as follows. As set forth above, it is desirable for a number of reasons to operate the system of the invention at relatively high voltages, e.g., 800 V or above, in the case of larger vehicles; this reduces the current flowing throughout the system, which allows use of plug-in rather than bolted connectors, allows use of inexpensive automatic disconnects, and reduces resistance heating losses.

More particularly, suppose that the "average maximum" current (e.g., defined as the maximum current flowing for more than, for example, thirty seconds; under most circumstances, the average current would be much less) is controlled to be 50 A. This allows use of inexpensive mass-produced plug-in connectors, and can be controlled by inexpensive mass-produced power electronic components, as needed to construct the inverter/charger units. These components can be designed to conduct up to approximately 200 A for up to thirty seconds, so that full acceleration can be provided for a time sufficient for the vehicle to reach essentially its maximum speed; according to this aspect of the invention, the peak current can accordingly be set at, for example, 150 A, and the power electronics components then sized based on this value.

More particularly, it appears useful to size the components with respect to one another, in particular, the battery bank with respect to the traction motor(s), so that the peak current is no more than about 150 A, and so that under peak electrical loading (usually under acceleration) a ratio of at least 2.5 : 1 of the battery voltage to the peak current is exceeded.

For example, suppose it is desired to implement the invention with respect to a relatively heavy, e.g., 6000 pound, vehicle having target acceleration capabilities such that a 120 HP electric traction motor, typically drawing 100 kW, will be required. The battery bank for such a vehicle is sized to provide a nominal voltage of 830 V (i.e., when not under load); this will drop to approximately 650 V under load. The battery bank will thus be required to produce 153 A (= 100 kW/650 V) during full acceleration, and the ratio of voltage to peak current is 3.92 (= 650 V/153 A).

In another example, of a much lighter 3000 lb vehicle, a 80 HP, 60 kW motor might be sufficient. To keep the peak current to 115 A, a battery bank of 600 V nominal, 500 V under load would be required. The ratio is then 4.3 (= 500V/115 A).

By comparison, insofar as known to the inventors, the Toyota "Prius" hybrid car now being marketed uses a 30 kW motor, and its battery bank provides approximately 230 V under load; the current required is thus approximately 120 A (= 30 kW/230 V) and the ratio between the voltage under load and the peak current is only about 2 (= 230V/120A). The motor in the Prius is incapable of providing adequate acceleration without assistance; this in turn requires that an internal combustion engine (ICE) be provided, and be connected to the wheels by way of a variable-ratio plantary gearset. Operation of the ICE in the Prius is thus constrained by the vehicle's torque requirements, which unacceptably complicates its operation and renders it incapable of maximally efficient operation.

Applicants assert, therefore, that according to the invention the components of the hybrid vehicles of the invention are to be sized so that the ratio between battery voltage under load to peak current is at least about 2.5, and preferably is at least 3.5 to 4 : 1; this allows adequate acceleration from low speeds without use of torque from the ICE, which in turn allows elimination of any multiple-speed or variable-ratio transmission, and allows the ICE to be declutched from the wheels except when the ICE can be employed efficiently to propel the vehicle (or the ICE is being motored during deceleration or coast-down, as above). In turn this requirement leads to operation at higher voltages than typical, to keep both average maximum and peak currents low, which provides the very significant advantages mentioned above.

Range-Broadening Transmission

As mentioned above, in some embodiments of the invention as disclosed by the present continuation-in-part application, a two-speed transmission may be provided to broaden the range of utility of the vehicle. An exemplary hybrid vehicle powertrain providing this and further additional features is shown in Fig. 14; where not otherwise described, this embodiment of the invention includes features in common with those discussed above in connnection with the '970 patent and the '817 and '743 applications.

More specifically, according to one embodiment of this aspect of the invention of the present continuation-in-part application, the range of efficient use of the hybrid vehicle of the invention is further broadened by providing a two-speed "range shifting" transmission, akin to those presently provided on SUVs and the like to allow shifting into a "low range", so that when the load is expected to be heavy for extended period of time, for example, when a heavy trailer is to be towed, the transmission can be operated to select the low range. As indicated, such a transmission would normally only be operated once per trip, and is accordingly not equivalent to a conventional multiple-speed transmission which is operated to provide a sequence of effective overall gear ratios each time the vehicle is accelerated, as suggested in numerous prior art references dealing with hybrid vehicles. However, in another embodiment, the two-speed transmission thus provided could be operated conventionally, i.e., shifted automatically during acceleration, or in "kick-down" mode responsive to the operator's demand for acceleration.

In one implementation of this aspect of the invention, as shown in Fig. 14, a planetary gearbox 33 is disposed between the output shafts from the traction motor 25 and the combination of engine 40 and starting motor 21. Gearbox 33 may be controlled directly by the operator, as conventional, or by the microprocessor 48, in response to an operator command or responsive to sensing that the road load has exceeded some predetermined value, e.g. 125% of MTO, for an extended time, e.g. several minutes, or conventionally, i.e., shifted under ordinary acceleration. Typically the gearbox 33 will be locked, providing a direct drive, under ordinary circumstances; when a lower ratio is needed, for example, when towing a heavy trailer, the gearbox 33 may be controlled to yield a reduction of 0.5 - 0.8 : 1.

Fig. 14 also shows a second traction motor 222 driving a second set of road wheels 210 through a second differential 211. This is a convenient way of providing a "four-wheel drive" hybrid vehicle, which avoids the fore-and-aft driveshaft and third differential needed by conventional four-wheel drive vehicles. In this embodiment, road wheels 210 are configured as the steering wheels of the vehicle; accordingly halfshaft assemblies 212 incorporating universal joints are employed allowing wheels 210 to pivot, as illustrated. Traction motor 222 is connected to battery bank ("BB" in Figs. 14 and 15) via a further inverter/charger 224, controlled by microprocessor 48 essentially similarly to traction motor 25. As noted above, a DC-to-DC converter 223 may be provided to allow the vehicle of the invention to be connected to vehicles having conventional 12 volt electrical systems for emergency starting purposes, and to provide 12 VDC for operation of conventional accessories.

Provision of separate traction motors 222 and 25 with respect to the corresponding pairs of road wheels 210 and 34 has several advantages with respect to conventional vehicles; as noted above, the fore-and-aft driveshaft and third differential normally required are eliminated, freeing substantial space normally required by these components. Further, "traction control" -- that is, control of the amount of torque directed to each pair of wheels responsive to the traction conditions, which is useful in driving in snow or mud, or on wet or icy pavement -- is conveniently accomplished by the microprocessor, simply by monitoring the wheels' response to given amounts of current and reducing the current to spinning wheels.

As shown by Fig. 14, vehicles according to the invention provided with two traction motors and having a planetary gearbox 33 between one traction motor and its corresponding road wheels may have a similar gearbox 213 between the second traction motor 222 and its wheels; however, this second gearbox 213 is not expected to be commonly required. Similarly, second traction motor 222 can be configured as a high-RPM unit, with its output shaft connected to the road wheels through reduction gears 214. In this implementation starter motor/generator 21 is also shown connected to the road wheels through a reduction device 34, illustrated as a chain drive; as indicated above, providing a mechanical reduction between the various motors 21, 25, and 222 and the respective road wheels is desirable in order that the motors can be selected and optimized to operate at higher speeds than engine 40.

Another possibility not shown specifically by Fig. 14, but within the scope of the invention, is to provide a "torque converter" of essentially conventional design, preferably fitted with a "lock-up" clutch, between the traction motor(s) and the corresponding wheels. As is well known, torque converters are commonly employed as part of automatic transmissions for passenger cars; the torque converter multiplies the input torque at low speeds. Such a torque converter would provide increased acceleration from rest. However, a similar effect can be obtained more simply by overdriving the traction motor(s) beyond their rated power for the first few seconds of acceleration.

Braking System

Numerous patents, including the '970 patent discussed above, recognize that one advantage of hybrid vehicles is that by appropriate control of electric motor/generators connected to the road wheels, a substantial fraction of the energy lost by conventional vehicles to friction can be recovered through regenerative braking, that is, by converting the vehicle's kinetic energy to stored battery power by using torque available at the road wheels to drive the motor(s) in generator mode, and storing the resulting electrical energy in the battery bank for use later. It is commonly estimated that most of the energy expended in accelerating the vehicle in city driving can be recovered in this way, since irrecoverable losses due to air resistance and rolling resistance contribute relatively little to the vehicle's energy demands at low speeds; by comparison, less of the energy expended to drive the vehicle at highway speeds can thus be recovered, although regenerative braking is nonetheless desirable.

More particularly, it is known to operate the motor/generator and cooperating inverter/charger electronics of hybrid vehicles so that electrical power is generated and stored in the battery bank when the operator desires to slow the vehicle. Accordingly "regenerative braking" *per se* is known. It is generally also apparent to those of skill in the art that a conventional mechanical braking system must also be provided, both for safety in the event of a failure in the regenerative braking system and to provide braking in the event the battery bank is fully charged; that is, it is important to avoid overcharging the battery bank in order to maximize its useful life. See Boll U.S. patent 5,788,597 and Frank U.S. patent 5,842,534. Similarly, mechanical braking is also needed when regenerative braking is not possible, e.g., at a stop. However, the art known to the inventors does not address all the concerns relevant to provision of a braking system of a hybrid vehicle, and to do so is another object of the present invention. See, e.g., Mikami et al patent 5,839,533, which suggests employment of engine braking (i.e., retardation of the vehicle using torque due to compression of air in the engine, and friction therein) as well as regenerative braking. The choice between the two is apparently to be made by the operator, at least in part responsive to the battery's state of charge. This would be far too complex for general acceptance.

The disclosure of the Boll patent itself is directed to optimizing the use of regenerative, engine, and mechanical braking. Boll also recognizes the desirability of maintaining a consistent brake pedal "feel" in the various brake modes.

German patent application DT 19 05 641 B2 to Strifler discloses a combined regenerative and mechanical braking system for an electric vehicle, wherein regenerative braking is effected upon the operator's first operating a brake lever, and mechanical braking is further effected upon reaching the maximum regenerative braking effect. If the battery cannot accept further charge, the mechanical braking is triggered relatively earlier, so that the operator experiences substantially the same pedal "feel" regardless whether regenerative or mechanical braking is being implemented.

The present invention also recognizes that providing proper brake "feel" to the operator is important to provision of a satisfactory vehicle, but differs substantially from the teachings of the art, and the Boll and Strifler references in particular, in the type of pedal feel preferred.

More particularly, it will be appreciated that typical vehicle mechanical brake systems provide a relatively linear relationship between the force exerted on the brake pedal and the retarding force exerted on the wheels by the brakes. It is essential that this relatively linear relationship be provided by the brake system of any hybrid vehicle, so that the operator can smoothly and controllably brake the vehicle as desired.

Providing a relatively linear relationship between the force exerted on the brake pedal and the retarding force exerted on the tires by the brakes is substantially straightforward in the case of conventional mechanical braking systems. It is much more complicated in the case of a brake system incorporating regenerative braking as described above, since such a system must provide a linear relationship between the force exerted on the brake pedal and the retarding force exerted on the tires by the brakes and motor/generator(s) under all circumstances. The problem is particularly complicated during transitions from one braking regime to another. For example, if regenerative braking is used to commence deceleration but hydraulic braking must take over, e.g., if the battery bank's state of charge becomes full during a long descent, or if a leisurely stop suddenly becomes abrupt, the braking regime must change smoothly and controllably. Regenerative braking is also not available when the vehicle is moving very slowly or is at rest, and mechanical brakes must be available under these circumstances.

In addition to maintenance of the linear relationship, it is deemed preferable by the present inventors that the operator be made aware by a change in the "feel" of the brake pedal that regenerative braking is not available, typically due to the battery bank's state of charge becoming full. As noted, this is contrary to the teachings of the Boll patent and the Strifler German application. More specifically, it is considered desirable by the inventors that the brake pedal resist depression by the operator to a degree proportional to the amount of regenerative braking actually being effected at all times.

Finally, it will be appreciated that the engine manifold vacuum as conventionally used to produce "power braking", i.e., servo assistance, is not available to a hybrid vehicle if the engine is not running; some other source of power for servo assistance is required in order that brake effort is not unacceptably high.

Fig. 15 shows schematically the principal components of a brake system for a hybrid vehicle that addresses the concerns above. Where common reference numerals are employed, the components are common with those shown in other Figures, while components not important to understanding of the braking system are omitted for simplicity. Thus, Fig. 15 shows traction motors 222 and 25 connected directly to the respective road wheels 210 and 34 respectively, omitting the other components discussed above. (In vehicles where a single traction motor drives a single pair of wheels, the improvements described herein would be provided as to these, while a four-wheel hydraulic braking system would also be provided.) As also discussed above, motors 222 and 25 are connected to battery bank 22 through respective inverter/chargers 224 and 27. Inverter/chargers 224 and 27 are controlled by microprocessor 48 to operate so that the motors can draw power from battery bank 22 and impart torque to the respective wheels to propel the vehicle in the appropriate modes of vehicle operation; during regenerative braking, inverter/chargers 224 and 27 are controlled so that the motors absorb torque from the wheels, slowing the vehicle, and storing the power thus generated in the battery bank 22.

Control of the inverter/chargers and motors to absorb a desired amount of torque from the wheels in response to a braking command from microprocessor 48 is considered to be within the skill of the art. The command itself may be determined by microprocessor 48 responsive to the degree to which brake pedal 70 is depressed, as measured by a potentiometer or similar device, indicated at 71. However, according to the invention, as above, a device is provided which varies the "feel" of the pedal (essentially its resistance to being depressed by the driver) responsive to the degree regenerative braking is in fact being implemented, thereby providing tactile feedback to the driver enabling smooth deceleration and, when appropriate, also providing an indication that regenerative braking is not available.

In the implementation of the invention shown, controllable resistance to the movement of brake pedal 70 is provided by connecting it to a microprocessor-controlled pneumatic cylinder assembly 230. A piston 232 fitting within a pneumatic cylinder 238 is driven by a connecting rod 234 attached to pedal 70 by a clevis 236. As the pedal is depressed, moving from right to left in Fig. 15, i.e., from the position shown in full to that shown in dotted lines, piston 232 expels air from the interior of cylinder 238 via vent 240. The rate at which air is expelled in response to any given pedal pressure is controlled by the spacing of a needle valve 242 from a seat 244; the needle valve 242 is moved closer to its seat 244 to increase the resistance to airflow, or moved away from seat 244 to reduce the resistance. The spacing is controlled by microprocessor 48 in order to vary the feel of the brake pedal 70; in the implementation shown, the needle valve 242 is threaded into the body in which valve seat 244 is formed, and the spacing is controlled by the microprocessor 48 by commands sent to a motor 248 rotating the needle valve 242 through a pair of gears 250. A spring 252 may be provided to return the pedal to its initial position. Thus, for example, if regenerative braking is not available, needle valve 242 is opened, so that the cylinder provides little resistance to the pedal, effectively informing the driver that only hydraulic braking is available. When regenerative braking is initiated, responsive to the microprocessor's detecting a signal from potentiometer 71, the needle valve is closed responsive to the degree of braking provided, resisting motion of the pedal 70, and so that the pedal feel provided to the operator is responsive to the degree of regenerative braking actually being effected. Obviously, numerous other arrangements to thus controllably vary the feel of the brake pedal will occur to those of skill in the art.

The mechanical design of the hydraulic braking system of the hybrid vehicle according to the invention is generally conventional, with two principal exceptions as follows: First, as the engine is not always running during movement of the hybrid vehicle, there is no consistent source of manifold vacuum as conventionally employed to provide servo assistance to braking. Therefore, a motor 254 powered directly by the battery bank BB is provided, and drives a vacuum pump 256, providing vacuum to a conventional servo booster 258, in turn operating conventional wheel brakes 260. The same motor 254 can be used to power other "ancillary" systems that in conventional vehicles are powered by the engine, such as the power steering pump and the air conditioning compressor. (The art does recognize that hybrid vehicles require different sources of power for ancillary devices, such as power steering pumps or power brake pumps. See Heidl patent 5,249,637, at col. 1, lines 7 - 45.) Second, in order that the initial movement of the brake pedal 70 activates only the regenerative braking process (in order to obtain the maximum benefit therefrom), a mechanism is provided so that the rod 262 actuating the piston within master cylinder 264 and thence the wheel brakes 260 moves a distance X before the master cylinder itself is actuated. In the implementation shown, this mechanism simply involves provision of a cross-pin 266 fixed to rod 262 and sliding within a slot 268 formed in the piston rod 270 of master cylinder 264; accordingly, the master cylinder piston(s) do not begin to move until the cross-pin 266 reaches the left end of slot

268. If the overall pedal travel Y is six inches, the distance X defined by slot 268 may be such as to allow pedal 70 to move freely through 1-1/2 inches before the piston(s) of the master cylinder 264 begins to move.

Thus, according to this aspect of the invention, potentiometer 71 provides a signal to the microprocessor 48 when the brake pedal 70 is depressed by the driver. The microprocessor 48 evaluates the battery bank state of charge (SOC) as indicated at 66; unless this is such that further charging is undesirable, the inverter/chargers 224 and 27 are operated such that motors 222 and 25 are operated as generators, so that torque provided to the wheels by the road is converted into electrical power, retarding the vehicle and charging the battery bank. The degree of retardation thus provided depends on the degree to which pedal 70 is depressed. The driver feels resistance to depressing the pedal from air resistance controlled by the opening of needle valve 242; microprocessor 48 controls the opening of valve 242 so that the pedal feel corresponds to the degree of regenerative braking that is provided. In the event regenerative braking is not available for some reason, perhaps because the battery bank is fully charged, because of some flaw in the charging circuits, or because the vehicle is stopped, valve 242 is opened, so that the driver feels little resistance to initial pedal travel, until the hydraulic brake system is activated.

It will be apparent that other types of devices for controlling the resistance to pedal travel to correspond to the amount of regenerative braking being provided, and thus to provide the desired linear relationship between pedal resistance and vehicle retardation, could be substituted for the pneumatic cylinder with microprocessor-controlled vent device shown. For example, a device controllably varying the friction between the pedal pivot and its mounting structure could be provided; a hydraulic system, similarly controlling the resistance to flow of a fluid through an orifice, might be provided; or a device varying the preload of a return spring might be provided. Other equivalent devices for achieving the same goals will occur to those of skill in the art.

HVAC System

The essential components of the heating, ventilation and air conditioning (HVAC) systems of conventional vehicles are a heater core, connected to the engine cooling system, an air conditioning system including an evaporator, and a fan to blow air over the heater core and evaporator and into the passenger cabin. There are several issues to be addressed in adapting the conventional automotive HVAC system to use in a hybrid vehicle. One is that conventionally the air conditioning compressor is driven by the engine through an electrically-controlled clutch; in a hybrid vehicle this is unacceptable, as the engine is not run constantly. Therefore the air conditioning compressor must be powered differently. Similarly, again as the engine is not run constantly, the heater core cannot be relied upon to heat the cabin.

The art does recognize that hybrid vehicles require different sources of power for ancillary devices, such as power steering pumps or power brake pumps. See Heidl patent 5,249,637, at col. 1, lines 7 - 45. Heidl's disclosure is to the effect that a motor/generator used to drive the ancillaries during electric operation can be used as a generator when the vehicle is propelled by an internal combustion engine.

Fig. 16 shows the principal components of an HVAC system for a hybrid vehicle according to the invention. The complex ducting that is typically provided to supply conditioned air throughout the vehicle cabin is represented by a single duct 300. A fan 302 forces air through the duct 300, and in succession past an evaporator 304, a heater core 306, and an electric heater 308. The evaporator 304 is connected to an air conditioning compressor 310 driven by an electric motor 312 powered from the battery bank, so that the air conditioning system can be operated independent of the engine 40.

Motor 312 could be the same motor used to power other ancillaries, such as the vacuum pump 256 (Fig. 15) used to provide servo assistance to the brake system, or could be a separate motor dedicated to powering the compressor 310. The latter may be preferred, as this would allow elimination of the clutch otherwise needed to permit operation of the compressor only when needed; elimination of the clutch would also allow elimination of seals that are a source of leaks. Another advantage of driving the compressor from the battery bank according to the invention is as follows. Conventionally, in order to be useful under all circumstances, the compressor must be sized to provide full cooling with the engine at idle. Such a compressor is very inefficient at higher speeds; by decoupling the compressor from the vehicle drivetrain according to the invention, it can be designed to be driven by motor 312 at a single optimally efficient speed. Cabin temperature can be thermostatically controlled by a throttling valve controlling the flow of refrigerant, or by turning motor 312 on and off as required. The other components of the air conditioning system, including an expansion valve 314 and a condenser 316, are shown schematically, and are generally conventional.

When the engine is running, it is efficient to employ waste heat from the engine cooling system to provide cabin heat, and accordingly an essentially conventional heater core 306 and control elements (not shown) are provided; heater core 306 is downstream of the evaporator 304 with respect to the flow of air through duct 300, as conventional, so that dehumidified air can be heated to provide efficient demisting.

In order to provide heat as may be required when the engine is not running, an electric heating element 308, essentially comprising a coil of Nichrome wire or the like, is provided, again downstream of the evaporator 304. Heating element 308 is provided with conventional controls (not shown) and is powered directly from the battery bank 22, as indicated.

It will be appreciated that according to this aspect of the invention, suitably heated or cooled cabin air is thus available regardless of the mode of operation of the vehicle, as needed in order that the hybrid vehicle of the invention suffers no comfort or convenience drawback with respect to conventional vehicles. Indeed, because ample electrical power is available from the large battery bank of the hybrid vehicle, electric heater 308 can be designed to heat the cabin much more rapidly than does the coolant heat exchanging core of a conventional engine, thus providing a convenience advantage. Similarly, conductors can be embedded in the vehicle windows and windshield and powered by the battery bank for improved electrically-operated de-misting and de-icing.

It will be appreciated that the hybrid vehicle and operational strategy therefor of the invention provide numerous advantages over the prior art discussed herein, and that further improvements and modifications thereto are within the skill of the art. Accordingly, while a preferred embodiment of the invention has been disclosed, and various alternatives mentioned specifically, the invention is not to be limited thereby.

1. In a method of controlling an internal combustion engine of a hybrid vehicle, said engine being operatively connected to drive wheels of said vehicle through a clutch, said vehicle further comprising a traction motor operatively connected to drive wheels of said vehicle, a starter/generator motor operatively connected to said engine for starting said engine and for providing electrical power in response to torque from said engine, a battery bank adapted to store electrical energy to power said traction motor and to start said engine, at least one inverter/charger adapted to cooperate with said traction motor and said starter/generator such that said traction motor can be operated to provide torque to said road wheels responsive to electrical power from said battery bank, or to provide electrical power to said battery bank responsive to torque from said road wheels, and such that said starter/generator can be operated to provide torque to start said engine, or to provide electrical power to said battery bank responsive to torque provided by said engine, and a microprocessor adapted to control operation of said engine, said traction motor, said starter/generator, and said at least one inverter/charger, so as to control flow of torque and electrical power therebetween in response to sensed parameters, the improvement comprising:

establishing at least four vehicle operating modes, including:

a mode I, wherein said engine is not operated and said vehicle is propelled by torque from said traction motor in response to electrical power drawn from said battery bank;

a mode II, wherein said vehicle is propelled by torque from said traction motor in response to electrical power drawn from said battery bank, and said starter/generator is driven by torque provided by said engine to provide electrical power to recharge said battery bank;

a mode III, wherein said vehicle is propelled by torque from said engine;

a mode IV, wherein said vehicle is propelled by torque from said engine and from said traction motor in response to electrical power drawn from said battery bank;

wherein said microprocessor controls operation of said engine, said traction motor, said starter/generator, and said at least one inverter/charger in response to the instantaneous torque demands (RL) of said vehicle, and such that said engine is operated only in response to a load equal at least to a predetermined minimum value of its maximum torque output.

2. The method of claim 1, wherein said starter/generator is sized with respect to said engine such that said starter/generator is capable of being driven by said engine in said mode II while said engine produces at least about 30% of its maximum torque output.

3. The method of claim 2, wherein said battery bank is sized such that the charging current supplied by said starter/generator in response to torque from said engine while producing at least about 30% of its maximum torque output is no more than about 50 amperes.

4. The method of claim 1, wherein said microprocessor controls operation of said vehicle such that said mode III is entered only when RL is at least equal to a predetermined fraction of the engine's maximum torque output (MTO).

5. The method of claim 4, wherein mode III is entered only when RL is substantially equal to at least 30% of MTO.

6. The method of claim 5, wherein said vehicle is operated in mode III while 30% < RL < 100% of MTO.

7. The method of claim 1, wherein mode IV is entered only when RL > 100% of MTO.

8. The method of claim 1, wherein said vehicle further comprises a turbocharger adapted to be controlled by said microprocessor so as to increase the torque output of said engine from its maximum value while normally aspirated (MTO), and wherein a further vehicle operating mode V is established, wherein said turbocharger is controlled to operate when RL is greater than MTO for more than a given period of time T.

9. The method of claim 8, wherein if said vehicle is in said mode IV, with RL between 30 and 100% of MTO, and if RL then exceeds 100% of MTO, torque required in excess of 100% of MTO is initially provided by said traction motor, and if RL continues to exceed 100% of MTO for more than a given period of time T, said turbocharger is activated by said microprocessor such that said engine produces torque in excess of 100% of MTO.

10. A brake system for a hybrid vehicle, said vehicle comprising a drive train including an internal combustion engine operated to provide vehicle propulsive torque only during predetermined modes of operation of said vehicle and at least one traction motor and corresponding inverter/charger adapted to provide vehicle propulsive torque during predetermined modes of operation of said vehicle and to provide electrical energy responsive to torque from wheels of said vehicle during a regenerative braking mode of operation of said vehicle, a battery bank adapted to provide electrical energy to said motor as required and to accept charging energy from said motor when operated as a generator during said regenerative braking mode of operation of said vehicle, and a microprocessor for controlling the mode of operation of said vehicle, said brake system comprising:

a brake pedal adapted to be operated by a driver of said vehicle,

a hydraulic brake system coupled to said brake pedal and comprising at least one master cylinder and a number of wheel brakes operatively connected to said master cylinder for retarding said vehicle upon actuation of said pedal,

a sensor for providing a signal to said microprocessor responsive to motion of said brake pedal,

a sensor for providing a signal to said microprocessor responsive to the state of charge of said battery bank,

a device controllable by said microprocessor to vary the resistance to motion of said pedal during braking responsive to the amount of regenerative braking being provided,

wherein said microprocessor controls the amount of regenerative braking provided upon motion of said pedal responsive to the state of charge of said battery bank, and controls the resistance to motion of said pedal during braking responsive to the amount of regenerative braking being provided.

11. The brake system of claim 10, wherein said device controllable by said microprocessor to vary the resistance to motion of said pedal during braking responsive to the amount of regenerative braking being provided comprises a pneumatic cylinder having a piston sliding therein, said piston being operated by said brake pedal, and comprising a vent passage including an orifice controllable by said microprocessor to control the resistance to motion of said pedal.

12. The brake system of claim 10, wherein said at least one master cylinder is coupled to said brake pedal by an actuating rod arranged so that said pedal can be moved through a predetermined distance before said master cylinder begins to apply pressure to said wheel brakes.

13. The brake system of claim 10, wherein said hydraulic brake system comprises a servo actuator and a vacuum pump driven by a motor responsive to electrical power supplied from said battery bank.

14. A heating, ventilation, and air conditioning (HVAC) system for a hybrid vehicle, said vehicle comprising a drive train including an internal combustion engine run only during predetermined modes of operation of said vehicle and at least one traction motor adapted to provide vehicle propulsive torque during predetermined modes of operation of said vehicle, a battery bank adapted to provide electrical energy to said motor as required, said HVAC system comprising:

a duct having a fan disposed therein for forcing air along said duct;

an evaporator in said duct;

an air conditioning compressor connected to said evaporator, and driven by an electric motor powered by said battery bank;

a heater core in said duct and connected to a cooling system of said engine; and

an electrical heating element in said duct and connected to said battery bank.

15. The HVAC system of claim 14, wherein said evaporator is disposed in said duct upstream of said heater core and said electrical heating element with respect to the direction of air flow through said duct.

16. A method for determining the relative sizes of the internal combustion engine, starting/charging and traction motors, and battery bank of a hybrid vehicle comprising said components, said method comprising the steps of:

a. selecting an internal combustion engine having sufficient torque to drive the vehicle without trailer at medium to high speed along a moderate grade;

b. sizing the starting/charging motor to provide an engine load during battery charging equal to at least approximately 30% of the engine's maximum torque output;

c. sizing the traction motor to provide adequate torque at zero speed to overcome the maximum grade specified from rest, with the starter motor assisting as needed;

d. determining the maximum power drawn by the selected motor under full power conditions;

e. calculating the battery voltage under load that will be required to provide the power to be drawn by the motor(s) under full power conditions, and so that the ratio of the battery voltage under load to the peak current drawn by the motor(s) is at least 2.5:1, and

f. selecting the battery bank to provide the calculated voltage under peak load conditions.

ABSTRACT OF THE DISCLOSURE

A hybrid vehicle comprises an internal combustion engine, a traction motor, a starter motor, and a battery bank, all controlled by a microprocessor in accordance with the vehicle's instantaneous torque demands so that the engine is run only under conditions of high efficiency, typically only when the load is at least equal to 30% of the engine's maximum torque output. In some embodiments, a turbocharger may be provided, activated only when the load exceeds the engine's maximum torque output for an extended period; a two-speed transmission may further be provided, to further broaden the vehicle's load range. A hybrid brake system provides regenerative braking, with mechanical braking available in the event the battery bank is fully charged, in emergencies, or at rest; a control mechanism is provided to control the brake system to provide linear brake feel under varying circumstances.

FIG. 1

(PRIOR ART)

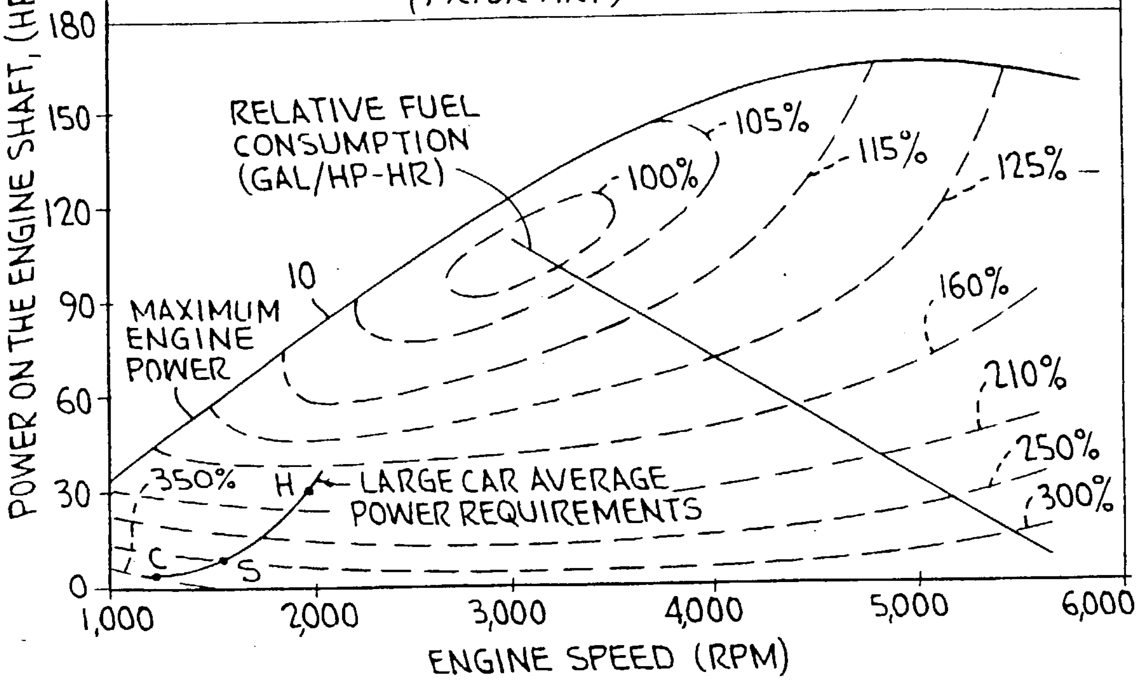
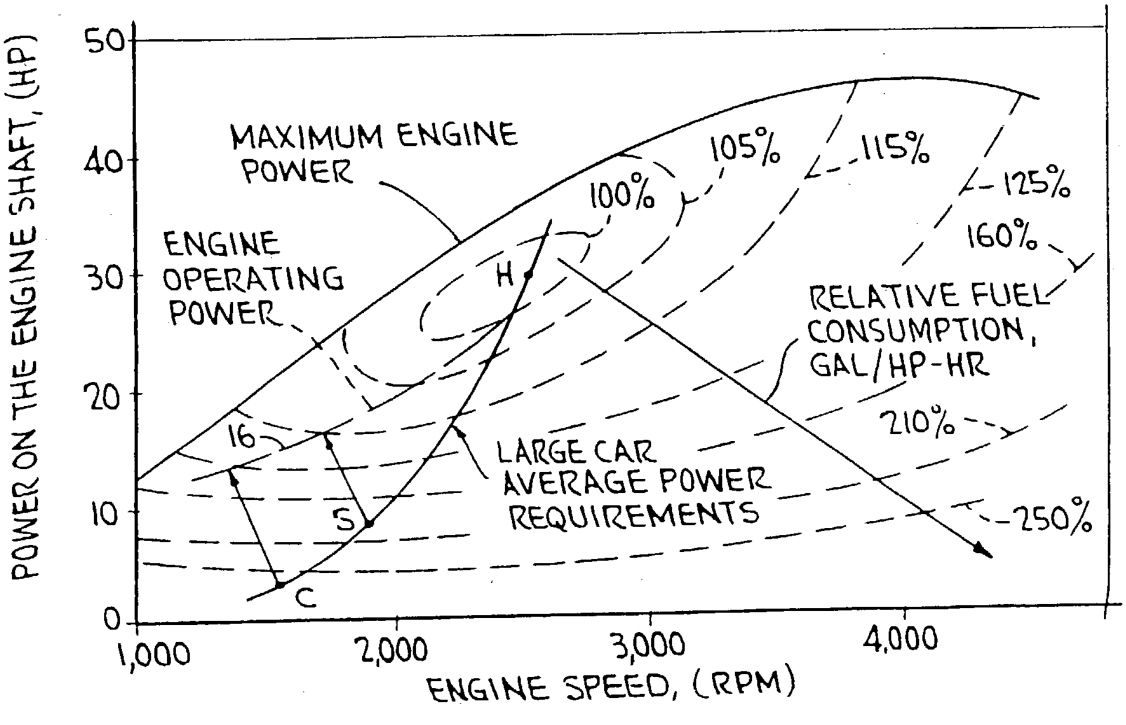
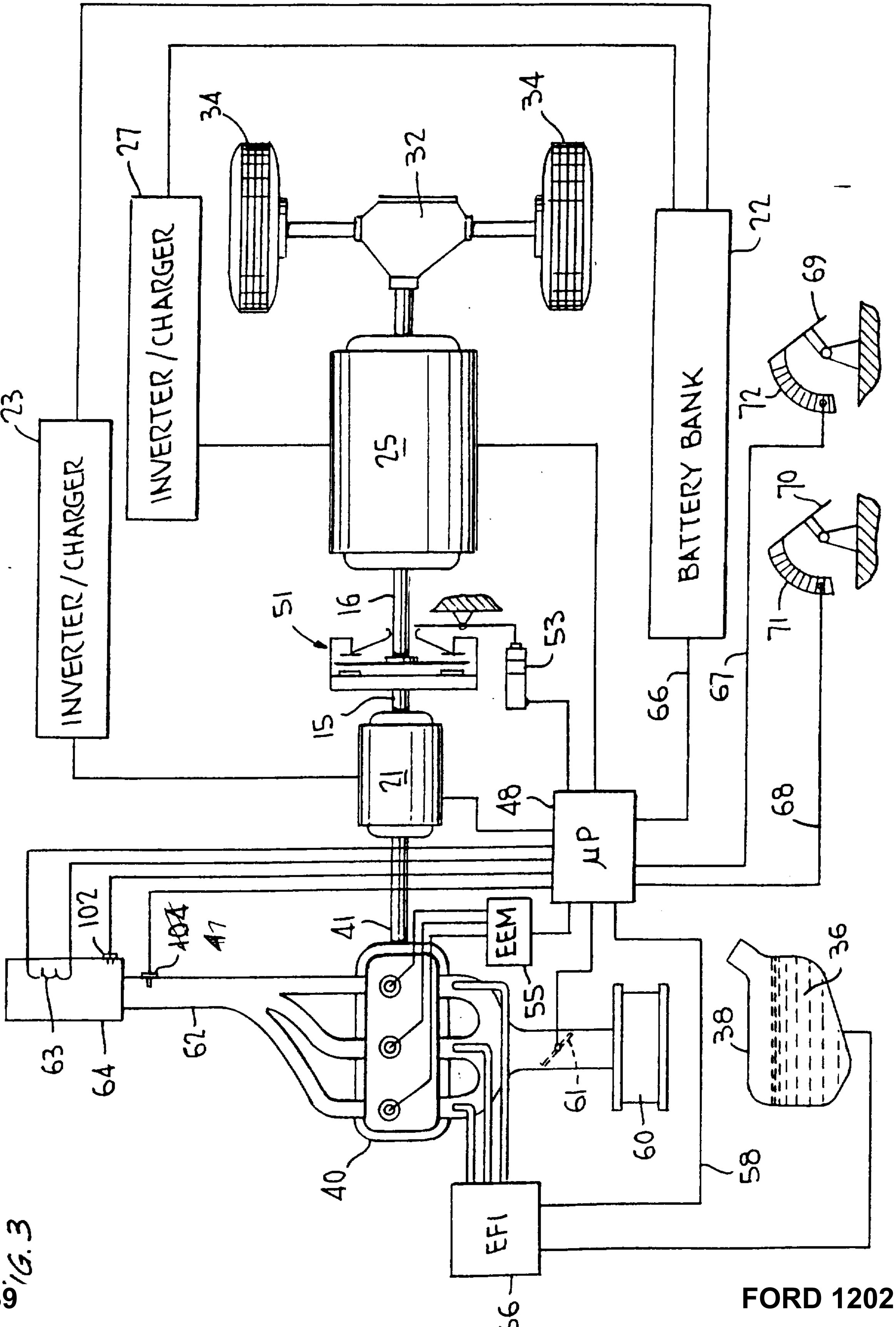


FIG. 2





23
INVERTER / CHARGER
27
INVERTER / CHARGER
34
34
32
25
22
BATTERY BANK
69
72
70
71
51
16
53
15
21
66
67
68
48
μP
102
~~104~~ 47
41
EEM
55
63
64
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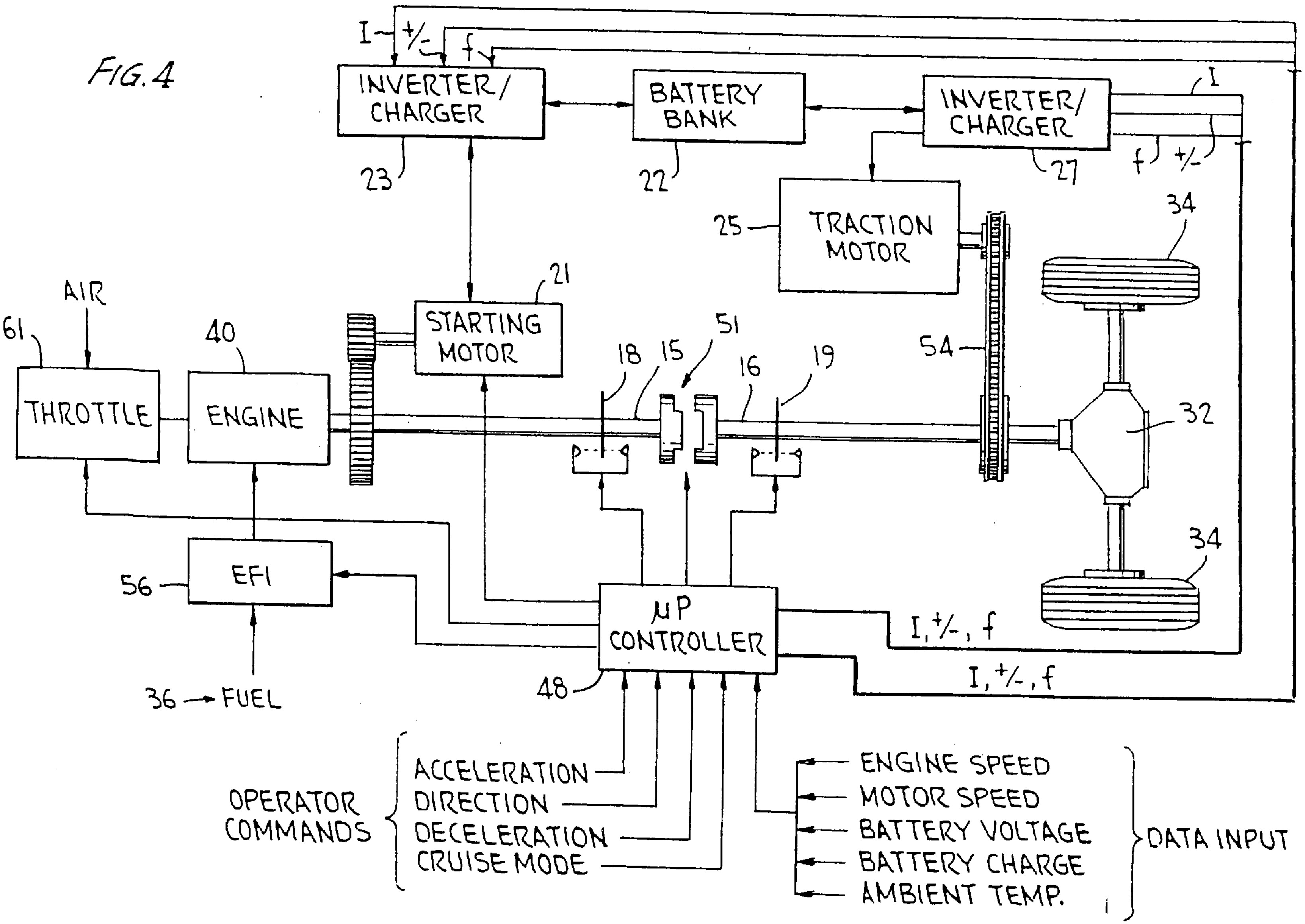
60
36
38
58
40
EFI
56

IG. 3

FIG. 4



INVERTER/ CHARGER
23
BATTERY BANK
22
INVERTER/ CHARGER
27
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TRACTION MOTOR
25
34
54
STARTING MOTOR
21
AIR
61
THROTTLE
40
ENGINE
18
15
51
16
19
32
34
56
EFI
36
FUEL
μP CONTROLLER
48
I, +/-, f
I, +/-, f
OPERATOR COMMANDS
ACCELERATION
DIRECTION
DECELERATION
CRUISE MODE
ENGINE SPEED
MOTOR SPEED
BATTERY VOLTAGE
BATTERY CHARGE
AMBIENT TEMP.
DATA INPUT

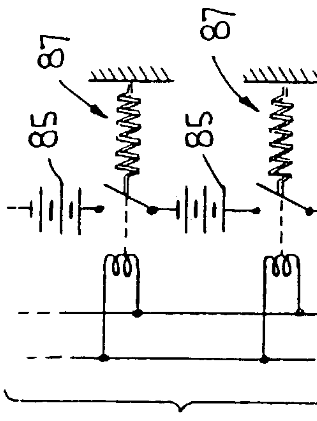


FIG. 5(a)
85
87
85
87

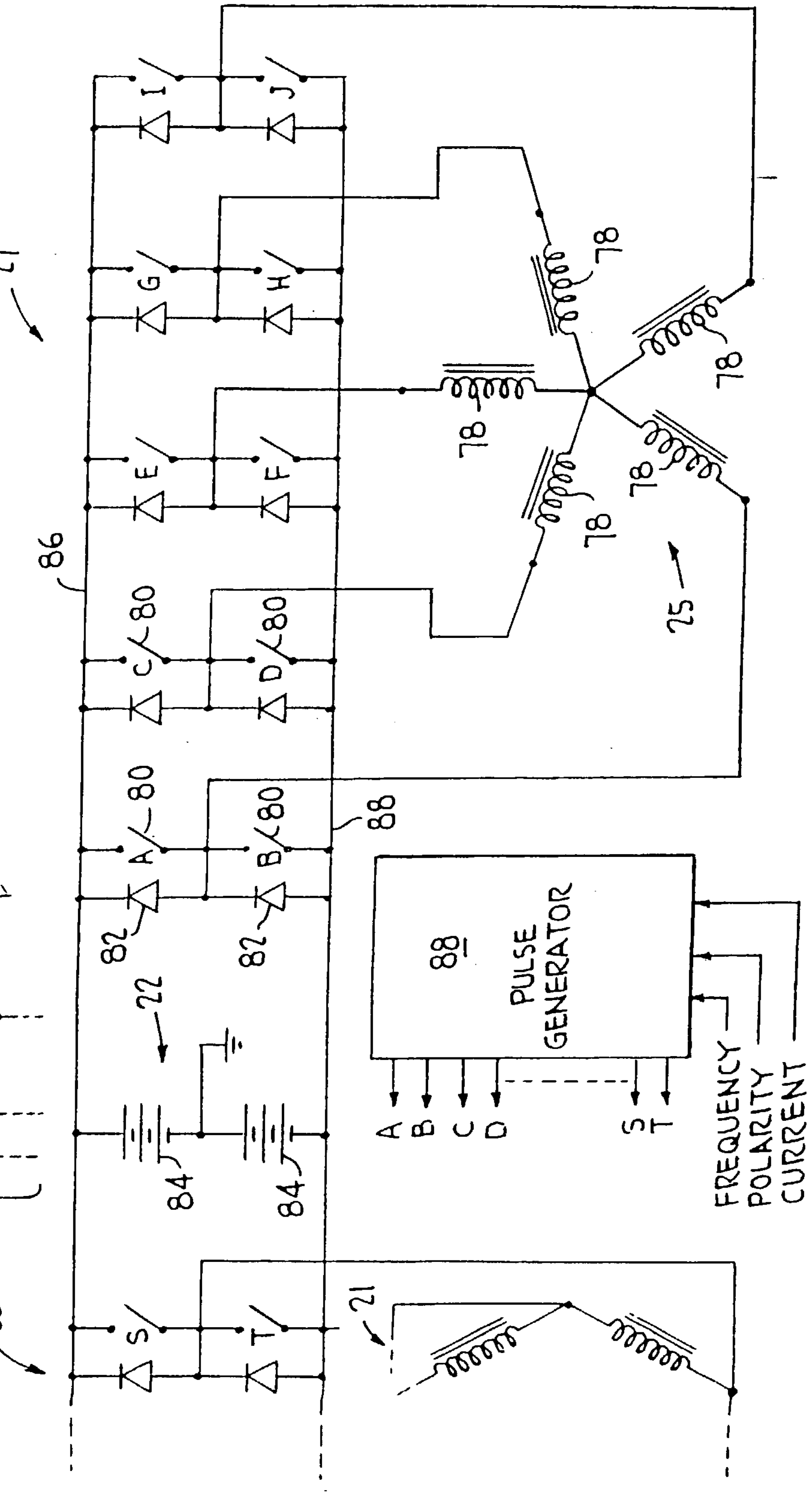


FIG. 5
27
86
88
80
80
80
80
82
82
22
84
84
23
21
A
B
C
D
E
F
G
H
I
J
S
T
78
78
78
78
78
78
25
88
PULSE GENERATOR
A
B
C
D
S
T
FREQUENCY
POLARITY
CURRENT

FIG. 6

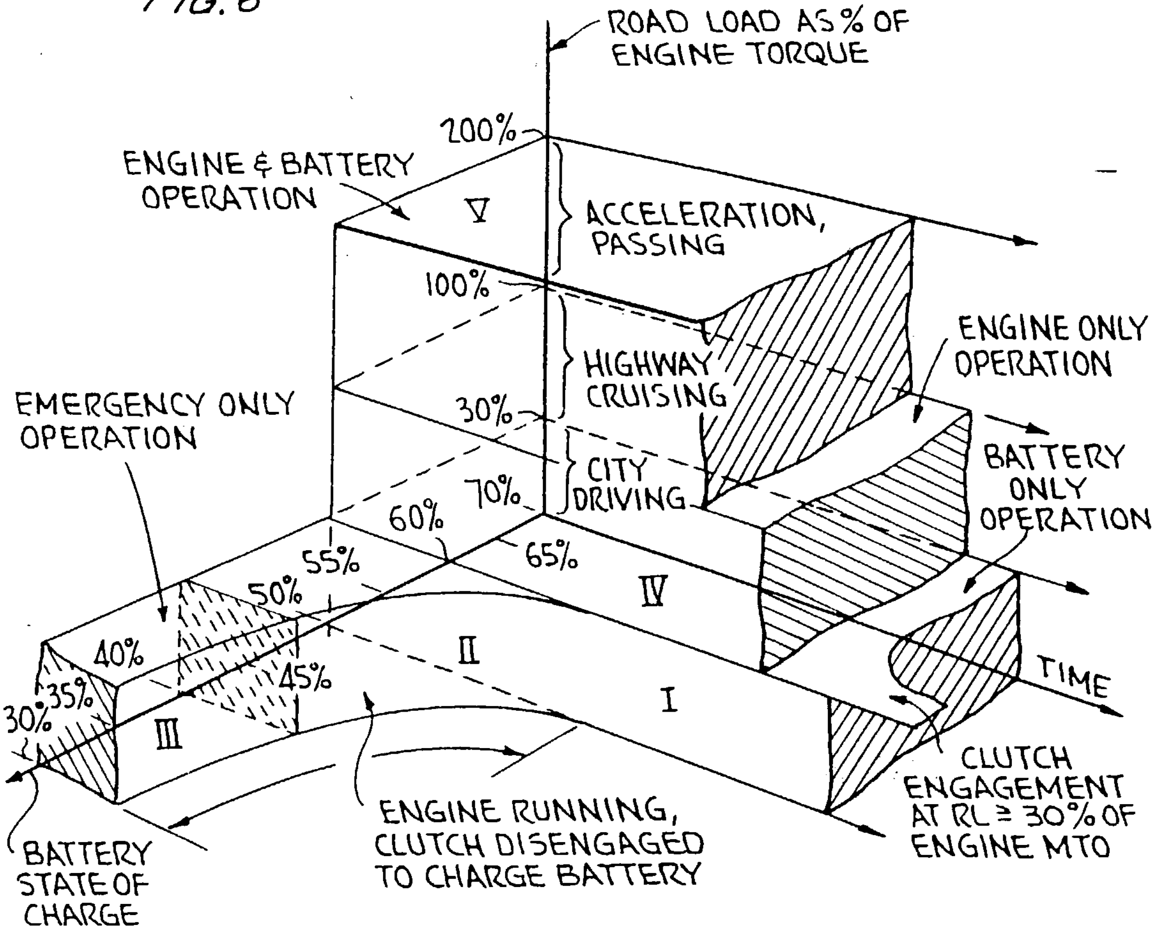
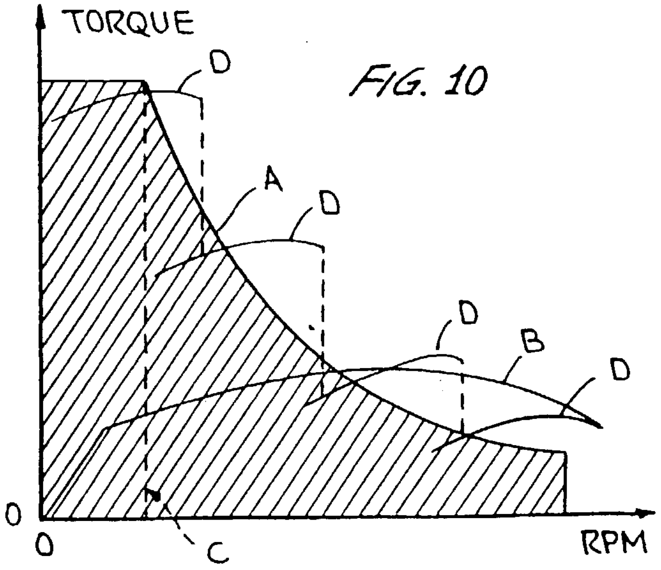

ROAD LOAD AS % OF ENGINE TORQUE
200%
ENGINE & BATTERY OPERATION
V
ACCELERATION, PASSING
100%
HIGHWAY CRUISING
30%
CITY DRIVING
ENGINE ONLY OPERATION
BATTERY ONLY OPERATION
EMERGENCY ONLY OPERATION
70%
60%
65%
55%
50%
40%
35%
30%
45%
IV
II
I
III
TIME
CLUTCH ENGAGEMENT AT RL ≥ 30% OF ENGINE MTO
ENGINE RUNNING, CLUTCH DISENGAGED TO CHARGE BATTERY
BATTERY STATE OF CHARGE

FIG. 10


TORQUE
D
A
D
D
B
D
0
0
C
RPM

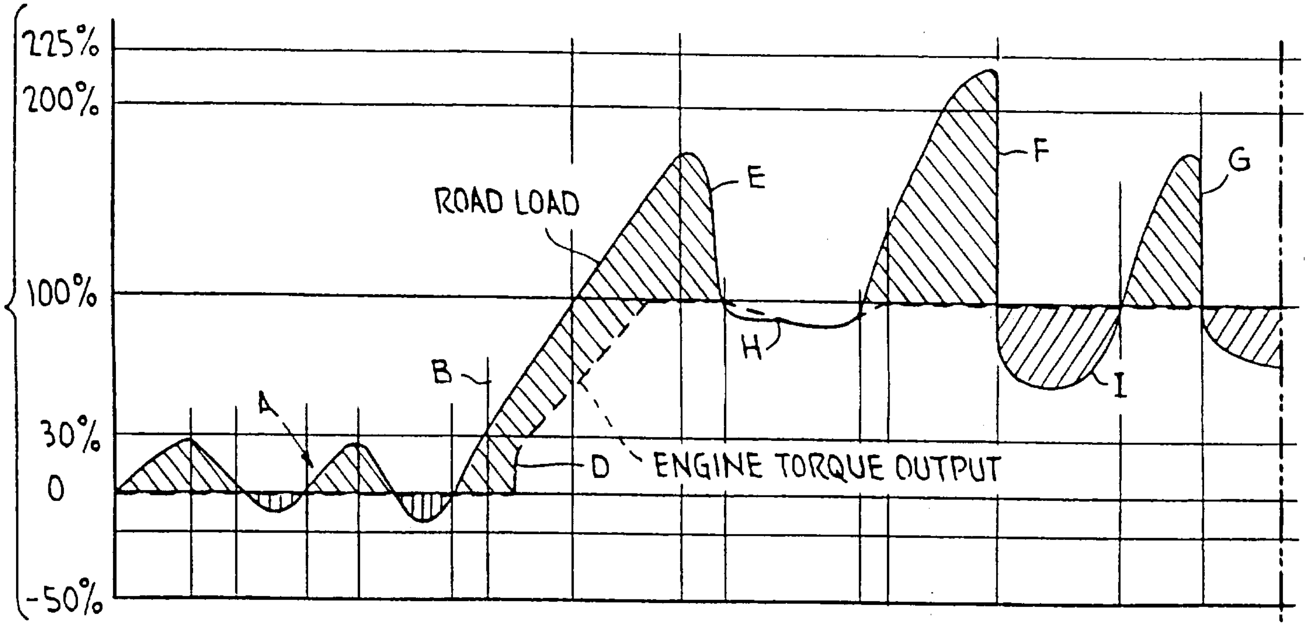


FIG. 7(a)

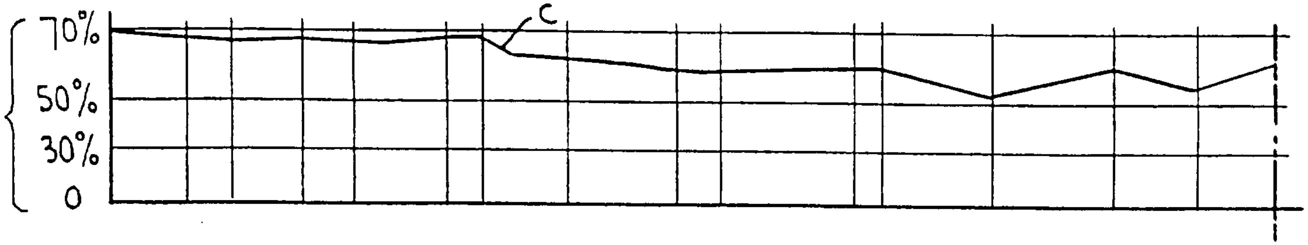


FIG. 7(b)

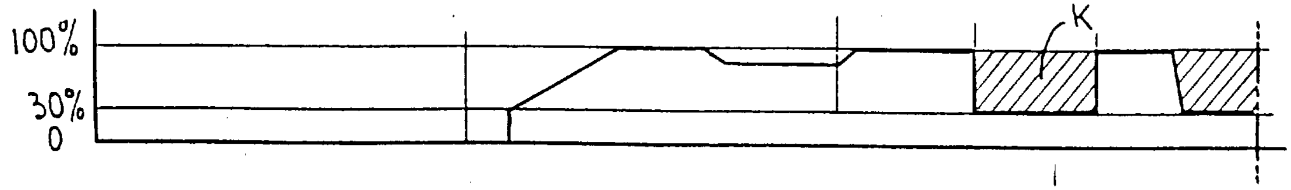


FIG. 7(c)

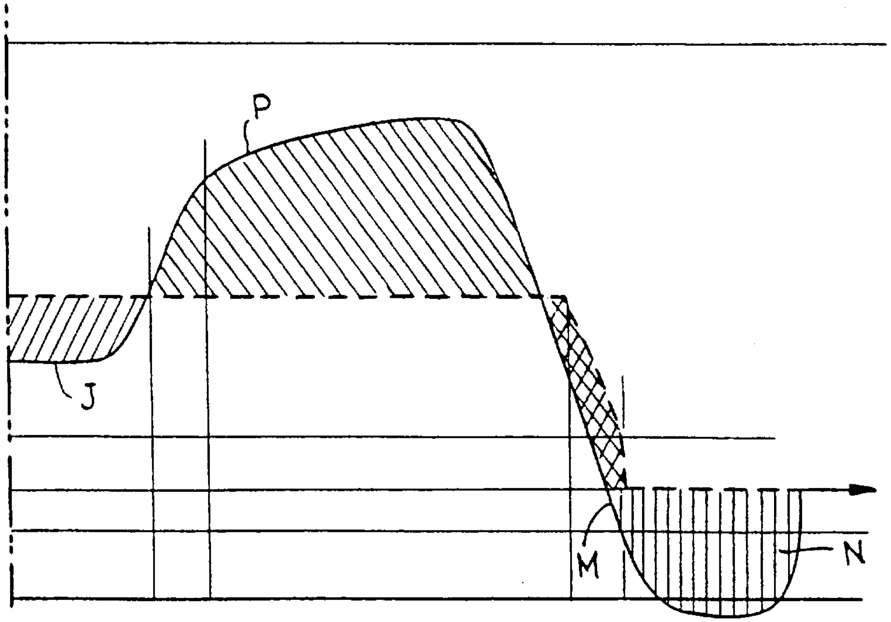


FIG. 7(a)
CONTINUED)

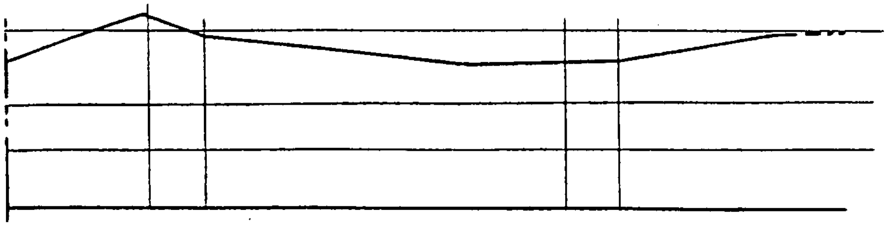


FIG. 7(b)
(CONTINUED)

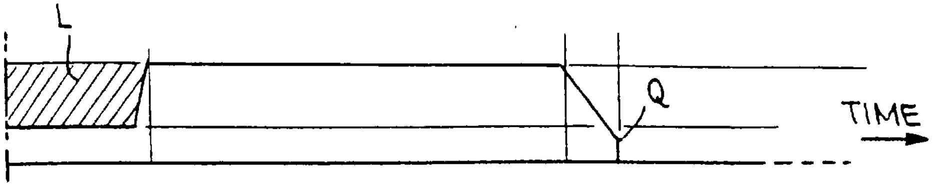


FIG. 7(c)
(CONTINUED)

FIG. 8(a)

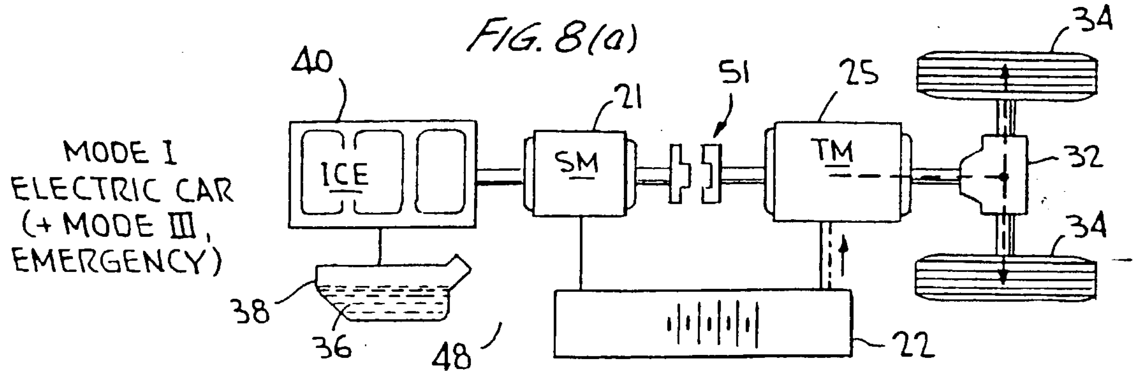


FIG. 8(b)

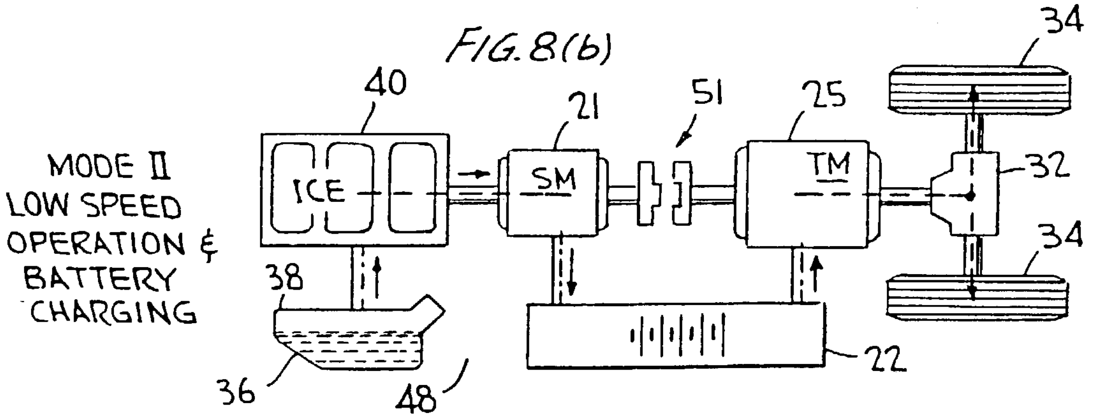


FIG. 8(c)

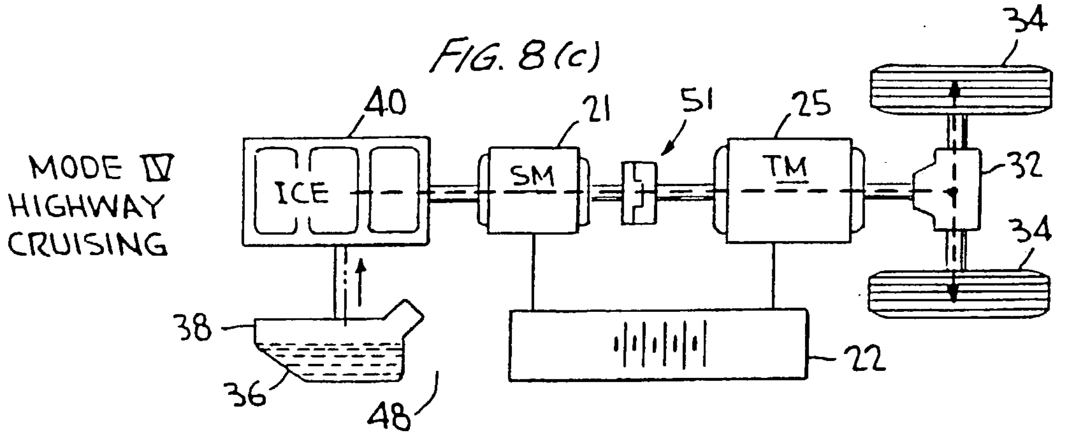


FIG. 8(d)

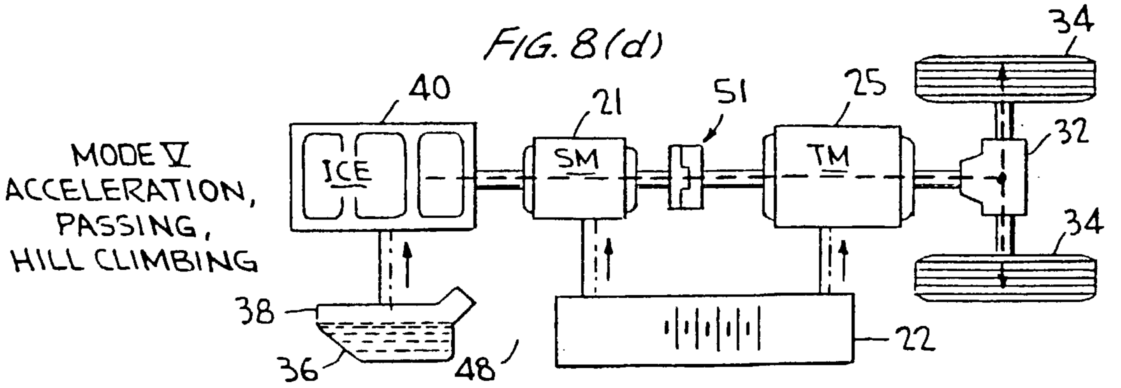


FIG. 9

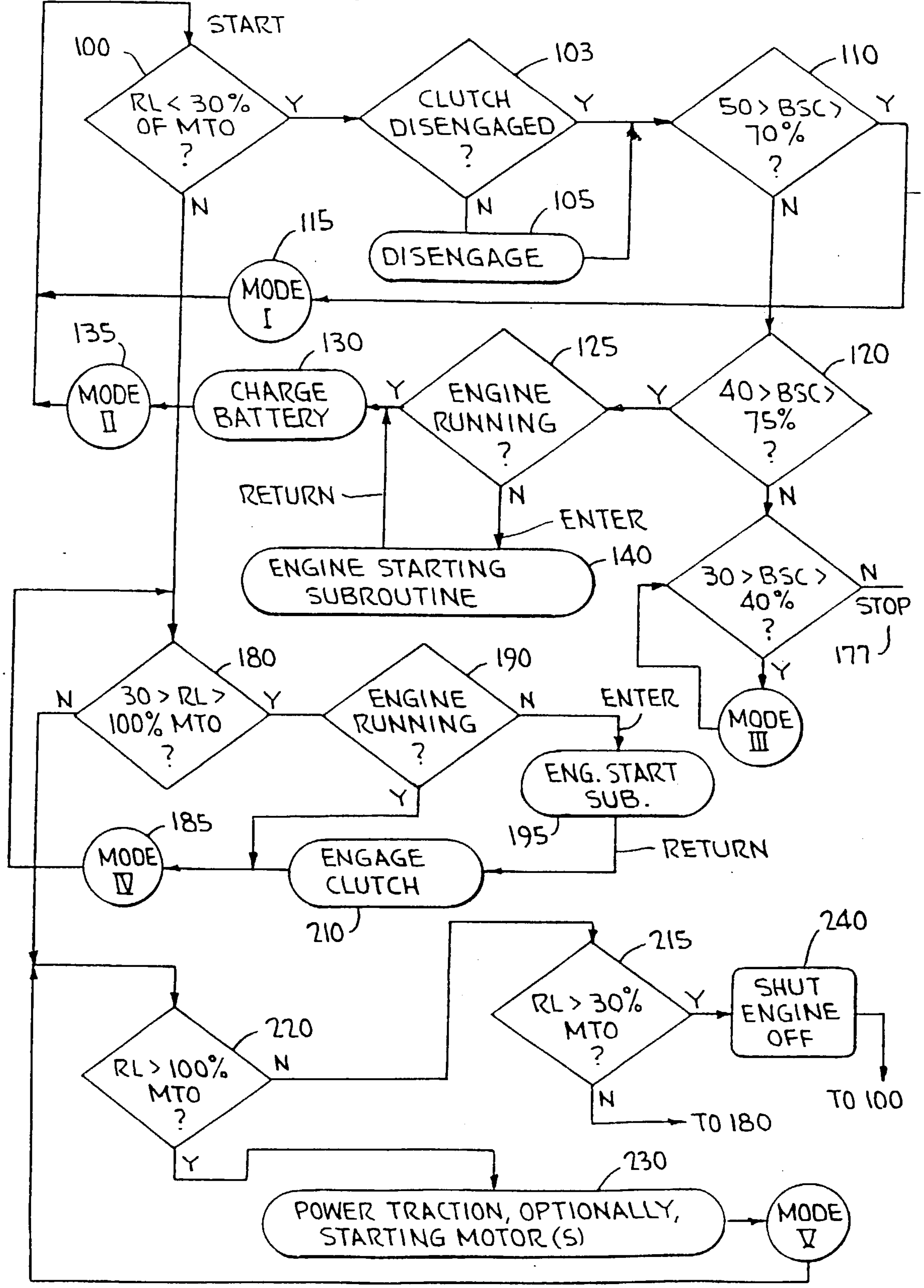

START
100
RL < 30% OF MTO ?
Y
N
103
CLUTCH DISENGAGED ?
Y
N
105
DISENGAGE
110
50 > BSC > 70% ?
Y
N
115
MODE I
135
MODE II
130
CHARGE BATTERY
Y
125
ENGINE RUNNING ?
N
Y
120
40 > BSC > 75% ?
N
RETURN
ENTER
ENGINE STARTING SUBROUTINE
140
30 > BSC > 40% ?
N
STOP
177
Y
MODE III
180
N
30 > RL > 100% MTO ?
Y
190
ENGINE RUNNING ?
N
ENTER
ENG. START SUB.
195
Y
185
MODE IV
ENGAGE CLUTCH
RETURN
210
240
215
RL > 30% MTO ?
Y
SHUT ENGINE OFF
TO 100
N
TO 180
220
RL > 100% MTO ?
N
Y
230
POWER TRACTION, OPTIONALLY, STARTING MOTOR(S)
MODE V

FIG. 9(a)

ENGINE STARTING SUBROUTINE

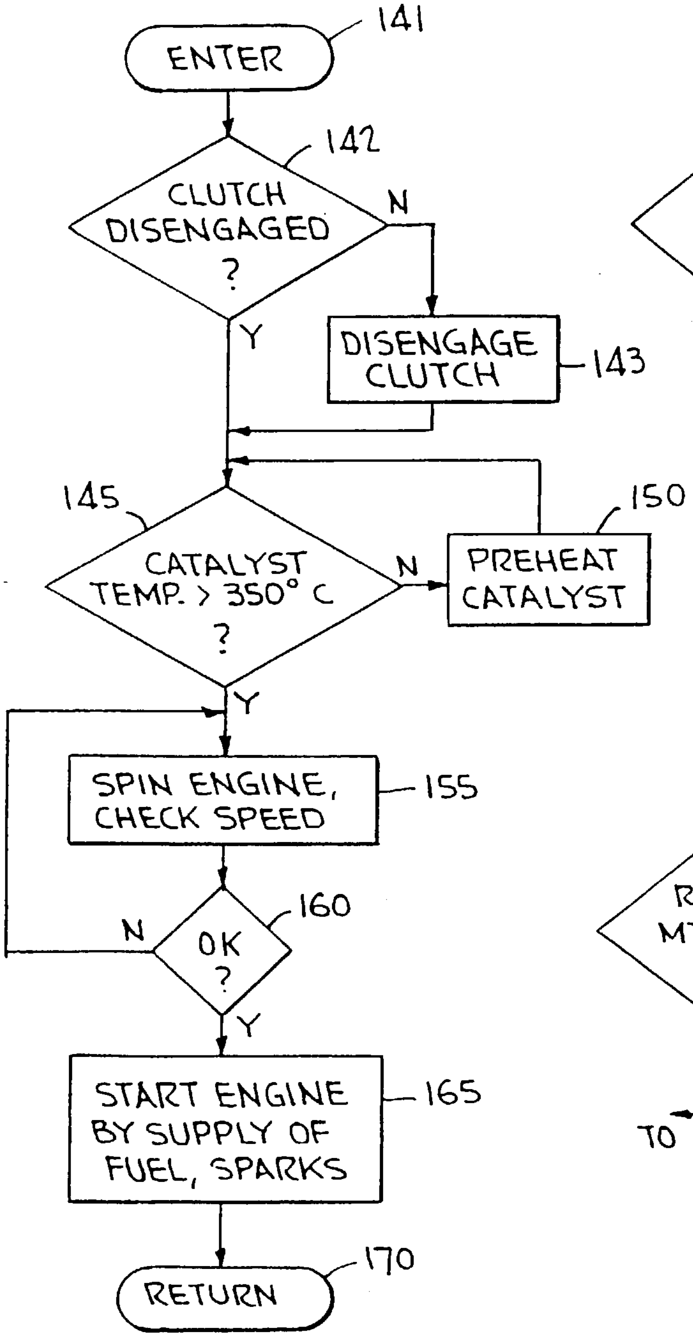


FIG. 9(b)

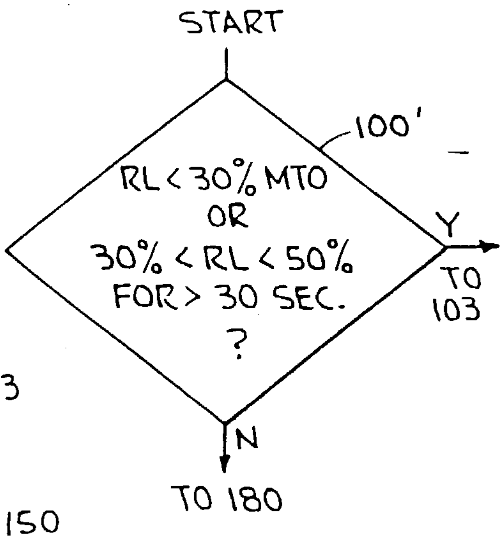
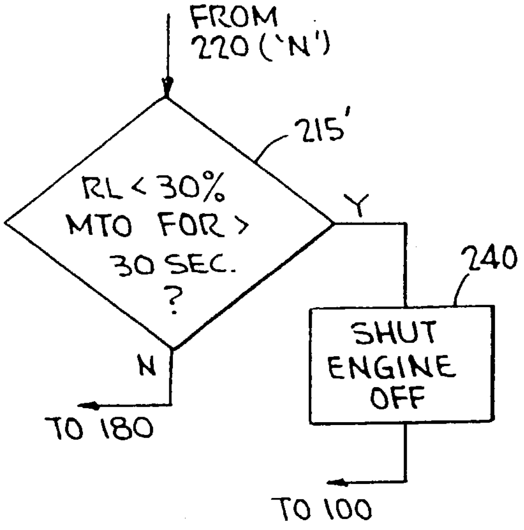


FIG. 9(c)



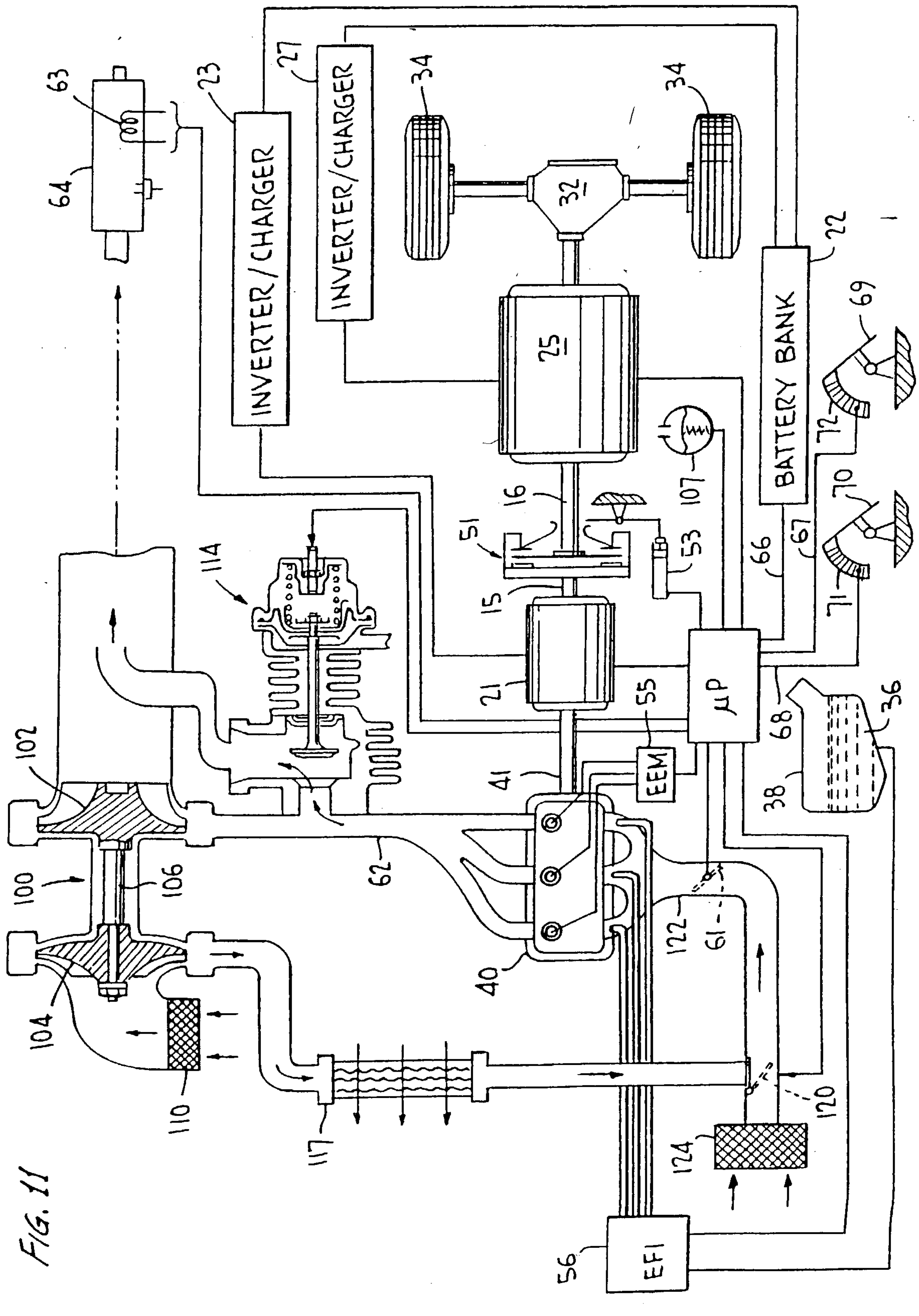

63
64
23
27
INVERTER/CHARGER
INVERTER/CHARGER
34
34
32
22
25
BATTERY BANK
69
72
70
107
16
51
53
15
66
67
71
114
21
55
μP
68
36
38
102
EEM
41
100
106
62
122
61
40
104
110
117
124
120
56
EFI

FIG. 11

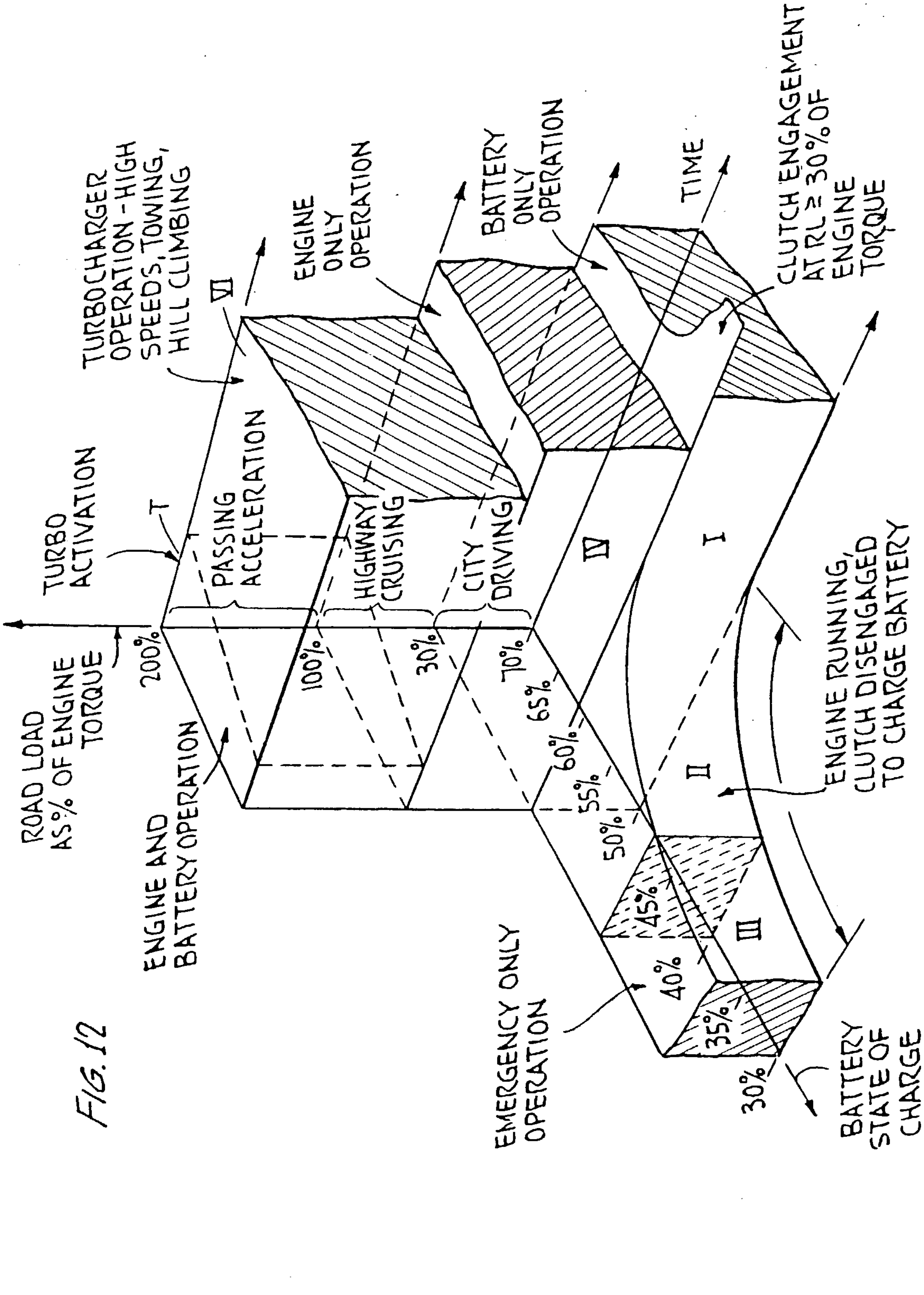


FIG. 12

ROAD LOAD AS% OF ENGINE TORQUE
ENGINE AND BATTERY OPERATION
TURBO ACTIVATION
T
TURBOCHARGER OPERATION - HIGH SPEEDS, TOWING, HILL CLIMBING
VI
PASSING ACCELERATION
HIGHWAY CRUISING
CITY DRIVING
ENGINE ONLY OPERATION
BATTERY ONLY OPERATION
TIME
CLUTCH ENGAGEMENT AT RL ≥ 30% OF ENGINE TORQUE
200%
100%
30%
70%
65%
60%
55%
50%
45%
40%
35%
30%
IV
I
II
III
EMERGENCY ONLY OPERATION
ENGINE RUNNING, CLUTCH DISENGAGED TO CHARGE BATTERY
BATTERY STATE OF CHARGE

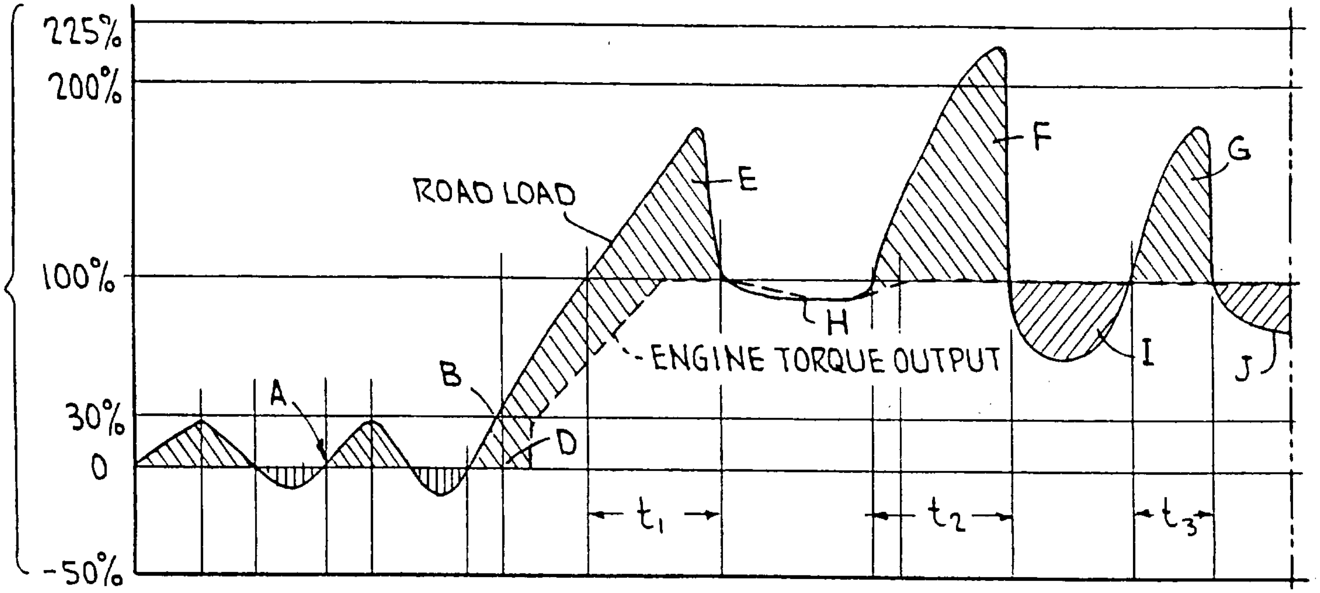


FIG. 13(a)
ROAD LOAD AS% OF ENGINE'S MAX. TORQUE (NORMALLY ASPIRATED)

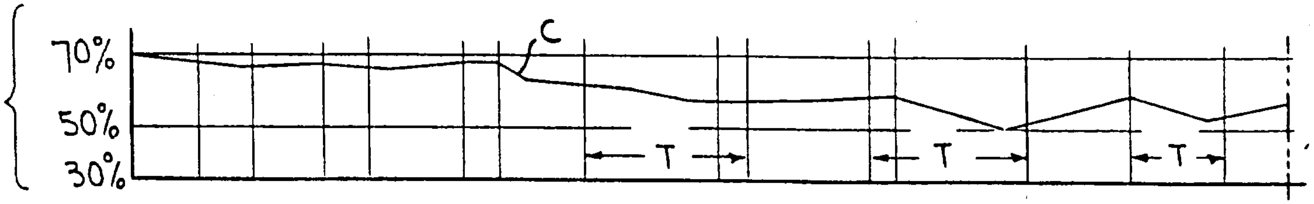


FIG. 13(b)
BATTERY STATE OF CHARGE

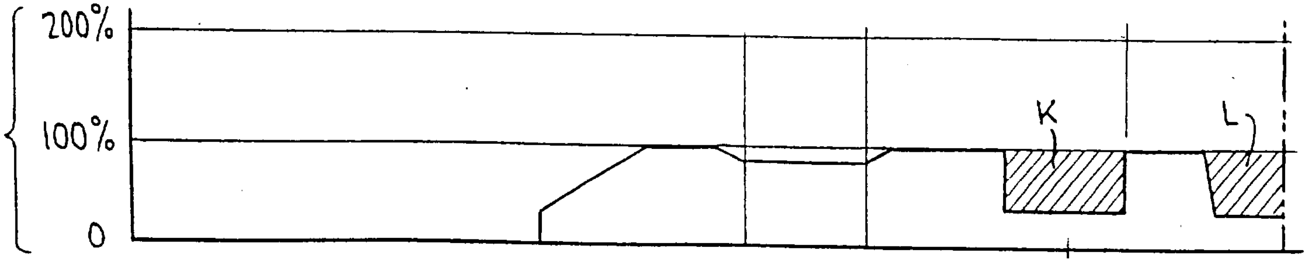


FIG. 13(c)
ENGINE + TURBO-CHARGER OPERATION

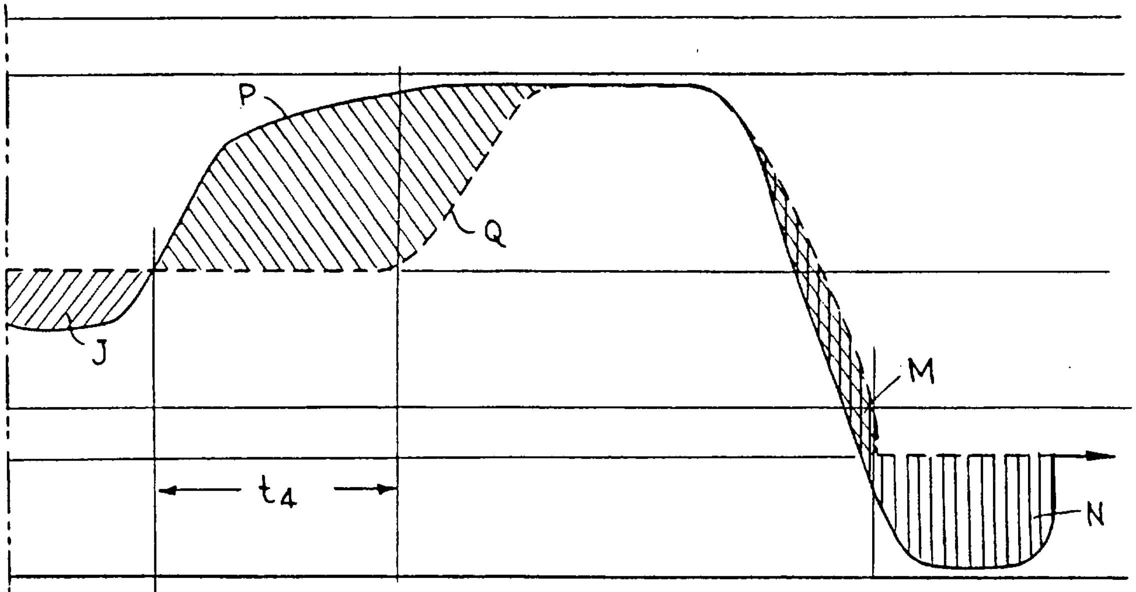


FIG. 13(a)
(CONTINUED)

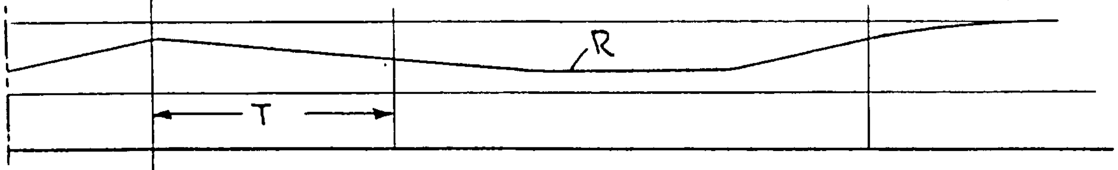


FIG. 13(b)
(CONTINUED)

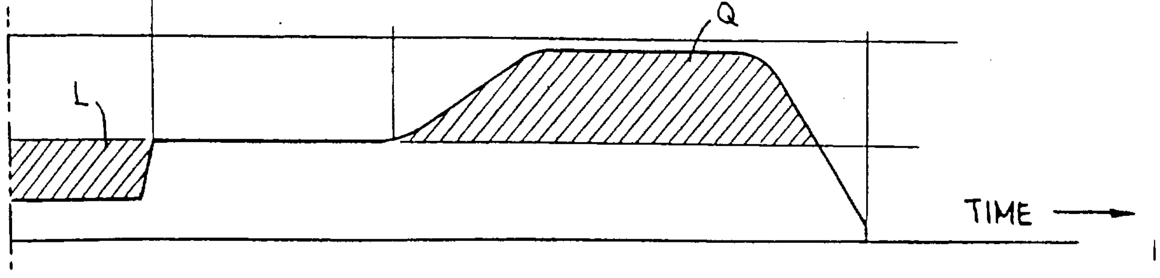


FIG. 13(c)
(CONTINUED)

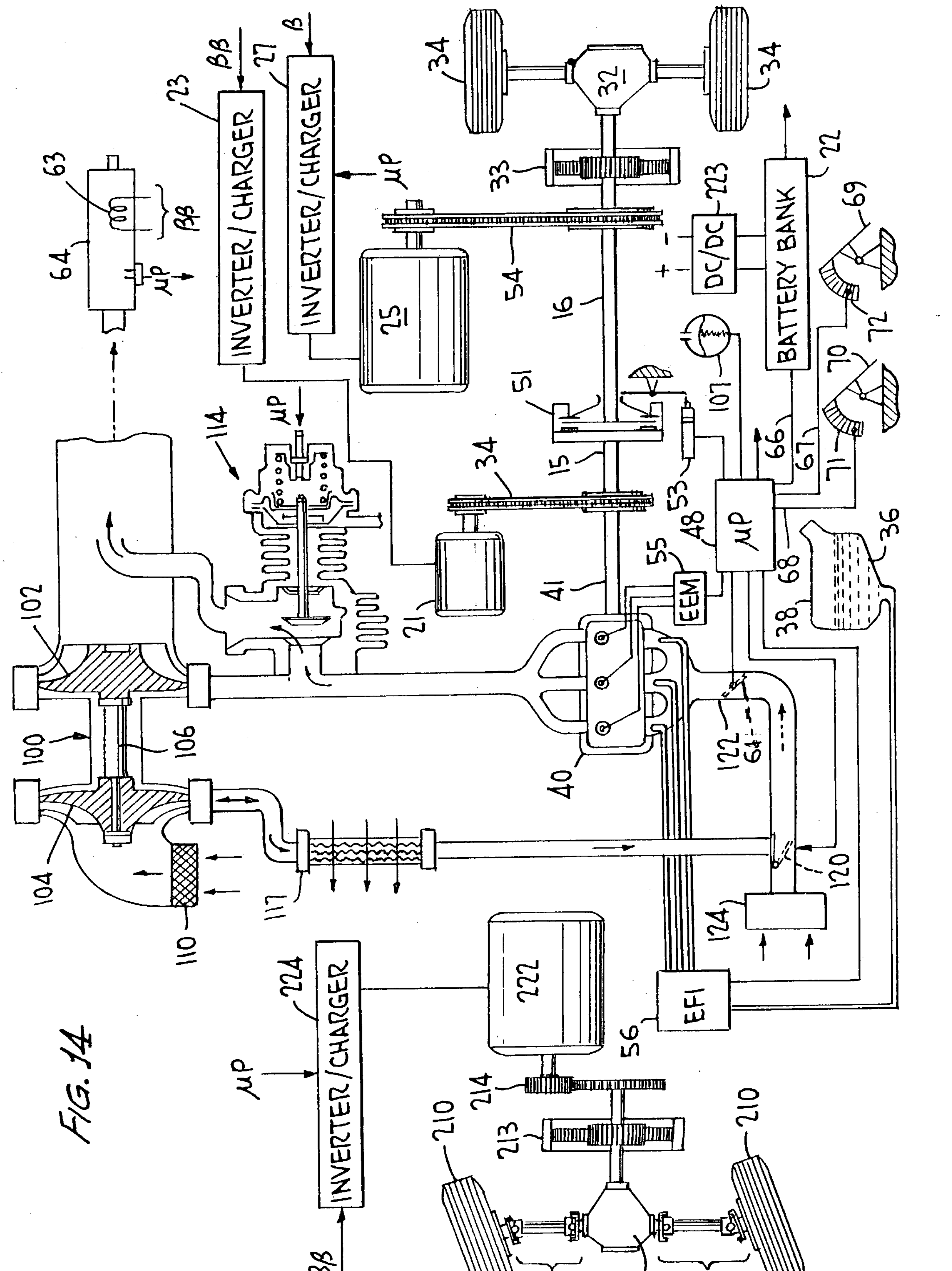

63
64
BB
μP
23
27
B
INVERTER/CHARGER
INVERTER/CHARGER
μP
25
54
16
33
32
34
34
22
223
DC/DC
+
-
BATTERY BANK
69
72
70
71
107
51
15
34
53
48
μP
66
67
68
36
38
55
EEM
41
21
114
μP
102
100
106
104
110
117
40
122
64
120
124
222
224
INVERTER/CHARGER
μP
BB
EFI
56
214
213
210
210
211
212
212

FIG. 14

FIG. 15

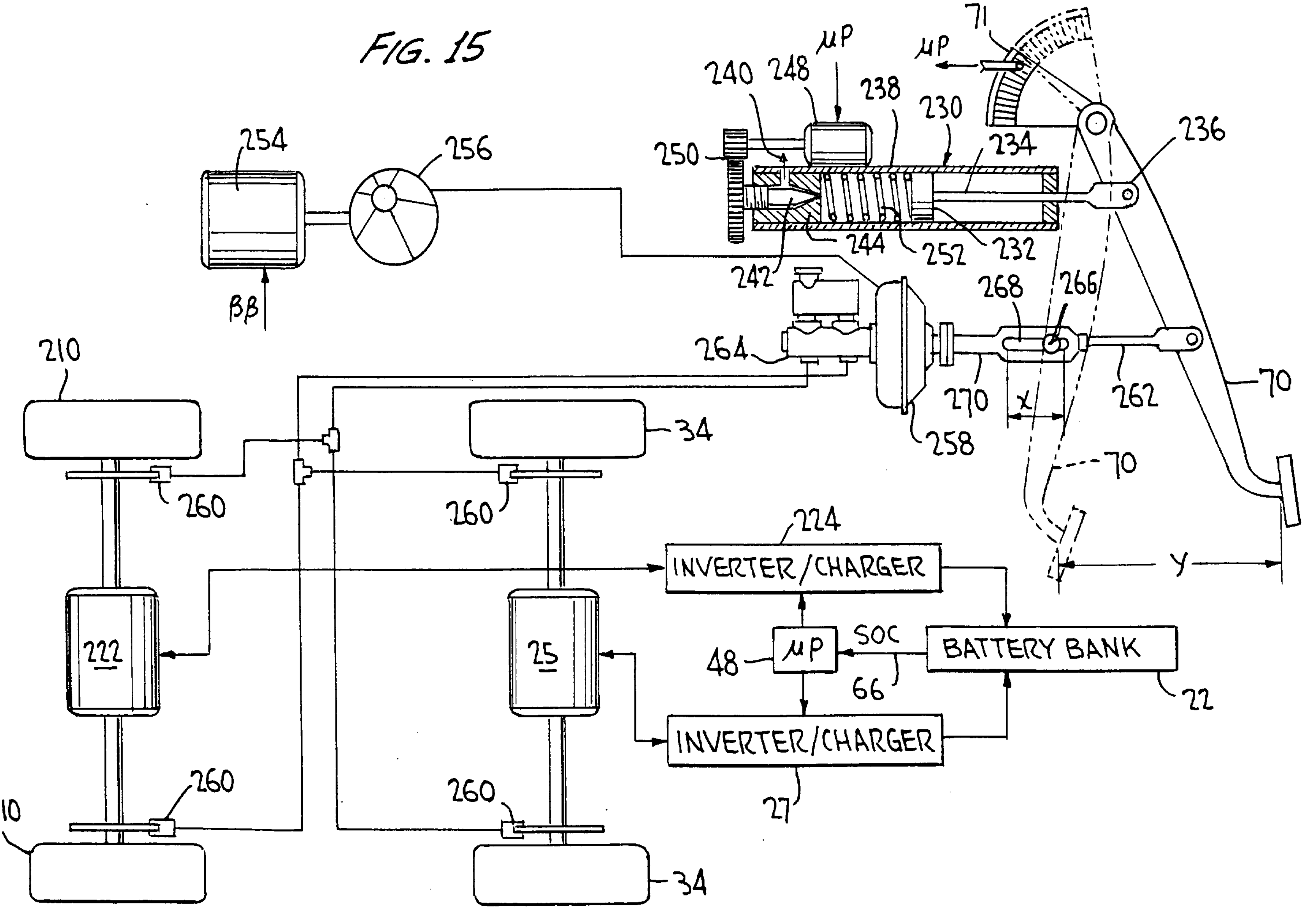
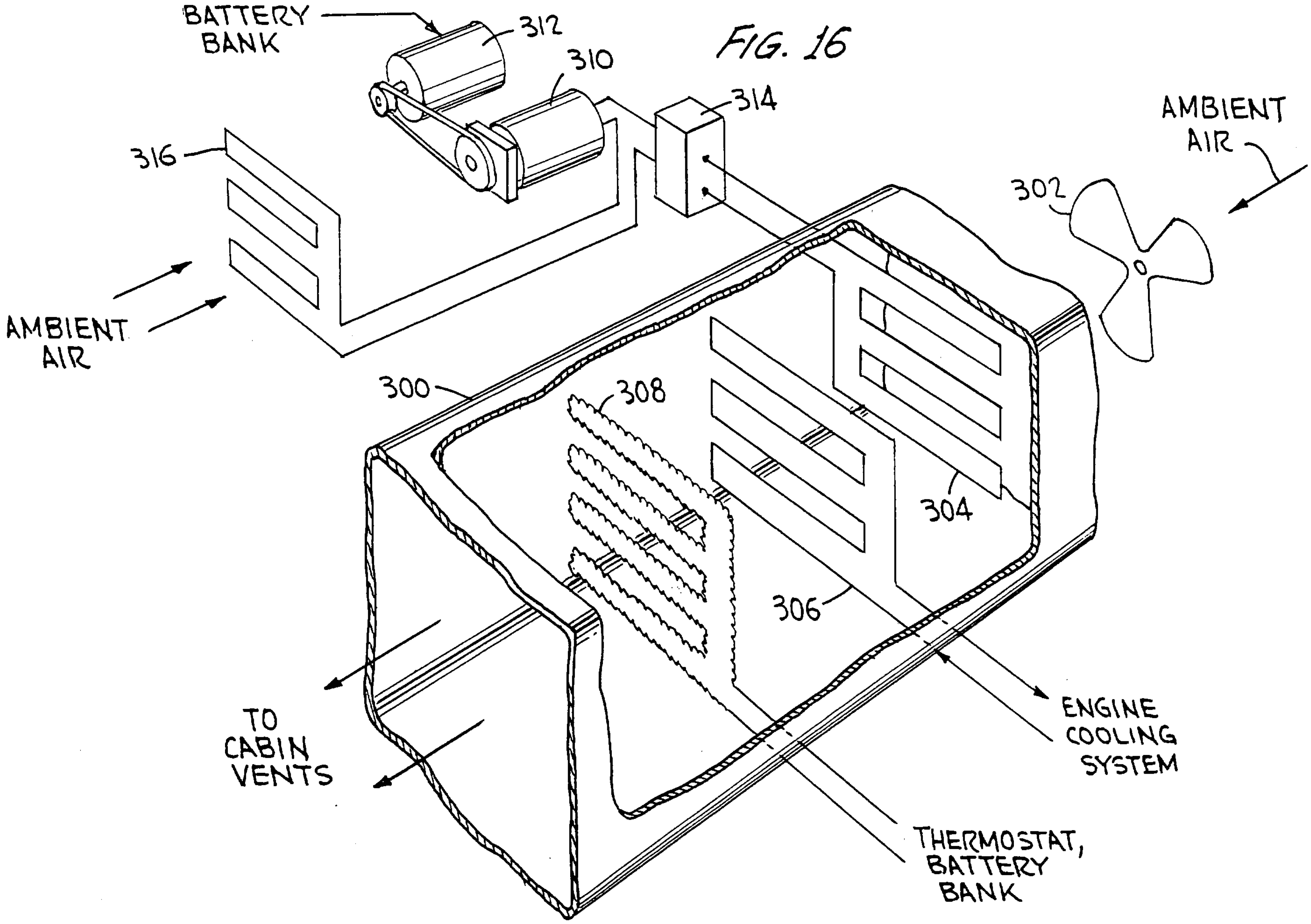

71
μP
μP
240
248
238
230
234
236
250
254
256
244
252
232
242
ββ
268
266
264
262
70
270
x
258
70
210
34
260
260
224
INVERTER/CHARGER
Y
222
25
48
μP
SOC
66
BATTERY BANK
22
INVERTER/CHARGER
27
260
260
210
34

FIG. 16


BATTERY BANK
312
310
314
316
AMBIENT AIR
302
AMBIENT AIR
300
308
304
306
TO CABIN VENTS
ENGINE COOLING SYSTEM
THERMOSTAT, BATTERY BANK

PATENT APPLICATION SERIAL NO. 10/382577

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

03/12/2003 MAHMED1 00000009 10382577
01 FC:1001 750.00 OP

PTO-1556
(5/87)

0, 14, 16

PATENT APPLICATION FEE DETERMINATION RECORD
Effective January 1, 2003

Application or Docket Number

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	7	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	7 minus 20=	* 0
INDEPENDENT CLAIMS	3 minus 3 =	* 0
MULTIPLE DEPENDENT CLAIM PRESENT	☐	

* If the difference in column 1 is less than zero, enter "0" in column 2

SMALL ENTITY TYPE ☐ OR OTHER THAN SMALL ENTITY

RATE	FEE		RATE	FEE
BASIC FEE	$375	OR	BASIC FEE	$750
X$ 9=		OR	X$18=	—
X42=		OR	X84=	—
+140=		OR	+280=	—
TOTAL		OR	TOTAL	750

CLAIMS AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	* 7	Minus	** 20	= /
Independent	* 3	Minus	*** 3	= /
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY OR OTHER THAN SMALL ENTITY

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	/
X42=		OR	X84=	/
+140=		OR	+280=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	* 65	Minus	** 20	= 45
Independent	* 8	Minus	*** 3	= 5
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	45 X$18=	810
X42=		OR	5 X84=	420
+140=		OR	+280=	[illegible]
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	* 126	Minus	** 65	= 61
Independent	* 11	Minus	*** 8	= 3
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	1098.00
X42=		OR	X84=	252.00
+140=		OR	+280=	/
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	1350.00

* 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.

FORM PTO-875 (Rev. 1/03)

Patent and Trademark Office U.S. DEPARTMENT OF COMMERCE

CLAIMS ONLY	**SERIAL NO.**	**FILING DATE**
	APPLICANT(S)	

CLAIMS

	AS FILED		**AFTER 1ST AMENDMENT**		**AFTER 2ND AMENDMENT**								
	IND	**DEP**	**IND**	**DEP**	**IND**	**DEP**		**IND**	**DEP**	**IND**	**DEP**	**IND**	**DEP**
1							51						
2							52						
3							53						
4							54						
5							55						
6							56						
7							57						
8							58						
9							59						
10	✓		✓				60						
11		✓		✓			61						
12		✓		✓			62						
13		✓		✓			63						
14	✓		✓				64						
15		✓		✓			65						
16	✓		✓				66						
17							67						
18							68						
19							69						
20							70						
21							71						
22							72						
23							73						
24							74						
25							75						
26							76						
27							77						
28							78						
29							79						
30							80						
31							81						
32							82						
33							83						
34							84						
35							85						
36							86						
37							87						
38							88						
39							89						
40							90						
41							91						
42							92						
43							93						
44							94						
45							95						
46							96						
47							97						
48							98						
49							99						
50							100						
TOTAL IND.	3		3				TOTAL IND.						
TOTAL DEP.	4		4				TOTAL DEP.						
TOTAL CLAIMS	7		7				TOTAL CLAIMS						

JC498 U.S. PTO
10/382577
03/07/03

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,

Michael de Angeli
Reg. No. 27,869
Suite 330
1901 Research Blvd.
Rockville, MD 20850
(301) 217-9585

#4 IDS

JC498 U.S. PTO
10/382577
03/07/03

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of :

Severinsky et al : Examiner: N/A

Serial No.: N/A : Group Art Unit: N/A

Filed: Herewith : Att. Dkt.: PAICE201.DIV

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

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

JC498 U.S. PTO
10/382577
03/07/03

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: 3619
Filed: April 2, 2001 : Att. Dkt.: PAICE201
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,

7/8/02
Dated

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER ANA201	APPLICATION NUMBER 09/822,866
	APPLICANT Severinsky et al	
	FILING DATE April 2, 2001	GROUP ART UNIT 3619

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
	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			
	6074321	6/2000	Maeda et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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	APPLICATION NUMBER 09/822,866
	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
	Re36678	5/2000	Moroto et al			
	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	DATE CONSIDERED

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Jc498 U.S. PTO
10/382577
03/07/03

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

Examiner: David Dunn
Group Art Unit: 3616
Att. Dkt.: PAICE201

For: Hybrid Vehicles

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

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JC498 U.S. PTO
10/382577
03/07/03

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201	APPLICATION NUMBER 09/822,866	
	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
	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			
	6059064	05/2000	Nagano et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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.

Jc498 U.S. PTO
10/382577
03/07/03

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

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JC498 U.S. PTO
10/382577
03/07/03

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201	APPLICATION NUMBER 09/822,866	
	APPLICANT Severinsky et al		
	FILING DATE 4/2/01	GROUP ART UNIT 3616	

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	NO
	63 8 2 2 8 3	6/1988	Japan				
	06 1 4 4 0 2 0	11/1992	Japan				
	06 0 8 0 0 4 8	11/1992	Japan				
	55 0 6 9 7 2 4	11/1978	Japan				
	04 2 7 4 9 2 6	2/1991	Japan				

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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.

JC498 U.S. PTO
10/382577
03/07/03

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
	5343970	9/94	Severinsky	180	65.2	
	5492192	2/96	Brooks et al			
	3566717	3/71	Berman et al			
	3732751	5/93	Berman et al			
	4165795	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			
	4305254	12/81	Kawakatsu			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO
	1905641	6/76	Germany			X	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Simanaitis, "Electric Vehicles", *Road & Track*, May 1992, pp. 126-136

Reynolds, "AC Propulsion CRX", *Road & Track*, Oct. 1992, pp. 126-129

Kalberlah, "Electric Hybrid Drive Systems...", SAE Paper No. 910247, 1991

Bullock, "The Technological Constraints of Mass,Volume, Dynamic Power Range and Energy Capacity..." SAE Paper No. 891659 1989

Electric and Hybrid Vehicle Technology, vol. SP-915, SAE, Feb. 1992

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.

Page 1 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
	4407132	10/83	Kawakatsu			
	4335429	6/82	Kawakatsu			
	4180138	12/19	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			
	4095664	6/78	Bray			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Wouk, "Hybrids: Then and Now", IEEE Spectrum, Vol. 32, 7, July 1995

Bates, "Getting a Ford HEV on...", IEEE Spectrum, Vol. 32, 7, July 1995

King et al, "Transit Bus takes...", IEEE Spectrum, Vol. 32, 7, July 1995

Yamaguchi, "Toyota readies gasoline/electric hybrid system", Automotive Engineering, July 1997, pp. 55-58

Wilson, "Not Electric, Not Gasoline..." Autoweek, June 2, 1997, pp. 17-18

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.

Page 2 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
	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	8/72	Yardney			
	3837419	9/74	Nakamura			
	3874472	4/75	Deane			
	4042056	8/77	Horwinski			
	4562894	1/86	Yang			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Bulgin, "The Future Works, Quietly", Autoweek, Feb. 23, 1998 pp. 12-13

"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	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	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
	4611466	9/86	Keedy			
	4815334	8/89	Lexen			
	3623568	11/71	Mori			
	3454122	8/69	Grady, Jr.			
	3211249	10/65	Papst			
	2666492	1/54	Nims et al			
	3502165	3/70	Matsukata			
	1824014	9/31	Froelich			
	3888325	10/75	Reinbeck			
	4578955	4/86	Medina			
	4765656	8/88	Weaver			
	4439989	4/84	Yamakawa			
	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	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.

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
	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			
	5558588	9/96	Schmidt			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	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 09/822,866
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
	5558595	10/96	Schmidt et al			
	5980077	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			
	5433282	7/95	Moroto et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER	DATE CONSIDERED

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	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
	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	Jenneret			
	5492189	2/96	Kreigler et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER	DATE CONSIDERED

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	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
	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.			
	4442285	4/84	Stewart et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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
	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			
	5713425	2/98	Buschhaus et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER	DATE CONSIDERED

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	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
	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			
	5566774	10/96	Yoshida			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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	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
	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			
	5463294	10/95	Valdivia			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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	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
	5562565	10/96	Moroto et al			
	5513719	6/96	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	Fattic et al			
	5643119	4/94	Yamaguchi et al			
	5644200	4/94	Yang			
	5489001	2/96	Yang			
	5653302	8/94	Edye et al			
	5350031	4/94	Sugiyama et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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
	5345761	4/94	King			
	5337848	8/94	Bader			
	5327992	4/94	Boll			
	5589743	12/96	King			
	5345154	9/94	King			
	4862009	8/89	King			
	5372213	12/94	Hasebe et al			
	5495912	5/96	Gray, Jr., et al			
	5588498	12/96	Kitada			
	5492189	2/96	Kriegler			
	5193634	3/93	Masut			
	5125469	6/92	Scott			
	4511012	4/85	Rauneker			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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.

Page 13 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
	4631456	12/86	Drescher			
	4680986	7/87	Elsner			
	4953646	9/90	Kim			
	5927417	7/99	Brunner	180	65.6	
	6048289	4/00	Hattori	477	15	
	6026921	2/00	Aoyama	180	65.2	
	6053842	4/00	Kitada	477	5	
	5767637	6/98	Lansberry			
	5934395	8/99	Koide et al			
	5969624	10/99	Sakai et al			
	5986376	11/99	Werson			
	6018198	1/00	Tsuzuki et al			
	6054844	4/00	Frank			

FOREIGN PATENT DOCUMENTS

	Document Number	Date	Country	Class	Subclass	Translation	
						Yes	No

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER

DATE CONSIDERED

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	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
	6059059	9/94	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			
	5327992	7/94	Boll			
	5249637	10/93	Heidl et al			
	5495906	3/96	Furutani			
	6018694	1/00	Egami et al			
	6209672	4/01	Severinsky			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER	DATE CONSIDERED

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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

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	

*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

UNITED STATES
PATENT AND
TRADEMARK OFFICE

Commissioner for Patents
Washington, DC 20231
www.uspto.gov

APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
10/382,577	03/07/2003	Alex J. Severinsky	PAICE201.DIV

Michael de Angeli
60 Intrepid Lane
Jamestown, RI 02835

CONFIRMATION NO. 9389

FORMALITIES LETTER

OC000000009913491

Date Mailed: 04/25/2003

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The oath or declaration is missing.
  A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.
- To avoid abandonment, a late filing fee or oath or declaration surcharge as set forth in 37 CFR 1.16(e) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$130** for a Large Entity

- **$130** Late oath or declaration Surcharge.

A copy of this notice MUST be returned with the reply.

YG

Customer Service Center
Initial Patent Examination Division (703) 308-1202

PART 3 - OFFICE COPY

OIPE JC139
JUN 17 2003
PATENT & TRADEMARK OFFICE

#3

MP

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

RESPONSE TO NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

Dear Sir:

In response to the Notice to File Missing Parts of Nonprovisional Application mailed in this application on April 25, 2003 (copy enclosed), indicating that the oath or declaration is missing, and requesting a surcharge, please note that this application is a divisional of Ser. No. 09/822,866, now Patent 6,544,088. As such, under 37 CFR § 1.63 (d) no new oath or declaration referring to this application per se is required; a copy of the declaration filed in the parent is enclosed, as is a check for the $130 surcharge.

Examination of the application on the merits is respectfully requested.

Respectfully submitted,

6/12/03
Dated

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

OIPE JC139
JUN 17 2003
PATENT & TRADEMARK OFFICE

UNITED STATES
PATENT AND
TRADEMARK OFFICE

Commissioner for Patents
Washington, DC 20231
www.uspto.gov

APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
10/382,577	03/07/2003	Alex J. Severinsky	PAICE201.DIV

CONFIRMATION NO. 9389

FORMALITIES LETTER

OC000000009913491

Michael de Angeli
60 Intrepid Lane
Jamestown, RI 02835

Date Mailed: 04/25/2003

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The oath or declaration is missing.
  A properly signed oath or declaration in compliance with 37 CFR 1.63, identifying the application by the above Application Number and Filing Date, is required.
- To avoid abandonment, a late filing fee or oath or declaration surcharge as set forth in 37 CFR 1.16(e) of $130 for a non-small entity, must be submitted with the missing items identified in this letter.

SUMMARY OF FEES DUE:

Total additional fee(s) required for this application is **$130** for a Large Entity

- **$130** Late oath or declaration Surcharge.

A copy of this notice MUST be returned with the reply.

06/18/2003 WABDELR1 00000050 10382577
01 FC:1051 130.00 OP

Y.G.
Customer Service Center
Initial Patent Examination Division (703) 308-1202

PART 2 - COPY TO BE RETURNED WITH RESPONSE

OIPE JC139
JUN 17 2003
PATENT & TRADEMARK OFFICE

#3

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:
Hybrid Vehicles,
the specification of which
___ is attached hereto
X was filed on April 2, 2001 now assigned Application Serial No. 09/822,866 and was amended on ______________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified application, including the specification and claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119, of the international application for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed: NONE

Prior International Application(s)

(Number)	(Country)	(Day/Month/Yr.Filed)	Priority Claimed Yes	No

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application SN)	(Filing Date)	Status (patented, pending abandoned, converted)
09/264,817	3/9/99	Issued (6,209,672)
60/100,095	9/14/98	Converted
09/392,743	9/9/99	Pending
60/122,296	3/1/99	Converted

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

Michael de Angeli, Reg. No. 27,869

Send correspondence to: Michael de Angeli
1901 Research Blvd.
Suite 330
Rockville, MD 20850

Direct Telephone Calls to: (301) 217-9585

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first joint inventor: Alex J. Severinsky

Inventor's Signature Alex J. Severinsky Date 5/18/2001

Residence: Washington, DC Citizenship: US

Post Office Address: 4707 Foxhall Crescent, Washington, DC 20007

Full name of second joint inventor, if any: Theodore Louckes

Inventor's Signature Theodore A. Louckes Date 5/25/2001

Residence: Holly, MI Citizenship: US

Post Office Address: 10398 Appomatox, Holly, MI, 48442

OIPE JC141
AUG 18 2003
PATENT & TRADEMARK OFFICE

3616
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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

RECEIVED
AUG 21 2003
GROUP 3600

Hon. Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Transmitted herewith is an amendment in the above - identified application.

X A check for the additional claim fee of $1230 as calculated below is enclosed for this amendment.

X The Commissioner is hereby authorized to charge any underpayment (or to credit overpayment) to our Deposit Account No. 04-0401. A duplicate copy of this sheet is attached.

LARGE ENTITY

	TOTAL CLAIMS	CLAIMS PREVIOUSLY PAID FOR		PRESENT EXTRA		ADDITIONAL RATE	
TOTAL	65	20	=	45	Extra	x 18	$ 810.00
INDEP.	8	3	=	5	Extra	x 84	$420.00
						TOTAL:	$1230.00

Respectfully submitted,

Aug. 11, 2003
Dated

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OIPE JC141
AUG 1 8 2003
PATENT & TRADEMARK OFFICE

8/29/03

6/13

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

RECEIVED
AUG 2 1 2003
GROUP 3600

PRELIMINARY AMENDMENT

Sir:

Prior to examination, kindly amend the above-identified application as follows:

08/19/2003 SZEWDIE1 00000112 10382577

01 FC:1201	420.00 OP
02 FC:1202	810.00 OP

IN THE CLAIMS:

Claims 1 - 9 (previously cancelled)

Claims 10 - 15 (cancelled)

16. (Amended) A method for determining the relative sizes of the internal combustion engine, starting/charging and traction motors, and battery bank of a hybrid vehicle comprising said components, said method comprising the steps of:

a. selecting an internal combustion engine having sufficient torque to drive the vehicle [without trailer] at medium to high speed along a moderate grade;

b. sizing the starting/charging motor to provide an engine load during battery charging equal to at least approximately 30% of the engine's maximum torque output;

c. sizing the traction motor to provide adequate torque at zero speed to overcome the maximum grade specified from rest, with the starter motor assisting as needed;

d. determining the maximum power drawn by the selected motor(s) under full power conditions;

e. calculating the battery voltage under load that will be required to provide the power to be drawn by the motor(s) under full power conditions, and so that the ratio of the battery voltage under load to the peak current drawn by the motor(s) is at least [2.5:1] 2.5 : 1, and

f. selecting the battery bank to provide the calculated voltage under peak load conditions.

--17. (New) A method for controlling the operation of a hybrid vehicle having at least two pairs of road wheels, said vehicle being operable in a plurality of differing modes, said vehicle comprising an internal combustion engine for providing torque up to a maximum torque output (MTO), said internal combustion engine being controllably coupled to said road wheels of said vehicle by a clutch, a first electric motor being coupled to said internal combustion engine, a second electric motor coupled to said road wheels of said vehicle, said first and second electric motors being operable as generators, a battery bank for providing electrical energy to and accepting energy from said first and second electric motors, and a controller for controlling operation of said internal combustion engine, clutch, and first and second electric motors, and controlling flow of electrical energy between said first and second electric motors and said battery bank,

characterized in that according to said method, said controller controls said internal combustion engine, said first and second electric motors, and said clutch in order to control selection of the operational mode of said vehicle between at least a low-load mode I, a cruising mode IV, and an acceleration mode V, wherein torque to propel said vehicle is provided by one or both of said first and second electric motors, said internal combustion engine, and both said engine and one or both of said first and second electric motors, respectively, in response to monitoring the instantaneous torque requirements (RL) of the vehicle, which is the torque on the output drive shaft of said vehicle, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, whereby said vehicle is operated in a plurality of operating modes responsive to the value of RL, and so that said internal combustion engine is operated only when the output torque thereof is at least equal to a minimum value at which torque is efficiently produced.--

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--18. (New) The method of claim 17, wherein said controller controls said vehicle to operate in said low load mode I while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO, said highway cruising mode IV while SP < RL < 100% of MTO, and said acceleration mode V while RL > 100% of MTO.--

--19. (New) The method of claim 18, wherein said setpoint SP is at least approximately 30% of MTO.--

--20. (New) The method of claim 18, comprising the further step of disengaging said clutch during operation in mode I and engaging said clutch during operation in modes IV and V. --

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--21. (New) The method of claim 18, wherein said controller further controls said vehicle to operate in a low-speed battery charging mode II, entered while RL < SP and the state of charge of the battery bank is below a predetermined level, during which said vehicle is propelled by torque provided by said second motor in response to energy supplied from said battery bank, and wherein said battery bank is simultaneously charged by supply of electrical energy from said first motor, being driven by torque by said internal combustion engine in response to supply of combustible fuel, said clutch being disengaged during operation in mode II.--

--22. (New) The method of claim 18, comprising the further step of employing said controller to monitor patterns of vehicle operation over time and vary said setpoint SP accordingly.--

--23. (New) The method of claim 18, comprising the further step of employing said controller to monitor RL over time, and to control transition between operation in modes I and IV accordingly, such that said transition occurs only when RL > SP for at least a predetermined time, or when RL > SP2, wherein SP2 is a larger percentage of MTO than SP.--

--24. (New) The method of claim 18, comprising the further step of employing said controller to monitor RL over time, and to control transition from operation in mode IV to operation in mode I accordingly, such that said transition occurs only when RL < SP for at least a predetermined time.--

--25. (New) The method of claim 18, comprising the further step of operating said controller to monitor RL over time, and to control the operating mode to change from operation in mode I directly to operation in mode V where a rapid increase in RL as desired by the operator is detected.--

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--26. (New) The method of claim 18, comprising the further step of operating said controller to accept operator input of a desired cruising speed, said controller thereafter controlling the instantaneous engine torque output in accordance with variation in RL so as to maintain vehicle speed substantially constant, and to prevent transition to mode I operation until the operator provides a further signal indicative that the desired cruising speed is no longer desired.--

--27. (New) The method of claim 18, comprising the further step of performing regenerative charging of the battery bank under controller control when the engine's instantaneous torque output > RL, when RL is negative, or when braking is initiated by the operator.--

--28. (New) The method of claim 18, wherein said first and second electric motors are controlled together to provide maximum torque at least equal to the maximum torque of said internal combustion engine.--

--29. (New) The method of claim 18, wherein the maximum speed of at least said second motor is controlled to be at least 150% of the maximum speed of said internal combustion engine.--

--30. (New) The method of claim 18, wherein said hybrid vehicle further comprises a turbocharger being operatively and controllably coupled to said internal combustion engine for increasing the maximum torque output of said internal combustion engine to more than MTO when desired, and wherein according to said method, said controller controls selection of the operational mode of said vehicle between a low-load mode I, a cruising mode IV, an acceleration mode V, and a turbocharged mode VI, in response to monitoring the instantaneous torque requirements (RL) of the vehicle over time.--

--31. (New) The method of claim 30, wherein said controller controls said vehicle to operate in said modes as follows:
in said low load mode I while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO, in said highway cruising mode IV while SP < RL < 100% of MTO, in said acceleration mode V while RL > 100% of MTO for less than a predetermined time T, and in said sustained high-power mode VI while RL > 100% of MTO for more than a predetermined time T.--

--32. (New) The method of claim 30, wherein said time T is controlled responsive to the state of charge of the battery bank.--

--33. (New) A hybrid vehicle, comprising:

a controller capable of accepting inputs indicative of vehicle operating parameters and providing control signals in response to a control program;

a battery bank;

an internal combustion engine;

a first electric motor electrically coupled to said battery bank for (a) accepting electrical energy from said battery bank and (b) providing electrical energy to said battery bank, and said first electric motor being mechanically coupled to said internal combustion engine, the combination of said internal combustion engine and said first electric motor being mechanically coupled to a clutch controlled by said controller for controllable torque-transmitting connection between said

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combination and road wheels of said vehicle,

said first electric motor being responsive to commands from said controller, such that said first electric motor can be controlled to (1) accept torque from said internal combustion engine to charge said battery bank, (2) accept energy from said battery bank to apply torque to said internal combustion engine for starting said internal combustion engine, (3) accept energy from said battery bank to apply torque to said road wheels to propel said vehicle, and (4) accept torque from said road wheels to charge said battery bank; and

a second electric motor, electrically coupled to said battery bank, such that said second electric motor can be controlled for (a) accepting electrical energy from said battery bank and (b) providing electrical energy to said battery bank, said second electric motor being mechanically coupled to road wheels of said vehicle and being responsive to commands from said controller in order to control said second electric motor to (1) accept energy from said battery bank to apply torque to said road wheels to propel said vehicle, and (2) accept torque from said road wheels to charge said battery bank;

characterized in that said controller is provided with a value for the road load (RL), which is the instantaneous torque required by said vehicle, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, and a value for the torque required to charge the battery bank, and controls said internal combustion engine, said first and second electric motors, and said clutch so that said vehicle is operated in a plurality of operating modes responsive to said values, and so that said engine is operated in certain of said operating modes to produce an amount of torque which is equal to the road load and/or additional torque required to charge said battery bank through one or both of said electric motors, and wherein said engine is operated only when loaded so as to produce torque in a range between a minimum value at which torque is efficiently produced (SP) and the maximum torque output of the internal combustion engine (MTO).--

--34. (New) The hybrid vehicle of claim 33, wherein changes in the torque to be applied to the vehicle wheels are determined by said controller at least in part by monitoring commands provided by the vehicle operator.--

--35. (New) The hybrid vehicle of claim 33, wherein road load (RL) and a setpoint SP, set equal to a minimum value at which torque is efficiently produced by said engine, are both expressed as percentages of MTO, and said operating modes include:

a low-load mode I, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL < SP,

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a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel, while SP < RL < 100% of MTO, and

an acceleration mode V, wherein said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel and by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL > 100% of MTO.--

--36. (New) The hybrid vehicle of claim 35, wherein said setpoint SP is at least approximately 30% of MTO.--

--37. (New) The hybrid vehicle of claim 35, wherein said clutch is disengaged during operation in mode I and engaged during operation in modes IV and V.--

--38. (New) The hybrid vehicle of claim 35, wherein said operating modes further include a low-speed battery charging mode II, entered while RL < SP and the state of charge of the battery bank is below a predetermined level, and wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery bank, and wherein said battery bank is simultaneously charged by supply of electrical energy from said first electric motor, being driven by torque in excess of SP by said internal combustion engine in response to supply of combustible fuel, said clutch being disengaged during operation in mode II.--

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--39. (New) The hybrid vehicle of claim 35, wherein said setpoint SP may be varied by said controller in response to monitoring patterns of vehicle operation over time.--

--40. (New) The hybrid vehicle of claim 35, wherein said setpoint SP may be varied by said controller as a function of engine speed.--

--41. (New) The hybrid vehicle of claim 35, wherein the transition between operation in modes I and IV is controlled to occur only when RL > SP for at least a predetermined time, or when RL > SP2, wherein SP2 is a larger percentage of MTO than SP.--

--42. (New) The hybrid vehicle of claim 35, wherein the transition from operation in mode IV to operation in mode I is controlled to occur only when RL < SP for at least a predetermined time.--

--43. (New) The hybrid vehicle of claim 35, wherein the controller may control transition of the operating mode from operation in mode I directly to operation in mode V where a rapid increase in the torque to applied to the wheels of the vehicle as desired by the operator is detected. --

--44. (New) The hybrid vehicle of claim 35, wherein the controller may accept operator input of a desired cruising speed, and thereafter controls the instantaneous torque output by said internal combustion engine in accordance with variation in RL so as to maintain vehicle speed substantially constant, and does not permit transition to mode I operation until the operator provides a further signal indicating that the desired cruising speed is no longer desired.--

--45. (New) The hybrid vehicle of claim 35, wherein regenerative charging of the battery bank is performed when the instantaneous torque output by the internal combustion engine > RL, when RL is negative, or when braking is initiated by the operator.--

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--46. (New) The hybrid vehicle of claim 35, wherein the total torque available at the road wheels from said internal combustion engine is no greater than the total torque available from said first and second electric motors combined.--

--47. (New) The hybrid vehicle of claim 33, wherein the engine and first electric motor are controllably coupled to a first set of road wheels of said vehicle and said second electric motor is coupled to a second set of road wheels of said vehicle.--

--48. (New) The hybrid vehicle of claim 33, further comprising a multispeed transmission disposed between said engine and said motors and the wheels of said vehicle, said transmission being operable to broaden the load-carrying range of said vehicle.

--49. (New) A hybrid vehicle, comprising:

a controller capable of accepting inputs indicative of vehicle operating parameters and providing control signals in response to a control program;

a battery bank;

an internal combustion engine fitted with a turbocharger that is operable in response to control signals from said controller in order to increase the torque output by said internal combustion engine;

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a first electric motor electrically coupled to said battery bank for (a) accepting electrical energy from said battery bank and (b) providing electrical energy to said battery bank, and said first electric motor being mechanically coupled to said internal combustion engine, the combination of said internal combustion engine and said first electric motor being mechanically coupled to a clutch controlled by said controller for controllable torque-transmitting connection between said combination and road wheels of said vehicle,

said first electric motor being responsive to commands from said controller, such that said first electric motor can be controlled to (1) accept torque from said internal combustion engine to charge said battery bank, (2) accept energy from said battery bank to apply torque to said internal combustion engine for starting said internal combustion engine, (3) accept energy from said battery bank to apply torque to said road wheels to propel said vehicle, and (4) accept torque from said road wheels to charge said battery bank; and

a second electric motor, electrically coupled to said battery bank, such that said second electric motor can be controlled for (a) accepting electrical energy from said battery bank and (b) providing electrical energy to said battery bank, said second electric motor being mechanically coupled to road wheels of said vehicle and being responsive to commands from said controller in order to control said second electric motor to (1) accept energy from said battery bank to apply torque to said road wheels to propel said vehicle, and (2) accept torque from said road wheels to charge said battery bank;

characterized in that said controller is provided with a value for the road load, which is the torque on the output drive shaft of said vehicle, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, and controls said internal combustion engine, said turbocharger, said first and second electric motors, and said clutch so that said vehicle is operated in a plurality of operating modes responsive to said values, and so that said engine is operated in certain of said operating modes to produce an amount of torque which is equal to the road load and/or additional torque required to charge said battery bank through one or both of said electric motors, and wherein said controller causes said turbocharger to operate, increasing the maximum output torque of said internal combustion engine, only when the instantaneous road load exceeds the internal combustion engine's normally-aspirated maximum torque output for more than a predetermined period of time, and wherein said internal combustion engine is operated only when loaded in a range between a minimum value at which torque is efficiently produced and its maximum torque output value.--

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--50. (New) The hybrid vehicle of claim 49, wherein the road load (RL) is expressed as a percentage of the maximum torque output of the internal combustion engine while normally-aspirated (MTO), and said operating modes include:

a low-load mode I, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO,

a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel, while SP < RL < 100%

of MTO,

an acceleration mode V, wherein said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel and by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL > 100% of MTO for less than a predetermined time T, and

a high-power mode VI, wherein said turbocharger is operated such that said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel while RL > 100% of MTO for more than a predetermined time T.

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--51. (New) The hybrid vehicle of claim 50, wherein said setpoint SP is at least approximately 30% of MTO.--

--52. (New) The hybrid vehicle of claim 50, wherein said clutch is disengaged during operation in mode I and engaged during operation in modes IV, V, and VI.--

--53. (New) The hybrid vehicle of claim 50, wherein said time T is controlled responsive to the state of charge of the battery bank.--

--54. (New) The hybrid vehicle of claim 49, wherein the engine and first electric motor are controllably coupled to a first set of road wheels of said vehicle and said second electric motor is coupled to a second set of road wheels of said vehicle.--

--55. (New) The hybrid vehicle of claim 49, further comprising a multispeed transmission disposed between said engine and said motors and the wheels of said vehicle, said transmission being operable to broaden the load-carrying range of said vehicle.--

--56. (New) A method for controlling the operation of a hybrid vehicle operable in a plurality of differing modes, said vehicle comprising an internal combustion engine for providing torque up to a maximum torque output (MTO), said internal combustion engine being controllably coupled to road wheels of said vehicle, a first electric motor being coupled to said internal combustion engine, said first electric motor being operable as a generator, a second motor coupled to the wheels of said vehicle and also operable as a generator, a battery bank for providing electrical energy to and accepting energy from said electric motors, and a controller for controlling operation of said internal combustion engine and the coupling of said engine to said road wheels, of said electric motors, and controlling flow of electrical energy between said electric motors and said battery bank,

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characterized in that according to said method, said controller controls said internal combustion engine, said electric motors, and the coupling of said engine to said wheels so that said vehicle is operated in a plurality of operating modes responsive to the instantaneous torque requirement (RL) of the vehicle, which is the torque on the output drive shaft of said vehicle, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, and so that said internal combustion engine is operated only when loaded such that the output torque thereof is at least equal to a minimum value at which torque is efficiently produced, said operating modes including:

a low load mode I entered into while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO, and in which torque propelling said vehicle is provided by said motors,

a highway cruising mode IV entered into while SP < RL < 100% of MTO and in which torque propelling said vehicle is provided by said engine, and

an acceleration mode V entered into while RL > 100% of MTO and in which torque propelling said vehicle is provided by said motors and said engine.--

--57. (New) The method of claim 56, wherein SP is equal to at least approximately 30% of MTO.--

--58. (New) The method of claim 56, comprising the further step of decoupling said engine from said wheels during operation in mode I and coupling said engine to said wheels during operation in modes IV and V. --

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--59. The method of claim 56, wherein said controller further controls said vehicle to operate in a low-load battery charging mode II, entered while RL < SP and the state of charge of the battery bank is below a predetermined level, during which said vehicle is propelled by torque provided by said second motor in response to energy supplied from said battery bank, and wherein said battery bank is simultaneously charged by supply of electrical energy from said first motor, being driven by torque by said internal combustion engine in response to supply of combustible fuel, said engine being decoupled from said wheels during operation in mode II.--

--60. (New) The method of claim 56, comprising the further step of employing said controller to monitor patterns of vehicle operation over time and vary said setpoint SP accordingly.--

--61. (New) The method of claim 56, comprising the further step of employing said controller to monitor RL over time, and to control transition between operation in modes I and IV accordingly, such that said transition occurs only when RL > SP for at least a predetermined time, or when RL > SP2, wherein SP2 is a larger percentage of MTO than SP.--

--62. (New) The method of claim 56, comprising the further step of employing said controller to monitor RL over time, and to control transition from operation in mode IV to operation in mode I accordingly, such that said transition occurs only when RL < SP for at least a predetermined time.--

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--63. (New) The method of claim 56, comprising the further step of operating said controller to monitor RL over time, and to control the operating mode to change from operation in mode I directly to operation in mode V where a rapid increase in the torque to be applied to the wheels as desired by the operator is detected.--

--64. (New) The method of claim 56, comprising the further step of operating said controller to accept operator input of a desired cruising speed, said controller thereafter controlling the instantaneous engine torque output in accordance with variation in RL so as to maintain vehicle speed substantially constant, and to prevent transition to mode I operation until the operator provides a further signal indicative that the desired cruising speed is no longer desired.--

--65. (New) The method of claim 56, comprising the further step of performing regenerative charging of the battery bank under controller control when the engine's instantaneous torque output > RL, when RL is negative, or when braking is initiated by the operator.--

--66. (New) The method of claim 56, wherein said hybrid vehicle further comprises a multispeed transmission disposed between said engine and said motors and the wheels of said vehicle, said transmission being operable responsive to a control signal from said controller to broaden the load-carrying range of said vehicle.--

--67. (New) The method of claim 56, wherein said hybrid vehicle further comprises a turbocharger being operatively and controllably coupled to said internal combustion engine for being operated and thereby increasing the maximum torque output of said internal combustion engine to more than MTO when desired, and wherein according to said method, said controller controls selection of the operational mode of said vehicle between a low-load mode I, a cruising mode IV, an acceleration mode V, and a turbocharged mode VI, in response to monitoring the instantaneous torque requirements (RL) of the vehicle over time.--

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--68. (New) The method of claim 67, wherein said controller controls said vehicle to operate in said modes as follows:
in said low load mode I while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO, in said highway cruising mode IV while SP < RL < 100% of MTO, in said acceleration mode V while RL > 100% of MTO for less than a predetermined time T, and in said sustained high-power mode VI while RL > 100% of MTO for more than a predetermined time T.--

--69. (New) The method of claim 67, wherein said time T is controlled responsive to the state of charge of the battery bank.--

--70. (New) The method of claim 67, comprising the further step of decoupling said engine from said wheels during operation in mode I and coupling said engine to said wheels during operation in modes IV, V, and VI.

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--71. (New) A hybrid vehicle operable in a plurality of differing modes, said vehicle comprising an internal combustion engine for providing torque up to a maximum normally-aspirated torque output (MTO), said internal combustion engine being fitted with a turbocharger operable in response to a control signal for increasing the maximum torque output of said internal combustion engine beyond MTO, said internal combustion engine being controllably connected to road wheels of said vehicle through means controllable by a controller, a first electric motor coupled to said engine, and a second electric motor coupled to road wheels of said vehicle, both said electric motors being operable as generators, a battery bank for providing electrical energy to and accepting energy from said electric motors, at least one controllable inverter/charger connected between said electric motors and said battery bank, and a controller for controlling operation of said internal combustion engine and connection thereof to said wheels, said electric motors, and said turbocharger, and for controlling flow of electrical energy between said electric motors and said battery bank,

characterized in that said controller is provided with a signal indicative of the instantaneous road load (RL) of said vehicle, which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, and controls operation of said internal combustion engine, conection of said engine to said wheels, said at least one electric motor, and said turbocharger, so that said vehicle is operated in said plurality of differing modes responsive to said signal, and said controller further controls operation of said vehicle so that said internal combustion engine is operated only when the output torque thereof is at least equal to a minimum value at which torque is efficiently produced; and wherein:

the road load (RL) is expressed as a percentage of the maximum torque output of the engine while normally-aspirated (MTO), and said operating modes include:

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a low-load mode I, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO,

a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel, while SP < RL < 100% of MTO, said turbocharger not being operated in said mode IV,

an acceleration mode V, wherein said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel and by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL > 100% of MTO for less than a predetermined time T, said turbocharger not being operated in said mode V, and

a high-power mode VI, wherein said turbocharger is operated such that said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel while RL > 100% of MTO for more than said predetermined time T.--

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--~~71~~. (New) The hybrid vehicle of claim 70, wherein said

Ex. Entry numbering

setpoint SP is at least approximately 30% of MTO.--

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--~~72~~. (New) The hybrid vehicle of claim 70, wherein said engine is disconnected from said wheels during operation in mode I and connected to said wheels during operation in modes IV, V, and VI. --

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--~~73~~. (New) The hybrid vehicle of claim 70, wherein said time T is controlled responsive to the state of charge of the battery bank.--

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--~~74~~. (New) The hybrid vehicle of claim 70, wherein torque from said internal combustion engine is transmitted to a first set of road wheels and torque from said second electric motor is transmitted to a second set of road wheels.--

B/ Rule 1.126

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--~~75~~. (New) The hybrid vehicle of claim 70, wherein said first electric motor is coupled to said internal combustion engine for starting said internal combustion engine in response to a control signal from said controller.--

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--~~76~~. (New) The hybrid vehicle of claim 70, further comprising a multispeed transmission disposed between said engine and said motors and the wheels of said vehicle, said transmission being operable to broaden the load-carrying range of said vehicle.--

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--~~77~~. (New) A method for controlling the operation of a hybrid vehicle operable in a plurality of differing modes, said vehicle comprising an internal combustion engine for providing torque up to a maximum torque output (MTO), said internal combustion engine being controllably coupled to road wheels of said vehicle by a clutch, a first electric motor being coupled to said internal combustion engine, a second electric motor coupled to road wheels of said vehicle, said first and second electric motors being operable as generators, a battery bank for providing electrical energy to and accepting energy from said first and second electric motors, and a controller for controlling operation of said internal combustion engine, clutch, and first and second electric motors, and controlling flow of electrical energy between said first and second electric motors and said battery bank,

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characterized in that according to said method, said controller controls selection of the operational mode of said vehicle between at least a low-load mode I and a cruising mode IV, wherein torque to propel said vehicle is provided by said at least said second electric motor or said internal combustion engine, respectively, in response to monitoring the instantaneous torque requirements (RL) of the vehicle, which is the torque on the output drive shaft of said vehicle, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, and said controller further controls operation of said vehicle so that said internal combustion engine is operated only when the output torque thereof is at least equal to a minimum value at which torque is efficiently produced, and

wherein said vehicle further comprises a catalytic converter comprising a catalyst for reducing undesirable emissions of CO, NOx, and unburned hydrocarbons from said internal combustion engine to harmless products, said catalytic converter being provided with means controlled by said controller for heating said catalyst to an effective working temperature, and wherein when said controller determines that it is desirable to start said engine, e.g., in order to change the operating mode of said vehicle from mode I to mode IV, or to charge said battery, said controller heats said catalyst to a minimum effective working temperature if necessary before controlling said first electric motor to spin said internal combustion engine for starting.--

B Rule 1.126

--~~78~~ 79. (New) A method for determining the relative sizes of the internal combustion engine, first and second electric motors, and battery bank of a hybrid vehicle comprising said components, and a method for operating the vehicle thus designed, the determining steps of said method comprising the steps of:

a. selecting the internal combustion engine having sufficient torque to drive the vehicle at medium to high speed along a moderate grade;

b. sizing the first electric motor to provide an internal combustion engine load during battery charging adequate to ensure that torque is produced efficiently by said engine;

c. sizing the second electric motor to provide adequate torque at zero speed to overcome the maximum grade specified from rest, with the first electric motor assisting as needed;

d. selecting the torque vs. speed profile of the second electric motor to allow convenient city driving, without use of torque from the internal combustion engine; and

e. selecting the battery capacity to be sufficient to avoid excessively frequent discharging and charging cycles; and

the operating steps of said method comprising the steps of:

a. monitoring the instantaneous torque requirement (RL) of the vehicle, which is the torque on the output drive shaft of said vehicle, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, and

b. employing a controller to control selection of the operational mode of said vehicle between at least a low-load mode I and a cruising mode IV, wherein torque to propel said vehicle is provided by said at least said second electric motor or said internal combustion engine, respectively, in response to RL, and wherein said controller further controls operation of said vehicle so that said internal combustion engine is operated only when the output torque thereof is at least equal to a minimum value at which torque is efficiently produced.--

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80 --~~79~~. The method of claim 79 ~~78~~, wherein said engine is provided with a turbocharger controlled by said controller to increase the engine's maximum torque output during extended operation under circumstances where RL exceeds the maximum torque output of the internal combustion engine in normally-aspirated mode for an extended period of time, wherein the turbocharger increases the engine's maximum torque output by at least about 25%.--

81 --~~80~~. The method of claim 79 ~~78~~, wherein said first electric motor is sized so as to load the internal combustion engine to approximately 70% of its maximum torque output at an engine speed at which torque is efficiently produced during battery charging.--

REMARKS

After entry of the above amendment, claims 16 - 80 remain in the application. Claims 10 - 15 were directed to different inventions and have been cancelled hereby, while claims 1 - 9 were issued in the parent patent. Claim 16 is an original claim to the method of sizing the components of a hybrid vehicle, while claim 78 and its dependent claims 79 and 80 are new claims directed similarly. All of the other new claims 17 - 77 added hereby are directed to the hybrid vehicle of the invention, defined in terms of its components and the method of control employed to ensure that they work together properly to achieve the objects of the invention, or to the method of the invention, which claims include a catalog of the parts of the vehicle as a means of establishing support for the method of the invention.

More specifically, claims 17 - 77 recite that the vehicle is operated in various operational modes, that is, in which the torque required to propel the vehicle is provided from different sources, and that the operational mode at any given time is chosen by a controller responsive to the road load of the vehicle, that is, its instantaneous torque requirement. This was also recited in original claim 1. Claims 16 and 78 - 80 refer as noted to the sizing of the various components that is needed to ensure that they can carry out these functions, i.e., in order to operate in the various operating modes, although these are not recited *per se* in claims 16 and 78 - 80. Since new claims 17 - 77 have the same inventive concept as claim 1, which distinguishes over all art known to the inventors, and since claims 16 and 78 - 80 are directed to sizing the components for so doing, it is respectfully submitted that claims 16 - 80 can properly be examined in a single application.

Hence it is respectfully submitted that all claims are properly examinable in a single application, and furthermore that they are allowable.

For the Examiner's information, an updated search for patents related to the inventive subject matter was recently completed, and it is the intention of the undersigned to file a further Information Disclosure Statement within the next few weeks.

Respectfully submitted,

Aug. 11, 2003
Dated

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MAY 2 0 2004

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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

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MAY 2 6 2004
GROUP 3600

AMENDMENT

Hon. Commissioner for Patents
P. O. Box 1450
Alexandria VA 22313-1450

Transmitted herewith is an amendment in the above - identified application.

_X_ A check for the additional claim fee of $ 1356 as calculated below is enclosed for this amendment.

___ The Commissioner is hereby authorized to charge any underpayment (or to credit overpayment) to our Deposit Account No. 04-0401. A duplicate copy of this sheet is attached.

LARGE ENTITY

	TOTAL CLAIMS	CLAIMS PREVIOUSLY PAID FOR		PRESENT EXTRA		ADDITIONAL RATE	
TOTAL	126	65	=	61	Extra	x 18	$ 1098.00
INDEP.	11	8	=	3	Extra	x 86	$ 258.00
						TOTAL:	$ 1356.00

5/19/04
Dated

Respectfully submitted,

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OIPE JC67
MAY 20 2004
PATENT & TRADEMARK OFFICE

6-2-04
7/C
Fee ok

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

RECEIVED
MAY 26 2004
GROUP 3600

Hon. Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

SUPPLEMENTAL PRELIMINARY AMENDMENT

Sir:

Prior to examination, kindly amend the above-identified Application as follows:

05/21/2004 YPOLITE1 00000043 10382577

01 FC:1201	258.00 OP
02 FC:1202	1098.00 OP

IN THE CLAIMS:

Claims 1 - 15 (previously cancelled)

16. (Amended) A method for determining the relative sizes of the internal combustion engine, starting/charging and traction motors, and battery bank of a hybrid vehicle of predetermined weight comprising said components, said method comprising the steps of:

a. selecting an internal combustion engine having sufficient torque to drive the vehicle at ~~medium to high~~ a specified speed along a ~~moderate~~ specified maximum grade;

b. sizing the starting/charging motor to provide an engine load during battery charging equal to at least approximately 30% of the engine's maximum torque output in normally-aspirated operation;

c. sizing the traction motor to provide adequate torque at zero speed to overcome the maximum grade specified from rest, with the engine and/or starting/charging ~~starter~~ motor assisting as needed;

d. determining the maximum power drawn by the selected motor(s) under full power conditions;

e. calculating the battery voltage under load that will be required to provide the power to be drawn by the motor(s) under full power conditions, and so that the ratio of the battery voltage under load to the peak current drawn by the motor(s) is at least 2.5 : 1, and

f. selecting the battery bank to provide the calculated voltage under peak load conditions.

--17. (Amended) A method for controlling the operation of a hybrid vehicle having at least two pairs of road wheels, said vehicle being operable in a plurality of differing modes, said vehicle comprising an internal combustion engine for providing torque up to a maximum torque output (MTO) when normally aspirated, said internal combustion engine being controllably coupled to said road wheels of said vehicle ~~by a clutch~~, a first electric motor being coupled to said internal combustion engine, a second electric motor coupled to said road wheels of said vehicle, said first and/or second electric motors being operable as generators, a battery bank for providing electrical energy to and/or accepting energy from said first and/or second electric motors, and a controller for controlling operation of said internal combustion engine, ~~clutch,~~ and first and second electric motors, ~~and~~ controlling flow of electrical energy between said first and second electric motors and said battery bank, and controlling flow of mechanical energy between said engine, said first and second electric motors, and said wheels,

characterized in that according to said method, said controller controls said internal combustion engine, said first and second electric motors, ~~and said clutch~~ and flow of electrical and mechanical energy therebetween in order to control selection of the operational mode of said vehicle between at least a low-load mode I, a cruising mode IV, and an acceleration mode V, wherein torque to propel said vehicle is provided by one or both of said first and second electric motors, said internal combustion engine, and both said engine and one or both of said first and second electric motors, respectively, in response to monitoring the instantaneous torque requirements (RL) of the vehicle, which is the torque ~~on the output drive shaft~~ required for propulsion of said vehicle, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, whereby said vehicle is operated in ~~a~~ said plurality of operating modes responsive to the value of RL, and so that said internal combustion engine is operated when the engine torque required to propel the vehicle, or to propel said vehicle and/or drive either or both electric motor(s) to charge said battery ~~only when the output torque thereof~~ is at least equal to a minimum value at which torque is efficiently produced.--

--18. (Amended) The method of claim 17, wherein said controller controls said vehicle to operate in said low load mode I while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO, said highway cruising mode IV while SP < RL < ~~100% of~~ MTO, and said acceleration mode V while RL > ~~100% of~~ MTO.--

--19. (previously presented) The method of claim 18, wherein said setpoint SP is at least approximately 30% of MTO.--

--20. (Amended) The method of claim 18, wherein said engine is controllably connected to said wheels by a clutch, and comprising the further step of disengaging said clutch during operation in mode I and engaging said clutch during operation in modes IV and V. --

--21. (Amended) The method of claim 18, wherein said controller further controls said vehicle to operate in a low-speed battery charging mode II, entered while RL < SP and the state of charge of the battery bank is below a predetermined level, during which said vehicle is propelled by torque provided by said second motor in response to energy supplied from said battery bank, and wherein said battery bank is simultaneously charged by supply of electrical energy from said first motor, being driven by torque by said internal combustion engine in response to supply of combustible fuel, said ~~clutch~~ engine being disengaged from said wheels during operation in mode II, and wherein said engine is loaded by said first motor such that it produces torque at least equal to SP while being operated in said mode II.--

--22. (previously presented) The method of claim 18, comprising the further step of employing said controller to monitor patterns of vehicle operation over time and vary said setpoint SP accordingly.--

--23. (previously presented) The method of claim 18, comprising the further step of employing said controller to monitor RL over time, and to control transition between operation in modes I and IV accordingly, such that said transition occurs only when RL > SP for at least a predetermined time, or when RL > SP2, wherein SP2 is a larger percentage of MTO than SP.--

--24. (previously presented) The method of claim 18, comprising the further step of employing said controller to monitor RL over time, and to control transition from operation in mode IV to operation in mode I accordingly, such that said transition occurs only when RL < SP for at least a predetermined time.--

--25. (previously presented) The method of claim 18, comprising the further step of operating said controller to monitor RL over time, and to control the operating mode to change from operation in mode I directly to operation in mode V where a rapid increase in RL as desired by the operator is detected.--

--26. (Amended) The method of claim 18, comprising the further step of operating said controller to accept operator input of a desired cruising speed, said controller thereafter controlling the instantaneous engine torque output and operation of said motor(s) to supply additional torque as needed in accordance with variation in RL so as to maintain vehicle speed substantially constant~~, and to prevent transition to mode I operation until the operator provides a further signal indicative that the desired cruising speed is no longer desired~~.--

--27. (previously presented) The method of claim 18, comprising the further step of performing regenerative charging of the battery bank under controller control when the engine's instantaneous torque output > RL, when RL is negative, or when braking is initiated by the operator.--

--28. (previously presented) The method of claim 18, wherein said first and second electric motors are controlled together to provide maximum torque at least equal to the maximum torque of said internal combustion engine.--

--29. (previously presented) The method of claim 18, wherein the maximum speed of at least said second motor is controlled to be at least 150% of the maximum speed of said internal combustion engine.--

--30. (previously presented) The method of claim 18, wherein said hybrid vehicle further comprises a turbocharger being operatively and controllably coupled to said internal combustion engine for increasing the maximum torque output of said internal combustion engine to more than MTO when desired, and wherein according to said method, said controller controls selection of the operational mode of said vehicle between a low-load mode I, a cruising mode IV, an acceleration mode V, and a turbocharged mode VI, in response to monitoring the instantaneous torque requirements (RL) of the vehicle over time.--

--31. (Amended) The method of claim 30, wherein said controller controls said vehicle to operate in said modes as follows:
in said low load mode I while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO, in said highway cruising mode IV while SP < RL < ~~100% of~~ MTO, in said acceleration mode V while RL > ~~100% of~~ MTO for less than a predetermined time T, and in said sustained high-power mode VI while RL > ~~100% of~~ MTO for more than a predetermined time T.--

--32. (previously presented) The method of claim 30, wherein said time T is controlled responsive to the state of charge of the battery bank.--

--33. (Amended) A hybrid vehicle, comprising:

a controller capable of accepting inputs indicative of vehicle operating parameters and providing control signals in response to a control program;

a battery bank;

an internal combustion engine;

a first electric motor electrically coupled to said battery bank for (a) accepting electrical energy from said battery bank and (b) providing electrical energy to said battery bank, and said first electric motor being mechanically coupled to said internal combustion engine, the combination of said internal combustion engine and said first electric motor being mechanically coupled to a~~ clutch controlled by said controller for ~~controllable torque-transmitting connection between said combination and road wheels of said vehicle,

said first electric motor being responsive to commands from said controller, such that said first electric motor can be controlled to (1) accept torque from said internal combustion engine to charge said battery bank, or(2) accept energy from said battery bank to apply torque to said internal combustion engine for starting said internal combustion engine~~, (3) accept energy from said battery bank to apply torque to said road wheels to propel said vehicle, and (4) accept torque from said road wheels to charge said battery bank~~; and

a second electric motor, electrically coupled to said battery bank, ~~such that said second electric motor can be controlled for (a) accepting electrical energy from said battery bank and (b) providing electrical energy to said battery bank, said second electric motor being~~ mechanically coupled to road wheels of said vehicle, and ~~being~~ responsive to commands from said controller in order to ~~control said second electric motor to~~ (1) accept energy from said battery bank to apply torque to said road wheels to propel said vehicle, or (2) accept torque from said road wheels to charge said battery bank;

characterized in that said controller is provided with a value for the road load (RL), which is the instantaneous torque required by said vehicle for propulsion, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, and a value for the torque required to charge the battery bank, and controls said internal combustion engine~~,~~ and said first and second electric motors, ~~and said clutch~~ so that said vehicle is operated ~~in a plurality of operating modes~~ responsive to said ~~values~~ value RL, and so that said engine is operated ~~in certain of said operating modes~~ when the engine torque required to propel said vehicle and/or charge said battery bank by producing ~~to produce~~ an amount of torque which is equal to the road load and/or additional torque required to charge said battery bank through one or both of said electric motors, ~~and wherein said engine is operated only when loaded so as to produce torque~~ is in a range between a minimum value at which torque is efficiently produced ~~(SP)~~ and the maximum torque output of the internal combustion engine when normally aspirated (MTO).--

--34. (Amended) The hybrid vehicle of claim 33, wherein changes in the torque to be applied to or accepted from the vehicle wheels are determined by said controller at least in part by monitoring commands provided by the vehicle operator.--

--35. (Amended) The hybrid vehicle of claim 33, wherein said vehicle is operated in a plurality of operating modes responsive to the value of RL ~~road load (RL)~~ and a setpoint SP, set equal to a minimum value at which torque is efficiently produced by said engine, ~~are~~ both expressed as percentages of MTO, and said operating modes include:

a low-load mode I, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL < SP,

a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine ~~in response to supply of combustible fuel~~, while SP < RL < ~~100%~~

~~of~~ MTO, and

an acceleration mode V, wherein said vehicle is propelled by torque provided by said internal combustion engine ~~in response to supply of combustible fuel~~ and by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL > ~~100% of~~ MTO.--

--36. (previously presented) The hybrid vehicle of claim 35, wherein said setpoint SP is at least approximately 30% of MTO.--

--37. (Amended) The hybrid vehicle of claim 35, wherein the combination of said ~~clutch~~ engine and said first motor is disengaged from said wheels during operation in mode I and engaged during operation in modes IV and V.--

--38. (Amended) The hybrid vehicle of claim 35, wherein said operating modes further include a low-speed battery charging mode II, entered while RL < SP and the state of charge of the battery bank is below a predetermined level, ~~and wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery bank~~, and wherein said battery bank is simultaneously charged by supply of electrical energy from said first electric motor, being driven by torque in excess of SP by said internal combustion engine in response to supply of combustible fuel, the combination of said engine and said first motor ~~said clutch~~ being disengaged from said wheels during operation in mode II.--

--39. (previously presented) The hybrid vehicle of claim 35, wherein said setpoint SP may be varied by said controller in response to monitoring patterns of vehicle operation over time.--

--40. (previously presented) The hybrid vehicle of claim 35, wherein said setpoint SP may be varied by said controller as a function of engine speed.--

--41. (previously presented) The hybrid vehicle of claim 35, wherein the transition between operation in modes I and IV is controlled to occur only when RL > SP for at least a predetermined time, or when RL > SP2, wherein SP2 is a larger percentage of MTO than SP.--

--42. (previously presented) The hybrid vehicle of claim 35, wherein the transition from operation in mode IV to operation in mode I is controlled to occur only when RL < SP for at least a predetermined time.--

--43. (Amended) The hybrid vehicle of claim 35, wherein the controller may control transition of the operating mode from operation in mode I directly to operation in mode V where a rapid increase in the torque to be applied to the wheels of the vehicle as desired by the operator is detected. --

--44. (Amended) The hybrid vehicle of claim 35, wherein the controller may accept operator input of a desired cruising speed, and thereafter controls the instantaneous torque output by said internal combustion engine and by either or both motor(s) in accordance with variation in RL so as to maintain vehicle speed substantially constant~~, and does not permit transition to mode I operation until the operator provides a further signal indicating that the desired cruising speed is no longer desired~~.--

--45. (Amended) The hybrid vehicle of claim 35, wherein regenerative charging of the battery bank is performed when the instantaneous torque output by the internal combustion engine > RL, when RL is negative, or when braking is initiated by the operator.--

--46. (previously presented) The hybrid vehicle of claim 35, wherein the total torque available at the road wheels from said internal combustion engine is no greater than the total torque available from said first and second electric motors combined.--

--47. (previously presented) The hybrid vehicle of claim 33, wherein the engine and first electric motor are controllably coupled to a first set of road wheels of said vehicle and said second electric motor is coupled to a second set of road wheels of said vehicle.--

--48. (previously presented) The hybrid vehicle of claim 33, further comprising a multispeed transmission disposed between said engine and said motors and the wheels of said vehicle, said transmission being operable to broaden the load-carrying range of said vehicle.

--49. (Amended) A hybrid vehicle, comprising:

a controller capable of accepting inputs indicative of vehicle operating parameters and providing control signals in response to a control program;

a battery bank;

an internal combustion engine fitted with a turbocharger that is operable in response to control signals from said controller in order to increase the torque output by said internal combustion engine;

a first electric motor electrically coupled to said battery bank for (a) accepting electrical energy from said battery bank and (b) providing electrical energy to said battery bank, and said first electric motor being mechanically coupled to said internal combustion engine, the combination of said internal combustion engine and said first electric motor being mechanically coupled to road wheels of said vehicle ~~to a clutch~~ by a ~~controlled by said controller for~~ controllable torque-transmitting connection between said combination and road wheels of said vehicle, said connection being controlled by said controller,

said first electric motor being responsive to commands from said controller, such that said first electric motor can be controlled to (1) accept torque from said internal combustion engine to charge said battery bank, and/or (2) accept energy from said battery bank to apply torque to said internal combustion engine for starting said internal combustion engine~~, (3) accept energy from said battery bank to apply torque to said road wheels to propel said vehicle, and (4) accept torque from said road wheels to charge said battery bank~~; and

a second electric motor, electrically coupled to said battery bank, ~~such that said second electric motor can be controlled for (a) accepting electrical energy from said battery bank and (b) providing electrical energy to said battery bank, said second electric motor being~~ mechanically coupled to road wheels of said vehicle, and ~~being~~ responsive to commands from said controller in order to ~~control said second electric motor to~~ (1) accept energy from said battery bank to apply torque to said road wheels to propel said vehicle, and (2) accept torque from said road wheels to charge said battery bank;

characterized in that said controller is provided with a value for the road load, which is the torque ~~on the output drive shaft~~ required for propulsion of said vehicle, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, and controls said internal combustion engine, said turbocharger, and said first and second electric motors~~, and said clutch so that said vehicle is operated in a plurality of operating modes responsive to said values, and~~ and wherein said controller causes said turbocharger to operate, increasing the maximum output torque of said internal combustion engine, ~~only when the instantaneous~~ when the road load exceeds a predetermined value for more than a predetermined period of time, and wherein said internal combustion engine is operated to propel said vehicle and/or drive either or both motors to charge said battery bank ~~only~~ when ~~loaded~~ the engine torque required to do so is in a range between a minimum value at which torque is efficiently produced and its maximum torque output value.--

--50. (previously presented) The hybrid vehicle of claim 49, wherein said vehicle is operated in a plurality of operating modes responsive to the road load (RL), which is expressed as a percentage of the maximum torque output of the internal combustion engine while normally-aspirated (MTO), and wherein said operating modes include:

a low-load mode I, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO,

a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel, while SP < RL < ~~100% of~~ MTO,

an acceleration mode V, wherein said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel and by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL > ~~100% of~~ MTO for less than a predetermined time T, and

a high-power mode VI, wherein said turbocharger is operated such that said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel while RL > ~~100% of~~ MTO for more than a predetermined time T.--

--51. (previously presented) The hybrid vehicle of claim 50, wherein said setpoint SP is at least approximately 30% of MTO.--

--52. (Amended) The hybrid vehicle of claim 50, wherein said ~~clutch~~ controllable torque-transmitting connection between said combination and road wheels of said vehicle is disengaged during operation in mode I and engaged during operation in modes IV, V, and VI.--

--53. (previously presented) The hybrid vehicle of claim

50, wherein said time T is controlled responsive to the state of charge of the battery bank.--

--54. (previously presented) The hybrid vehicle of claim 49, wherein the engine and first electric motor are controllably coupled to a first set of road wheels of said vehicle and said second electric motor is coupled to a second set of road wheels of said vehicle.--

--55. (previously presented) The hybrid vehicle of claim 49, further comprising a multispeed transmission disposed between said engine and said motors and the wheels of said vehicle, said transmission being operable to broaden the load-carrying range of said vehicle.--

--56. (Amended) A method for controlling the operation of a hybrid vehicle operable in a plurality of differing modes, said vehicle comprising an internal combustion engine for providing torque up to a maximum torque output (MTO), said internal combustion engine being controllably coupled to road wheels of said vehicle, a first electric motor ~~being coupled to said internal combustion engine, said first electric motor~~ being operable as a ~~generator~~ starter, a second motor coupled to the wheels of said vehicle and ~~also~~ operable as a generator, a battery bank for providing electrical energy to and accepting energy from said electric motors, and a controller for controlling operation of said internal combustion engine and the coupling of said engine to said road wheels, of said electric motors, and controlling flow of electrical energy between said electric motors and said battery bank,

characterized in that ~~according to said method~~ said controller controls said internal combustion engine, said electric motors, and the coupling of said engine to said wheels so that said vehicle is operated in a plurality of operating modes, said controller producing control signals in response to vehicle operating conditions to arbitrate between said plurality of operating modes, said controller producing a control signal to operate said internal combustion engine when the ~~responsive to~~ instantaneous torque requirement (RL) of the vehicle, which is the torque ~~on the output drive shaft of~~ required to propel said vehicle, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, exceeds a predetermined minimum level so that said internal combustion engine is operated such that the output torque thereof is at least equal to a minimum value at which torque is efficiently produced, said operating modes including:

a low load mode I entered into while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO, and in which torque propelling said vehicle is provided by said motors,

a highway cruising mode IV entered into while SP < RL < ~~100% of~~ MTO and in which torque propelling said vehicle is provided by said engine, and

an acceleration mode V entered into while RL > ~~100% of~~ MTO and in which torque propelling said vehicle is provided by one or both of said motors and said engine.--

--57. (previously presented) The method of claim 56, wherein SP is equal to at least approximately 30% of MTO.--

--58. (previously presented) The method of claim 56, comprising the further step of decoupling said engine from said wheels during operation in mode I and coupling said engine to said wheels during operation in modes IV and V. --

--59. (Amended) The method of claim 56, wherein said controller further controls said vehicle to operate in a low-load battery charging mode II, entered while RL < SP and the state of charge of the battery bank is below a predetermined level, during which said vehicle is propelled by torque provided by said second motor in response to energy supplied from said battery bank, and wherein said battery bank is simultaneously charged by supply of electrical energy from said first motor being operated as a generator and ~~,~~ being driven by torque at least equal to SP provided by said internal combustion engine, said engine being decoupled from said wheels during operation in mode II.--

--60. (previously presented) The method of claim 56, comprising the further step of employing said controller to monitor patterns of vehicle operation over time and vary said setpoint SP accordingly.--

--61. (previously presented) The method of claim 56, comprising the further step of employing said controller to monitor RL over time, and to control transition between operation in modes I and IV accordingly, such that said transition occurs only when RL > SP for at least a predetermined time, or when RL > SP2, wherein SP2 is a larger percentage of MTO than SP.--

--62. (previously presented) The method of claim 56, comprising the further step of employing said controller to monitor RL over time, and to control transition from operation in mode IV to operation in mode I accordingly, such that said transition occurs only when $RL < SP$ for at least a predetermined time.--

--63. (previously presented) The method of claim 56, comprising the further step of operating said controller to monitor RL over time, and to control the operating mode to change from operation in mode I directly to operation in mode V where a rapid increase in the torque to be applied to the wheels as desired by the operator is detected.--

--64. (Amended) The method of claim 56, comprising the further step of operating said controller to accept operator input of a desired cruising speed, said controller thereafter controlling the instantaneous engine torque output in accordance with variation in RL so as to maintain vehicle speed substantially constant~~, and to prevent transition to mode I operation until the operator provides a further signal indicative that the desired cruising speed is no longer desired~~.--

--65. (Amended) The method of claim 56, comprising the further step of performing regenerative charging of the battery bank ~~under controller control~~ when the engine's instantaneous torque output $> RL$, when RL is negative, or when braking is initiated by the operator.--

--66. (previously presented) The method of claim 56, wherein said hybrid vehicle further comprises a multispeed transmission disposed between said engine and said motors and the wheels of said vehicle, said transmission being operable responsive to a control signal from said controller to broaden the load-carrying range of said vehicle.--

--67. (Amended) The method of claim 56, wherein said hybrid vehicle further comprises a turbocharger being operatively and controllably coupled to said internal combustion engine for being operated and thereby increasing the maximum torque output of said internal combustion engine to more than MTO when desired, and wherein according to said method, said controller controls selection of the operational mode of said vehicle between a low-load mode I, a cruising mode IV, an acceleration mode V, and a turbocharged mode VI, in response to monitoring the instantaneous torque requirements (RL) of the vehicle over time.--

--68. (Amended) The method of claim 67, wherein said controller controls said vehicle to operate in said modes as follows:

in said low load mode I while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO, in said highway cruising mode IV while SP < RL < MTO, in said acceleration mode V while RL > MTO for less than a predetermined time T, and in said sustained high-power mode VI while RL > MTO for more than a predetermined time T.--

--69. (Amended) The method of claim ~~67~~ 68, wherein said time T is controlled responsive to the state of charge of the battery bank.--

--70. (previously presented) The method of claim 67, comprising the further step of decoupling said engine from said wheels during operation in mode I and coupling said engine to said wheels during operation in modes IV, V, and VI.--

--71. (Amended) A hybrid vehicle operable in a plurality of differing modes, said vehicle comprising an internal combustion engine for providing torque up to a maximum normally-aspirated torque output (MTO), said internal combustion engine being fitted with a turbocharger operable in response to a control signal for increasing the maximum torque output of said internal combustion engine beyond MTO, said internal combustion engine being controllably connected to road wheels of said vehicle through ~~means~~ a torque-transmitting connection controllable by a controller, a first electric motor coupled to said engine, and a second electric motor coupled to road wheels of said vehicle, both said electric motors being operable as generators, a battery bank for providing electrical energy to and accepting energy from said electric motors, at least one controllable inverter/charger connected between said electric motors and said battery bank, and a controller for controlling operation of said internal combustion engine and connection thereof to said wheels, said electric motors, and said turbocharger, and for controlling flow of electrical energy between said electric motors and said battery bank,

characterized in that said controller is provided with a signal indicative of the instantaneous road load (RL) of said vehicle, which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, and controls operation of said internal combustion engine, ~~conection~~ connection of said engine to said wheels, said at least one electric motor, and said turbocharger, so that said vehicle is operated in said plurality of differing modes responsive to said signal, and said controller further controls operation of said vehicle so that said internal combustion engine is operated ~~only~~ when the output torque required to be produced by the engine to prople the vehicle or to propel the vehicle while charging the battery bank ~~thereof~~ is at least equal to a minimum value at which torque is efficiently produced~~;~~ , and wherein:

the road load (RL) is expressed as a percentage of the maximum torque output of the engine while normally-aspirated (MTO), and said operating modes include:

a low-load mode I, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO,

a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel, while SP < RL < ~~100% of~~ MTO, said turbocharger not being operated in said mode IV,

an acceleration mode V, wherein said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel and by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL > ~~100% of~~ MTO for less than a predetermined time T, said turbocharger not being operated in said mode V, and

a high-power mode VI, wherein said turbocharger is operated such that said vehicle is propelled by torque provided by said internal combustion engine in response to supply of combustible fuel while RL > ~~100% of~~ MTO for more than said predetermined time T.--

--71. (previously presented) The hybrid vehicle of claim 70, wherein said setpoint SP is at least approximately 30% of MTO.--

--72. (previously presented) The hybrid vehicle of claim 70, wherein said engine is disconnected from said wheels during operation in mode I and connected to said wheels during operation in modes IV, V, and VI. --

--73. (previously presented) The hybrid vehicle of claim 70, wherein said time T is controlled responsive to the state of charge of the battery bank.--

--74. (previously presented) The hybrid vehicle of claim 70, wherein torque from said internal combustion engine is transmitted to a first set of road wheels and torque from said second electric motor is transmitted to a second set of road wheels.--

--75. (previously presented) The hybrid vehicle of claim 70, wherein said first electric motor is coupled to said internal combustion engine for starting said internal combustion engine in response to a control signal from said controller.--

--76. (previously presented) The hybrid vehicle of claim 70, further comprising a multispeed transmission disposed between said engine and said motors and the wheels of said vehicle, said transmission being operable to broaden the load-carrying range of said vehicle.--

--77. (Amended) A method for controlling the operation of a hybrid vehicle operable in a plurality of differing modes, said vehicle comprising an internal combustion engine for providing torque up to a maximum torque output (MTO), said internal combustion engine being controllably coupled to road wheels of said vehicle ~~by a clutch~~, a first electric motor being coupled to said internal combustion engine, a second electric motor coupled to road wheels of said vehicle, at least one of said first and second electric motors being operable as ~~generators~~ a generator, a battery bank for providing electrical energy to and accepting energy from said first and second electric motors, and a controller for controlling operation of said internal combustion engine, ~~clutch,~~ and first and second electric motors, and controlling flow of electrical energy between said first and second electric motors and said battery bank,

characterized in that according to said method, said controller controls selection of the operational mode of said vehicle between at least a low-load mode I and a cruising mode IV, wherein torque to propel said vehicle is provided by said at least said second electric motor or said internal combustion engine, respectively, in response to monitoring the instantaneous torque requirements (RL) of the vehicle, which is the torque ~~on the output drive shaft of~~ required to propel said vehicle, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, and said controller further controls operation of said vehicle so that said internal combustion engine is operated ~~only~~ in response to a signal indicative of the instantaneous torque demands (RL) of the vehicle, and when loaded such that ~~when~~ the output torque thereof is at least equal to a minimum value at which torque is efficiently produced, and

wherein said vehicle further comprises a catalytic converter comprising a catalyst for reducing undesirable emissions of CO, NOx, and unburned hydrocarbons from said internal combustion engine to harmless products, said catalytic converter being provided with means controlled by said controller for heating said catalyst to an effective working temperature, and wherein when said controller determines that it is desirable to start said engine~~, e.g., in order to change the operating mode of said vehicle from mode I to mode IV, or to charge said battery~~, said controller heats said catalyst to a minimum effective working temperature if necessary before controlling said first electric motor to spin said internal combustion engine for starting.--

--78. (Amended) A method for determining the relative sizes of the internal combustion engine, first and second electric motors, and battery bank of a hybrid vehicle of predetermined weight comprising said components, and a method for operating the vehicle thus designed, the determining steps of said method comprising the steps of:

a. selecting the internal combustion engine having sufficient torque to drive the vehicle at ~~medium to high~~ specified speed along a ~~moderate~~ specified maximum grade;

b. sizing the first electric motor to provide an internal combustion engine load during battery charging adequate to ensure that torque is produced efficiently by said engine;

c. sizing the second electric motor to provide adequate torque at zero speed to overcome the maximum grade specified from rest, with the first electric motor assisting as needed;

d. selecting the torque vs. speed profile of the second electric motor to allow convenient city driving, without use of torque from the internal combustion engine; and

e. selecting the battery capacity to be sufficient to avoid excessively frequent discharging and charging cycles; and

the operating steps of said method comprising the steps of:

a. monitoring the instantaneous torque requirement (RL) of the vehicle, which is the torque ~~on the output drive shaft~~ required for propulsion of said vehicle, and which can be positive, as during steady-state cruising or acceleration, zero, or negative, as during regenerative braking, and

b. employing a controller to control selection of the operational mode of said vehicle between at least a low-load mode I and a cruising mode IV, wherein torque to propel said vehicle is provided by said at least said second electric motor or said internal combustion engine, respectively, in response to RL, and wherein said controller further controls operation of said vehicle so that said internal combustion engine is operated ~~only~~ when loaded such that the output torque thereof is at least equal to a minimum value at which torque is efficiently produced.--

--79. (Previously presented)The method of claim 78, wherein said engine is provided with a turbocharger controlled by said controller to increase the engine's maximum torque output during extended operation under circumstances where RL exceeds the maximum torque output of the internal combustion engine in normally-aspirated mode for an extended period of time, wherein the turbocharger increases the engine's maximum torque output by at least about 25%.--

--80. (Previously presented) The method of claim 78, wherein said first electric motor is sized so as to load the internal combustion engine to approximately 70% of its maximum torque output at an engine speed at which torque is efficiently produced during battery charging.--

Add the following new claims:

--81. (New) A hybrid vehicle, comprising:

an internal combustion engine controllably coupled to road wheels of said vehicle;

a first electric motor connected to said engine and operable to start the engine responsive to a control signal;

a second electric motor connected to road wheels of said vehicle, and operable as a motor, to apply torque to said wheels to propel said vehicle, and as a generator, for accepting torque from at least said wheels for generating current;

a battery, for providing current to said motors and accepting charging current from at least said second motor; and

a controller for controlling the flow of electrical and mechanical power between said engine, first and second motors, and wheels,

wherein said controller starts and operates said engine when torque produced by said engine to propel the vehicle or to propel the vehicle and/or to drive either one or both said electric motor(s) to charge said battery is at least equal to a setpoint (SP) above which said engine torque is efficiently produced.--

--82. (New) The vehicle of claim 81, wherein said controller monitors patterns of vehicle operation over time and varies said setpoint SP accordingly.--

--83. (New) The vehicle of claim 81, wherein said controller monitors RL over time, and controls transition between propulsion of said vehicle by said motor(s) to propulsion by said engine responsive to RL reaching SP, such that said transition occurs only when RL > SP for at least a predetermined time, or when RL > SP2, wherein SP2 > SP.--

--84. (New) The vehicle of claim 83, wherein said controller further controls transition from propulsion of said vehicle by said engine to propulsion by said motor(s) such that said transition occurs only when $RL < SP$ for at least a predetermined time.--

--85. (New) The vehicle of claim 81, wherein said setpoint SP may be varied by said controller as a function of engine speed.--

--86. (New) The vehicle of claim 81, wherein said setpoint SP is at least approximately 30% of the maximum torque output of the engine when normally-aspirated (MTO).--

--87. (New) The vehicle of claim 81, wherein said vehicle is operated in a plurality of operating modes responsive to the value for the road load (RL) and said setpoint SP, both expressed as percentages of the maximum torque output of the engine when normally-aspirated (MTO), and said operating modes include:

a low-load mode I, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery bank, while $RL < SP$,

a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine, while $SP < RL < MTO$, and

an acceleration mode V, wherein said vehicle is propelled by torque provided by said internal combustion engine and by torque provided by either or both electric motor(s) in response to energy supplied from said battery bank, while $RL > MTO$.--

--88. (New) The vehicle of claim 87, wherein the combination of said engine and said first motor is disengaged from said wheels during operation in mode I and engaged during operation in modes IV and V.--

--89. (New) The vehicle of claim 87, wherein said operating modes further include a low-speed battery charging mode II, entered while RL < SP and the state of charge of the battery bank is below a predetermined level, and during which said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery bank, and wherein said battery bank is simultaneously charged by supply of electrical energy from said first electric motor, being driven by torque in excess of SP by said internal combustion engine, the combination of said engine and said first motor being disengaged from said wheels during operation in mode II.--

--90. (New) The vehicle of claim 87, wherein the controller may control transition of the operating mode from operation in mode I directly to operation in mode V where a rapid increase in the torque to be applied to the wheels of the vehicle as desired by the operator is detected. --

--91. (New) The vehicle of claim 87, further comprising a turbocharger operatively and controllably coupled to said internal combustion engine for being operated and thereby increasing the maximum torque output of said internal combustion engine to more than MTO when desired, and wherein said controller controls selection of the operational mode of said vehicle between a low-load mode I, a cruising mode IV, an acceleration mode V, and a turbocharged mode VI, in response to monitoring the instantaneous torque requirements (RL) of the vehicle over time.--

--92. (New) The vehicle of claim 91, wherein said controller controls said vehicle to operate in said modes as follows:

in said low load mode I while RL < SP, in said highway cruising mode IV while SP < RL < MTO, in said acceleration mode V while RL > MTO for less than a predetermined time T, and in said sustained high-power mode VI while RL > MTO for more than a predetermined time T.--

--93. (New) The vehicle of claim 92, wherein said time T is controlled responsive to the state of charge of the battery bank.--

--94. (New) The vehicle of claim 81, wherein the controller may accept operator input of a desired cruising speed, and thereafter controls the instantaneous torque output by said internal combustion engine and by either or both motor(s) in accordance with variation in RL so as to maintain vehicle speed substantially constant.--

--95. (New) The vehicle of claim 81, wherein regenerative charging of the battery bank is performed when the instantaneous torque output by the internal combustion engine > RL, when RL is negative, or when braking is initiated by the operator.--

--96. (New) The vehicle of claim 81, wherein the total torque available at the road wheels from said internal combustion engine is no greater than the total torque available from said first and second electric motors combined.--

--97. (New) The vehicle of claim 81, wherein the engine and first electric motor are controllably coupled to a first set of road wheels of said vehicle and said second electric motor is coupled to a second set of road wheels of said vehicle.--

--98. (New) The vehicle of claim 81, further comprising a variable-ratio transmission disposed between said engine and said motors and the wheels of said vehicle.--

--99. (New) The hybrid vehicle of claim 81, wherein said engine is rotated before starting such that its cylinders are heated by compression of air therein.--

--100. (New) The hybrid vehicle of claim 81, wherein the rate of change of torque produced by said engine is limited, such that combustion of fuel within said engine can be controlled to occur substantially at the stoichiometric ratio, and wherein if said engine is incapable of supplying the instantaneous torque required, the additional torque required is supplied by either or both of said motor(s).--

--101. (New) The hybrid vehicle of claim 81, wherein said engine is controllably coupled to road wheels of said vehicle by a clutch.--

--102. (New) The vehicle of claim 81, wherein said engine can be operated at torque output levels less than SP under abnormal and transient conditions, e.g., in order to allow starting and stopping of the engine or to provide torque to satisfy drivability or safety considerations.--

--103. (New) A method of control of a hybrid vehicle, said vehicle comprising an internal combustion engine capable of efficiently producing torque at loads between a lower level SP and a maximum torque output MTO, a battery bank, and one or more electric motors being capable of providing output torque responsive to supplied current, and of generating electrical current responsive to applied torque, said engine being controllably connected to wheels of said vehicle for applying propulsive torque thereto and to said at least one motor for applying torque thereto, said method comprising the steps of:

determining the instantaneous torque RL required to propel said vehicle responsive to an operator command;

monitoring the state of charge of said battery bank;

employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;

employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;

employing both said at least one electric motor and said engine to propel said vehicle when the torque RL required to do so is more than MTO; and

employing said engine to propel said vehicle when the torque RL required to do so is less than said lower level SP and using the torque between RL and SP to drive said at least one electric motor to charge said battery when the state of charge of said battery bank indicates the desirability of doing so.--

--104. (New) The method of claim 103, comprising the further step of employing said controller to monitor patterns of vehicle operation over time and vary said setpoint SP accordingly.--

--105. (New) The method of claim 103, comprising the further step of employing said controller to monitor RL over time, and to control transition between propulsion of said vehicle by said motor(s) to propulsion by said engine such that said transition occurs only when RL > SP for at least a predetermined time, or when RL > SP2, wherein SP2 is a larger percentage of MTO than SP.--

--106. (New) The method of claim 103, comprising the further step of employing said controller to monitor RL over time, and to control transition between propulsion of said vehicle by said engine to propulsion by said motor(s) such that said transition occurs only when RL < SP for at least a predetermined time.--

--107. (New) The method of claim 103, comprising the further step of operating said controller to accept operator input of a desired cruising speed, said controller thereafter controlling the instantaneous engine torque output and operation of said motor(s) to supply additional torque as needed in accordance with variation in RL to maintain the speed of said vehicle substantially constant.--

--108. (New) The method of claim 103, wherein said vehicle is operated in a plurality of operating modes responsive to the values for the road load RL and said setpoint SP, said operating modes including:

a low-load mode I, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery bank, while RL < SP, a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine, while $SP < RL < MTO$, and

an acceleration mode V, wherein said vehicle is propelled by torque provided by said internal combustion engine and by torque provided by either or both electric motor(s) in response to energy supplied from said battery bank, while $RL > MTO$.--

--109. (New) The method of claim 108, wherein said setpoint SP is at least approximately 30% of MTO.--

--110. (New) The method of claim 108, comprising the further step of decoupling said engine from said wheels during operation in mode I and coupling said engine to said wheels during operation in modes IV and V. --

--111. (New) The method of claim 108, wherein said controller further controls said vehicle to operate in a low-load battery charging mode II, entered while $RL < SP$ and the state of charge of the battery bank is below a predetermined level, during which said vehicle is propelled by torque provided by said second motor in response to energy supplied from said battery bank, and wherein said battery bank is simultaneously charged by supply of electrical energy from said first motor being operated as a generator and being driven by torque at least equal to SP provided by said internal combustion engine, said engine being decoupled from said wheels during operation in mode II.--

--112. (New) The method of claim 108, comprising the further step of operating said controller to monitor RL over time, and to control the operating mode to change from operation in mode I directly to operation in mode V where a rapid increase in the torque to be applied to the wheels as desired by the operator is detected.--

--113. (New) The method of claim 108, wherein said hybrid vehicle further comprises a turbocharger being operatively and controllably coupled to said internal combustion engine for being operated and thereby increasing the maximum torque output of said internal combustion engine to more than MTO when desired, and wherein according to said method, said controller controls selection of the operational mode of said vehicle between a low-load mode I, a cruising mode IV, an acceleration mode V, and a turbocharged mode VI, in response to monitoring the instantaneous torque requirements (RL) of the vehicle over time.--

--114. (New) The method of claim 113, wherein said controller controls said vehicle to operate in said modes as follows:

in said low load mode I while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO, in said highway cruising mode IV while SP < RL < MTO, in said acceleration mode V while RL > MTO for less than a predetermined time T, and in said sustained high-power mode VI while RL > MTO for more than a predetermined time T.--

--115. (New) The method of claim 114, wherein said time T is controlled responsive to the state of charge of the battery bank.--

--116. (New) The method of claim 103, comprising the further step of performing regenerative charging of the battery bank when the engine's instantaneous torque output > RL, when RL is negative, or when braking is initiated by the operator.--

--117. (New) The method of claim 103, wherein said hybrid vehicle further comprises a variable-ratio transmission disposed between said engine and said motors and the wheels of said vehicle, said transmission being operable responsive to a control signal from said controller.--

--118. (New) The method of claim 103, wherein a clutch connects a first output shaft of or driven by said engine and/or first motor with a second output shaft of or driven by said second motor connected to said wheels, and wherein the speeds of said engine and/or first motor and of said second motor are controlled such that when said clutch is engaged the speeds of the first and second output shafts are substantially equal, whereby said shafts may be connected by a non-slipping clutch.-

--119. (New) The method of claim 103, wherein the rate of change of torque output by said engine is limited, such that combustion of fuel within said engine can be controlled to occur substantially at the stoichiometric ratio, and wherein if said engine is incapable of supplying the instantaneous torque required, the additional torque required is supplied by either or both of said motor(s).--

--120. (New) The method of claim 103, wherein said engine is rotated before starting such that its cylinders are heated by compression of air therein.--

--121. (New) The method of claim 103, wherein said engine can be operated at torque output levels less than SP under abnormal and transient conditions, e.g., in order to allow starting and stopping of the engine or to provide torque to satisfy drivability or safety considerations.--

--122. (New) A hybrid vehicle of predetermined weight comprising an internal combustion engine, starting/charging and traction motors, and battery bank, said components being specified as follows:

a. the internal combustion engine having sufficient torque to drive the vehicle at specified speed along a specified maximum grade;

b. the starting/charging motor being connected to the engine and providing an engine load during battery charging equal to at least a setpoint SP which is a minimum level at which the engine efficiently produces torque;

c. the traction motor providing adequate torque at zero speed to overcome the maximum grade specified from rest, with the starter motor assisting as needed; and

d. the battery bank being sized so that is is capable of being charged by said starting/charging motor while loading said engine to said setpoint SP, and so that the ratio of the battery voltage to the peak current drawn by the motor(s) when producing maximum torque is at least 2.5 : 1.--

--123. (New) The method of claim 20, wherein said clutch connects a first output shaft of or driven by said engine and/or first motor with a second output shaft of or driven by said second motor connected to said wheels, and wherein the speeds of said engine and/or first motor and of said second motor are controlled such that when said clutch is engaged during the transition from mode I to mode IV, the speeds of the first and second output shafts are substantially equal, whereby said shafts may be connected by a non-slipping clutch.-

--124. (New) The method of claim 17, wherein the rate of change of torque output by said engine is limited, such that combustion of fuel within said engine can be controlled to occur substantially at the stoichiometric ratio, and wherein if said engine is incapable of supplying the instantaneous torque required, the additional torque required is supplied by either or both of said motor(s).--

--125. (New) The hybrid vehicle of claim 17, wherein said engine is rotated before starting such that its cylinders are heated by compression of air therein.--

--126. (New) The hybrid vehicle of claim 35, wherein the rate of change of torque output by said engine is limited, such that combustion of fuel within said engine can be controlled to occur substantially at the stoichiometric ratio, and wherein if said engine is incapable of supplying the instantaneous torque required, the additional torque required is supplied by either or both of said motor(s).--

--127. (New) The hybrid vehicle of claim 33, wherein said engine is rotated before starting such that its cylinders are heated by compression of air therein.--

--128. (New) The hybrid vehicle of claim 33, further comprising a transmission for varying the ratio between the speeds of input and output shafts thereof, disposed between said engine and said motors and the wheels of said vehicle.--

--129. (New) The method of claim 56, wherein the rate of change of torque output by said engine is limited, such that combustion of fuel within said engine can be controlled to occur substantially at the stoichiometric ratio, and wherein if said engine is incapable of supplying the instantaneous torque required, the additional torque required is supplied by either or both of said motor(s).--

--130. (New) The method of claim 56, comprising the further step of rotating said engine before starting such that its cylinders are heated by compression of air therein.--

--131. (New) The hybrid vehicle of claim 71, further comprising a transmission for varying the ratio between the speeds of input and output shafts thereof, disposed between said engine and said motors and the wheels of said vehicle.--

--132. (New) The hybrid vehicle of claim 77, wherein said engine is rotated before starting such that its cylinders are heated by compression of air therein.--

--133. (New) The method of claim 16, wherein step (c) precedes either or both of steps (a) and (b). --

--134. (New) The vehicle of claim 33, wherein said controllable torque-transmitting connection between the combination of the engine and first electric motor and the wheels of said vehicle is made by a clutch.--

--135. (New) The method of claim 56, wherein said engine is controllably coupled to the wheels of said vehicle by a clutch.--

--136. (previously presented as claim 71, second occurrence) The hybrid vehicle of claim ~~70~~ 71, wherein said setpoint SP is at least approximately 30% of MTO.--

--137. (New) The hybrid vehicle of claim 71, wherein said engine is controllably connected to the wheels of said vehicle by a clutch.--

--138. (New) The vehicle of claim 33, wherein said engine can be operated at torque output levels less than SP under abnormal and transient conditions, e.g., in order to allow starting and stopping of the engine or to provide torque to satisfy drivability or safety considerations.--

--139. (New) The method of claim 17, wherein said engine can be operated at torque output levels less than SP under abnormal and transient conditions, e.g., in order to allow starting and stopping of the engine or to provide torque to satisfy drivability or safety considerations.--

--140. (New) The vehicle of claim 49, wherein said engine can be operated at torque output levels less than SP under abnormal and transient conditions, e.g., in order to allow starting and stopping of the engine or to provide torque to satisfy drivability or safety considerations.--

--141. (New) The method of claim 56, wherein said engine can be operated at torque output levels less than SP under abnormal and transient conditions, e.g., in order to allow starting and stopping of the engine or to provide torque to satisfy drivability or safety considerations.--

REMARKS

After entry of the above amendment, claims 16 - 141 remain in the application. Amendments have been made to some of claims 16 - 80 presented previously to clarify the scope of the invention, while claims 81 - 141 are new. All claims are directed to the hybrid vehicle, its method of control, or the relative capabilities of its components, which are all closely related aspects of the invention. It is respectfully submitted that claims 16 - 141 can properly be examined in a single application.

No new matter is added by this amendment. The subject matter of the independent claims has clearly been addressed in the parent application. As to the new dependent claims, support for claim 118 (non-slipping clutch) is provided at page 46, lines 11 - 34, page 47, lines 20 - 33, for claims 99, 120, 125, 127, 130 and 132 (rotating the engine before starting to preheat the cylinders) at page 69, lines 17 - 21; for claims 117, 128, and 131 (transmission) at page 57, lines 11 - 15; and for claims 119, 124, 126 and 129 (control of rate of change of engine speed with the motors supplying the torque deficiency, if any) at page 70, line 17 - page 71, line 1 and page 69, lines 22 - 26.

Support for claims 102, 121, and 131 - 141 (operation of engine at torque output levels less than SP under abonormal or emergency conditions) is provided by discussion of use of "fuzzy logic" to vary SP responsive to variation in operating conditions, usage over time, and the like. See page 63, lines 2 - 12. Further, it will be realized that such conditions as starting and stopping the engine are essential, but during which the engine cannot produce torque at least equal to SP; thus it would be realized by one of skill in the art that the engine would necessarily operated other than at outputs less than SP during these transient or abnormal circumstances. Production of torque less than SP during starting is also shown in Fig. 7(a), at point D.

Entry of the Amendment and favorable action on the merits is earnestly solicited.

For the Examiner's information, a Supplemental Information Disclosure Statement reflecting the results of several new searches, action before foreign Patent Offices, and other sources of information is intended to be filed shortly.

Respectfully submitted,

5/19/04
Dated

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In re the Patent Application of :
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Severinsky et al : Examiner: N/A
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For: Hybrid Vehicles

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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,

May 19, 2004
Dated

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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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	6019698	2/2000	Lawrie			

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	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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	SUBCLASS	FILING DATE
	5993350	11/1999	Lawrie et al			
	5979257	11/1999	Lawrie			
	6006620	12/1999	Lawrie et al			
	6291953	9/2001	Lovatt et al			
	6332257	12/2001	Reed Jr. et al			
	5943918	8/1999	Reed Jr. et al			
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	6119799	9/2000	Morisawa			
	5984034	11/1999	Morisawa			
	6334498	1/2002	Morisawa			

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	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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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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	6203468	3/2001	Nitta			
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	6070680	6/2000	Oyama			
	6123642	9/2000	Saito			
	6158541	12/2000	Tabata			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Published application US 2001/0037905 of Nogi et al

EXAMINER	DATE CONSIDERED

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	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 3616

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	6317665	11/2001	Tabata			
	6183389	2/2001	Tabata			
	5873426	2/1999	Tabata			
	5923093	7/1999	Tabata			
	6340339	1/2002	Tabata			
	5935040	8/1999	Tabata			
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	6328122	12/2001	Yamada			
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						YES	NO
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	4929642	8/1974	Japan			"	

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EXAMINER	DATE CONSIDERED

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	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 3616

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	5081365	1/1992	Field et al			
	6044922	4/2000	Field			
	6481516	11/2002	Field et al			
	3719881	3/1971	Shibata et al			
	4187436	2/1980	Etienne			
	5772502	3/1998	Kubo			
	6231135	5/2001	Bower et al			
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	6265692	7/2001	Umebayahi et al			
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	467703	3/1992	Japan			"	
	6245317	2/1993	Japan			"	
	4297330	10/1992	Japan			"	
	51103220	8/1976	Japan			"	

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Mayrhofer et al "A Hybrid Drive Based on a Structure Variable Arrangement" (1994)

EXAMINER	DATE CONSIDERED

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"Diesel-Electric VW", *Popular Science*, December 1990, p. 30.

"Electric Vehicles Only", *Popular Science*, May 1991, pp. 76-81 and 110.

"Lightweight, High-Energy Lead/Acid Battery" *NASA Tech Briefs*, 4/91, 22-24.

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	APPLICANT Severinsky et al	
	FILING DATE 3/7/03	GROUP ART UNIT 3616

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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)

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	5242335	9/1993	Kutter			
	5264764	11/1993	Kuang			
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	5947855	9/1999	Weiss			
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	APPLICANT Severinsky et al	
	FILING DATE 3/7/03	GROUP ART UNIT 3616

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	4099589	7/1978	Williams			
	4233858	11/1980	Rowlett			
	4287792	9/1981	Dailey			

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	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

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	APPLICANT Severinsky et al	
	FILING DATE 3/7/03	GROUP ART UNIT 3616

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	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
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	Yamaguchi et al, "Dual System - Newly Developed Hybrid System" (incomplete)
	Takaoka et al "A High-Expansion-Ratio Gasoline Engine for the Toyota Hybrid System", *Toyota Technical Review* **47**, 2, 1998
	Sasaki et al, "Toyota's Newly Developed Electric-Gasoline Hybrid Powertrain System" (publication data not available)

EXAMINER	DATE CONSIDERED

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	FILING DATE 3/7/03	GROUP ART UNIT 3616

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EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLAS	FILING DATE
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	6041877	3/2000	Yamada et al			
	5887670	3/1999	Tabata et al			
	6123163	9/2000	Otsu et al			
	6260644	7/2001	Otsu			
	6253865	7/2001	Suzuki			
	6435296	8/2002	Arai			
	5258651	11/1993	Sherman			
	5789823	8/1998	Sherman			
	6007443	12/1999	Onimaru			

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	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO
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	Ehsani et al, "Parametric Design of the Drive Train of an Electrically Peaking Hybrid (ELPH) Vehicle", SAE paper 970294 (1997)
	Yamaguchi et al, "Development of a New Hybrid System - Dual System", SAE papers 960231 (1996)

EXAMINER	DATE CONSIDERED

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Partial Translation of JPP'626

Title of the Invention: Driving System for a Vehicle

Inventor: Shohtaroh Naitoh

Applicant: Kabushiki Kaisha Hitachi Seisakusho

Filing date: December 10, 1971

Filing Number: 46-99430

Publication Date: September 6, 1973

Publication No.: 48-64626

- Scope of claim for Patent

1. A driving system for a vehicle characterized by providing an engine for driving one of front wheels or rear wheels, and a motor for driving another of front wheels or rear wheels.

- Brief description of the drawings

Figure 1 is a constitutional drawing of an embodiment of a driving system for a vehicle according to the present invention.

- Reference Numerals

1 ... Frame of Vehicle
2 ... Engine
4a, 4b ... Front wheel
5 ... Motor
7a, 7b ... Rear Wheel
8 ... Generator
9 ... High Voltage Battery
10 ... Charging Diode
11 ... Control System
12 ... Low Voltage Battery for starting up a vehicle
13 ... Pole Changing Switch

Partial Translation of JPP'642

Title of the Invention: Driving Mechanism Control System for a Vehicle with an Electric Motor and an Internal Combustion Engine

Inventor: Kohhei Iritani

Applicant: Kabushiki Kaisha Toyota Jidohshokki Seisakusho

Filing date: September 9, 1970

Filing Number: 45-85443

Patent Grant Date: August 6, 1974

Patent No.: 49-29642

- Scope of claim for Patent

1. Driving mechanism control system for a vehicle comprising:

an electric motor,

an internal combustion engine which drives a generator for supplying electric power to said electric motor,

a connecting clutch for connecting said electric motor to said internal combustion engine only when the rotating speed of said electric motor is greater than a predetermined speed,

an one-way clutch which can transmit driving force from said internal combustion engine to said electric motor, and is connected with said connecting clutch in series, and

a connecting mechanism for connecting a control pedal for controlling electric power supplied to said electric motor with a lever of a control system for controlling fuel amount supplied to said internal combustion engine when said internal combustion engine is in operation and said connecting clutch is in a connecting state.

• Brief description of drawings

Figure shows an embodiment of a driving mechanism control system for a vehicle according to the present invention.

• Reference Numeral

1 ... Internal combustion engine
2 ... Transmission gear
3 ... Connecting clutch
4 ... One-way clutch
5 ... Electric motor
6 ... Differential gear
7 ... Driving wheel
8 ... Chain
9 ... Generator
10 ... Relay
11 ... Battery
12 ... Vehicle speed sensor
13 ... Acceleration pedal
14 ... Control unit
15 ... Sliding contact
16 ... Driving rod
17 ... Control system
18 ... Lever
19 ... Contact
20 ... Sliding cylinder
21 ... Solenoid
22 ... Rod
23 ... Switch
24 ... Electric power source
25 ... Ignition switch

26 ... Spring
27 ... Back spring
28 ... Switch
29 ... Manual grounding switch
30 ... Driving system
31 ... Clutch

⑲ Japanese Patent Office (JP)

⑫ Unexamined Utility Model Publication

⑪ Unexamined Utility Model Publication

53-55105

㊸ Publication Date: May 11, 1978

(51) IPC

H 02 P 9/14
B 60 L 11/12
H 02 J 7/16

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(54) Name of Invention: Generator Control System for a Hybrid Vehicle

㉑ Utility Model Application No: 51-138199

㉒ Filing Date: October 13, 1976

(71) Applicant: Toyo Kohgyo Kabushiki Kaisha

(57) Scope of Claims for Utility Model

Generator control system for a hybrid vehicle, which provides different kinds of power sources, an engine and a motor powered by a battery, and is driven by at least one of said power sources, wherein

said battery is charged by a generator driven by said engine,

a detecting means is provided for detecting a depressing amount of an accelerator which controls output of said engine, and

at least one of a field circuit and an armature circuit of said generator is controlled by said detecting circuit.

Brief Description of the Drawings

Figure 1 is an explanatory drawing of a hybrid vehicle

Figure 2 is a circuit diagram of a generator controlled by a generator control system of the present invention.

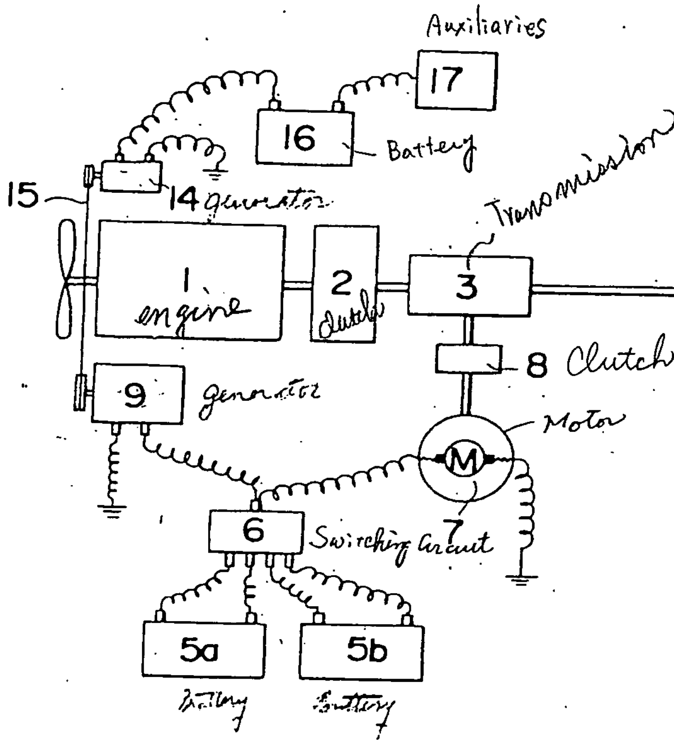
Figure 3 is an explanatory drawing of a relationship between an accelerator and an accelerator switch.

Figure 4 is a modified embodiment of an accelerator switch.

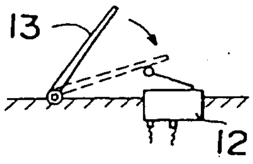
Figure 5 is a graph showing torques at various gear positions when a generator is charged and when a generator is not charged.

1 ... engine
5a, 5b ... battery for running
7 ... motor
9 ... generator
12 ... accelerator switch
13 ... accelerator
A ... armature circuit
F ... field circuit

第1図



第3図



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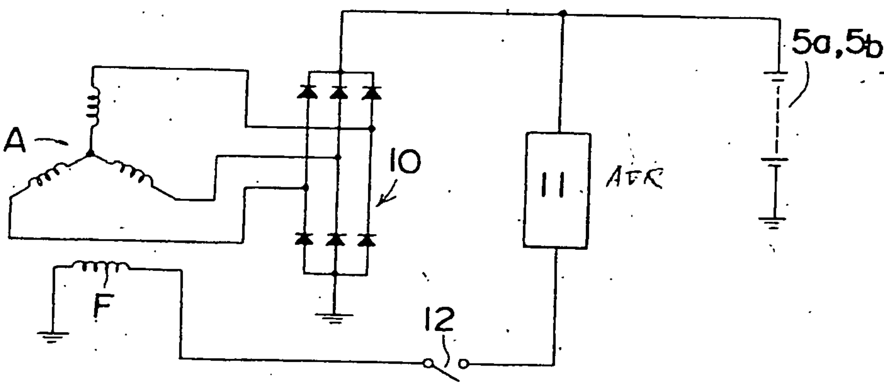

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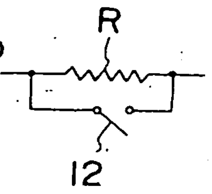
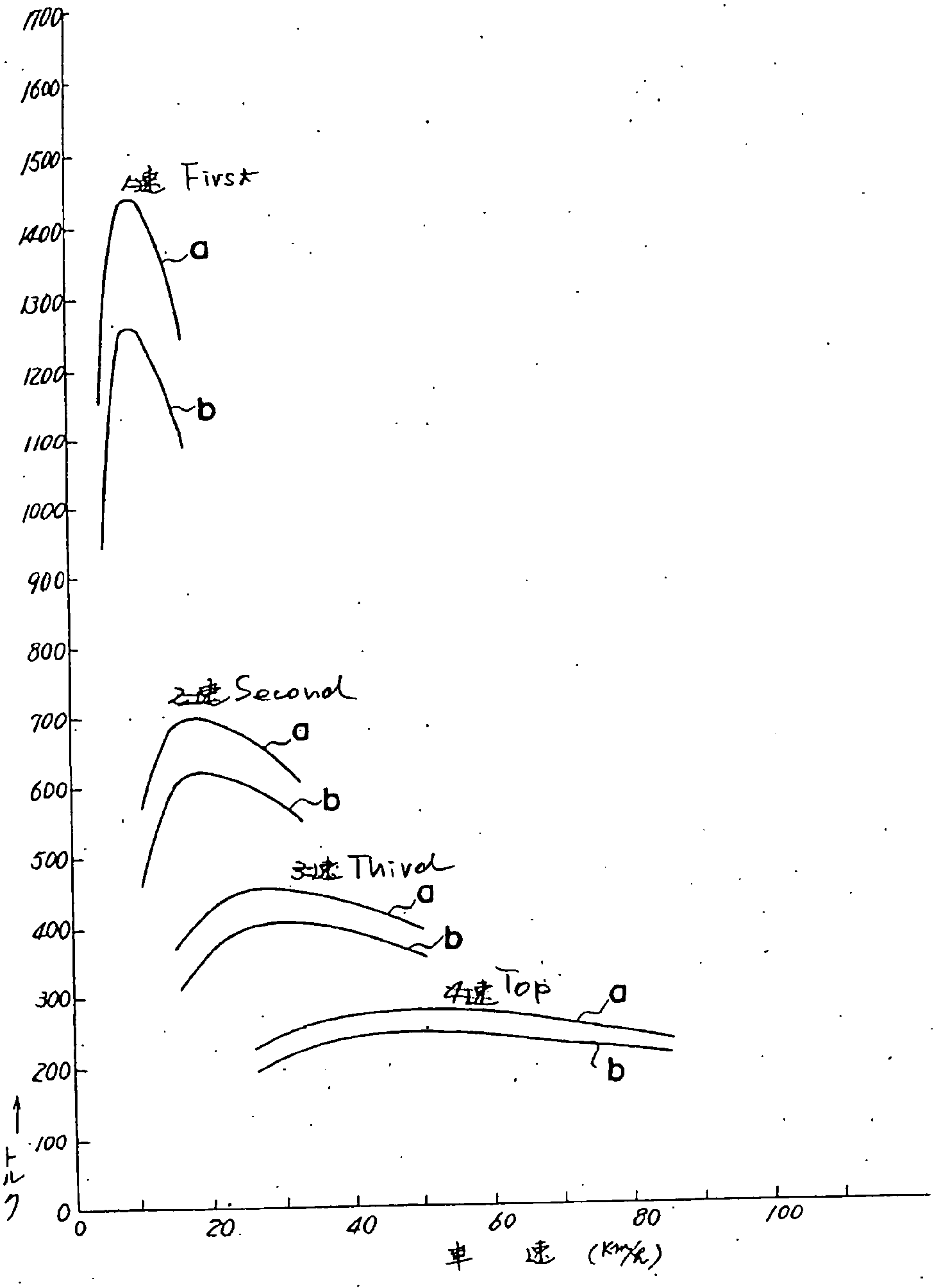


第5図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⑲ Japanese Patent Office (JP)

⑫ Unexamined Patent Publication

⑪ Unexamined Patent Publication
4-67703

㊸ Publication Date: March 3, 1992

(51) IPC

B 60 L 11/02
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(54) Name of Invention: Electric Vehicle

㉑ Patent Application No.: 2-176218

㉒ Filing Date: July 5, 1990

(71) Applicant: Nissan Corporation

(57) Scope of Claims for Patent

Electric vehicle comprising;

an electric motor for driving a vehicle;

auxiliary equipments arranged on said vehicle;

rechargeable battery for powering to said electric motor and said auxiliary equipments;

generating means for generating power to charge said rechargeable battery;

detecting means for detecting operating conditions of said vehicle; and

controlling means for directly supplying electric power from said generating means to said electric motor, and gradually decreasing electric power to said auxiliary equipments.

Brief Description of the Drawings

Figure 1 is a structural diagram of the present invention.

Figure 2 is a block diagram of one embodiment of the present invention.

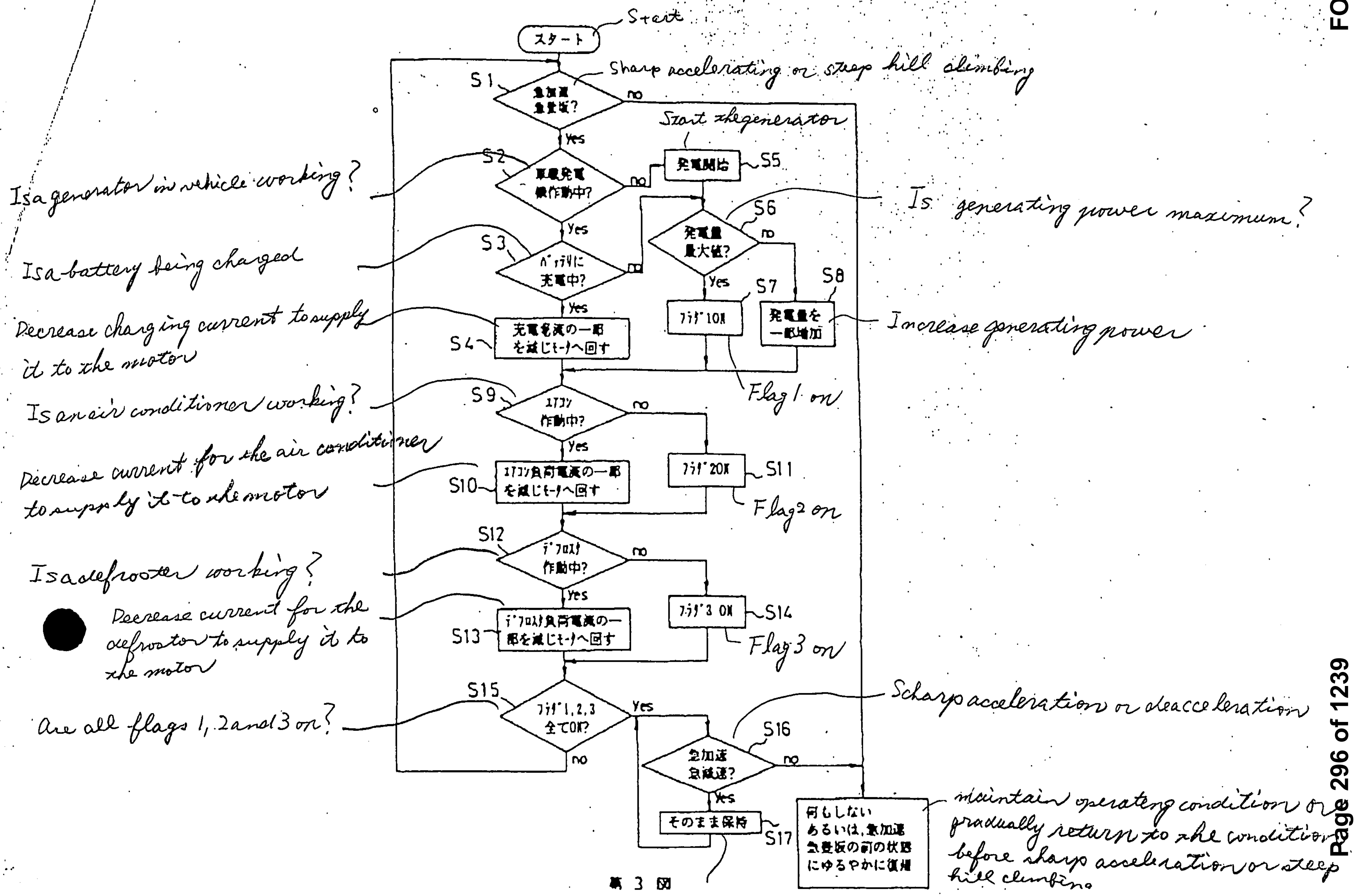
Figure 3 is a flowchart for the block diagram of Figure 2.

Figure 4 is a flowchart for another embodiment of the present invention.

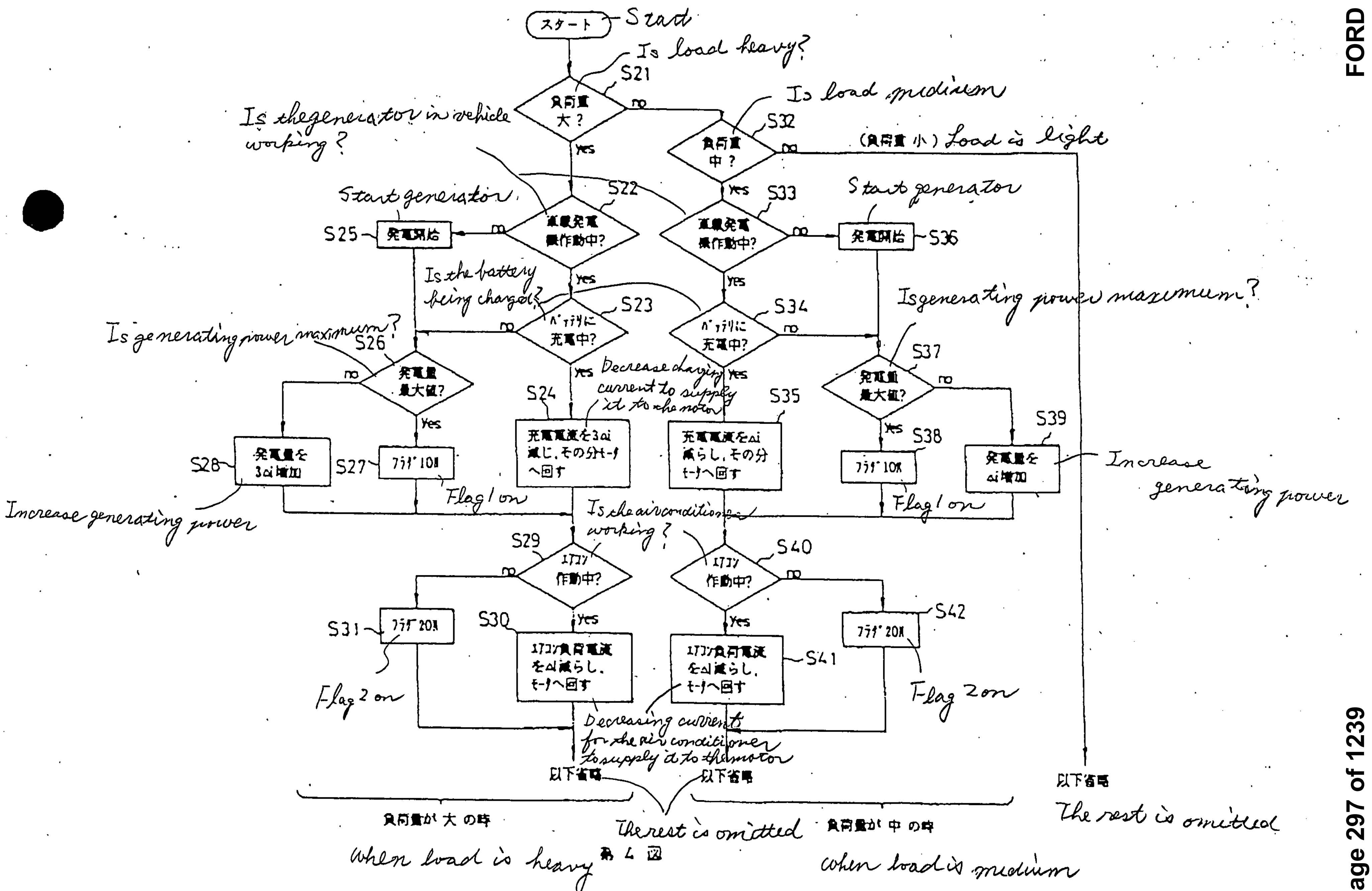
1 ... electric motor
3 ... air conditioner (auxiliary equipment)
5 ... defroster (auxiliary equipment)
7 ... lump (auxiliary equipment)
9 ... 100 Volt battery (rechargeable battery)
CL1 ... generating means
CL2 ... controlling means
CL3 ... operating condition detecting means
11 ... 12 Volt Battery
13 ... in vehicle generator
15 ... solar battery
17 ... regenerating brake
19 ... controller
21 ... controller
23 ... charge/discharge controller

25 ... D/D converter
27 ... controller
29 ... controller
33 ... central controller
35 ... speed sensor
37 ... accelerator opening sensor

acep


スタート
Start
S1
急加速急登坂?
Sharp accelerating or steep hill climbing
Yes
no
S2
車載発電機作動中?
Is a generator in vehicle working?
no
S5
発電開始
Start the generator
Yes
S3
ﾊﾞｯﾃﾘに充電中?
Is a battery being charged
no
S6
発電量最大値?
Is generating power maximum?
Yes
no
S7
ﾌﾗｸﾞ1ON
Flag 1 on
S8
発電量を一部増加
Increase generating power
Yes
S4
充電電流の一部を減じﾓｰﾀへ回す
Decrease charging current to supply it to the motor
S9
ｴｱｺﾝ作動中?
Is an air conditioner working?
no
S11
ﾌﾗｸﾞ2ON
Flag 2 on
Yes
S10
ｴｱｺﾝ負荷電流の一部を減じﾓｰﾀへ回す
Decrease current for the air conditioner to supply it to the motor
S12
ﾃﾞﾌﾛｽﾀ作動中?
Is a defroster working?
no
S14
ﾌﾗｸﾞ3 ON
Flag 3 on
Yes
S13
ﾃﾞﾌﾛｽﾀ負荷電流の一部を減じﾓｰﾀへ回す
Decrease current for the defroster to supply it to the motor
S15
ﾌﾗｸﾞ1,2,3全てON?
Are all flags 1, 2 and 3 on?
Yes
no
S16
急加速急減速?
Scharp acceleration or deacceleration
no
Yes
S17
そのまま保持
何もしないあるいは，急加速急登坂の前の状態にゆるやかに復帰
maintain operating condition or gradually return to the condition before sharp acceleration or steep hill climbing

第 3 図


スタート
Start
Is load heavy?
S21
負荷量大?
Yes
no
Is load medium
S32
負荷量中?
(負荷量小) Load is light
Is the generator in vehicle working?
S22
車載発電機作動中?
S33
車載発電機作動中?
Start generator
S25
発電開始
Start generator
発電開始
S36
Is the battery being charged?
S23
バッテリに充電中?
S34
バッテリに充電中?
Is generating power maximum?
S26
発電量最大値?
Is generating power maximum?
S37
発電量最大値?
Decrease charging current to supply it to the motor
S24
充電電流を3Δi減じ、その分モータへ回す
S35
充電電流をΔi減らし、その分モータへ回す
S28
発電量を3Δi増加
Increase generating power
S27
フラグ1ON
Flag 1 on
S38
フラグ1ON
Flag 1 on
S39
発電量をΔi増加
Increase generating power
Is the air conditioner working?
S29
エアコン作動中?
S40
エアコン作動中?
S31
フラグ2ON
Flag 2 on
S30
エアコン負荷電流をΔi減らし、モータへ回す
S41
エアコン負荷電流をΔi減らし、モータへ回す
S42
フラグ2ON
Flag 2 on
Decreasing currents for the air conditioner to supply it to the motor
以下省略
以下省略
以下省略
The rest is omitted
The rest is omitted
負荷量が大の時
When load is heavy
負荷量が中の時
When load is medium

第4図

3/5/1
DIALOG(R)File 347:JAPIO

04573417

MOTOR CONTROLLER FOR ELECTRIC AUTOMOBILE EQUIPPED WITH ENGINE DRIVEN GENERATOR

PUB. NO.:	06-245317 [JP 6245317 A]
PUBLISHED:	September 02, 1994 (19940902)
INVENTOR(s):	FURUYA MASAYUKI
APPLICANT(s):	TOYOTA MOTOR CORP [000320] (A Japanese Company or Corporation), JP (Japan)
APPL. NO.:	05-023135 [JP 9323135]
FILED:	February 12, 1993 (19930212)
INTL CLASS:	[5] B60L-011/02; B60L-009/18; B60L-011/18
JAPIO CLASS:	26.1 (TRANSPORTATION -- Railways); 21.2 (ENGINES & TURBINES, PRIME MOVERS -- Internal Combustion); 26.2 (TRANSPORTATION -- Motor Vehicles); 43.4 (ELECTRIC POWER -- Applications)
JOURNAL:	Section: M, Section No. 1714, Vol. 18, No. 633, Pg. 76, December 02, 1994 (19941202)

ABSTRACT

PURPOSE: To obtain a motor controller for electric automobile equipped with an engine driven generator in which abrupt overdischarge of battery is prevented when the engine driven generator is not operating and the service life of battery is prolonged by protecting the battery against damage.

CONSTITUTION: An SOC meter 10 detects charged state of a battery 6 and when the charged state is deteriorated, an engine 1 is driven to start operation of a generator 3. When a decision is made that the generator 3 is not operating normally based on a detection value of a voltmeter 13, an ECU 11 controls an inverter 5 to limit current supply to a motor 7 to 1/3-1/2 of normal level. This constitution prevents overdischarge of the battery 6 upon failure of the generator 3.

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Patent Abstracts of Japan

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PUBLICATION DATE : 02-09-94
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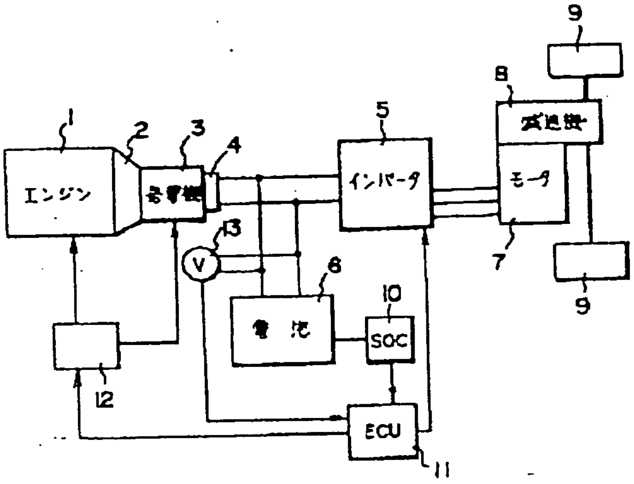
APPLICATION DATE : 12-02-93



VOL: 18 NO: 633 (M - 1714)
AB. DATE : 02-12-1994 PAT: A 6245317
PATENTEE : TOYOTA MOTOR CORP
PATENT DATE: 02-09-1994

INVENTOR : FURUYA MASAYUKI

INT.CL. : B60L11/02; B60L9/18; B60L11/18

TITLE : MOTOR CONTROLLER FOR ELECTRIC AUTOMOBILE EQUIPPED WITH ENGINE DRIVEN GENERATOR

ABSTRACT : PURPOSE:To obtain a motor controller for electric automobile equipped with an engine driven generator in which abrupt overdischarge of battery is prevented when the engine driven generator is not operating and the service life of battery is prolonged by protecting the battery against damage.
CONSTITUTION:An SOC meter 10 detects charged state of a battery 6 and when the charged state is deteriorated, an engine 1 is driven to start operation of a generator 3. When a decision is made that the generator 3 is not operating normally based on a detection value of a voltmeter 13, an ECU 11 controls an inverter 5 to limit current supply to a motor 7 to 1/3-1/2 of normal level. This constitution prevents overdischarge of the battery 6 upon failure of the generator 3.

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報**（Ａ）　(11)特許出願公開番号

特開平6－245317

(43)公開日　平成6年(1994)9月2日

(51)Int.Cl.⁵	識別記号	庁内整理番号	ＦＩ	技術表示箇所
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9/18	Ｊ	9380－4H		
11/18	Ａ	6821－5H		
	Ｃ	6821－5H		

審査請求　未請求　請求項の数１　ＯＬ　（全５頁）

(21)出願番号　特願平5－23135

(22)出願日　平成5年(1993)2月12日

(71)出願人　000003207
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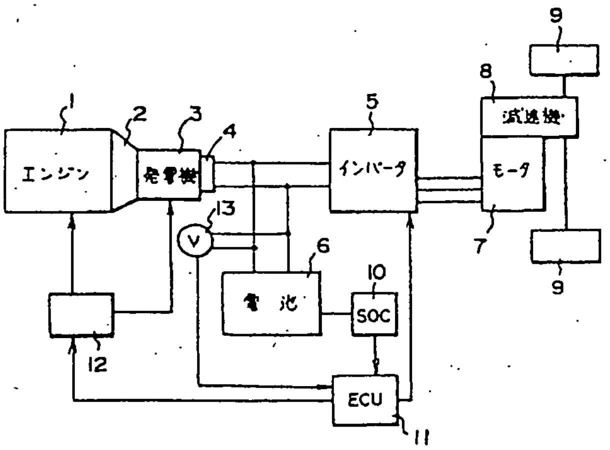
(74)代理人　弁理士　吉田　研二　（外２名）

(54)【発明の名称】　エンジン駆動発電機付電気自動車のモータ制御装置

(57)【要約】

【目的】　エンジン駆動発電機が作動しない場合の電池の急激な過放電を防止し、電池の損傷を低減し長寿命化することができるエンジン駆動発電機付電気自動車のモータ制御装置を得る。

【構成】　ＳＯＣメータ１０により電池６の充電状態を検出し、充電状態が悪化した場合には、エンジン１を駆動して発電機３による発電を開始する。ここで、電圧計１３の検出値により、発電機３が正常に動作していないことを検出した場合には、ＥＣＵ１１は、インバータ５を制御して、モータ７への供給電流を通常の１／３～１／２程度に制限する。これにより、発電機３の故障時における電池６の過放電を防止できる。



全体構成

【特許請求の範囲】

【請求項1】　電気自動車を駆動するためのモータと、このモータを駆動するための充電可能な電池と、前記電池に電力を供給するエンジン駆動発電機とを有するエンジン駆動発電機付電気自動車のモータ制御装置であって、
電池の充電状態を検出する充電状態検出手段と、
この充電状態検出手段により検出された電池の充電状態値が低下した時にエンジン駆動発電機の作動を指示する作動信号を出力するエンジン駆動発電機制御手段と、
エンジン駆動発電機の作動を検出する発電機作動検出手段と、
上記エンジン駆動発電機制御手段より作動信号および発電機作動検出手段の検出結果より、作動信号が出力されたにもかかわらずエンジン駆動発電機が作動しないと判定されたとき、モータの出力に制限を加えるモータ出力制限手段と、
を備えたことを特徴とするエンジン駆動発電機付電気自動車のモータ制御装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】この発明は、電池に充電電力を供給するエンジン駆動発電機を有するエンジン駆動発電機付電気自動車のモータ制御装置に関する。

【0002】

【従来の技術】近年、公害防止の観点から電気自動車が注目されている。しかし、電気自動車は、そのエネルギー源として電池を搭載するが、この電池はかなりの大容積、大重量のものであっても、その電気容量で走行可能な距離はそれ程大きくない。そこで、一充電当たりの走行距離を伸ばすために、エンジン駆動発電機を搭載し、発電電力によって電池を充電するエンジン駆動発電機付電気自動車が知られている。

【0003】このエンジン駆動発電機付電気自動車では、エンジン駆動時に排ガスが発生する。このため、電池の充電状態が悪化したときにのみエンジン駆動発電機を作動させ、エンジンの駆動を最小限としている。そこで、低公害性を維持しつつ、バッテリを増加することなく一充電当たりの走行距離を延長することができる。このようなエンジン駆動発電機付電気自動車は、例えば特開昭55－157901号公報に示されている。

【0004】

【発明が解決しようとする課題】ここで、上述のような従来のエンジン駆動発電機付電気自動車においては、エンジン駆動発電機が正常に作動し、ここから電力が供給されることを前提としている。このため、電池の充電状態が悪化した場合にもモータの出力は通常時と同様に制御される。

【0005】ところが、エンジン駆動発電機は絶対に故障しないとはいえない。そこで、エンジンが作動しなかったり、発電機が故障したりし、発電ができなかったり、発電はできても発電量が所定量に達しない場合もある。

【0006】そして、エンジン駆動発電機を作動させるということは、電池の充電状態が悪化していることを意味しており、この状態で通常のモータ駆動を続けた場合には、電池の充電状態はさらに悪化し、走行不能となる。また、このように、走行が不能になるまで、電池が放電すると、過放電により電池を損傷するおそれがあり、電池の容量や寿命の低下を来すという問題点があった。

【0007】この発明は、上記問題点を解消するためになされたものであり、エンジン駆動発電機が作動しない場合に生じる電池の急激な過放電を防止することができるエンジン駆動発電機付電気自動車のモータ制御装置を得ることを目的とする。

【0008】

【課題を解決するための手段】本発明は、電気自動車を駆動するためのモータと、このモータを駆動するための充電可能な電池と、前記電池に電力を供給するエンジン駆動発電機とを有するエンジン駆動発電機付電気自動車のモータ制御装置であって、電池の充電状態を検出する充電状態検出手段と、この充電状態検出手段により検出された電池の充電状態値が低下した時にエンジン駆動発電機の作動を指示する作動信号を出力するエンジン駆動発電機制御手段と、エンジン駆動発電機の作動を検出する発電機作動検出手段と、上記エンジン駆動発電機制御手段より作動信号および発電機作動検出手段の検出結果より、作動信号が出力されたにもかかわらずエンジン駆動発電機が作動しないと判定されたとき、モータの出力に制限を加えるモータ出力制限手段と、を備えたことを特徴とするエンジン駆動発電機付電気自動車のモータ制御装置。

【0009】

【作用】この発明におけるエンジン駆動発電機付電気自動車のモータ制御装置は、電池の充電状態を検出する充電状態検出手段により検出された電池の充電状態値に応じ、電池の充電状態値が低下した時にエンジン駆動発電機制御手段によりエンジン駆動発電機を作動させる信号を出力し、エンジン駆動発電機を作動させ、電池を充電する。

【0010】そして、電池の充電状態値が低下し、エンジン駆動発電機を作動させる信号が出力されたにもかかわらずエンジン駆動発電機が作動しない時は、モータ出力制限手段によりモータの出力に制限を加えることができる。従って、エンジン駆動発電機が作動しない場合には、モータの出力を小さくでき、これによって電池の急激な過放電を防止し、電池の損傷を低減し、長寿命化することができる。

【0011】

【実施例】以下、この発明の一実施例を図について説明する。

【００１２】図１において、エンジン１は、動力を発生する原動機であり、増速機２を介して回転速度を増加させた後、発電機３を駆動して発電する。発電される電力は交流なので、整流器４により整流し直流に変換した後、インバータ５および電池６に供給されるようになっている。モータ７は、交流誘導モータであり、インバータ５を介して供給される所定の交流電力により駆動される。モータ７のトルクは減速機８を介してタイヤ９を駆動するようになっている。ＳＯＣメータ１０は電池の充電状態を検出する充電状態検出手段であり、ＥＣＵ（電子制御ユニット）１１は各種処理を行う。ＳＯＣメータ１０は電池６の充放電量をカウント（放電電流量を積算）し、電池６の充電状態情を把握し、ＥＣＵ１１に提供する。ＥＣＵ１１は、ドライバからのアクセル信号やブレーキ信号を入力としてインバータ５をコントロールして、モータの出力を制御すると共に、ＳＯＣメータ１０の充電状態値信号に基づき発電機３を作動・停止させるエンジン駆動発電機制御手段として機能する。すなわち、エンジン発電ユニットコントローラ１２にその作動・停止信号を送る。また、電圧計１３は、電池６の端子間電圧を計測するものであり、検出値をＥＣＵ１１に供給する。ＥＣＵ１１は、電圧計１３の検出電圧により、発電機３の異常を検出する。

【００１３】図２は、上記エンジン駆動発電機付電気自動車のモータ制御装置のエンジン発電ユニットコントローラ１２の作動・停止制御動作を示すフローチャートである。まず、ＳＯＣメータ１０により、ＳＯＣ（Ｓｔａｔｅ Ｏｆ Ｃｈａｒｇｅ：充電状態値）を検出し（Ｓ１０１）、検出したＳＯＣが所定値Ａ（例えば、３０～６０％程度の任意の値）より大きいかどうかを判断する（Ｓ１０２）。Ｓ１０２においてＮＯ、すなわちＳＯＣが所定値未満の場合、電池６は充電を要する状態なので、発電機３による発電を開始するため、ＥＣＵ１１は発電機３の作動を指令する作動信号をエンジン発電ユニットコントローラ１２に送る。そして、エンジン発電ユニットコントローラ１２は、エンジン１を駆動開始すると共に、所定の界磁電流を発電機３に供給し、発電を開始する（Ｓ１０３）。なお、Ｓ１０２でＹＥＳの場合は、電池が充分な充電状態にあるので発電を行わず、Ｓ１０１に戻ってＳＯＣ検出を再度実行する。

【００１４】そして、Ｓ１０３で発電を開始した後、Ｓ１０４に進み、正常動作か否かを判定する（Ｓ１０４）。この判定は、例えば電圧計１３により、電池６の端子間電圧を計測し、これが所定値以上となったことにより、正常動作であることを判定する。なお、正常か否かの判定は、Ｓ１０４の判定がＹＥＳの場合は、次にＳＯＣがＢ（例えば５０～８０％の任意の値で上述のＡより所定以上大きい値）より大きいか否かを判断する（Ｓ１０５）。Ｓ１０５で、ＹＥＳの場合、電池が充分な充電状態にあるので、発電を停止する（Ｓ１０６）。一方、Ｓ１０５においてＮＯの場合は、電池６の充電状態が十分回復していないため、発電を継続するため、Ｓ１０４に戻って正常動作がなされているか否かの判定を繰り返す。

【００１５】そして、Ｓ１０４でＮＯの場合、すなわち、ＥＣＵ１１からエンジン発電ユニットコントローラ１２に動作信号が発信されたにもかかわらず、エンジン発電ユニットコントローラ１２、発電機３、またはエンジン１の燃料系や点火系の故障によりエンジン１が作動しなくなったり、発電機３が発電しないか所定の出力がでない時には、ＥＣＵ１１に備えられたモータ出力制限手段の機能によりモータ出力に制限を加える。この時の出力制限は、ＳＯＣの減り方に応じて、本来の最大出力の１／３～１／２位に設定される。この出力制限は、インバータ５の駆動制御により行い、例えばＥＣＵ１１に入力されたトルク指令値自体を１／３～１／２にし、インバータ５の駆動を制御することによって行う。これによって、モータ７に供給される電流量が制限され、電池の急激な放電を防止することができる。なお、このようなエンジン駆動発電機の異常をドライバーに知らせるために、警報ブザーや警告表示を行うとよい。また、エンジン駆動発電機の自動点検手段を設けておき、エンジン１、増速機２、発電機３、整流器４のいずれの異常かを検出したり、その原因を自動的に検出、表示するようにしてもよい。また、エンジンの始動ミスの場合にはリトライを促したり、自動的にリトライするようにしてもよい。

【００１６】以上のようにして、本実施例によれば、電池６の充電状態値が低下しエンジン駆動発電機を作動させる信号が出力されたにもかかわらず発電機３が正常に作動しない時、ＥＣＵ１１に備えられたモータ出力制限手段によりモータ７の出力に制限を加え、電池６の急激な過放電を防止し、電池の損傷を低減し寿命を引き延ばすことができる。

【００１７】

【発明の効果】以上説明したように、この発明のエンジン駆動発電機付電気自動車のモータ制御装置は、エンジン駆動発電機を作動させる信号が出力されたにもかかわらずエンジン駆動発電機が作動しない時、モータ出力制限手段によりモータの出力に制限を加える。そこで、エンジン駆動発電機が作動しない場合にモータを高出力で駆動し、電池が急激に放電することを防止できる。このため、電池の過放電を防止し、電池の損傷を低減し、長寿命化することができる。

【図面の簡単な説明】

【図１】この発明の一実施例の全体構成を示すブロック図である。

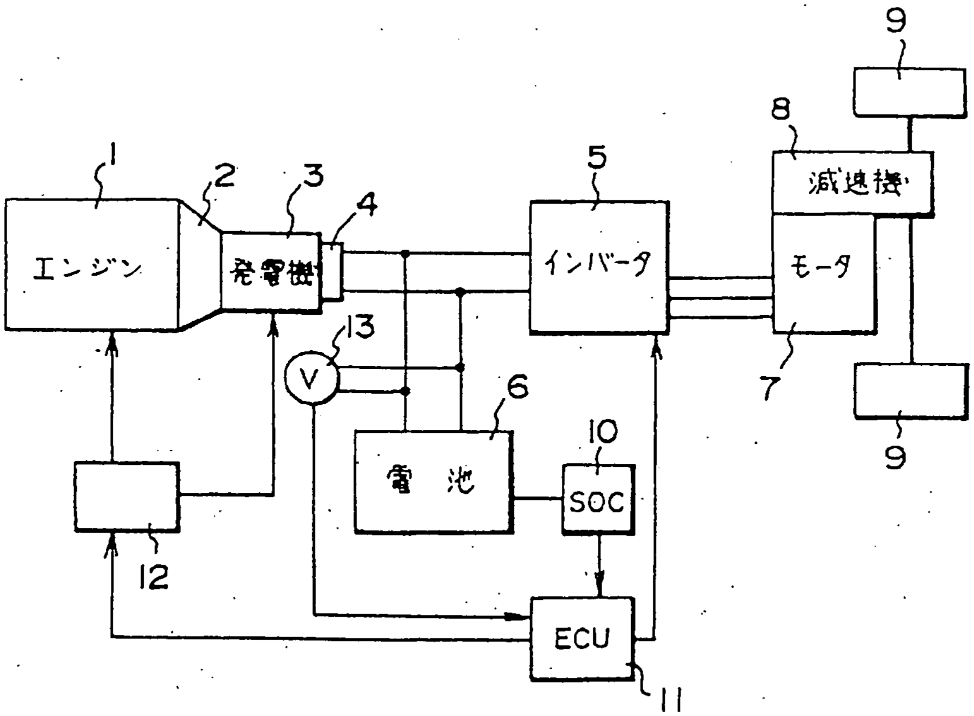
【図２】この発明の一実施例の制御動作を示すフローチャ

ャートである。

【符号の説明】

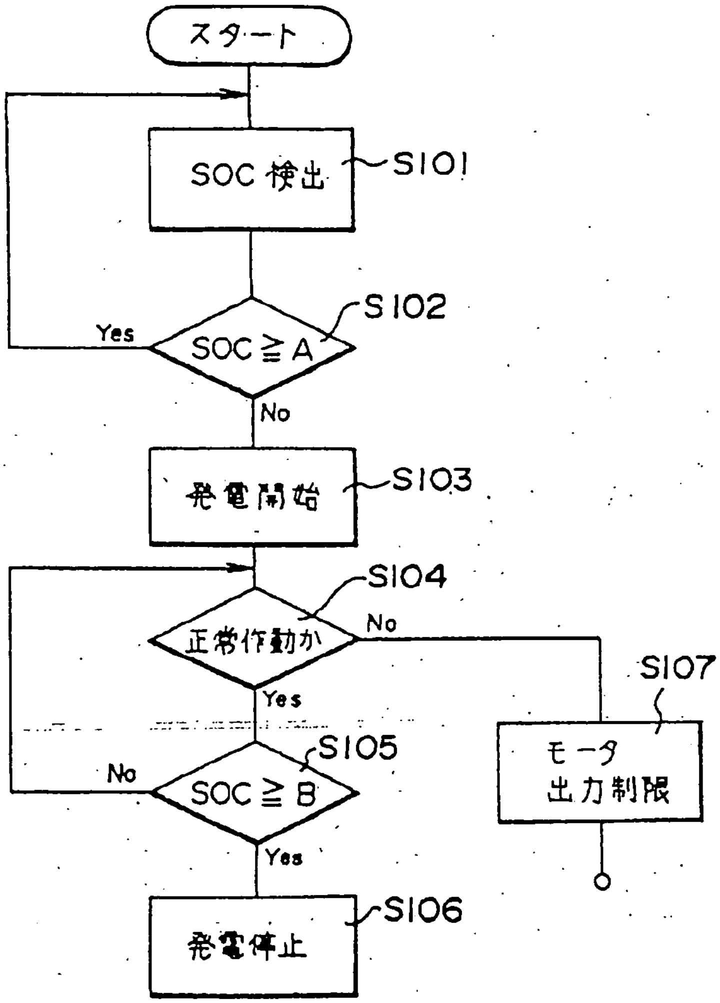
1　エンジン
2　増速機
3　発電機
4　整流器
5　インバータ
6　電池
7　モータ
8　減速機
9　タイヤ
10　SOCメータ
11　ECU
12　エンジン発電ユニットコントローラ
13　電圧計

【図1】



全体構成

【図2】


スタート
SOC検出
S101
SOC≧A
S102
Yes
No
発電開始
S103
正常作動か
S104
No
Yes
S107
モータ
出力制限
SOC≧B
S105
No
Yes
発電停止
S106

制御フロー

3/5/2

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SERIES-PARALLEL COMPLEX HYBRID CAR SYSTEM

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ABSTRACT

PURPOSE: To provide such a series-parallel complex hybrid car system that is solving any regenerative braking torque shortage at the high speed side of a motor at time of regenerative braking, and capable of securing an almost constant regenerative braking torque ranging from low to high speed rotation.

CONSTITUTION: The system is provided with an engine 1, a generator 3, a traveling motor 9 and a battery 17, while it installs a continuously variable transmission 5 in space between the engine 1 and the motor 9, and simultaneously there is provided a control means 18 which controls the continuously variable transmission 5 so as to make up for a regenerative braking torque insufficient portion at the high speed side of the motor 9 with the resultant torque of friction torque of the engine 1 and regenerative braking torque of the generator 3.

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8/00				
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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。

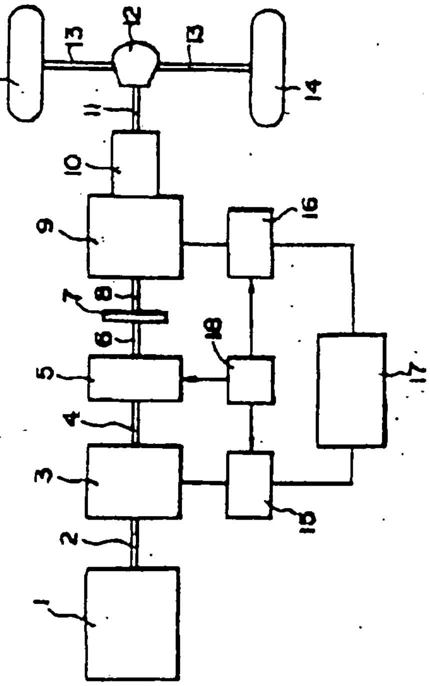


図1

【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】

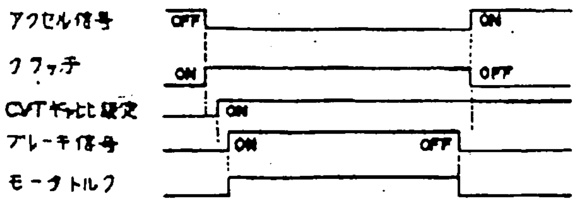


図５

【図1】

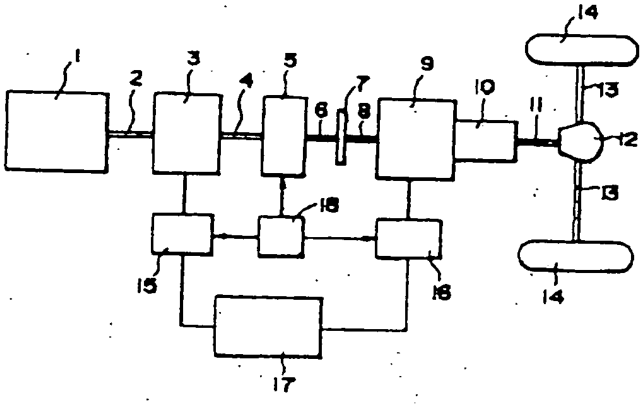
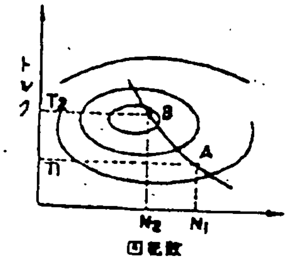
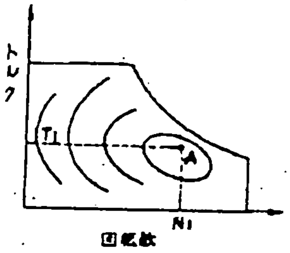


図 1

【図2】



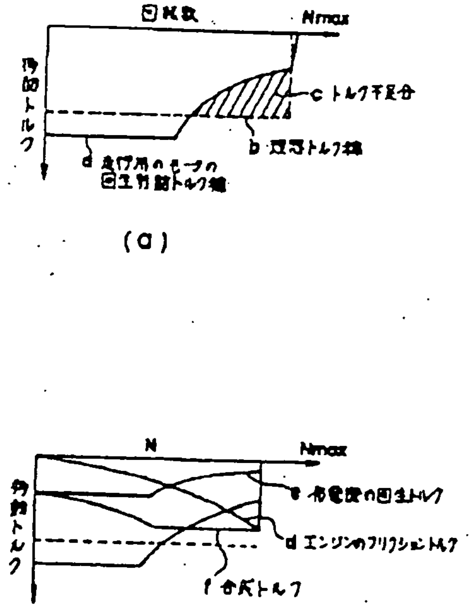
(a) エンジン



(b) モータ

図2

【図3】



(a)

(b)

図 3

【図4】

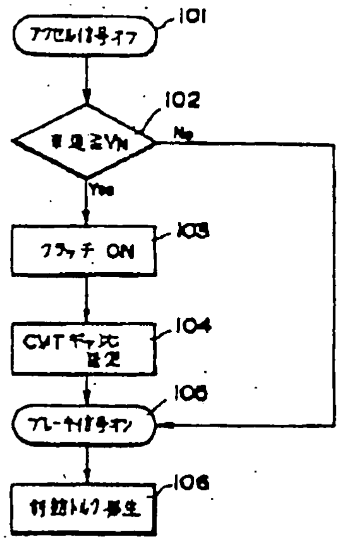


図4 フローチャート

フロントページの続き

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⑲ Japanese Patent Office (JP)

⑫ Unexamined Utility Model Publication

⑪ Unexamined Utility Model Publication

51-103220

㊸ Publication Date: August 18, 1976

(51) IPC

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11/12

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(54) Name of Invention: Control System for a Hybrid Vehicle

㉑ Utility Model Application No: 50-21601

㉒ Filing Date: February 18, 1975

(71) Applicant: Toyota Jidosha Kabushiki Kaisha

(57) Scope of Claims for Utility Model

Control system for a hybrid vehicle, in which an output shaft of an engine is connected to a rotating shaft of a motor powered by a battery through a clutch, said battery is charged by power generated by a generator connected to said output shaft of said engine, and a solenoid valve controlled by an electric signal is arranged on an oil tube connected to said clutch, comprising:

rotating speed sensors for detecting rotating speeds of said output shaft of said engine and said rotating shaft of said motor respectively;

a comparator for comparing a rotating speed of said output shaft of said engine detected by said output shaft rotating speed sensor with a rotating speed of said rotating shaft of said motor detected by said rotating shaft rotating speed sensor, outputting an electric signal when said rotating shaft rotating speed is higher or equal than said output shaft rotating speed, and for controlling said solenoid valve to open said oil tube when said comparator outputs said electric signal;

an oil pressure switch for generating an electric signal when oil pressure reaches to a clutch connecting pressure; and

an interrupting means for interrupting a field circuit of said generator when electric signals are generated from said comparator and said oil pressure switch simultaneously.

Brief Description of the Drawings

Figure 1 is a contractual drawing showing an embodiment of a hybrid vehicle according to the present invention.

Figure 2 is a circuit diagram of a control system according to the present invention.

Figure 3 is timing graphs when the operation mode is transferred from the first mode to the second mode

1 ... engine
2 ... output shaft
3 ... clutch
4 ... motor
5 ... rotating shaft
6 ... speed up gear
7 ... generator
9 ... battery
10, 11 .... sensor

12 ... oil pipe
13 ... solenoid valve
18 ... oil pressure switch
19 ... comparator
20 ... AND gate
25 ... inverter
27 ... field coil
31 ... coil

⑲ Europäisches Patentamt
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⑪ Publication number: **0 510 582 A2**

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㊾ **Vehicle powerplant featuring thermal and electrical drive means.**

(57) A powerplant comprising a combustion engine (1) connected to a transmission (2) via a propeller shaft (3) fitted with a clutch (4); a current generator (7) for supplying current to a storage battery (8), and powered by a countershaft (5) connected to the propeller shaft (3) via a first gear drive (6) upstream from the clutch (4); and an electric motor (10) connected to the propeller shaft (3) via a second gear drive (11) downstream from the clutch (4); a second clutch (12) being provided between the electric motor (10) and the second drive (11).

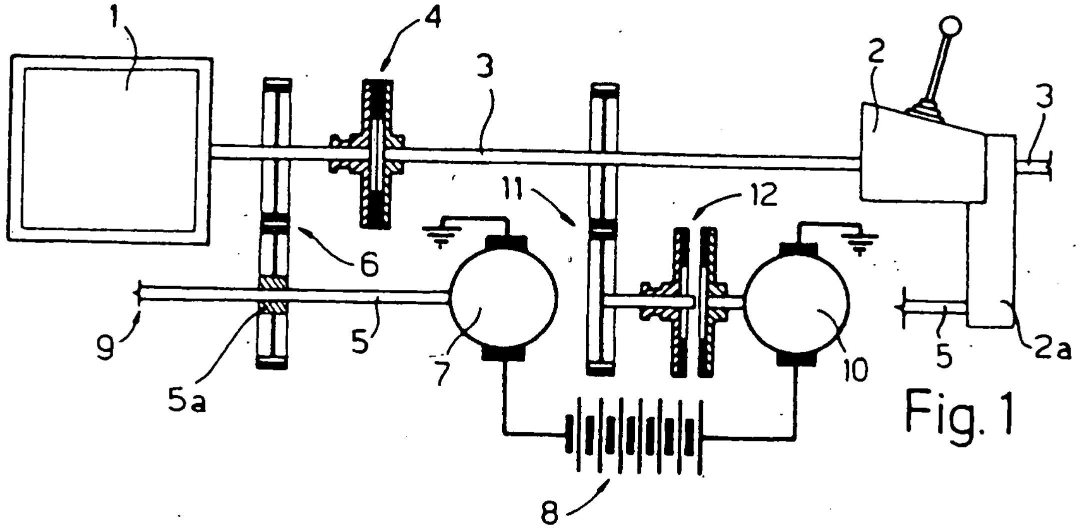

Fig. 1

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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.

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 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 clutch located between said engine and said transmission and which may be set to a first and second position wherein said combustion engine is respectively connected to and disconnected from said transmission; characterized by the fact that it comprises:

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 clutch;

an electric motor, the rotor element of which is connected by a first drive to said drive line downstream from said 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.

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.

In particular, the rotor element of current generator 7 may be connected directly to drive line 3, upstream from coupling 4, instead of via the interposition of shaft 5 and gear drive 6 as described herein.

In this case, shaft 5 may still be connected to line 3 via gear drive 6, as shown in the accompanying drawings, but no longer to the rotor element of current generator 7.

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 clutch (4) located between said engine (1) and said transmission (2) and which may be set to a first and second position wherein said combustion engine (1) is respectively connected to and disconnected from said transmission (2); characterized by the fact that it comprises:

   a current generator (7) for supplying electric current to a storage battery (8), and the rotor element of which is connected to said drive line (3) upstream from said clutch (4);

   an electric motor (10), the rotor element of which is connected by a first drive (11) to said drive line (3) downstream from said clutch (4), said electric motor (10) being driven by the current supplied by said battery (8);

   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).

2. A powerplant as claimed in Claim 1, characterized by the fact that it also comprises a shaft (5) connected by a second drive (6) to said drive line (3) upstream from said clutch (4), and which provides for a power takeoff (9) for operating the accessory devices of said vehicle; the rotor element of said current generator (7) being connected to said shaft (5).

3. A powerplant as claimed in one of the foregoing Claims, characterized by the fact that said current generator (7) is also designed to operate 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).

4. 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.

5. 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).

6. A powerplant as claimed in one of the foregoing Claims from 1 to 4, characterized by the fact that said first drive (11) is connected to said drive line (3) downstream from said transmission (2).

7. 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).

8. 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).

9. 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).

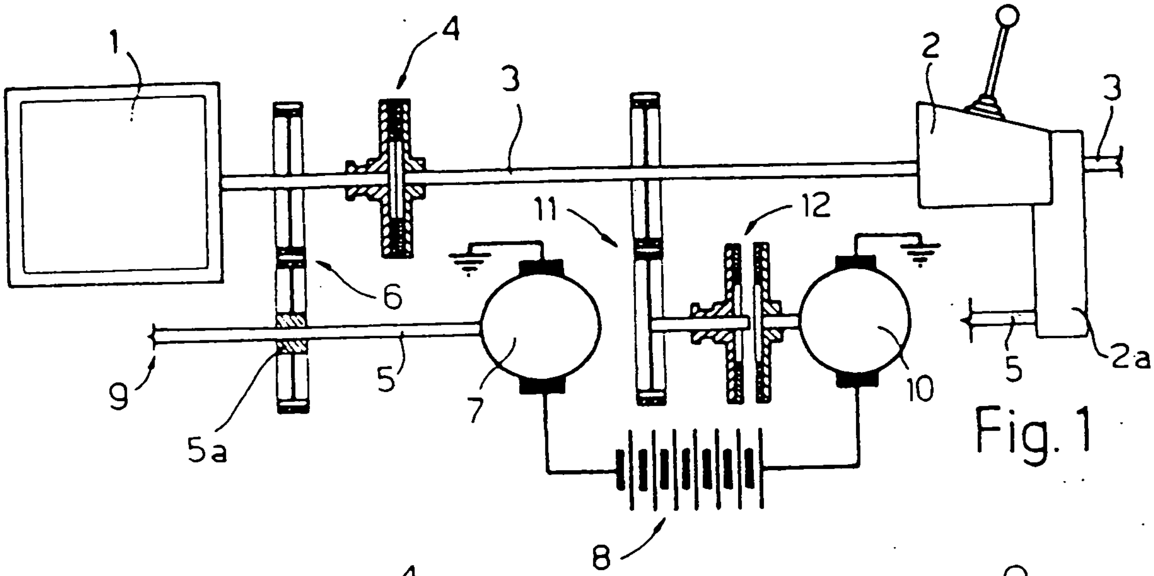

Fig. 1

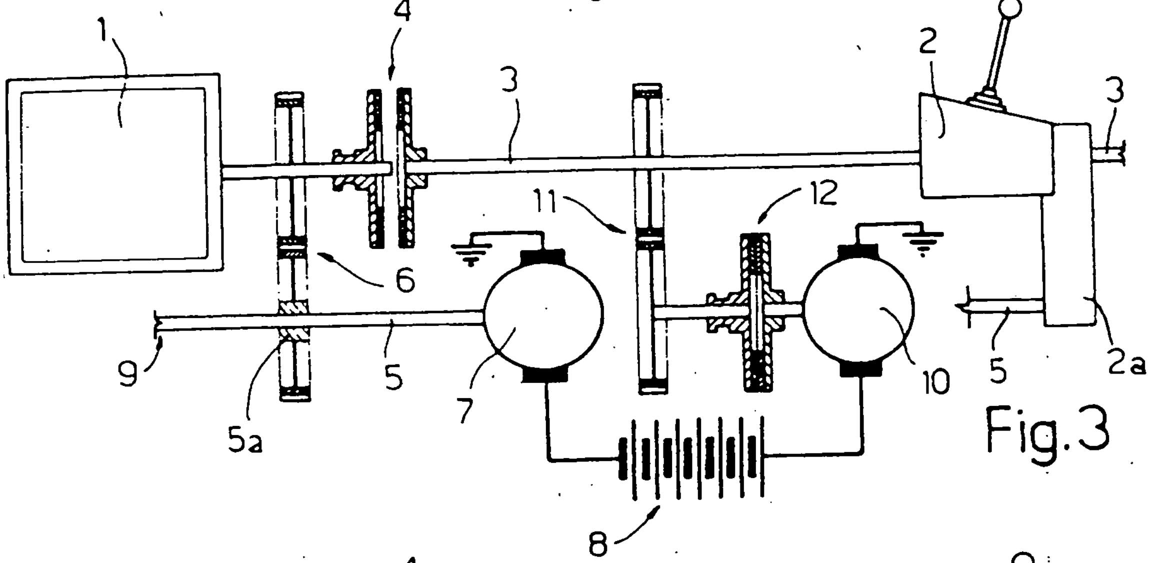

Fig.3

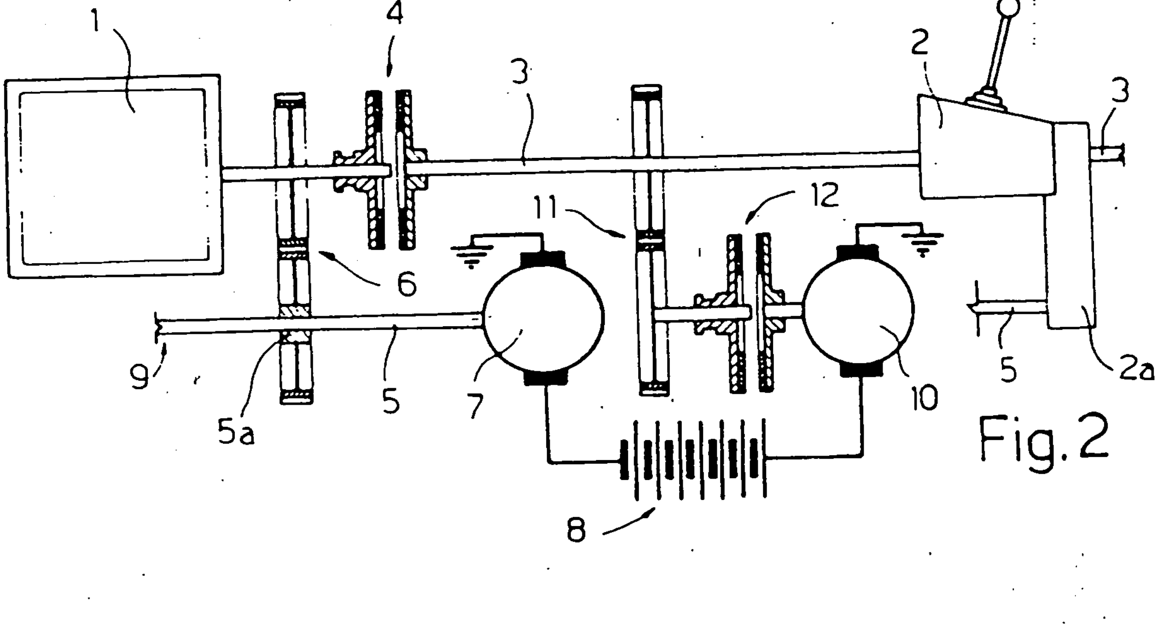

Fig. 2

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⑪ Publication number: **0 136 055**
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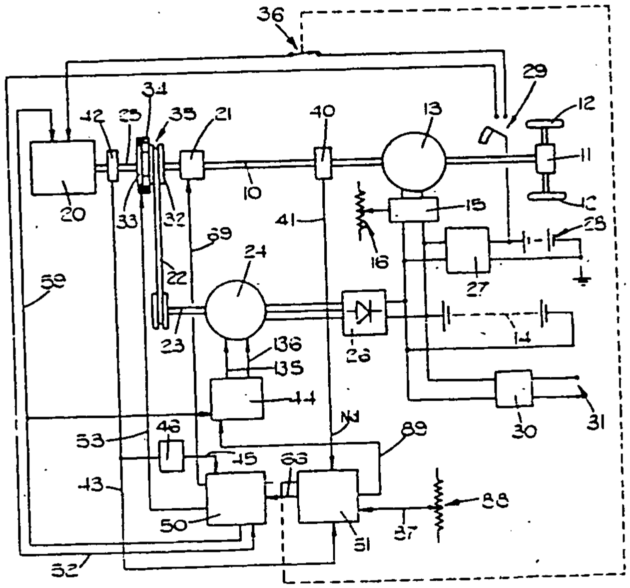
(54) Drive system.

(57) An engine drive shaft (10) may be powered by an electric motor (13) or an internal combustion engine (20). The engine (20) is engageable with the shaft (10) through a clutch (21) and the engine speed is matched with that of the shaft (10) before engagement of the clutch (21) by loading the engine (20) with an electric generator (24) and varying the generator field current until the speeds are equal, when the clutch (21) is automatically engaged.



EP 0 136 055 A1

ACTORUM AG

DRIVE SYSTEM

This invention relates to a drive system for a and in particular to a system in which a vehicle may be propelled either by an electric motor or by an internal combustion engine.

In such a system it is commonly required to change from electrical to internal combustion power while the vehicle is running, and in known systems it has been the practice to match the engine and motor speeds by operating the engine throttle. However before the engine shaft is engaged with an output shaft of the system the response of the unloaded engine to throttle adjustments results in the engine speed hunting above and below its desired value. The consequent mismatch of the engine and motor speeds is likely to result in damage or severe wear to a clutch used to couple the engine to the output shaft.

According to the invention there is provided a drive system, comprising a main drive shaft for the vehicle, an internal combustion engine, a first clutch for coupling said engine to said drive shaft, means for electrically loading said engine to vary the speed thereof and means for actuating said first clutch only when the speeds of said engine and said shaft are substantially equal.

In one embodiment said means for coupling the engine to the drive shaft includes a rotor shaft of said motor.

In a preferred embodiment said engine speed is controllable by an electric generator, and there is provided means for varying the load applied to said engine by said generator.

In a particular embodiment said generator is connectable to charge said battery.

An embodiment of the invention will now be described by way of example only and with reference to the accompanying drawings in which:-

Figure 1 is a diagram of a vehicle propulsion system according to the invention,

Figure 2 is a diagram of a clutch control circuit forming part of Figure 1,

Figure 3 is a diagram of a speed comparator circuit forming part of Figure 1, and

Figures 4, 5 and 6 show respective parts of a circuit forming part of the system of Figure 1.

As shown in Figure 1 a vehicle drive system includes a main drive shaft 10 which is connected through a known type of differential gear 11 to driving wheels 12 of the vehicle. Drivingly coupled to the shaft 10 is the rotor of an electric motor 13 which can be energised by a battery 14 by way of a control circuit 15. The speed of the motor 13 is adjustable by a suitable control 16.

An internal combustion engine 20 has an output shaft 25 which can be coupled to the shaft 10 by means of an electro-magnetic clutch 21. A non-slipping belt and pulley arrangement 22 is coupled to a further shaft 23.

A three-phase alternator 24 is drivingly coupled to the shaft 23. The arrangement 22 includes a pulley 32 which is loose on the shaft 25. A plate 33 is drivingly coupled to the shaft 25. A stationary electromagnet 34 surrounds the pulley 32 and plate 33 and is energisable to urge the plate 33 and pulley 32 into frictional driving engagement. The pulley 32, plate 33 and electromagnet 34 combine to provide a further clutch 35. Output current from the alternator 24 is supplied to a rectifier circuit 26 whose output is connected across the battery 14.

The battery 14 comprises eighteen 12 volt battery units, providing 216 volts. A dc/dc converter 27 is connected across the output of the battery 14 for maintaining a charge on an auxiliary 12 volt battery 28 which can supply, inter alia, the starter and ignition circuits of the engine 20, through a switch 29.
In its fully clockwise position the switch 29 supplies current to a starter (not shown) of the engine 20 through a switch 36.

A battery charging circuit 30 is also connected across the terminals of the battery 14 and can be connected to a 240 volt mains supply through terminals 31.

A transducer 40 is coupled to the shaft 10 and provides, on a line 41, a signal Nd corresponding to the speed of the shaft 10. A further transducer 42 is coupled to the shaft 25 and provides, on a line 43 a signal Ne corresponding to the speed of the engine 20. A limit detecting circuit 46 is responsive to the engine speed signal Ne on line 43 to provide a signal on a line 45 when the signal Ne exceeds a predetermined low value. A circuit 44 is shown in detail in Figures 4 to 6 and acts to regulate the field current of the alternator 24, and thereby the load imposed by the alternator 24 on the engine 20 when the clutch 35 is operated.

The propulsion system can be operated in at least five modes:-

1. With the clutch 21 disengaged and the motor 13 energised by the battery 14 to drive the shaft 10.

2. With the clutch 21 disengaged, the battery 14 energising the motor 13 to drive the shaft 10, the engine 20 running and the clutch 35 engaged to drive the alternator 24 and thereby to maintain the charge of the battery 14 and to provide at least part of the current supply to the motor 13.

3. With the engine 20 running, clutch 21 engaged, clutch 35 disengaged and the motor 13 de-energised by means of its control circuit 15. In this condition the engine 20 is driving the shaft 10 directly and the rotor of the motor 13 acts, effectively, as a flywheel.

4. With the engine 20 running, the clutch 21 engaged and the motor 13 energised to drive the shaft 10. In this condition the engine 20 is supplementing the power output of the motor 13.

5. With the engine 20 running, the clutch 21 engaged and the motor 13 acting as a generator to charge the battery 14.

In any of operating modes 3, 4 or 5 above, the speed of the engine 20 is controlled in a conventional manner by a throttle operated by a pedal.

Operation in modes 3, 4 and 5 will usually be commenced when the vehicle is moving at a substantial speed. It is therefore necessary to match the speed of the engine 20 with that of the shaft 10 before the clutch 21 is engaged. Speed matching is effected by engaging the clutch 35 while the engine 20 is stationary, starting the engine, opening the engine throttle sufficiently to enable its speed to be raised to a level at which the clutch 21 can be operated, and varying the load applied by the alternator 24 to the engine 20, to cause operation of the clutch 21 by circuits 50, 51 shown in detail in Figures 2 and 3 respectively.

As shown in Figure 2 the circuit 50 includes a relay R1 having normally-closed contacts R1a and normally open contacts R1b. A further relay R2 has normally open contacts R2a and normally closed contacts R2b. A third relay R3 has normally closed contacts R3a and normally open contacts R3b. A fourth relay R4 has normally open contacts R4a and a fifth relay R5 has normally closed contacts R5a. When the engine ignition switch 29 (Figure 1) is in its central, normally-running position a signal is provided on a line 52 to the circuit 50.

The line 52 is connected to the clutch 35 through a line 53, by way of the relay contacts R4a. The line 52 is also connected to the line 53 through a series arrangement of the contacts R1a, contacts R2b, diodes 54, 55 connected cathode to cathode and the contacts R5a. The relay R4 is connected in parallel with a RC delay circuit 56 to the junction between the diodes 54, 55. The line 45 is connected through a diode 57 and a resistor 58 to a line 59 connected to the ignition circuit of the engine 20. A series arrangement of two diodes 60, 61 connected cathode to cathode, the contacts R2a and contacts R1a are also connected between the line 45 and the line 52. The relay R2 is connected between earth and the junction of the diodes 60, 61. The relay R3 can be energised from the line 52 through the contacts R1b and a switch 65 arranged in series. The switch 65 is operable by a signal on a line 66 from the circuit 51 (Figure 1). The line 52 can be connected to the relay R1 by means of a manually operable switch 67. Energisation of relay R1 closes contacts R1b and the relay R1 is thereafter maintained energised through a diode 68. The relay R5 is energisable from the line 52 through a series arrangement of the contacts R1b, R3b and a diode 73. The relay R5 is also energisable from the line 52 when the contacts R1b and the switch 65 are both closed. A line 69 to the clutch 21 (Figure 1) communicates with the line 52 when the contacts R1b and R3b are both closed. Indicator devices 70, 71 are energised when signals are present on the lines 53, 69 respectively. A further indicator device 72 is energised when the relay R1 is latched on through the contacts R1b and diode 68.

As shown in Figure 3 the circuit 51 includes a differential amplifier 80 which is responsive to the signals Nd, Ne on lines 41, 43 respectively. An output signal from the amplifier 80 is supplied to a zero-level detecting circuit 81 which provides a signal on the lines 66 to the circuit 50 when the speeds of the drive shaft 10 and engine 20 are substantially equal. An alternative form of the device 81 provides a signal when a difference between these speeds is less than a predetermined amount. For example a signal may be provided on lines 66 when the speed of the engine 20 is less than one or two hundred rpm above or below that of the shaft 10. Output signals from the amplifier 80 are also supplied to a proportional plus integral amplifier 82 whose output is connected through a switch 83 and a resistor 84 to the inverting input of a further differential amplifier 85. The switch 83 is ganged with the switch 67 in the circuit 50 (Figure 2) and the switch 36 in the line to the engine starter (Figure 1), so these switches are operated at the same time and that when the switches 67, 83 are closed, the switch 36 is open. The inverting input of the amplifier 85 is also supplied, through a resistor 86, with an engine speed demand signal on a line 87 from a selector device 88 (Figure 1). The non-inverting input of the amplifier 85 is supplied with the engine speed signal Ne on line 43. The output of the amplifier 85 forms a field current demand signal which is supplied on a line 89 to the control circuit 44 (Figure 1) for the alternator 24, to regulate the alternator field current, and thereby the load imposed by the alternator 24 on the engine 20 when the clutch 25 is engaged.

If the propulsion system is operating in mode 1 above, and it is required to couple the engine 20 to the shaft 10 to operate in any of modes 3, 4 or 5, the switch 29 applies and maintains a signal on line 52 and subsequently starts the engine 20. Return of the switch 29 to its central position maintains the signal on the line 52. This signal passes through contacts R1a, R2b and diode 54 to operate the relay R4 and close the contacts R4a, the resulting voltage on line 53 energising the clutch 35 to couple the engine 20 to the alternator 24. When the engine speed signal Ne exceeds a predetermined low value limit detection circuit 46 provides a signal on line 45 which is applied through the diode 57 and resistor 58 to the line 59, to supply the ignition circuit of the engine 20. At the same time the control circuit 44 provides a field current to the alternator 24, thereby imposing a load on the engine 20.

The signal on line 45 energises the relay R2 (Figure 2), opening the contact R2b and shutting the contacts R2a. Since contacts R4a have been shut, relay R4 is maintained energised through the normally-closed contacts R5a and the diode 55. Closure of contacts R2a maintains the relay R2 energised through the diode 61.

The switch 67 is now operated to energise relay R1 from the supply on line 52, closing contact R1b and opening contact R1a. Relay R2 is nevertheless maintained energised by the signal on line 45 and relay R4 by the latch provided by contacts R4a, R5a. Closure of contacts R1b energises the indicating device 72 through the normally-closed contacts R3a, providing an indication that driving connection between the engine 20 and the shaft 10 has been selected, but has not yet occurred.

When the speed of the engine 20 is substantially equal to that of the shaft 10 the switch 65 is closed, energising relay R3 and closing the contacts R3b. The voltage signal on line 52 is then applied through line 69 to energise the clutch 21. Closure of contacts R3b also energises relay R5 through the diode 73, opening contacts R5a and de-energising relay R4. Contacts R4a open after a delay imposed by the circuit 56, causing the clutch 35 to be disengaged. The alternator 24 is, however, no longer required to load the engine 20, since speed matching has already occurred. Indicator device 72 is de-energised and device 71 is energised to show that the clutch 21 is engaged.

After the ganged switches 67, 83 in circuits 50, 51 respectively have been closed, but before the switch 65 is closed the speed of the engine 20 is varied by adjusting the load of the alternator 24 thereon, by means of the signal on line 87 from the speed selector device 88 (Figure 1). As shown in Figure 3 the engine speed signal Ne and the shaft speed signal Nd on lines 43, 41 respectively are applied to the amplifier 80 and any speed error is subjected to proportional plus integral amplification before being applied through the switch 83 and resistor 84 to the inverting input of the amplifier 85, to which input the signal on line 87 is also applied. The engine speed signal Ne is also applied to the non-inverting input of amplifier 85. The effect is that a required increase in engine speed results in the signal on line 89 being applied to the circuit 44 to reduce the field current of the alternator 24, and hence the load of the latter on the engine 20. When the speed signals Ne, Nd are equal, the resulting zero output from the amplifier 80 is detected by the circuit 81 and provides a signal on the line 66 to operate the switch 65, resulting in energisation of the clutch 21, as described above.

After the clutch 35 has been disengaged it is necessary to prevent the clutch 21 from being disengaged while the engine 20 is running, since the engine would then be unloaded and could overspeed. This requirement is met by the arrangement described, since if switch 67 (Figure 2) is opened while the engine is running the relay R1 nevertheless remains energised through the contacts R1b and the diode 68. The contacts R3b are thus maintained shut by relay R3 and the clutch 21 remains energised.
Additionally, since relay R1 remains energised the contacts R1a are open. Contacts R4a are also open and the clutch 35 cannot be re-engaged with the engine 20 running.

In order to de-energise the relay R1 and disengage the clutch 21 it is necessary to operate the switch 29 to remove the voltage supply from line 52. If, with the switch 67 open the switch 29 is first operated to remove the voltage on line 52, de-energisation of relay R1 closes contacts R1a and opens contacts R1b. Relay R3 is de-energised, contacts R3a close and contacts R3b open, and clutch 21 is disengaged. If switch 29 is subsequently shut while the speed Ne of the engine 20 is above that required to provide the signal on line 45, relay R2 remains energised and contacts R2b are open. Relay R4 cannot therefore be energised through contacts R1a and the clutch 35 cannot be engaged while the engine speed Ne is above its predetermined low value.

The switch 36, being ganged to the switches 67, 83, prevents the engine 20 from being started when the switch 67 is closed, since if this occurred the clutch 21 would be engaged while the engine 20 was running unloaded by the alternator 24, by way of the clutch 35.

As described above the control circuit 44 controls the field current of the alternator 24 in accordance with the magnitude of the signal online 89. The circuit 44 comprises well-known circuit arrangements which operate in a known manner, and which do not of themselves form part of the invention. The circuit 44 will therefore be described only insofar as to enable its operation to be understood.

As shown in Figures 4, 5 and 6 the circuit 44 may be considered as comprising parts 44A, 44B and 44C. Part 44A is an amplifier stage responsive to the signal on line 89 from the circuit 51 (Figure 3) and to the ignition voltage on line 59 (Figure 1). Two amplifier circuits 100, 101 respond to the signal on line 89 to provide a signal on a line 102. A semiconductor switch arrangement 103 is responsive to the ignition voltage signal on line 59, absence of this signal connecting the line 102 to an earth rail 104. A buffer circuit 105 is responsive to the signal on line 102 to supply a signal on a line 106 to the part 44B (Figure 5).

As shown in Figure 5 the signals on line 106 is applied to the inverting input of an amplifier 95 whose other input is connected to a feedback line 122. The amplifier 95 forms one element of an integrated circuit of the type available from Motorola under the designation MC3301, the numerals adjacent the amplifier indicating the terminals to which respective connections are made. The amplifier 95 has associated externally connected components to provide an integrating term and its output is supplied on a line 96 to an oscillator circuit 97 which also forms an element of the aforementioned Motorola integrated circuit.

The frequency of the output of oscillator 97 is dependent on the magnitude of the signal on line 96 and typically is in the range of 100 Hz to 1 KHz. The oscillator output is applied to the base of a npn transistor 110, through a resistor 98 which forms part of a resistor-capacitor network 99 connected between a +12v rail 111 and an earth rail 112, and provides a suitable bias at the output of oscillator 97. The transistor 110 is connected between the rails 111, 112 through a +8V regulating circuit 107 and the arrangement is such that a negative signal on the base of transistor 110 results in a positive voltage on a line 113. A diode, resistor and capacitor network 114 acts as a voltage pulse shaping circuit for the signals on line 113.

The signals on line 113 are applied through a potential divider 115 to a line 116 to the base of npn transistor 117 which is connected between the rails 111, 112 so that a positive signal on its base results in a low level signal on the base of a pnp transistor 118. Transistor 118 is connected between the rails 111, 112 so that in response to the low level signal on its base it provides a positive signal on the base of a npn transistor 119, causing the latter to conduct.

The transistor 119 is connected between the rails 11, 112 in series with the primary of a transformer 120. The transistors 117, 118, 119 and their associated capacitors and resistors comprise a voltage to current switching circuit which provides current pulses in the primary of the transformer 120, these pulses having the frequency of the oscillator circuit 97. A capacitor 130 and resistor 131 in series between the transformer primary and the rail 112 act to suppress voltage spikes.

The secondary winding of the transformer 120 is centre-tapped and is connected to a network 132 of resistors, diodes and zener diodes which shape the transformer output current pulses to provide drive pulses to the base of a power transistor 133, and also provide protection against excessive voltage on the base of the transistor 133. The transistor 133 is connected through the primary winding of a transformer 134 between the negative terminal of the 216 volt battery 14 (Figure 1) and a lead 135 to the field winding of the alternator 24. A second lead 136 from the field winding is connected to the positive terminal of the battery 14. A diode 137 is connected between the lines 135, 136 so as to be reverse biased with respect to the dc voltage on these lines, and acts as a so-called "free-wheel" diode to maintain the field current during intervals when the transistor 133 is switched off.

As described the primary winding of the transformer 134 is connected in the -216 volt line. Switching of the transistor 116 in response to the pulses on line 115 results in current pulses through the primary of the transformer 120. These pulses have the frequency of the output of the oscillator 109 and are detected by the secondary of the transformer 134.

A resistor, capacitor and diode network 138 forms a compensated peak-to-peak detection circuit which provides a feedback signal on the line 122, this signal comprising a dc level proportional to the peak-to-peak magnitude of the current pulses through the primary of the transformer 134.

The arrangement is such that the magnitude of the signal on line 122 is dependent on the magnitude of the field current. An increase in the field current demand signal on line 106 results in an increase in frequency of the field current, and a signal corresponding to the increased current is fed back to the amplifier 95 on the line 122 to provide a new steady-state condition.

CLAIMS

1. A propulsion system for a vehicle, comprising a main drive shaft (10) for the vehicle, an internal combustion engine (20), an electric battery (14), an electric motor (13) energisable by said battery (14), a driving coupling between said motor (13) and said shaft (10), and a first clutch (21) operable to couple said engine (20) to said drive shaft (10), characterised in that there is provided an apparatus (24, 35, 44) for electrically loading said engine (10) to vary the speed thereof, and a control device (50, 51) for operating said first clutch (21) only when the speeds of said engine (20) and said shaft (10) are substantially equal.

2. A system as claimed in claim 1 in which said apparatus for electrically loading the engine (20) comprises an electric generator (24) and a device (35) for providing a driving connection between said engine (20) and said generator (24).

3. A system as claimed in claim 2 in which said device for providing the driving connection is a second clutch (35).

4. A system as claimed in claim 3 in which said second clutch (35) is electrically operable and which includes a first switching device (R4) operable to energise said second clutch (35).

5. A system as claimed in claim 4 which includes means (R2, 60) responsive to the speed of the engine (20) for maintaining said first switching device (R4) operated to energise said second clutch (35) when said engine speed exceeds a predetermined value.

6. A system as claimed in claim 4 or claim 5 in which said control device (50, 51) includes a control circuit (51) for providing a first control signal when the speeds of said engine (20) and said drive shaft (10) are substantially equal, said first switching device (R4) being responsive to said first control signal to de-energise said second clutch (35).

7. A system as claimed in claim 6 in which said first clutch is electrically energisable to couple said engine (20) to said drive shaft (10) and which includes further switching devices (R3, 65) responsive to said first control signal to energise said first clutch.

8. A system as claimed in any of claims 2 to 7 in which said control device (50, 51) includes means (85) for generating a second control signal dependent on a difference between desired and sensed values of engine speed, and which includes a field current regulator (44) for said generator (24), said field current regulator (44) being responsive to said second control signal.

9. A system as claimed in claim 8 which includes means (80, 82, 84) for modifying said second control signal in response to the speed of said drive shaft (10).

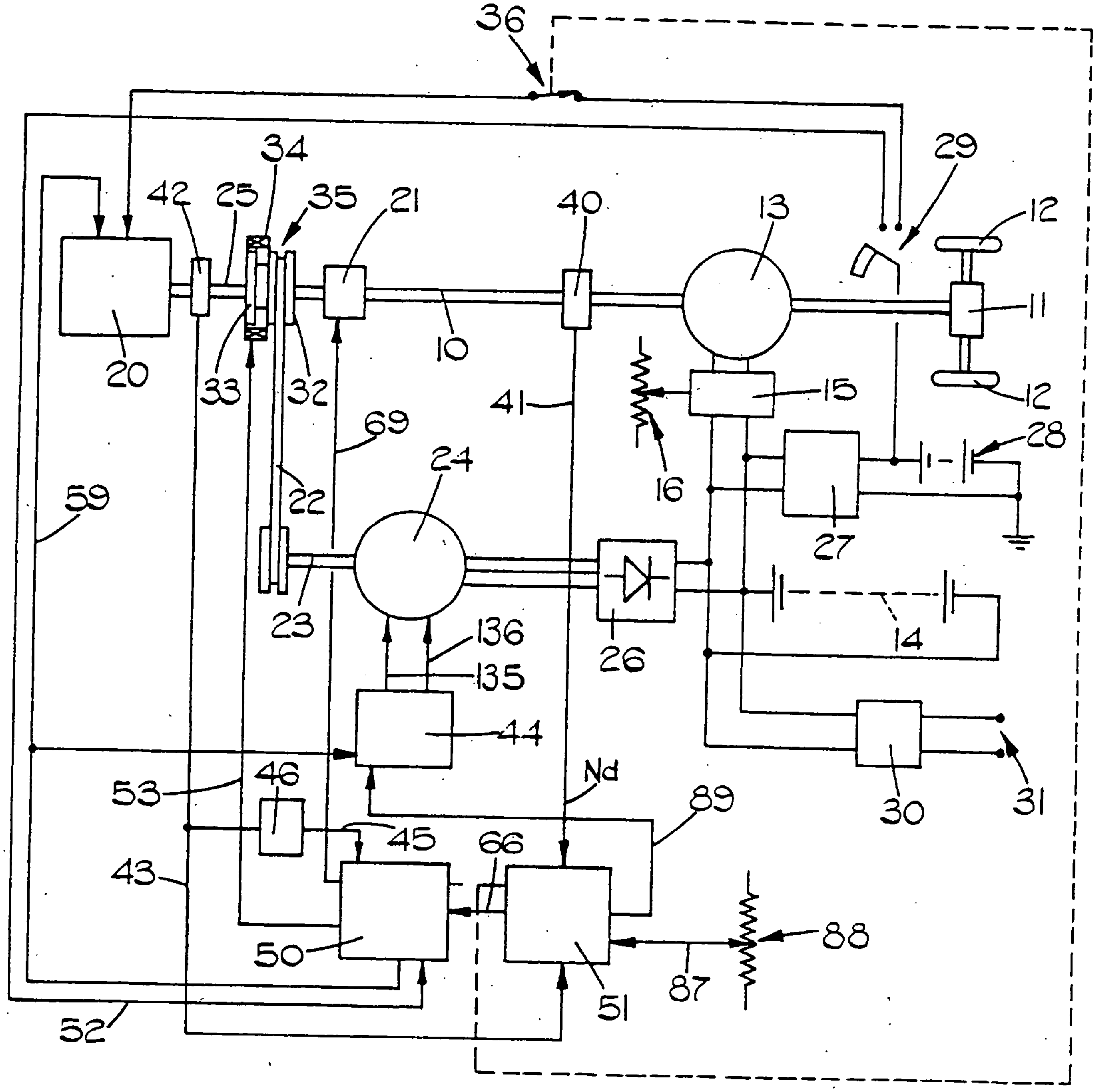

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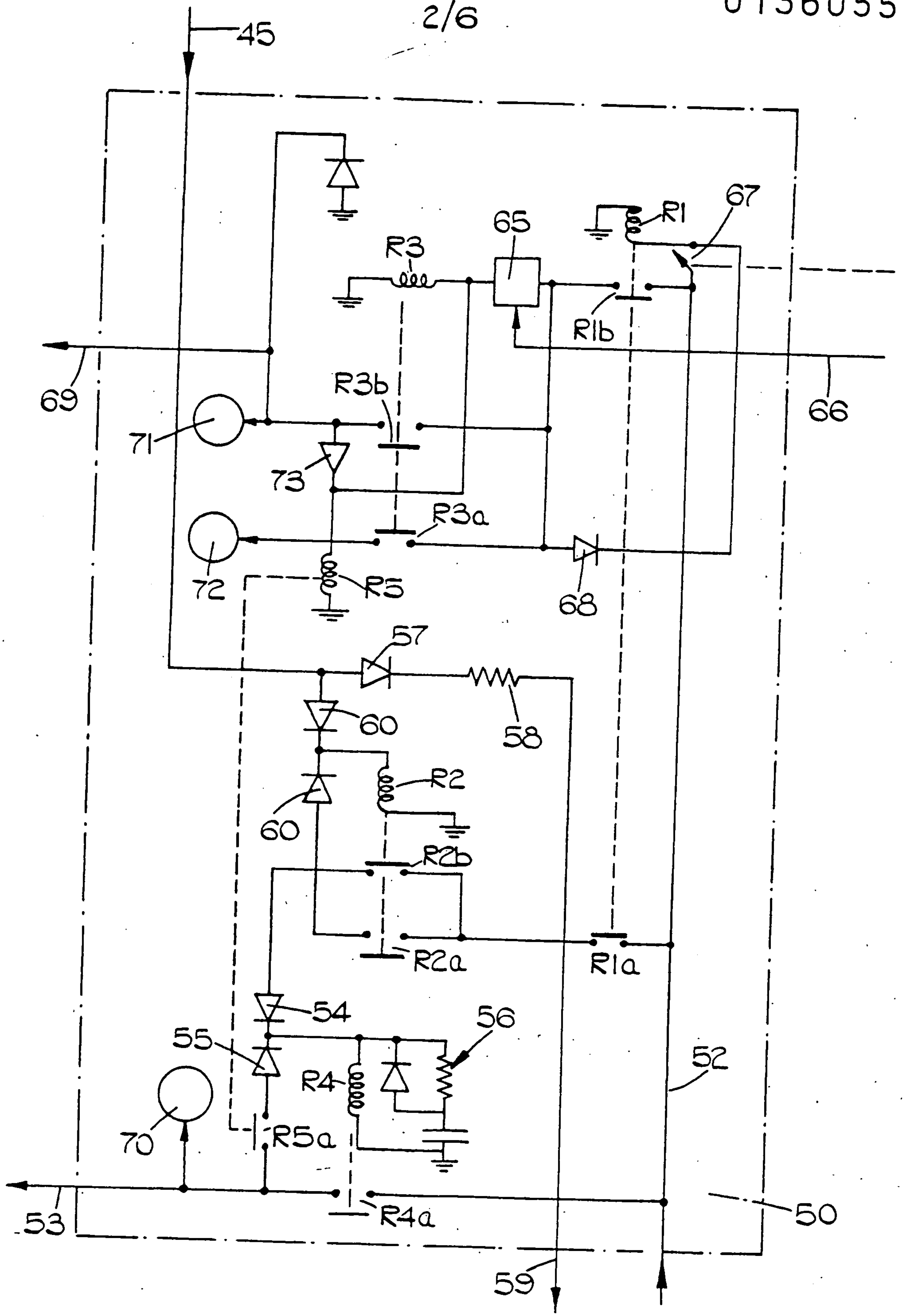
FIG. 1.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R1
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R3
R1b
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R3b
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R5
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60
R2
60
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R2a
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R5a
R4a
53
50
59

FIG.2.

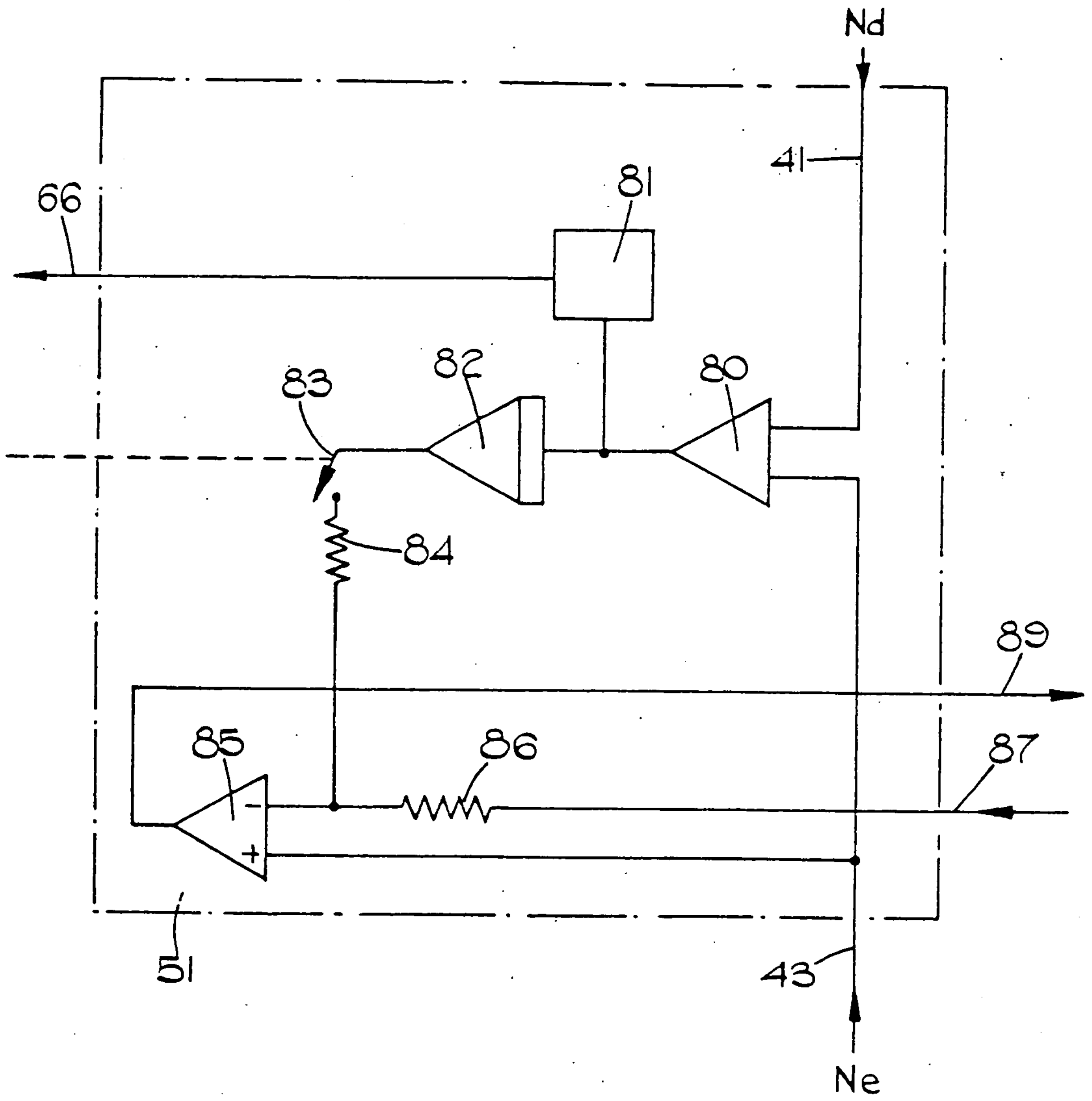


FIG.3.

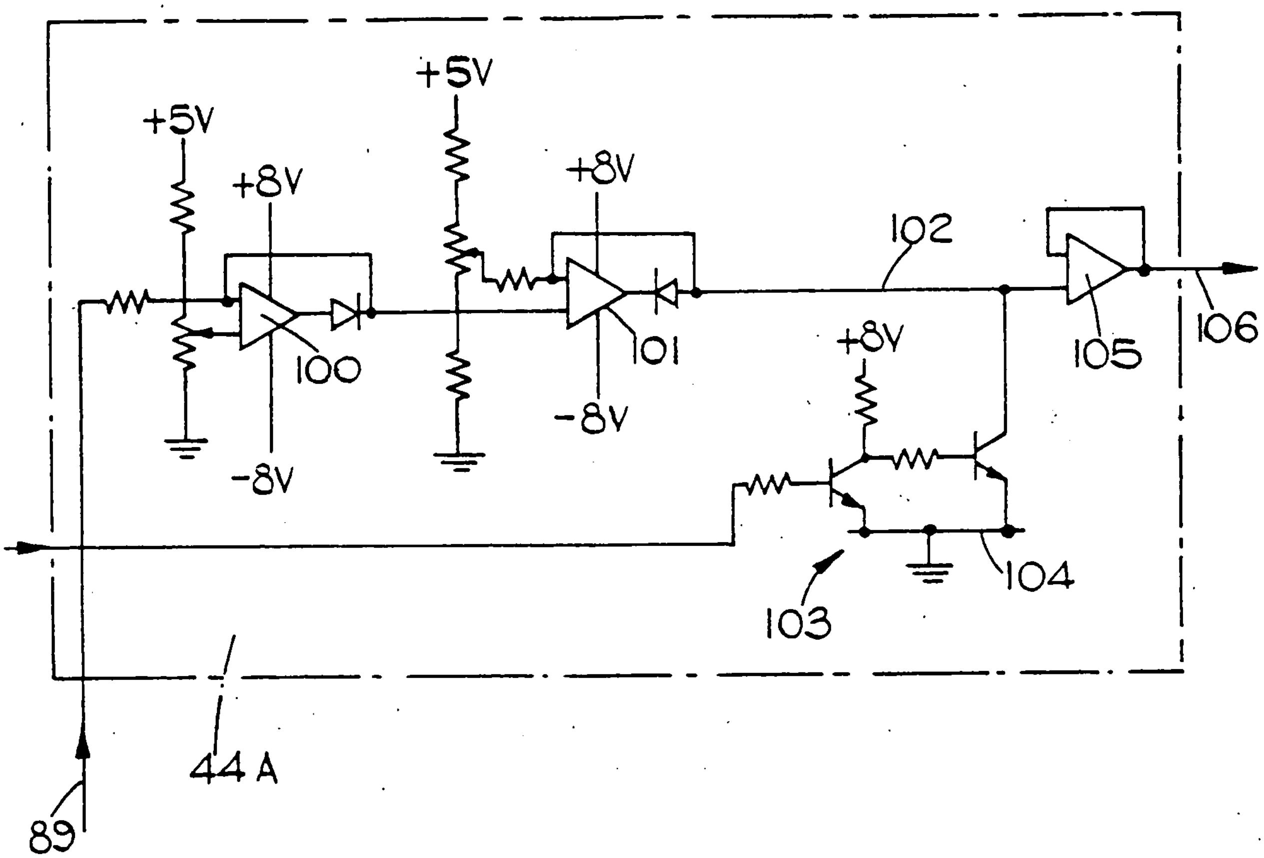
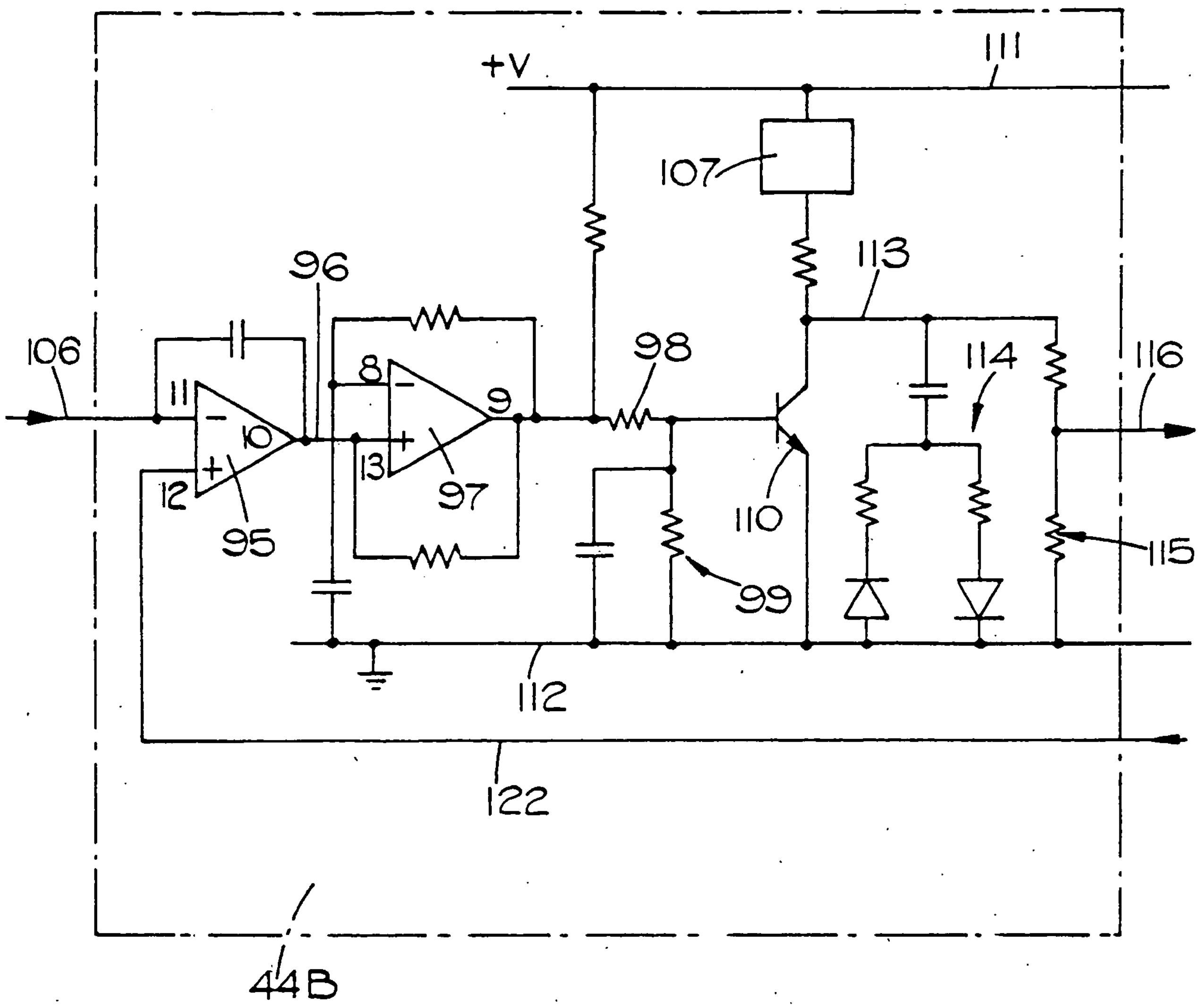


FIG.4.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13
12
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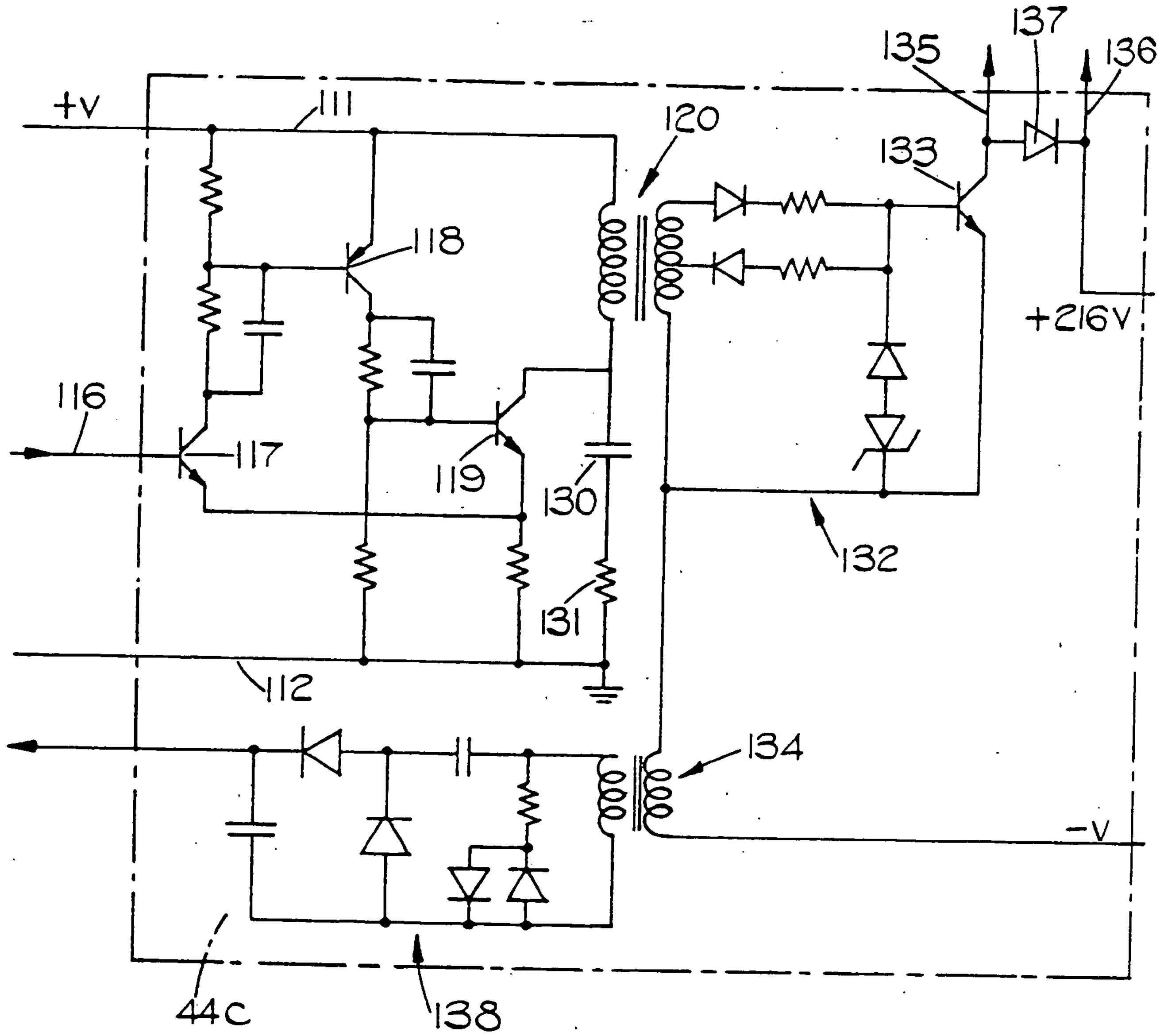
99
112
122
44B

FIG.5.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+216V
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134
-V
44c
138

FIG.6.

European Patent
Office

EUROPEAN SEARCH REPORT

0136055
Application number

EP 84305672.2

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 4)
A	AT - B - 321 729 (ROBERT BOSCH GMBH) * Fig.; page 2, line 50 - page 3, line 28 * --	1-3	B 60 K 1/00
A	DE - A - 2 309 680 (GES GESELLSCHAFT FÜR ELEKTRISCHEN STRASSENVERKEHR MBH) * Fig.; page 6, paragraph 2 - page 7, line 11 * --	1,3-6, 8	
A	WO - A1 - 83/00 464 (STEWART) * Fig. 1; claim 1; page 9, line 1 - page 10, line 1 * --	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl 4)
A	DE - A - 2 258 707 (ROBERT BOSCH GMBH) --		B 60 K
A	DE - A - 1 917 581 (YARDNEY) ----		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	15-11-1984	DENK

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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P : intermediate document
T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

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(51) Int. Cl. 2: B 60 K 1-04

OCT 0 -1975

(19) BUNDESREPUBLIK DEUTSCHLAND

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FIAT
M1043W/45 ★DT 2517-110
Hybrid drive vehicle with constant torque turbine - having comparator circuit to distribute generator output to drive and to battery
FIAT SPA 19.04.74-IT-068260
Q13 (30.10.75) B60k-01/04

The turbine drives a generator/alternator which either charges the battery or drives the electric transmission, or both. The battery is connected to the transmission by a first current loop whose current is monitored. A current dependent signal is fed to a comparator circuit, along with a reference signal. The comparator output activates the turbine starter when the current exceeds a set level. A second control system regulates the alternator so that a constant load is generated, with the load split between the battery charging and the drive. This enables the turbine to run at optimum setting, with minimal exhaust emission, while a smaller capacity battery can be used.
1. 75 as 517110 (11pp).

(71) Anmelder:

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DT 25 17 110 A1

(51) Int. Cl. 2: B 60 K 1-04 OCT 0 -1975

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DEUTSCHES PATENTAMT

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(11) # Offenleg

(21)

(22)

(43)

Adaptive braking system modulator
BENDIX CORP 22.04.74-US-462690
Q18 (30.10.75) *US3902-764 B60t-08/02
The adaptive braking system is provided with a brake pressure modulating valve which is responsive to output signals generated by an electronic control unit to control braking pressure communicated to the brakes of the vehicle when an incipient skidding condition exists. The modulator is responsive to the output signals to decay braking pressure, and upon termination of the incipient skidding condition the modulator permits braking pressure to increase. The modulator includes a device responsive to the initial signal generated by the electronic controller to restrict communication into the modulator to a predetermined rate, thereby limiting subsequent pressure increase to the predetermined rate. 22. 4. 75 as 517778 (18pp).

VARI-
M1074W/45 ★DT 2517-789
Vehicle hydrodynamic transmission unit - has torque convertor and pu

(30) Unionspriorität:

(32) (33) (31)

(54) Bezeichnung: Kraftfahrzeug mit Mehrfachantrieb (Hybridantrieb)

(71) Anmelder: Fiat S.p.A., Turin (Italien)

(74) Vertreter: Fincke, H., Dr.-Ing.; Bohr, H., Dipl.-Ing.; Staeger, S., Dipl.-Ing.; Pat.-Anwälte, 8000 München

(72) Erfinder: Savonuzzi, Giovanni; Brusaglino, Giampiero; Moncalieri, Turin (Italien)

25 17 110 A1

zeuger und/oder der Batterie gespeist. Bei diesem System ist eine Steuervorrichtung vorgesehen, die die Turbine automatisch starten läßt, wenn die Batterieladung eine vorgegebene Höhe unterschreitet; dann liefert der von der Turbine angetriebene Wechselstromerzeuger Strom für den Antriebsmotor des Fahrzeugs und für die Wiederaufladung der Batterie, bis der Ladungszustand der Batterie ein Niveau erreicht hat, das es erlaubt, den Motor wieder aus der Batterie zu speisen; nun wird die Turbine automatisch angehalten.

Die Erfindung stellt eine Weiterentwicklung eines derartigen Systems dar. Der Erfindung liegt die Aufgabe zugrunde, ein besonders wirtschaftlich arbeitendes System der oben angegebenen allgemeinen Art zu entwickeln, mit dem die Ausnützung der in den Fahrzeugbatterien gespeicherten Energie wirkungsvoller erfolgen kann. Auf diese Weise wird der Gesamtwirkungsgrad des Systems verbessert, so daß man ein Fahrzeug vorgegebener Größe, das mit einem Elektromotor vorgegebener Stärke ausgerüstet ist, mit Batterien geringerer Kapazität ausstatten kann; derartige Batterien sind kleiner und leichter und bedeuten somit für das System einen weiteren Vorteil.

Ferner liegt der Erfindung die weitere Aufgabe zugrunde, eine Einrichtung zum Steuern der Leistung des Wechselstromerzeugers anzugeben, derart, daß die verlangte Ausgangsleistung der Turbine konstant gehalten wird, was zu einer Herabsetzung der Abgasemissionen der Turbine selbst führt.

Gemäß der Erfindung ist ein Antriebssystem für Kraftfahrzeuge vorgesehen, mit einer Elektromotoranlage für den Antrieb mindestens eines Fahrzeugrades, einer Turbine, einem von der Turbine angetriebenen Wechselstromerzeuger, der, wenn er angetrieben wird, Strom an den Motor abgibt, und einer Batterie, die über eine erste Speiseleitung mit der Motoranlage verbunden ist; das Antriebssystem ist dadurch gekennzeichnet, daß eine auf den aus der Batterie über die genannte erste Speiseleitung fliessenden Strom ansprechende Einrichtung vorgesehen ist, ferner eine Komparatorschaltung, der ein Bezugssignal sowie ein Signal zugeführt wird, das den aus der Batterie über die genannte erste Speiseleitung entnommenen Strom repräsentiert, ferner eine die Turbine in Betrieb setzende Startvorrichtung, die durch das Ausgangssignal der Komparatorschaltung gesteuert wird, um die Turbine zu starten, wenn der über die genannte erste Speiseleitung aus der Batterie entnommene Strom einen durch das Bezugssignal bestimmten Wert übersteigt, und schließlich eine Steuerung, die den Betrieb des Wechselstromerzeugers derart zu steuern vermag, daß der Wechselstromerzeuger, wenn er angetrieben wird, eine praktisch gleichbleibende Leistung über eine an die erste Speiseleitung angeschlossene zweite Speiseleitung abgibt.

Bei einem System dieser Art wird ein Energiefluß zwischen Turbogenerator und Elektromotor, Turbogenerator und Batterie und Batterie und Motor und umgekehrt hergestellt, ohne daß besonders zu betätigende Schaltvorrichtungen benutzt werden, vielmehr ausschließlich gemäß den Energieverhältnissen des Systems und den Fahrleistungsansprüchen, die von der Art abhängen, in der das Fahrzeug gefahren wird.

Nach einem wesentlichen Merkmal der Erfindung weist die Steuereinrichtung zum Steuern der Ausgangsgröße des Wechselstromerzeugers einen Leistungsmeßfühler auf, der auf die Ausgangsgröße des Wechselstromerzeugers anspricht und ein Ausgangssignal an einen Steuerkreis abgibt, dessen Ausgangsgröße den Erregerkreis des Wechselstromerzeugers so beeinflußt, daß die Ausgangsleistung des Wechselstromerzeugers und daher die von der Turbine abgegebene Leistung konstant bleibt.

Dieses System ermöglicht die Steuerung der Ausgangsleistung des Wechselstromerzeugers ohne Verwendung kostspieliger Bauelemente, wie Dioden, Regeldioden usw., und läßt die Turbine mit gleichbleibender Ausgangsleistung arbeiten, was dann eine Herabsetzung der Emission schädlicher Abgase aus der Turbine zur Folge hat. Die Steuerung der Startvorrichtung für die Turbine erfolgt über einen Komparator, dessen einem Eingang ein Signal zugeführt wird, das den aus der Batterie über die erste Speiseleitung geführten Strom repräsentiert, während dem anderen Eingang des Komparators das Bezugssignal zugeführt wird, so daß, wenn der von der Batterie abgegebene Strom über einen vorgegebenen Wert hinausgeht, die Turbine selbsttätig gestartet wird; aus diesem Grund kann man Batterien von geringerem Gewicht verwenden, denn der aus der Batterie entnommene Strom kann begrenzt werden. Wegen der Begrenzung der Stromstärke verlängert sich die Lebensdauer der Batterie, denn eine schnelle Entladung durch hohe Ströme läßt sich vermeiden.

Eine Ausführungsform der Erfindung soll nun im einzelnen beispielshalber anhand der Zeichnung beschrieben werden, die ein schematisches Blockschaltbild der Erfindung wiedergibt. Die Figur zeigt einen Motor M (an dessen Stelle auch eine Gruppe von Motoren treten kann), der über ein Kraftübertragungssystem T mit einem Rad R (oder einer Anzahl Räder) eines (nicht gezeichneten) Kraftfahrzeugs verbunden ist. Der Motor M erhält Strom aus einer Batterie B über eine Speiseleitung 10 und einen üblichen Regler RE; oder von einem Wechselstromgenerator A über eine Speiseleitung 12; der von dem Wechselstromerzeuger A herkommende Strom fließt ebenfalls durch den Regler RE. Die beiden Speiseleitungen 10 bzw. 12, die von der Batterie bzw. dem Wechselstromerzeuger in den Regler laufen, sind an einem Verbindungspunkt 14 zusammengeführt, so daß der Regler RE nur einen einzigen Stromeingang hat, gleichgültig, ob der Strom von der Batterie B oder von dem Generator A geliefert wird. In dem Regler befindet sich eine übliche Schaltung von

Regeldioden, die durch Signale durchlässig getriggert werden, die von einem Steuerkreis 16 herrühren, der seinerseits durch Eingangssignale aus zwei Vorrichtungen 18 bzw. 20 gesteuert wird, die auf das Fahrpedal (18) bzw. eine Bremse (20) des Fahrzeugs ansprechen. Das Steuersystem aus Regler RE, Steuerkreis 16 und den Meßfühlern 18, 20 ist an sich bekannt: ein Beispiel eines derartigen Steuersystems ist in unserer italienischen Patentanmeldung No. 67045-A/72 beschrieben.

Die Leitung 10 ist an den Pluspol 22 der Batterie B angeschlossen, und der Minuspol 24 der Batterie B ist geerdet. Ein Strommeßfühler 26 liegt in der Leitung 10 und liefert ein Signal, das von einer Leitung 28 an einen Eingang eines Komparatorkreises 30 geführt wird. Eine Leitung 32 führt das Ausgangssignal von dem Meßfühler 26 in eine den Ladungszustand berücksichtigende Schaltung 34, die ausserdem Informationen über die Spannung Vb an dem Pluspol der Batterie B, die Temperatur P der Batterie B und den Druck G des in der Batterie entwickelten Gases erhält: die Schaltung 34 verarbeitet Informationen, die in den Signalen dieser Parameter enthalten sind, die die Ladungsverhältnisse der Batterie charakterisieren, und veranlaßt die Erzeugung von zwei Signalen; eines dieser Ausgangssignale wird über eine Leitung 36 in die Steuerschaltung 16 geführt, die den Regler RE steuert, und das andere Ausgangssignal gelangt über eine Leitung 38 zu einer Startvorrichtung 40 für eine Turbine TU, die den Generator A antreibt.

Die Datenverarbeitungsschaltung 34, die die Signale verarbeitet, die eine Aussage über den Ladezustand der Batterie liefern, und die beiden Ausgangssignale liefert, und die Art und Weise, wie diese Ausgangssignale den Kreis 16 und die Startvorrichtung 40 steuern, sind im einzelnen in dem Italienischen Patent No. 977 869 beschrieben.

Dem anderen Eingang des Komparators 30 wird ein Bezugssignal S zugeführt; der Wert dieses Signals bestimmt den Maximalwert des von der Batterie zu liefernden Stroms. Wenn bei schnellem Anfahren des Fahrzeugs aus dem Stillstand oder bei starkem Beschleunigen des bereits in Bewegung befindlichen Fahrzeugs der aus der Batterie B entnommene Strom den durch das Signal S festgelegten Wert übersteigt, so liefert der Komparator 30 ein Signal an die Startvorrichtung 40, die die Turbine TU anlaufen läßt. Die Batterie braucht daher niemals starke Ströme zu liefern, und infolgedessen hat sie eine längere Nutzungslebensdauer: ausserdem läßt sich nun für einen bestimmten Motor und ein Fahrzeug bestimmter Größe eine deutlich kleinere Batterie verwenden als sie in einem üblichen System der oben allgemein beschriebenen Art erforderlich wäre.

Der Ausgang des Generators A gelangt über einen Leistungsfühler 42, der auf einen Steuerkreis 44 wirkt, um den Erregerkreis 46 des Generators zu steuern; ein Übersteuereingang L für den Erregerkreis 46 ist vorgesehen, um eine stärkere Erregung zu erreichen, falls das von Zeit zu Zeit erforderlich ist. Auf diese Weise arbeiten Generator und Turbine normalerweise mit gleichbleibender Leistung, und infolgedessen wird die Abgasemission der Turbine herabgesetzt.

Wie sich aus der vorstehenden Beschreibung ergibt, kann man die Turbogeneratoranlage in Abhängigkeit von dem Energiebedarf des Motors ein- oder abschalten; dieser Energiebedarf kann unter Umständen die Leistungsgrenze des Generators übersteigen. Wenn beispielsweise die maximale Stromlieferung der Batterie größer als die Maximalleistung des Generators oder gleich dieser ist, kann der dem Motor von Generator und Batterie zugeleitete Gesamtstrom, weil der Generator der vollständig geladenen Batterie keinen Strom zuführt, grösser sein

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als der Maximalstrom, den der Generator liefern kann.

Das beschriebene System erreicht einen hohen Wirkungsgrad. Wenn man erreichen will, daß die Luftverunreinigung auf einen kleinstmöglichen Wert herabgesetzt wird, sollte in dem System eine Turbine verwendet werden, die häufig und sofort angelassen werden kann, ohne daß eine wesentlich grössere Abgasemission stattfindet, als wenn sie ständig liefe.

Die konstruktiven Einzelheiten können gegenüber den beschriebenen zahlreiche Abweichungen zeigen. Beispielsweise ist es möglich, zwischen den Komparator 30 und die Startvorrichtung 40 einen Zeitgeber, z.B. einen RC-Kreis, zu schalten, um zu verhindern, daß der Turbogenerator eingeschaltet wird, wenn ein erhöhter Strombedarf nur während sehr kurzer Zeit besteht.

Patentansprüche:

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Patentansprüche:

1. Antriebssystem für Kraftfahrzeuge, mit einer Elektromotoranlage für den Antrieb mindestens eines Fahrzeugrades, einer Turbine, einem von der Turbine angetriebenen Wechselstromerzeuger, der, wenn er angetrieben wird, Strom an den Motor abgibt, und einer Batterie, die über eine erste Speiseleitung mit der Motoranlage verbunden ist, dadurch gekennzeichnet, daß eine auf den aus der Batterie über die genannte erste Speiseleitung fliessenden Strom ansprechende Einrichtung vorgesehen ist, ferner eine Komparatorschaltung (30), der ein Bezugssignal sowie ein Signal zugeführt wird, das den aus der Batterie über die genannte erste Speiseleitung entnommenen Strom repräsentiert, ferner eine die Turbine (TU) in Betrieb setzende Startvorrichtung (40), die durch das Ausgangssignal der Komparatorschaltung (30) gesteuert wird, um die Turbine (TU) zu starten, wenn der über die genannte erste Speiseleitung (10) aus der Batterie (B) entnommene Strom einen durch das Bezugssignal bestimmten Wert übersteigt, und schließlich eine Steuerung (42, 44), die den Betrieb des Wechselstromerzeugers (A) derart zu steuern vermag, daß der Wechselstromerzeuger (A) eine praktisch gleichbleibende Leistung über eine an die erste Speiseleitung (10) angeschlossene zweite Speiseleitung (12) abgibt.

2. Antriebssystem nach Anspruch 1, dadurch gekennzeichnet,

daß die Steuerung (42, 44) zum Steuern der Ausgangsgröße desWechselstromgenerators einen Leistungsfühler (42) aufweist, der auf die Ausgangsleistung des Wechselstromerzeugers anspricht und Ausgangssignale auf einen Steuerkreis (44) gibt, dessen Ausgangsgröße den Erregerkreis (46) des Wechselstromerzeugers derart beeinflußt, daß die Ausgangsleistung des Wechselstromerzeugers und daher die von der Turbine (TU) gelieferte Leistung konstant bleiben.

Für: FIAT SOCIETA PER AZIONI

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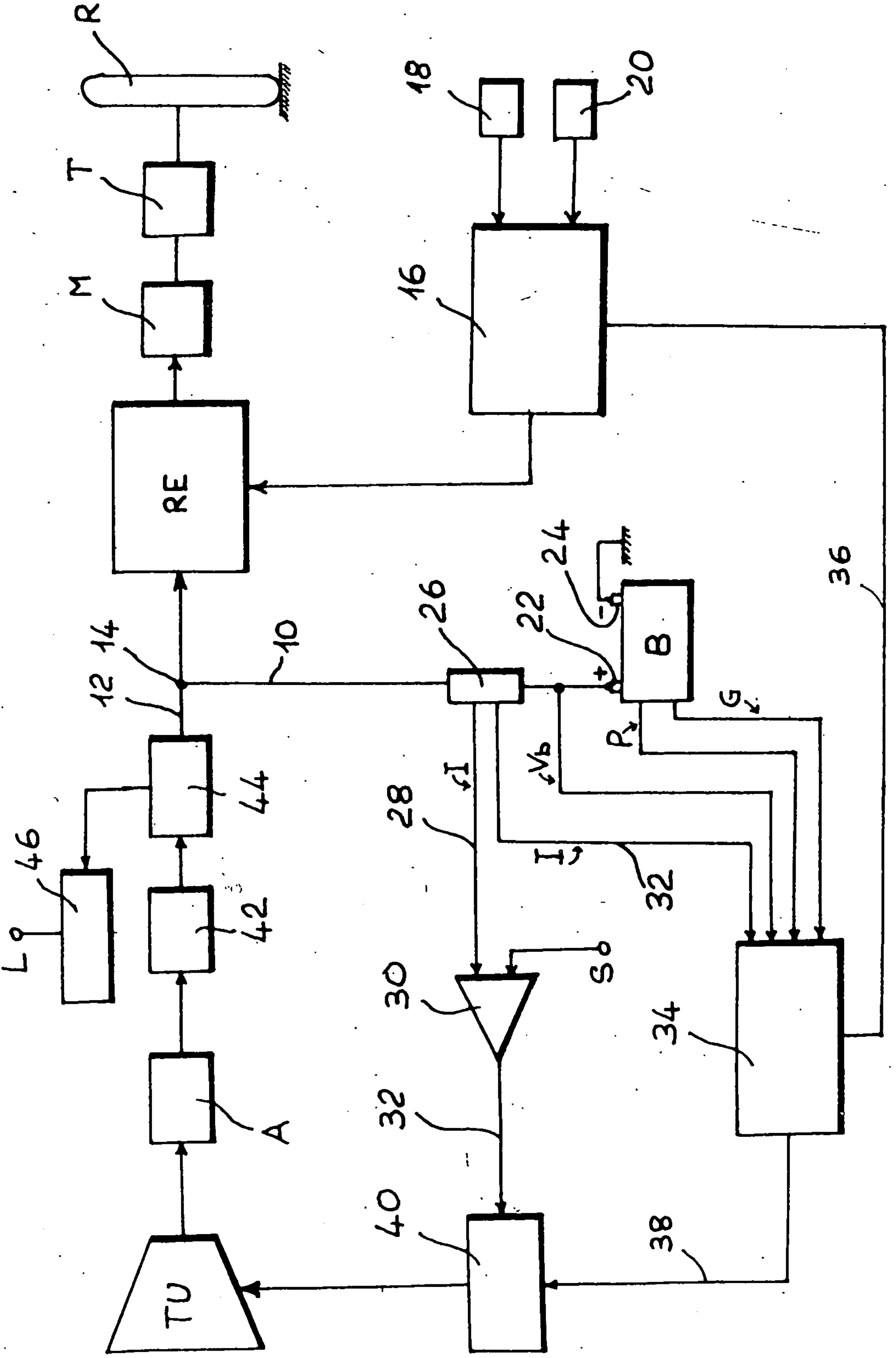

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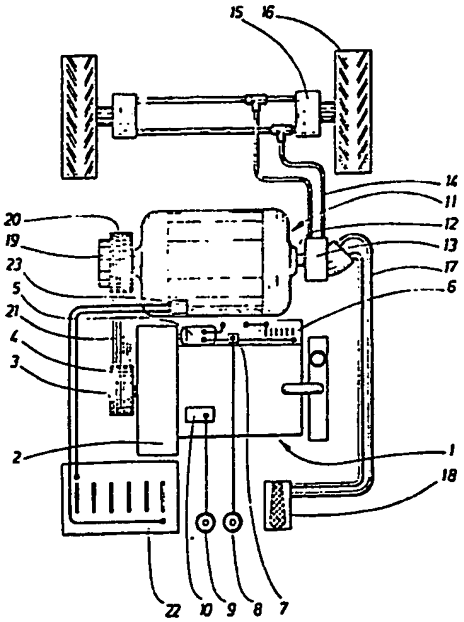

(57) Abstract

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.

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.

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.

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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.

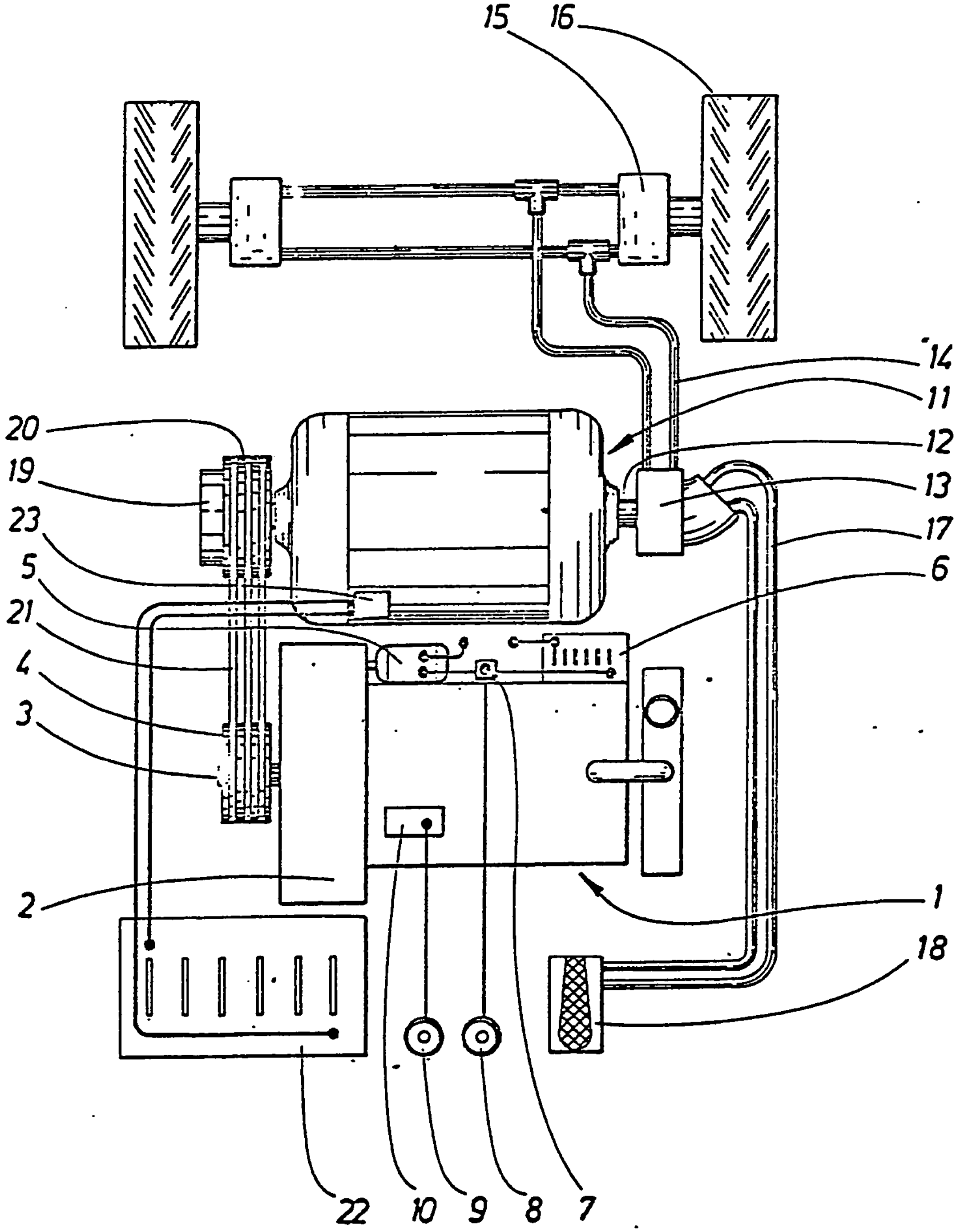

FIG. 1

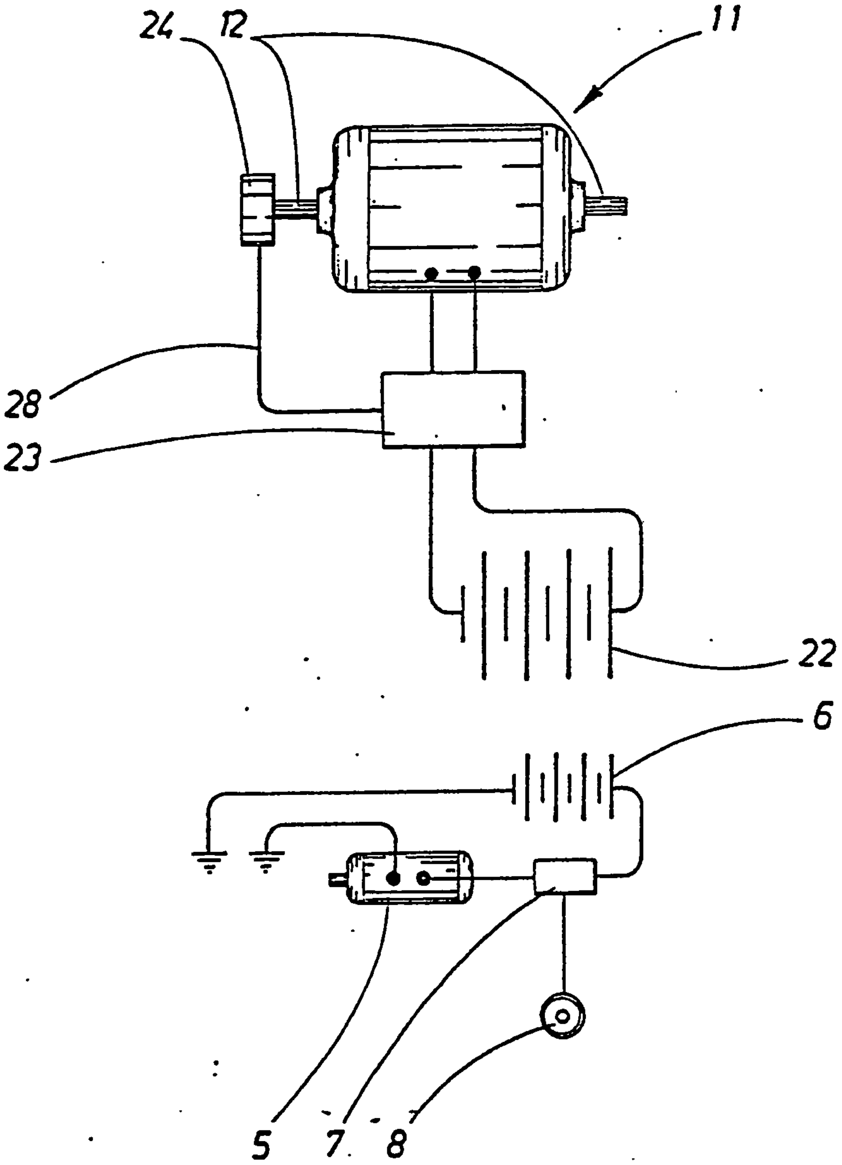

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/SE81/00280

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, 1 390 038 (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] 1981-12-03	Date of Mailing of this International Search Report [2] [illegible]
International Searching Authority [1] Swedish Patent Office	Signature of Authorized Officer [1] Håkan Sandh

Form PCT/ISA/210 (second sheet) (October 1981)

Partial Translation of JPP'328

Title of the Invention: Vehicle with Front and Rear Wheels Driving Mechanism

Inventor: Katsuhiko Irie, Shohji Nakae

Applicant: Tohyoh Kogyo Kabushiki Kaisha

Filing date: January 29, 1979

Filing Number: 54-10388

Publication Date: August 2, 1980

Publication No.: 55-110328

- Scope of claim for Patent

1. A vehicle with front and rear wheels driving mechanism which runs by driving either one of front wheels or rear wheels driven by a main driving unit, and provides an auxiliary driving unit for driving another one of said front wheels or said rear wheels,

characterized by controlling said auxiliary driving unit in accordance with a difference in rotating speed between said front wheels and said rear wheels.

2. A vehicle with front and rear wheels driving mechanism according to claim 1, characterized by that said auxiliary driving unit is an electrical motor.

- Brief description of the drawings

Figure 1 is a diagram of a vehicle according to the present invention, and

Figure 2 is a circuit diagram of the controller for controlling the auxiliary driving unit.

- Reference Numerals

1 ... Front wheels
2 ... Vehicle
3 ... Internal combustion engine
4 ... Transition gear
5 ... Differential gear
6 ... Rear wheels
7 ... Electric motor
8 ... Differential Gear
9 ... Generator
10 ... Controller
11 ... Mode switch

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	1064062	engine	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2004/11/29 14:16
S2	165640	motor WITH (generator or generating or generate or generates)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2004/11/18 15:58
S3	699640	battery	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2004/11/18 15:58
S4	1249318	controller	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2004/11/18 15:58
S5	1085	S1 same S2 same S3 same S4	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2004/11/18 15:59
S6	330	S5 same torque	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2004/11/19 14:46
S7	1	("6554088").PN.	USPAT	OR	OFF	2004/11/19 15:02
S8	2	(("4815334") or ("3454122")).PN.	USPAT	OR	OFF	2004/11/19 15:04
S9	2	(("5980077") or ("5908077")).PN.	USPAT	OR	OFF	2004/11/19 15:04

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S30	1	("6394209").PN.	USPAT	OR	OFF	2004/11/29 15:09
S31	1	("6081042").PN.	USPAT	OR	OFF	2004/11/29 15:41
S32	7588	hybrid adj vehicle	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2004/11/30 11:33
S33	22959	voltage WITH current with ratio	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2004/11/29 15:56
S34	56	S32 and S33	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2004/11/29 15:57
S35	310	dunn-da$.xa. or dunn-da$.xp.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2004/11/30 11:18
S36	1605	(hybrid adj vehicle) and toyota	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2004/11/30 11:33
S37	15	(hybrid adj vehicle) and toyota$.in.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2004/11/30 11:34

S38	1521	(hybrid adj vehicle) and toyota$. as.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2004/11/30 11:36
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S40	614	S38 and torque	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	OFF	2004/11/30 11:37

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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 12/03/2004

Michael de Angeli
60 Intrepid Lane
Jamestown, RI 02835

EXAMINER	
DUNN, DAVID R	

ART UNIT	PAPER NUMBER
3616	

DATE MAILED: 12/03/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

Office Action Summary	**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 --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *07 March 2003*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-142* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-142* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ 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:

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)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)

3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *5/28/04 and 3/7/03*.

4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

5) ☐ Notice of Informal Patent Application (PTO-152)

6) ☐ Other: _____.

U.S. Patent and Trademark Office
PTOL-326 (Rev. 1-04) **Office Action Summary** Part of Paper No./Mail Date 20041130

DETAILED ACTION

Information Disclosure Statement

1. The information disclosure statements filed 3/07/03 and 5/28/04 are acknowledged. See enclosed IDS forms.

NOTE: there are two claims numbered 71; claims have been renumbered starting with the second 71 becoming number 72, etc.

Claim Rejections - 35 USC § 112

2. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

3. Claims 1-142 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Applicant's claims are unduly multiplied. See MPEP 2173.05(n).

On November 18, 2004, Michael de Angeli selected by telephone to have claims 82-123 (prior claims 81-122, see note above) examined.

Claim 82 is indefinite as the final paragraph is unclear. The phrase "to propel the vehicle or" before "to propel the vehicle and/or to drive either..." appears to be repetitive and unnecessary as the second phrase already has an and/or clause, such that "to propel the vehicle" could be used alone in the case of the "or".

Claim 84 is indefinite as it unclear what "RL" means in the claim. The examiner recommends reciting --road load-- before this abbreviation the first time it is used in a claim string.

Claim 96 recites the limitation "the battery bank". There is insufficient antecedent basis for this limitation in the claim.

Regarding claims 103 and 122, the phrase "e.g." renders the claim indefinite because it is unclear whether the limitation(s) following the phrase are part of the claimed invention. See MPEP § 2173.05(d).

Claim Rejections - 35 USC § 102

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

5. Claims 82, 88-90, 95, 96, 99, 100, 102, and 103 are rejected under 35 U.S.C. 102(b) as being anticipated by Frank (6,054,844).

Frank discloses a hybrid vehicle comprising an internal combustion engine (10); a first electric motor (50); a second electric motor/generator (24); a battery (26); a controller (30); wherein the controller starts and operates the engine when the torque produced by the engine to propel the vehicle (column 5, lines 24-26) or drive either one or both of the electric motors to charge the battery (column 4, lines 61-66) is at least equal to a setpoint above which the engine torque is efficiently produced (the vehicle inherently has a point where the engine operates, a "setpoint above which said engine torque is efficiently produced" is a broad phrase as neither the "setpoint" or "efficiently" is defined by the claim to provide any sort of limits). Regarding claim 88, the vehicle has the operating modes as recited (see column 9, line 55- column 10, line 13). Regarding claim 94, the controller inherently accepts operator input to control the engine to maintain a vehicle speed. Regarding claim 95, regenerative charging of the battery is performed when braking is initiated (see column 8, lines 5-20). Regarding claim 99, the vehicle includes a variable-ration transmission (18).

6. Claims 82, 88-90, 96, 104, 108, 109, and 117 are rejected under 35 U.S.C. 102(b) as being anticipated by Mayrhofer et al. ("A hybrid drive based on a structure variable arrangement"; cited in IDS).

Mayrhofer et al. discloses a hybrid vehicle comprising an IC engine two electric motors and a battery (see Figure 2) which operates by the electric drive in a first mode (see Table 1); employs the engine (in another mode), an employs the engine and motor in a further mode; and employs the engine to propel the vehicle and charge the battery (see mode 6; Table 1); see also page 191, final paragraph.

Claim Rejections - 35 USC § 103

7. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

8. Claims 101 and 123 are rejected under 35 U.S.C. 103(a) as being unpatentable over Frank alone.

Frank is discussed above and does not show the engine operating at the stoichiometric ratio of combusion or the ratio of battery voltage to current being at least 2.5: 1.

The examiner takes Office Notice that the operation of a combustion engine at the stoichiometric ratio is old and well known and it would have been obvious to one of ordinary skill in the art at the time the invention was made to operate the engine at the stoichiometric ratio in order to provide an efficient use of the engine.

Additionally, while Frank does not disclose the ratio of the battery voltage to current, it would have been obvious to one of ordinary skill in the art at the time the invention was made to operate the battery at least at this ratio as such a selection would have been within the skill level of one of ordinary skill in the art. Further, applicant does not give any specific reason why this ratio solves any stated problem or is for any particular purpose.

9. Claims 101 and 120 are rejected under 35 U.S.C. 103(a) as being unpatentable over Mayrhofer et al. alone.

Mayrhofer et al. is discussed above and does not show the engine operating at the stoichiometric ratio of combusion or the ratio of battery voltage to current being at least 2.5: 1.

The examiner takes Office Notice that the operation of a combustion engine at the stoichiometric ratio is old and well known and it would have been obvious to one of ordinary skill in the art at the time the invention was made to operate the engine at the stoichiometric ratio in order to provide an efficient use of the engine.

Allowable Subject Matter

10. Claims 83-87, 91-94, 97-99, 105-107, 110-116, 118, 119, 121, and 122 would be allowable if rewritten to overcome the rejection(s) under 35 U.S.C. 112, 2nd paragraph, set forth in this Office action and to include all of the limitations of the base claim and any intervening claims.

Conclusion

11. Any inquiry concerning this communication or earlier communications from the examiner should be directed to David Dunn whose telephone number is 703-305-0049. The examiner can normally be reached on Mon-Thur, alt. Fridays, 9:00-5:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Paul Dickson can be reached on 703-308-2089. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

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

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	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~~ 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	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER	DATE CONSIDERED 11/19/04

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Jc498 U.S. PTO
10/382577
03/07/03

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)

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J498 U.S. PTO
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03/07/03

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201	APPLICATION NUMBER ~~09/822,866~~	
	APPLICANT Severinsky et al	10/382577	1
	FILING DATE 4/2/01	GROUP ART UNIT 3616	

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	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 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~~ 3616

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			☒	

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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

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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	4 4 0 7 1 3 2	10/83	Kawakatsu			
	4 3 3 5 4 2 9	6/82	Kawakatsu			
	4 1 8 0 1 3 8	12/~~19~~ 79	Shea			
	4 3 5 1 4 0 5	9/82	Fields et al			
	4 4 3 8 3 4 2	3/84	Kenyon			
	4 5 9 3 7 7 9	6/86	Krohling			
	4 9 2 3 0 2 5	5/90	Ellers			
	3 7 9 1 4 7 3	2/74	Rosen			
	4 2 6 9 2 8 0	5/81	Rosen			
	4 4 0 0 9 9 7	8/83	Fiala			
	4 6 9 7 6 6 0	10/87	Wu et al			
	3 9 7 0 1 6 3	7/76	Kinoshita			
DD	4 0 9 5 6 6 4	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

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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	8/72	Yardney			
	3837419	9/74	Nakamura			
	3874472	4/75	Deane			
	4042056	8/77	Horwinski			
DD	4562894	1/86	Yang			

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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

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	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

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	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	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			
DD	5558588	9/96	Schmidt			

FOREIGN PATENT DOCUMENTS

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	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~~077 08	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

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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	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	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER	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
DD	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.			
DD	4442285	4/84	Stewart et al			

FOREIGN PATENT DOCUMENTS

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	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

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	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	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			
DD	5566774	10/96	Yoshida			

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 4/19/04

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	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

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U.S. PATENT DOCUMENTS

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DD	5562565	10/96	Moroto et al			
	5513719	5~~6~~/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 ~~4~~/94	Sugiyama et al			

FOREIGN PATENT DOCUMENTS

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U.S. PATENT DOCUMENTS

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DD	5345761	9 ~~8~~/94	King et al			
	5337848	8/94	Bader			
	5327992	7 ~~6~~/94	Boll			
	5589743	12/96	King			
	5345154	9/94	King			
	4862009	8/89	King			
	5372213	12/94	Hasebe et al			
	5495912	3 ~~5~~/96	Gray, Jr., et al			
	5588498	12/96	Kitada			
	5492189	2/96	Kriegler			
	5193634	3/93	Masut			
	5125469	6/92	Scott			
DD	4511012	4/85	Rauneker			

FOREIGN PATENT DOCUMENTS

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	APPLICANT Severinsky et al	
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U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	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			
	5934395	8/99	Koide et al	180	65.2	
	5969624	10/99	Sakai et al	340	636	
	5986376	11/99	Werson			
	6018198	1/00	Tsuzuki et al			
DD	6054844	4/00	Frank	322	16	

FOREIGN PATENT DOCUMENTS

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U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	6 0 5 9 0 5 9	5/00 ~~9/94~~	Schmidt-Brucken			
	6 0 9 8 7 3 3	8/00	Ibaraki et al			
	6 1 6 1 3 8 4	12/00	Reinbold et al			
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DD	5 3 2 7 9 9 2	7/94	Boll			
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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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DD	6281660	08/2001	Abe			
	~~5915937~~	~~5/1996~~	~~Adler et al~~			previously cited
DD	5336932	4/1994	Barske			
DD	6170587	1/2001	Bullock			
DD	5887674	3/1999	Gray			
DD	4762191	8/88	Hagin et al.			
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OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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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

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*		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
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	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
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*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
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	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)

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Part of Paper No. 14

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	APPLICANT Severinsky et al	
	FILING DATE 3/7/2003	GROUP ART UNIT 3616

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	~~5993350~~	~~11/1999~~	~~Lawrie et al~~			
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OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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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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DD	5895333	4/1999	Morisawa			
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DD	6344008	2/2002	Nagano			
DD	6090007	7/2000	Nakajima			
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DD	6123642	9/2000	Saito			
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	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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EXAMINER	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	
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DD	5847469	12/1998	Tabata			
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DATE CONSIDERED 11/29/04

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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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DD	6247437	6/2001	Yamaguchi et al			
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DD	5081365	1/1992	Field et al			
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DD	6481516	11/2002	Field et al			
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DD	4187436	2/1980	Etienne			
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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICB201.DIV	APPLICATION NUMBER 10/382,577	
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INFORMATION DISCLOSURE CITATION IN AN APPLICATION

DOCKET NUMBER	PAICE201.DIV
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APPLICANT	Severinsky et al
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U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
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OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

EXAMINER

DATE CONSIDERED 4/29/04

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	APPLICANT Severinsky et al	
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Index of Claims

Application No.	Applicant(s)
10/382,577	SEVERINSKY ET AL.
Examiner	**Art Unit**
David Dunn	3616

√	**Rejected**	–	**(Through numeral) Cancelled**	N	**Non-Elected**	A	**Appeal**
=	**Allowed**	÷	**Restricted**	I	**Interference**	O	**Objected**

Claim		Date								
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Part of Paper No. 20041130

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		

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)

	DATE	EXMR
EAST text search	11/29/2004	DD

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CONFIRMATION NO. 9389

SERIAL NUMBER 10/382,577	FILING DATE 03/07/2003 RULE	CLASS 180	GROUP ART UNIT 3616	ATTORNEY DOCKET NO. PAICE201.DIV

APPLICANTS

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Theodore Louckes, Holly, MI;

** CONTINUING DATA *************************

This application is a DIV of 09/822,866 04/02/2001 PAT 6,554,088
which is a CIP of 09/264,817 03/09/1999 PAT 6,209,672
which claims benefit of 60/100,095 09/14/1998
This application 10/382,577
is a CIP of 09/392,743 09/09/1999 PAT 6,338,391
which claims benefit of 60/122,296 03/01/1999

YES D.D

** FOREIGN APPLICATIONS ********************

NONE DD

IF REQUIRED, FOREIGN FILING LICENSE GRANTED
** 04/25/2003

Foreign Priority claimed ☐ yes ☑ no 35 USC 119 (a-d) conditions met ☐ yes ☐ no ☐ Met after Allowance Verified and Acknowledged ______ Examiner's Signature ______ Initials	STATE OR COUNTRY DC	SHEETS DRAWING 17	TOTAL CLAIMS 7	INDEPENDENT CLAIMS 3

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TITLE
Hybrid vehicles

FILING FEE RECEIVED 3466	FEES: Authority has been given in Paper No. _________ to charge/credit DEPOSIT ACCOUNT No. _________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue)

OIPE JC98
FEB 22 2005
PATENT & TRADEMARK OFFICE

IFW

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

AMENDMENT

Hon. Commissioner for Patents
P. O. Box 1450
Alexandria VA 22313-1450

Transmitted herewith is an amendment in the above - identified application.

__ A check for the additional claim fee of $ 0 as calculated below is enclosed for this amendment.

___ The Commissioner is hereby authorized to charge any underpayment (or to credit overpayment) to our Deposit Account No. 04-0401. A duplicate copy of this sheet is attached.

LARGE ENTITY

	TOTAL CLAIMS	CLAIMS PREVIOUSLY PAID FOR		PRESENT EXTRA		ADDITIONAL RATE	
TOTAL	41	126	=	0	Extra	x 18	$ .00
INDEP.	2	11	=	0	Extra	x 88	$ .00
						TOTAL:	$ .00

Respectfully submitted,

2/18/05
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OIPE JC98
FEB 22 2005
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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AMENDMENT

Sir:

In response to the Office Action mailed December 3, 2004, and setting a shortened statutory period for response to expire on March 3, 2005, kindly amend the above-identified Application as follows:

Amend the claims (claims 71 - 141 having been renumbered by the Examiner as claims 82 - 142, respectively) to appear as follows:

Claims 16 - 81 (canceled).

--82. (Amended) A hybrid vehicle, comprising:

an internal combustion engine controllably coupled to road wheels of said vehicle;

a first electric motor connected to said engine and operable to start the engine responsive to a control signal;

a second electric motor connected to road wheels of said vehicle, and operable as a motor, to apply torque to said wheels to propel said vehicle, and as a generator, for accepting torque from at least said wheels for generating current;

a battery, for providing current to said motors and accepting charging current from at least said second motor; and

a controller for controlling the flow of electrical and mechanical power between said engine, first and second motors, and wheels,

wherein said controller starts and operates said engine when torque produced by said engine ~~to propel the vehicle or~~ to propel the vehicle and/or to drive either one or both said electric motor(s) to charge said battery is at least equal to a setpoint (SP) above which said engine torque is efficiently produced, and wherein the torque produced by said engine when operated at said setpoint (SP) is substantially less than the maximum torque output (MTO) of said engine.--

--83. (Amended) The vehicle of claim ~~81~~ 82, wherein said controller monitors patterns of vehicle operation over time and varies said setpoint SP accordingly.--

--84. (Amended) The vehicle of claim ~~81~~ 82, wherein said controller monitors the road load (RL) on the vehicle ~~RL~~ over time, and controls transition between propulsion of said vehicle by said motor(s) to propulsion by said engine responsive to RL reaching SP, such that said transition occurs only when RL > SP for at least a predetermined time, or when RL > SP2, wherein SP2 > SP.--

--85. (Amended) The vehicle of claim ~~83~~ 84, wherein said controller further controls transition from propulsion of said vehicle by said engine to propulsion by said motor(s) such that said transition occurs only when RL < SP for at least a predetermined time.--

--86. (Amended) The vehicle of claim ~~81~~ 82, wherein said setpoint SP may be varied by said controller as a function of engine speed.--

--87. (Amended) The vehicle of claim ~~81~~ 82, wherein said setpoint SP is at least approximately 30% of the maximum torque output of the engine when normally-aspirated (MTO).--

--88. (Amended) The vehicle of claim ~~81~~ 82, wherein said vehicle is operated in a plurality of operating modes responsive to the value for the road load (RL) and said setpoint SP, both expressed as percentages of the maximum torque output of the engine when normally-aspirated (MTO), and said operating modes include:

a low-load mode I, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery ~~bank~~, while RL < SP,

a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine, while SP < RL < MTO, and

an acceleration mode V, wherein said vehicle is propelled by torque provided by said internal combustion engine and by torque provided by either or both electric motor(s) in response to energy supplied from said battery ~~bank~~, while RL > MTO.--

--89. (Amended) The vehicle of claim ~~87~~ 88, wherein the combination of said engine and said first motor is disengaged from said wheels during operation in mode I and engaged during operation in modes IV and V.--

--90. (Amended) The vehicle of claim ~~87~~ 88, wherein said operating modes further include a low-speed battery charging mode II, entered while RL < SP and the state of charge of the battery ~~bank~~ is below a predetermined level, and during which said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery ~~bank~~, and wherein said battery ~~bank~~ is simultaneously charged by supply of electrical energy from said first electric motor, being driven by torque in excess of SP by said internal combustion engine, the combination of said engine and said first motor being disengaged from said wheels during operation in mode II.--

--91. (Amended) The vehicle of claim ~~87~~ 88, wherein the controller may control transition of the operating mode from operation in mode I directly to operation in mode V where a rapid increase in the torque to be applied to the wheels of the vehicle as desired by the operator is detected. --

--92. (Amended) The vehicle of claim ~~87~~ 88, further comprising a turbocharger operatively and controllably coupled to said internal combustion engine for being operated and thereby increasing the maximum torque output of said internal combustion engine to more than MTO when desired, and wherein said controller controls selection of the operational mode of said vehicle between a low-load mode I, a cruising mode IV, an acceleration mode V, and a sustained high-power turbocharged mode VI, in response to monitoring the instantaneous torque requirements (RL) of the vehicle over time.--

--93. (Amended) The vehicle of claim ~~91~~ 92, wherein said controller controls said vehicle to operate in said modes as follows:

in said low load mode I while RL < SP, in said highway cruising mode IV while SP < RL < MTO, in said acceleration mode V while RL > MTO for less than a predetermined time T, and in said sustained high-power turbocharged mode VI while RL > MTO for more than a predetermined time T.--

--94. (Amended) The vehicle of claim ~~92~~ 93, wherein said time T is controlled responsive to the state of charge of the battery ~~bank~~.--

--95. (Amended) The vehicle of claim ~~81~~ 82, wherein the controller may accept operator input of a desired cruising speed, and thereafter controls the instantaneous torque output by said internal combustion engine and by either or both motor(s) in accordance with variation in RL so as to maintain vehicle speed substantially constant.--

--96. (Amended) The vehicle of claim ~~81~~ 82, wherein regenerative charging of the battery ~~bank~~ is performed when the instantaneous torque output by the internal combustion engine > RL, when RL is negative, or when braking is initiated by the operator.--

--97. (Amended) The vehicle of claim ~~81~~ 82, wherein the total torque available at the road wheels from said internal combustion engine is no greater than the total torque available from said first and second electric motors combined.--

--98. (Amended) The vehicle of claim ~~81~~ 82, wherein the engine and first electric motor are controllably coupled to a first set of road wheels of said vehicle and said second electric motor is coupled to a second set of road wheels of said vehicle.--

--99. (Amended) The vehicle of claim ~~81~~ 82, further comprising a variable-ratio transmission disposed between said engine and said motors and the wheels of said vehicle.--

--100. (Amended) The hybrid vehicle of claim ~~81~~ 82, wherein said engine is rotated before starting such that its cylinders are heated by compression of air therein.--

--101. (Amended) The hybrid vehicle of claim ~~81~~ 82, wherein the rate of change of torque produced by said engine is limited, such that combustion of fuel within said engine can be controlled to occur substantially at the stoichiometric ratio, and wherein if said engine is incapable of supplying the instantaneous torque required, the additional torque required is supplied by either or both of said motor(s).--

--102. (Amended) The hybrid vehicle of claim ~~81~~ 82, wherein said engine is controllably coupled to road wheels of said vehicle by a clutch.--

--103. (Amended) The vehicle of claim ~~81~~ 82, wherein said engine can be operated at torque output levels less than SP under abnormal and transient conditions, ~~e.g., in order to allow~~ said conditions comprising starting and stopping of the engine ~~or to provide~~ and provision of torque to satisfy drivability or safety considerations.--

--104. (Amended) A method of control of a hybrid vehicle, said vehicle comprising an internal combustion engine capable of efficiently producing torque at loads between a lower level SP and a maximum torque output MTO, a battery ~~bank~~, and one or more electric motors being capable of providing output torque responsive to supplied current, and of generating electrical current responsive to applied torque, said engine being controllably connected to wheels of said vehicle for applying propulsive torque thereto and to said at least one motor for applying torque thereto, said method comprising the steps of:

determining the instantaneous torque RL required to propel said vehicle responsive to an operator command;

monitoring the state of charge of said battery ~~bank~~;

employing said at least one electric motor to propel said vehicle when the torque RL required to do so is less than said lower level SP;

employing said engine to propel said vehicle when the torque RL required to do so is between said lower level SP and MTO;

employing both said at least one electric motor and said engine to propel said vehicle when the torque RL required to do so is more than MTO; and

employing said engine to propel said vehicle when the torque RL required to do so is less than said lower level SP and using the torque between RL and SP to drive said at least one electric motor to charge said battery when the state of charge of said battery ~~bank~~ indicates the desirability of doing so; and wherein the torque produced by said engine when operated at said setpoint (SP) is substantially less than the maximum torque output (MTO) of said engine.--

--105. (Amended) The method of claim ~~103~~ 104, comprising the further step of employing said controller to monitor patterns of vehicle operation over time and vary said setpoint SP accordingly.--

--106. (Amended) The method of claim ~~103~~ 104, comprising the further step of employing said controller to monitor RL over time, and to control transition between propulsion of said vehicle by said motor(s) to propulsion by said engine such that said transition occurs only when RL > SP for at least a predetermined time, or when RL > SP2, wherein SP2 is a larger percentage of MTO than SP.--

--107. (Amended) The method of claim ~~103~~ 104, comprising the further step of employing said controller to monitor RL over time, and to control transition between propulsion of said vehicle by said engine to propulsion by said motor(s) such that said transition occurs only when RL < SP for at least a predetermined time.--

--108. (Amended) The method of claim ~~103~~ 104, comprising the further step of operating said controller to accept operator input of a desired cruising speed, said controller thereafter controlling the instantaneous engine torque output and operation of said motor(s) to supply additional torque as needed in accordance with variation in

RL to maintain the speed of said vehicle substantially constant.--

--109. (Amended) The method of claim ~~103~~ 104, wherein said vehicle is operated in a plurality of operating modes responsive to the values for the road load RL and said setpoint SP, said operating modes including:

a low-load mode I, wherein said vehicle is propelled by torque provided by said second electric motor in response to energy supplied from said battery ~~bank~~, while RL < SP,

a highway cruising mode IV, wherein said vehicle is propelled by torque provided by said internal combustion engine, while SP < RL < MTO, and

an acceleration mode V, wherein said vehicle is propelled by torque provided by said internal combustion engine and by torque provided by either or both electric motor(s) in response to energy supplied from said battery ~~bank~~, while RL > MTO.--

--110. (Amended) The method of claim ~~108~~ 109, wherein said setpoint SP is at least approximately 30% of MTO.--

--111. (Amended) The method of claim ~~108~~ 109, comprising the further step of decoupling said engine from said wheels during operation in mode I and coupling said engine to said wheels during operation in modes IV and V.--

--112. (Amended) The method of claim ~~108~~ 109, wherein said controller further controls said vehicle to operate in a low-load battery charging mode II, entered while RL < SP and the state of charge of the battery ~~bank~~ is below a predetermined level, during which said vehicle is propelled by torque provided by said second motor in response to energy supplied from said battery ~~bank~~, and wherein said battery ~~bank~~ is simultaneously charged by supply of electrical energy from said first motor being operated as a generator and being driven by torque at least equal to SP provided by said internal combustion engine, said engine being decoupled from said wheels during operation in mode II.--

--113. (Amended) The method of claim ~~108~~ 109, comprising the further step of operating said controller to monitor RL over time, and to control the operating mode to change from operation in mode I directly to operation in mode V where a rapid increase in the torque to be applied to the wheels as desired by the operator is detected.--

--114. (Amended) The method of claim ~~108~~ 109, wherein said hybrid vehicle further comprises a turbocharger being operatively and controllably coupled to said internal combustion engine for being operated and thereby increasing the maximum torque output of said internal combustion engine to more than MTO when desired, and wherein according to said method, said controller controls selection of the operational mode of said vehicle between a low-load mode I, a cruising mode IV, an acceleration mode V, and a sustained high-power turbocharged mode VI, in response to monitoring the instantaneous torque requirements (RL) of the vehicle over time.--

--115. (Amended) The method of claim ~~113~~ 114, wherein said controller controls said vehicle to operate in said modes as follows:

in said low load mode I while RL < SP, wherein SP is a setpoint expressed as a predetermined percentage of MTO, in said highway cruising mode IV while SP < RL < MTO, in said acceleration mode V while RL > MTO for less than a predetermined time T, and in said sustained high-power turbocharged mode VI while RL > MTO for more than a predetermined time T.--

--116. (Amended) The method of claim ~~114~~ 115, wherein said time T is controlled responsive to the state of charge of the battery ~~bank~~.--

--117. (Amended) The method of claim ~~103~~ 104, comprising the further step of performing regenerative charging of the battery ~~bank~~ when the engine's instantaneous torque output > RL, when RL is negative, or when braking is initiated by the operator.--

--118. (Amended) The method of claim ~~103~~ 104, wherein said hybrid vehicle further comprises a variable-ratio transmission disposed between said engine and said motors and the wheels of said vehicle, said transmission being operable responsive to a control signal from said controller.--

--119. (Amended) The method of claim ~~103~~ 104, wherein a clutch connects a first output shaft of or driven by said engine and/or first motor with a second output shaft of or driven by said second motor connected to said wheels, and wherein the speeds of said engine and/or first motor and of said second motor are controlled such that when said clutch is engaged the speeds of the first and second output shafts are substantially equal, whereby said shafts may be connected by a non-slipping clutch.-

--120. (Amended) The method of claim ~~103~~ 104, wherein the rate of change of torque output by said engine is limited, such that combustion of fuel within said engine can be controlled to occur substantially at the stoichiometric ratio, and wherein if said engine is incapable of supplying the instantaneous torque required, the additional torque required is supplied by either or both of said motor(s).--

--121. (Amended) The method of claim ~~103~~ 104, wherein said engine is rotated before starting such that its cylinders are heated by compression of air therein.--

--122. (Amended) The method of claim ~~103~~ 104, wherein said engine can be operated at torque output levels less than SP under abnormal and transient conditions, ~~e.g.,~~ said conditions comprising ~~in order to allow~~ starting and stopping of the engine ~~or to provide~~ and provision of torque to satisfy drivability or safety considerations.--

Claims 123 - 142 (Canceled).

REMARKS

Claims 82 - 122 (renumbered from claims 81 - 121 by the Examiner, prior to issue of the Office Action) have been further amended hereby, to correct dependency errors resulting from the claim renumbering, and to further and unobviously define the invention claimed with respect to the prior art, as discussed further below. Claims 16 - 81 and 123 - 142 have been canceled, of course without prejudice to their presentation in further application(s), in response to the Examiner's "undue multiplicity" rejection. The claims have also been amended in response to the Examiner's Sect. 112 objections.

More specifically, with respect to the Sect. 112 objections, "battery bank", where used, has been amended to "battery", for consistency. It was also noted that mode VI, in which a turbocharger is employed for sustained operation of the engine above MTO (its normally-aspirated maximum torque output) had been referred to inconsistently as a "turbocharged" and a "sustained high-power" mode; for consistency, both terms are now employed to characterize mode VI. See claims 92 and 93, and 114 and 115.

Thus claims 82 and 104 are the only remaining independent claims. These have both been amended to recite that the engine is run when it is loaded (either by the vehicle's propulsion requirement, the battery charging load, or both) in excess of a setpoint SP, which is now defined to be "substantially less than the maximum torque output (MTO) of said engine". It is respectfully submitted that this recitation clearly and patentably distinguishes over the references relied upon.

It is of course admitted that the language "... substantially less than the maximum torque output of said engine" is not mathematically precise. It is respectfully submitted that some imprecision is permissible here in view of the fact that such minimum values are stated in the specification (see for example, page 68, line 29 of the application) to be typically at least 30% of MTO (though this figure is repeatedly stated to be exemplary only; see page 72, lines 6 - 10) and normally not in excess of 50% of MTO (see page 72, line 9). Note also that "MTO" as used herein refers to the engine's maximum torque output (in normally-aspirated mode, when a turbocharger is also provided) at or near its rated top RPM. It is also within the scope of the invention to employ the engine efficiently by loading it at a lower RPM; the specification at page 88, lines 6 - 10 gives the example of sizing the generator to load the engine to 70% of its maximum output at 1200 - 1500 RPM. Given these examples it is respectfully submitted that this language is adequately definite to define the invention and to satisfy 35 USC Sect. 112.

It is respectfully submitted that this language is also sufficient to distinguish over Frank patent 6,054,844, which the Examiner relied upon in rejecting claims 82, 88 - 90, 95, 96, 99, 100, 102 and 103 under 35 USC Sect. 102, and claims 101 and 123 under Sect. 103. Frank clearly intends operation of the engine thereof near MTO at all times. More specifically, Frank states at col. 12, lines 20

- 24 that it is an object of his invention to "always operate [the engine] at wide open throttle or along the best efficiency (ideal speed/torque) operating line..." Frank thus teaches specifically away from operating the engine when loaded to above a setpoint which is substantially less than MTO, as claimed.

It is acknowledged that Frank goes on to say that the engine could be operated "in accordance with any other desired operating characteristics" (lines 25 - 26). This is literally broad enough to include applicants' operation above a setpoint, of course. However, Frank's broad statement again fails to teach the invention as claimed.

Furthermore, Frank does not teach operating the engine when it is loaded to a given degree, as claimed, but solely in response to the operator's pressing of one or other of the accelerator and brake pedals. See Fig. 8, and the discussion thereof at cols. 8 - 11. The Examiner appears to agree on this point, since claims 87 and 110, specifying that the setpoint SP is 30% of MTO, were indicated to contain allowable subject matter. That indication is gratefully acknowledged. However, especially in view of the statements made throughout the specification that this figure is somewhat arbitrary, it is respectfully submitted that to thus limit the independent claims would be unduly limiting of the applicants' invention, and that claims 82 and 104 as amended above correctly define the invention.

The Mayrhoefer et al paper was relied upon by the Examiner in rejecting claims 82, 88 - 90, 96, 104, 108, 109, and 117 under 35 USC 102, and claims 101 and 120 under

Sect. 103. The amendments made above to independent claims 82 and 104 distinguish over Mayrhoefer in the same manner in which they distinguish over Frank, as above. Specifically, Mayrhoefer shows a hybrid vehicle that is intended to be operated as an electric car in low-emission (urban and environmentally sensitive) areas, so that the IC engine is to be started, presumably responsive to a signal from the operator, when the vehicle leaves such an area. The engine's operation "is intended to be steady-state" (page 189) and a planetary gearbox is provided to operate as a continuously-variable transmission (page 191). Thus Mayrhoefer clearly fails to disclose or suggest a vehicle in which the engine is operated when loaded by the combination of propulsive and battery-charging loads, to at least a setpoint SP which is substantially less than MTO, as claimed.

A Second Supplemental Information Disclosure Statement is being filed herewith, making of record a number of new references that have come to applicants' attention as a result of prosecution of corresponding foreign applications and further searching, and the Examiner is respectfully requested to consider these new references and to indicate in the file of the application that he has done so.

It is thus respectfully submitted that the claims as amended distinguish over the references cited, and a Notice of Allowance is therefore earnestly solicited.

Respectfully submitted,

Dated: 2/17/05

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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
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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,

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OIPE JC98
FEB 22 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
	6067801	5/2000	Harada et al			
	4411171	10/1983	Fiala			
	3620323	5/1968	Maeda			
	6317665	11/2001	Tabata et al			
	6183389	2/2001	Tabata et al			
	5565711	10/1996	Hagiwara			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO
	754983	2/1995	Japan			X	
	4244658	9/1992	Japan			X	
	11082261	3/1999	Japan				X
	11122712	4/1999	Japan			partial	
	62113956	5/1987	Japan			partial	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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	SUBCLASS	FILING DATE

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO
	11082260	3/1999	Japan				X
	19838853	8/1998	Germany				X
	19814402	3/1998	Germany				X

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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.

PATENT ABSTRACTS OF JAPAN

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F16H 61/10
F16H 61/16
// F16H 59:24
F16H 59:44

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(21)Application number : 05-205945

(22)Date of filing : 20.08.1993

(71)Applicant : TOYOTA MOTOR CORP

(72)Inventor : NAKAGAWA NORIHISA
MATSUOKA HIROKI

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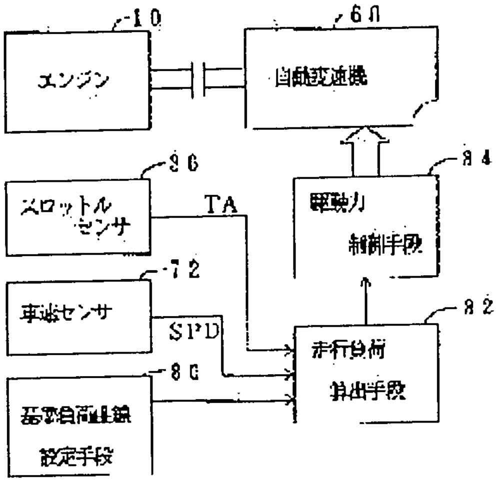
(54) DRIVING FORCE CONTROL DEVICE FOR CAR

(57)Abstract:

PURPOSE: To provide a driving force control device for car which can present good operating characteristics irrespective of running load in the whole running ranges of the car.

CONSTITUTION: When the reference running load curve for the steady running condition of a car is set by a reference load curve setting means 80, a running load calculating means 82 calculates one by one the size of the running load factor KFUKASM by reference to the set curve, wherein the factor KFUKASM is expressed on the basis of the degree of throttle opening TA and the car speed SPD. A driving force control means 84 controls the gearing position of an automatic transmission 68 on the basis of the factor KFUKASM calculated from time to time and adjusts the driving force of the car. Accordingly the driving force is adjusted on the basis of the size of the actual running load over the whole running ranges of the car, so that good operating characteristics can be obtained in the whole running ranges of the car irrespective of varying running load due to the gradient of the road surface, etc.



LEGAL STATUS

[Date of request for examination] 20.05.1998

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[Date of final disposal for application]

[Patent number] 2962112

[Date of registration]	06.08.1999
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

(19)日本国特許庁（JP）

(12) **公開特許公報**（A）

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特開平7－54983

(43)公開日　平成7年(1995)2月28日

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F16H	61/00		9240－3J		
	61/10		9240－3J		
	61/16	Z	9328－3J		
// F16H	59:24				
	59:44				

審査請求　未請求　請求項の数8　OL　（全24頁）

(21)出願番号　特願平5－205945

(22)出願日　平成5年(1993)8月20日

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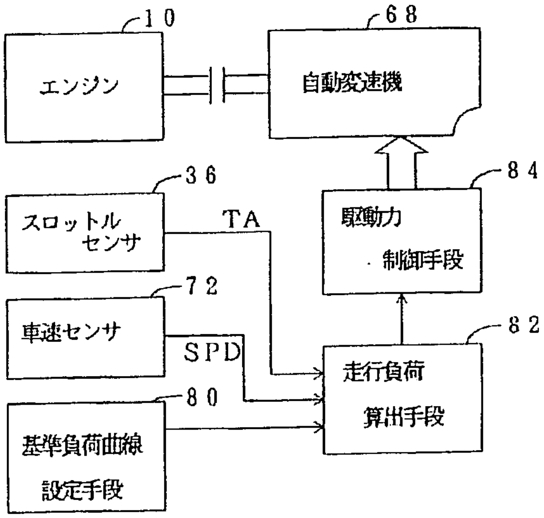
(54)【発明の名称】　車両用駆動力制御装置

(57)【要約】
【目的】　車両の走行領域全域において走行負荷に拘わらず良好な運転性が得られる車両用駆動力制御装置を提供する。

【構成】　基準負荷曲線設定手段80により、車両の定常走行における基準走行負荷曲線が設定されると、走行負荷算出手段82により、スロットル弁開度TAおよび車速SPDに基づいて表される走行負荷係数KFUKASMの大きさが、上記基準走行負荷曲線を基準として逐次算出される。駆動力制御手段84により、上記逐次算出された走行負荷係数KFUKASMに基づいて自動変速機68のギヤ段が制御されて車両の駆動力が調節される。したがって、車両の走行領域全域にわたって、実際の走行負荷の大きさに基づいて前記車両の駆動力が調節されるので、路面傾度などによる走行負荷の変化に拘わらず車両の走行領域全域において良好な運転性が得られる。



【特許請求の範囲】

【請求項１】 エンジンの出力が駆動輪へ伝達される車両において、該車両の駆動力を制御する駆動力制御装置であって、
前記車両の定常走行におけるエンジンの負荷量および車速により表される基準走行負荷曲線を設定する基準負荷曲線設定手段と、
エンジンの負荷量および車速に基づいて表される走行負荷の大きさを、前記基準走行負荷曲線を基準として逐次算出する走行負荷算出手段と、
該走行負荷算出手段により逐次算出された走行負荷に基づいて前記車両の駆動力を調節する駆動力制御手段と
を、含むことを特徴とする車両用駆動力制御装置。

【請求項２】 前記走行負荷算出手段は、前記基準走行負荷曲線からエンジンの負荷量に基づいて基準走行負荷車速を決定する基準走行負荷車速決定手段と、車速と該基準走行負荷車速とに基づいて走行負荷に対応した走行負荷係数を逐次算出する走行負荷係数算出手段とを含み、該走行負荷係数を走行負荷として出力するものである請求項１の車両用駆動力制御装置。

【請求項３】 前記車両は、変速比が自動的に変化させられる自動変速機と、該自動変速機の変速比を予め設定された変速線からエンジンの負荷量および車速に基づいて制御する変速制御手段とを備えたものであり、前記駆動力制御手段は、前記走行負荷に基づいて該変速線を補正するものである請求項１または２の車両用駆動力制御装置。

【請求項４】 前記走行負荷が第１の判断基準値を超えたとき、前記自動変速機のシフトアップを禁止するシフトアップ禁止手段をさらに含むものである請求項３の車両用駆動力制御装置。

【請求項５】 前記走行負荷が第２の判断基準値未満となったとき、前記自動変速機のシフトアップの禁止を解除するシフトアップ禁止解除手段を含むものである請求項４の車両用駆動力制御装置。

【請求項６】 前記シフトアップ禁止解除手段は、前記自動変速機のシフトアップの禁止中において、減速から加速への反転が所定回行われる毎に最高速ギヤ段へのシフトアップを実行すべきか否かを判断し、実行すべきであると判断される場合には該シフトアップの禁止を解除して該最高速ギヤ段へのシフトアップを実行するものである請求項５の車両用駆動力制御装置。

【請求項７】 前記シフトアップ禁止解除手段により用いられる前記第２の判断基準値を、シフトアップの禁止が開始されたときの走行負荷、またはシフトアップの禁止中に所定回の減速から加速への反転が検出されたときの走行負荷のうち、最新のものよりも所定値小さい値に設定する第２の判断基準値設定手段を含むものである請求項５または６の車両用駆動力制御装置。

【請求項８】 前記駆動力制御手段は、前記走行負荷算出手段により算出された走行負荷が所定値未満且つエンジン負荷量が所定の判断基準値以下で加速度が所定の判断基準値以上であるとき、前記自動変速機をエンジンブレーキが作用するギヤ段へ優先的にシフトダウンさせるものである請求項３の車両用駆動力制御装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は車両用駆動力制御装置に係り、特に、車両の走行領域全体において走行負荷に拘わらず良好な運転性を得る技術に関するものである。

【０００２】

【従来の技術】スロットル弁開度の調節や自動変速機の変速比の調節により車両の駆動力を制御する車両用駆動力制御装置が知られている。たとえば、変速比が自動的に変化させられる自動変速機を備えた車両では、予め設定された変速線図から実際のエンジン負荷量および車速に基づいて自動変速機の変速比を変化させ、車両の駆動力を適切な値とする変速制御装置が用いられている。このような変速制御装置の変速線図は通常最も頻度の高い平坦路での走行において運転性および燃費が両立するように設定されることから、登坂路走行では、駆動力が不足して良好な運転性が得られない傾向となる。

【０００３】これに対し、特開昭６２－１８０１５３号公報に記載されているように、スロットル弁開度が所定値を超えた領域において車速がシフトダウン線を高速側から低速側へ横切ったときに登坂走行であると判定し、シフトアップを禁止して低速段を保持するようにした変速制御装置が提案されている。これによれば、登坂走行であると判定された場合には、シフトアップが禁止されて車両の駆動力が高められるので、登坂走行での運転性が改善される。

【０００４】

【発明が解決しようとする課題】しかしながら、上記従来の変速制御装置では、スロットル弁開度が所定値以上の領域において車速がシフトダウン線を高速側から低速側へ横切ったときにのみ登坂走行が判定されることから、その他の走行領域においては車両の走行負荷の変化に基づく駆動力の改善が得られず、車両の走行領域全域にわたって良好な運転性が得られないという欠点があった。

【０００５】本発明は以上の事情を背景として為されたもので、その目的とするところは、車両の走行領域全域において走行負荷に拘わらず良好な運転性が得られる車両用駆動力制御装置を提供することにある。

【０００６】

【課題を解決するための手段】かかる目的を達成するための本発明の要旨とするところは、エンジンの出力が駆動輪へ伝達される車両において、その車両の駆動力を制御する駆動力制御装置であって、(a) 前記車両の定常走行におけるエンジンの負荷量および車速により表される

基準走行負荷曲線を設定する基準負荷曲線設定手段と、(b) エンジンの負荷量および車速に基づいて表される走行負荷の大きさを、前記基準走行負荷曲線を基準として逐次算出する走行負荷算出手段と、(c) その走行負荷算出手段により逐次算出された走行負荷に基づいて前記車両の駆動力を調節する駆動力制御手段とを、含むことにある。

【０００７】

【作用および発明の効果】このようにすれば、基準負荷曲線設定手段により、車両の定常走行におけるエンジンの負荷量および車速により表される基準走行負荷曲線が設定され、走行負荷算出手段により、エンジンの負荷量および車速に基づいて表される走行負荷の大きさが、上記基準走行負荷曲線を基準として逐次算出される。そして、駆動力制御手段により、その走行負荷算出手段により逐次算出された走行負荷に基づいて前記車両の駆動力が調節される。したがって、車両の走行領域全域にわたって、走行負荷の大きさに基づいて前記車両の駆動力が調節されるので、路面勾配などによる走行負荷の変化に拘わらず車両の走行領域全域において良好な運転性が得られるのである。

【０００８】ここで、好適には、前記走行負荷算出手段は、前記基準走行負荷曲線からエンジンの負荷量に基づいて基準走行負荷車速を決定する基準走行負荷車速決定手段と、車速とその基準走行負荷車速とに基づいて走行負荷に対応した走行負荷係数ＫＦＵＫＡを逐次算出する走行負荷係数算出手段とを含み、その走行負荷係数ＫＦＵＫＡにより走行負荷を表すようにする。上記基準走行負荷および走行負荷を表すために、エンジン負荷量を表すスロットル弁開度を用いて基準走行負荷開度とし、実際のスロットル弁開度とその基準走行負荷開度とから走行負荷係数を算出することもできるが、このような場合には、スロットル弁開度は車速よりも変動が多く且つ速やかであるため、検出される走行負荷開度が加減速操作の影響を受けて不安定となるが、上記のようにすれば、車速とその基準走行負荷車速とに基づいて走行負荷係数を算出する場合には、上記加減速操作の影響が除去される利点がある。

【０００９】また、上記走行負荷係数算出手段は、車速が前記基準走行負荷車速よりも低い場合と高い場合とでは、前記走行負荷係数ＫＦＵＫＡを算出する演算式を変更するように構成される。

【００１０】たとえば、上記走行負荷係数算出手段は、車速が基準走行負荷車速ａよりも低い値ｂである場合には、$\mathrm{KFUKA}=2-(b/a)$式から走行負荷係数ＫＦＵＫＡを算出するが、高い値ｃである場合には、$\mathrm{KFUKA}=a/c$式から走行負荷係数ＫＦＵＫＡを算出する。

【００１１】また、好適には、前記走行負荷係数算出手段は、前記逐次算出された走行負荷係数ＫＦＵＫＡになまし処理を施して平滑化することによりなまし処理後走行負荷係数ＫＦＵＫＡＳＭを算出するなまし処理手段をさらに含み、そのなまし処理後走行負荷係数ＫＦＵＫＡＳＭを走行負荷として出力する。

【００１２】上記なまし処理手段は、好適には、走行負荷係数ＫＦＵＫＡになまし処理を施すに際し、車両の走行条件に従ってなまし量を変更するように構成される。

【００１３】また、前記走行負荷係数算出手段は、好適には、車両の発進期間において、なまし処理後走行負荷係数ＫＦＵＫＡＳＭを実質的に変更しないように構成される。

【００１４】また、前記走行負荷係数算出手段は、好適には、なまし処理前の走行負荷係数ＫＦＵＫＡが１以上の状態から１未満の状態となった時点から所定時間ＣＨＡＮＴＥＮ内は、なまし処理後走行負荷係数ＫＦＵＫＡＳＭを実質的に変更しないように構成される。

【００１５】また、前記車両は、好適には、変速比が自動的に変化させられる自動変速機と、その自動変速機の変速比を予め設定された変速線からエンジンの負荷量および車速に基づいて制御する変速制御手段とを備えたものであり、前記駆動力制御手段は、前記走行負荷に基づいて上記変速線を補正する補正手段を含む。このようにすれば、燃費と動力性能とが両立する利点がある。

【００１６】上記補正手段は、前記なまし処理後走行負荷係数ＫＦＵＫＡＳＭに基づいて上記変速線を補正する。

【００１７】上記補正手段は、前記なまし処理後走行負荷係数ＫＦＵＫＡＳＭの勾配に対する特性を補正するための補正係数を、なまし処理後走行負荷係数ＫＦＵＫＡＳＭに基づいて設定する補正係数設定手段を含み、該補正係数設定手段により設定された補正係数により前記変速線を実質的に補正する。

【００１８】また、好適には、逐次算出される走行負荷が第１の判断基準値を超えたとき、前記自動変速機のシフトアップを禁止するシフトアップ禁止手段がさらに設けられる。このようにすれば、ダウンシフトにより駆動力が高められるのでアクセルペダルを戻し操作して駆動力を抑えようとするが、そうするとシフトアップが発生して駆動力が不足するため再びアクセルペダルを踏み込み操作するのでダウンシフトが発生するというビジーシフトが改善される利点がある。

【００１９】また、上記シフトアップ禁止手段は、たとえば、前記なまし処理後走行負荷係数ＫＦＵＫＡＳＭが前記第１の判断基準値を超えたとき、前記自動変速機のシフトアップを禁止する。

【００２０】また、上記シフトアップ禁止手段は、アクセルペダルの踏み込み操作によりスロットル弁開度が開かれたことにより最高速ギヤ段からそれより１段下のギヤ段へのシフトダウンが発生した後において、シフトアップを禁止する。

【００２１】また、好適には、逐次算出される走行負荷が第２の判断基準値未満となったとき、前記自動変速機のシフトアップの禁止を解除するシフトアップ禁止解除手段がさらに設けられる。この第２の判断基準値は前記第１の判断基準値よりも小さい値に設定されるので、その第２の判断基準値と第１の判断基準値との間のヒステリシスにより、シフトアップ禁止およびその解除が連続的に行われることが解消される。

【００２２】また、上記シフトアップ禁止解除手段は、好適には、前記シフトアップ禁止手段による自動変速機のシフトアップの禁止中において、減速から加速への反転が所定回行われる毎に最高速ギヤ段へのシフトアップを実行すべきか否かを判断し、実行すべきであると判断される場合には該シフトアップの禁止を解除して該最高速ギヤ段へのシフトアップを実行する。シフトアップ禁止の解除は高駆動力側から低駆動力側への解除であり、加速時の要求駆動力で判断する必要がある。このようにすれば、加速への反転毎に高駆動力を維持すべきか否かを判定するため、要求駆動力に応じてシフトアップが可能となる利点がある。

【００２３】また、好適には、上記シフトアップ禁止解除手段は、前記第２の判断基準値を、シフトアップの禁止が開始されたときの走行負荷、またはシフトアップの禁止中に所定回の減速から加速への反転が検出されたときの走行負荷のうち、最新のものよりも所定値小さい値に設定する第２の判断基準値設定手段をさらに含む。このようにすれば、シフトアップの禁止の解除の遅れが短縮される利点がある。その走行負荷としては、たとえばなまし処理後走行負荷係数ＫＦＵＫＡＳＭが用いられる。

【００２４】また、前記駆動力制御手段は、好適には、前記走行負荷算出手段により算出された走行負荷が所定の判断基準値未満且つエンジン負荷量が所定値以下で加速度が所定値以上であるとき、前記自動変速機をエンジンブレーキが作用するギヤ段へ優先的にシフトダウンさせる。このようにすれば、エンジンブレーキ力を向上させることができる。

【００２５】また、前記駆動力制御手段は、好適には、逐次算出されたなまし処理後走行負荷係数ＫＦＵＫＡＳＭが第１の判断基準値未満であり、且つ、スロットル開度が所定値以下で加速度が所定値以上のとき、エンジンブレーキの効く変速段へ強制的にシフトダウンさせるシフトダウン手段を含む。

【００２６】また、前記駆動力制御手段は、好適には、逐次算出されたなまし処理前の走行負荷係数ＫＦＵＫＡが第２の判断基準値以上となると、上記シフトダウン手段による制御を解除するシフトダウン解除手段を含む。

【００２７】

【実施例】以下、本発明の一実施例を図面に基づいて詳細に説明する。

【００２８】図１において、ガソリンエンジン１０の燃焼室１２内には、エアクリーナ１４，エアフローメータ１６，吸気通路１８，スロットル弁２０，バイパス通路２２，サージタンク２４，インテークマニホルド２６，および吸気弁２８を介して空気が吸入されるとともに、その空気には、インテークマニホルド２６に設けられた燃料噴射弁３０から噴射される燃料ガスが混合されるようになっている。エアフローメータ１６は、実際の吸入空気量Ｑｍを検出するためのもので本実施例では可動ベーン式のものが用いられており、その実際の吸入空気量Ｑｍを表す吸入空気量信号ＳＱｍをエンジン用電子制御装置３２およびトランスミッション用電子制御装置３４に供給する。スロットル弁２０は、図示しないアクセルペダルに機械的に連結されており、その操作量に対応して開閉されることにより吸入空気量を連続的に変化させるようになっているとともに、そのスロットル弁２０にはアイドルスイッチ付スロットルセンサ３６が設けられて、アイドル位置を示す信号およびスロットル弁開度ＴＡを表すスロットル弁開度信号ＳＴＡをエンジン用電子制御装置３２およびトランスミッション用電子制御装置３４に供給するようになっている。バイパス通路２２はスロットル弁２０と並列に配設されているとともに、そのバイパス通路２２にはアイドル回転数制御弁３８が設けられており、エンジン用電子制御装置３２によってアイドル回転数制御弁３８の開度が制御されることにより、スロットル弁２０をバイパスして流れる空気量が調整されてアイドル時のエンジン回転数が制御される。燃料噴射弁３０も、エンジン用電子制御装置３２によってその噴射タイミングや噴射量が制御される。なお、上記エアフローメータ１６の上流側には吸入空気の温度を測定する吸気温センサ４０が設けられ、その吸気温を表す信号をエンジン用電子制御装置３２に供給するようになっている。

【００２９】エンジン１０は、吸気弁２８，排気弁４２，ピストン４４，および点火プラグ４６を備えて構成されており、点火プラグ４６は、エンジン用電子制御装置３２によって制御されるイグナイタ４８からディストリビュータ５０を介して供給される高電圧によって点火火花を発生し、燃焼室１２内の混合ガスを爆発させてピストン４４を上下動させることによりクランク軸を回転させる。吸気弁２８および排気弁４２は、クランク軸の回転に同期して回転駆動されるカムシャフトにより開閉されるようになっているとともに、エンジン用電子制御装置３２によって制御される可変バルブタイミング機構５２により、カムシャフトとクランク軸との回転位相が変更されて開閉タイミングが調整されるようになっている。燃焼室１２内で燃焼した排気ガスは、排気弁４２からエキゾーストマニホルド５４，排気通路５６，触媒装置５８を経て大気に排出される。エンジン１０にはエンジン冷却水温を測定する水温センサ６０が設けられてお

り、そのエンジン冷却水温を表す信号をエンジン用電子制御装置３２に供給するようになっているとともに、エキゾーストマニホルド５４には排気ガス中の酸素濃度を検出する酸素センサ６２が設けられており、その酸素濃度を表す信号をエンジン用電子制御装置３２に供給するようになっている。また、ディストリビュータ５０にはクランク軸の回転に同期してパルスを発生する回転角センサが設けられており、そのパルス信号をエンジン用電子制御装置３２に供給するようになっているとともに、そのパルス信号はエンジン１０の回転速度ＮＥを表すエンジン回転速度信号ＳＮＥとしてトランスミッション用電子制御装置３４にも供給されるようになっている。

【００３０】上記エンジン用電子制御装置３２，トランスミッション用電子制御装置３４は、何れもＣＰＵ，ＲＡＭ，ＲＯＭ，入出力インタフェース回路，Ａ／Ｄコンバータ等を備えて構成されており、ＲＡＭの一時記憶機能を利用しつつＲＯＭに予め記憶されたプログラムに従って信号処理を行うもので、エンジン用電子制御装置３２には前記各信号の他、エアコンスイッチ６４からエアコンのＯＮ，ＯＦＦを表す信号等が供給されるとともに、トランスミッション用電子制御装置３４には、運転席のシフトレバー操作位置、すなわち「Ｐ（パーキング）」，「Ｎ（ニュートラル）」，「Ｄ（ドライブ）」，「１（ファースト）」，「２（セカンド）」，「Ｒ（リバース）」等を表す信号がシフトセレクトセンサ６６から供給される。トランスミッション用電子制御装置３４にはまた、前記エンジン１０の回転速度を例えば前進４段および後進１段で変速する自動変速機６８の変速段が「１ｓｔ」，「２ｎｄ」，「３ｒｄ」，および「４ｔｈ」の何れであるかを表す変速段信号ＳＧがシフトポジションスイッチ７０から供給されるとともに、その自動変速機６８の出力軸の回転速度すなわち車速ＳＰＤを表す車速信号ＳＳＰＤが車速センサ７２から供給されるようになっている。自動変速機６８は、遊星歯車装置や油圧式摩擦係合装置などを備えた良く知られたもので、油圧回路が切り換えられて油圧式摩擦係合装置の係合状態が変更されることにより、上記前進４段および後進１段が成立させられるように構成されている。なお、両電子制御装置３２と３４との間でも必要な情報が通信インターフェイスを介して授受されるようになっており、前記吸入空気量信号ＳＱｍ，スロットル弁開度信号ＳＴＡ，およびエンジン回転速度信号ＳＮＥは、少なくとも何れかの制御用電子制御装置３２または３４に供給されるようになっていれば良い。また、例えばブレーキペダルのＯＮ，ＯＦＦやステアリングホイールの操舵角、路面の勾配、排気温度など、自動車の運転状態を表す他の種々の信号を取り込んでエンジン制御やトランスミッションの変速制御に用いることも可能である。

【００３１】そして、上記エンジン用電子制御装置３２は、前記吸入空気量Ｑｍやスロットル弁開度ＴＡ，エンジン回転速度ＮＥ，エンジン１０の冷却水温度，吸入空気温度，排気通路５６内の酸素濃度，エアコンのＯＮ－ＯＦＦなどに応じて、例えば必要なエンジン出力を確保しつつ燃費や有害排出ガスを低減するように予め定められたデータマップや演算式などに基づいて、前記燃料噴射弁３０による燃料ガスの噴射量や噴射タイミング、イグナイタ４８による点火時期、アイドル回転数制御弁３８によるアイドル回転数、および可変バルブタイミング機構５２による吸排気弁２８，４２の開閉タイミングなどを制御する。

【００３２】トランスミッション用電子制御装置３４は、吸入空気量Ｑｍやスロットル弁開度ＴＡ，エンジン回転速度ＮＥ，車速ＳＰＤ，自動変速機６８の変速段，シフトレバー操作位置などに応じて、予め定められた変速条件に従って自動変速機６８の変速段を切換制御する。以下、シフトレバー操作位置が「Ｄ」で、前進４段で変速が行われる場合の変速制御作動の要部について、フローチャートを参照しつつ具体的に説明する。

【００３３】図２に示すフローチャートは、一定の周期たとえば３２ms毎に繰り返し実行される走行負荷検出ルーチンである。図において、ステップＳＤ１乃至ＳＤ３では、スロットル弁開度ＴＡ、車速ＳＰＤ、および自動変速機６８の実際のギヤ段Ｇが読み込まれる。続いて、基準負荷曲線設定手段に対応するステップＳＤ４では、予め記憶された複数の基準負荷曲線から実際のギヤ段Ｇに対応した基準負荷曲線関係、たとえば図３に示すスロットル弁開度ＴＡと基準走行負荷車速ＳＰＤ$_s$の関係が選択される。この基準負荷曲線は平坦路を定常走行する場合のスロットル弁開度ＴＡと基準走行負荷車速ＳＰＤ$_s$の関係である。

【００３４】次いで、走行負荷算出手段に対応するステップＳＤ５乃至ＳＤ２０が実行されることにより実際の走行負荷を基準走行負荷を基準として表した走行負荷係数ＫＦＵＫＡおよびそれを平滑化したなまし処理後の走行負荷係数ＫＦＵＫＡＳＭが算出される。先ず、基準走行負荷車速決定手段に対応するステップＳＤ５では、ステップＳＤ４により設定された図３の関係から実際のスロットル弁開度ＴＡに対応した基準走行負荷車速ＳＰＤ$_s$が決定される。たとえば、スロットル弁開度ＴＡの値がｓであるとすると図３のＡ点に対応する車速値ａが基準走行負荷車速として決定される。続くステップＳＤ６では、ステップＳＤ５にて求められた基準走行負荷車速ＳＰＤ$_s$が実際の走行負荷の影響を受けている車速ＳＰＤよりも大きいか否かが判断される。

【００３５】上記ステップＳＤ６の判断が否定された場合、たとえば実際の車両状態が図３のＣ点であるとすると、基準走行負荷車速ａが実車速ｃよりも小さい場合（ａ＜ｃ）には、ステップＳＤ７において予め設定された式ＫＦＵＫＡ＝ａ／ｃから走行負荷係数ＫＦＵＫＡが算出され、ステップＳＤ８においてフラグＸＣＯＡＳＴ

の内容が「１」にセットされる。しかし、上記ステップＳＤ６の判断が肯定された場合、たとえば実際の車両状態が図３のＢ点であるとすると、基準走行負荷車速ａが実車速ｂより大きい場合（ａ＞ｂ）には、ステップＳＤ９において予め設定された式ＫＦＵＫＡ＝２－（ｂ／ａ）から走行負荷係数ＫＦＵＫＡが算出され、ステップＳＤ１０においてフラグＸＣＯＡＳＴの内容が「０」にクリアされる。このフラグＸＣＯＡＳＴは、その内容が「０」であるときになまし処理前の走行負荷係数ＫＦＵＫＡが高走行負荷領域で決定されたことを示し、「１」であるときになまし処理前の走行負荷係数ＫＦＵＫＡが低走行負荷領域で決定されたことを示すものである。図４に示すように、上記のようにして算出された走行負荷係数ＫＦＵＫＡは、平坦路定常走行では１に近い値を示すが、下り坂走行などの低負荷走行では１よりも大きい値を示し、登坂路走行などの高負荷走行では１より小さい値を示す。

【００３６】上記走行負荷係数ＫＦＵＫＡの算出に際して、高走行負荷時でも低走行負荷時の式ＫＦＵＫＡ＝ａ／ｃが適用されると、高負荷となる程走行負荷係数ＫＦＵＫＡが飽和して後述のなまし処理の影響が大きくなるので、低走行負荷時とは異なる式ＫＦＵＫＡ＝２－（ｂ／ａ）が用いられる。これにより、走行負荷係数ＫＦＵＫＡは、実車速ＳＰＤに対する変化割合が高負荷走行時でも低負荷走行と略同様とされるので、走行負荷に関係なくなまし処理の影響が同等となるのである。

【００３７】続くステップＳＤ１１では、上記フラグＸＣＯＡＳＴの内容が反転したか否か、換言すれば車両の走行負荷領域が基準走行負荷状態を境にして変化したか否かが判断される。このステップＳＤ１１の判断が肯定された場合には、ステップＳＤ１２において反転タイマーＣＨＡＮＴＥＮの内容が「０」にセットされてその計時が開始される。しかし、ステップＳＤ１１の判断が否定された場合には、ステップＳＤ１３において走行負荷係数ＫＦＵＫＡがＲＡＭ内の所定の記憶場所に記憶される。

【００３８】続くステップＳＤ１４、ＳＤ１５、ＳＤ１６では、走行負荷係数ＫＦＵＫＡ、反転タイマーＣＨＡＮＴＥＮの内容、発進タイマーＣＨＡＳＳＩＮの内容がそれぞれ読み込まれる。それら反転タイマーＣＨＡＮＴＥＮおよび発進タイマーＣＨＡＳＳＩＮは、図５に示す発進、加減速状態判定ルーチンにより制御される。この発進、加減速状態判定ルーチンは、たとえば図２の走行負荷検出ルーチンよりも長い周期、たとえば１２８ms程度の周期により繰り返し実行される。

【００３９】図５のステップＳＨ１では車速ＳＰＤが読み込まれた後、ステップＳＨ２では発進タイマーＣＨＡＳＳＩＮの内容が読み込まれる。続くステップＳＨ３およびＳＨ４では、車両の発進状態を検出するために、車速ＳＰＤがたとえば４０km/h程度の判断基準値より低いか否か、および車速ＳＰＤがたとえば１０km/h程度の判断基準値以上であるか否かがそれぞれ判断される。上記ステップＳＨ３の判断が否定された場合にはステップＳＨ５において発進タイマーＣＨＡＳＳＩＮがクリアされるが、上記ステップＳＨ４の判断が否定された場合には車両が停止状態であるのでステップＳＨ６において発進タイマーＣＨＡＳＳＩＮがセットされ、上記ステップＳＨ４の判断が肯定された場合には発進タイマーＣＨＡＳＳＩＮの内容が減算される。すなわち、発進タイマーＣＨＡＳＳＩＮは、車両が発進した以後の経過時間の計時を継続するが、４０km/h程度の所定の速度に到達するとクリアされるのである。

【００４０】続くステップＳＨ８では発進タイマーＣＨＡＳＳＩＮの内容が記憶され、ステップＳＨ９では反転タイマーＣＨＡＮＴＥＮの内容が読み込まれ、ステップＳＨ１０では反転タイマーＣＨＡＮＴＥＮの内容が減算され、ステップＳＨ１１では反転タイマーＣＨＡＮＴＥＮの内容が記憶される。前記発進タイマーＣＨＡＳＳＩＮおよび上記反転タイマーＣＨＡＮＴＥＮは、所謂減算カウンタであり、その内容が零に到達したときにカウントの満了と判断される。それら発進タイマーＣＨＡＳＳＩＮおよび反転タイマーＣＨＡＮＴＥＮは、初期状態では所定の時間に対応する値にそれぞれ予め設定されている。たとえば、発進タイマーＣＨＡＳＳＩＮは６．０sec 程度に設定され、反転タイマーＣＨＡＮＴＥＮは１．２sec 程度に設定される。それらの設定値は、発進時および反転時になまし処理を一時停止させるための期間に対応している。

【００４１】そして、ステップＳＨ１２では前回の制御サイクルの車速ＳＰＤＯが読み込まれた後、ステップＳＨ１３では実際の車速ＳＰＤと前回の制御サイクルの車速ＳＰＤＯとが比較され、前者が高いと判断された場合はステップＳＨ１４においてフラグＸＫＡＳＯＫＵの内容が「１」にセットされてからステップＳＨ１６においてその内容が記憶され、後者が高いと判断された場合はステップＳＨ１５においてフラグＸＫＡＳＯＫＵの内容が「０」にクリアされてからステップＳＨ１６においてその内容が記憶されるが、両者が同じ値であると判断された場合はステップＳＨ１６が直接実行される。すなわち、フラグＸＫＡＳＯＫＵは、その内容が「１」であるときに車両の加速状態を示し、「０」であるときに車両の減速状態を示す。

【００４２】続くステップＳＨ１７では、アイドルスイッチがオフ状態であるか否かが判断される。このステップＳＨ１７の判断が否定された場合は、ステップＳＨ２２においてアイドルオフディレイタイマＣＩＤＬＯＦの内容がクリアされる。しかし、ステップＳＨ１７の判断が肯定された場合は、ステップＳＨ１８においてスロットル弁開度ＴＡが読み込まれ、ステップＳＨ１９においては図６に示す予め設定された関係から実際のスロット

ル弁開度ＴＡに基づいて第３速自動シフトダウン解除ディレイ時間ＫＯＦＦが算出され、ステップＳＨ２０ではアイドルオフディレイタイマＣＩＤＬＯＦの内容が読み込まれ、ステップＳＨ２１ではアイドルオフディレイタイマＣＩＤＬＯＦの内容が加算され、ステップＳＨ２３ではアイドルオフディレイタイマＣＩＤＬＯＦの内容が記憶される。すなわち　アイドルオフディレイタイマＣＩＤＬＯＦは、アクセルペダルが踏み込まれてからの経過時間を示している。また、上記第３速自動シフトダウン解除ディレイ時間ＫＯＦＦは、後述の第３速への自動シフトダウンの解除を判定するための判断基準値となる。

【００４３】図２に戻って、ステップＳＤ１７では、上記反転タイマーＣＨＡＮＴＥＮの内容が「０」であるか否かが判断され、ステップＳＤ１８では、発進タイマーＣＨＡＳＳＩＮの内容が「０」であるか否かが判断される。それらのステップＳＤ１７およびＳＤ１８の判断のいずれかが否定された場合には、発進時および反転時の所定期間はなまし処理を一時停止するためにステップＳＤ１９およびＳＤ２０が実行されることなく、ステップＳＤ２１が直ちに実行される。しかし、それらのステップＳＤ１７およびＳＤ１８の判断が共に肯定された場合には、ステップＳＤ１９において、予め設定された図７に示す表から運転条件に従ってなまし量が決定される。すなわち、前記なまし処理前の走行負荷係数ＫＦＵＫＡの状態を示すフラグＸＣＯＡＳＴ、なまし処理後の走行負荷係数ＫＦＵＫＡＳＭの状態を示すフラグＸＴＯＨＡＮ、スロットル弁開度の全閉を検出するアイドルスイッチの作動状態を示す信号ＹＩＤＬ、車両の加速状態を示すフラグＸＫＡＳＯＫＵの内容に従って、１／２乃至１／１２８のなまし量が選択されるのである。なお、図７の表において、＊印はなまし量の選択対象ではないことを示しており、＊印を除く条件の成立でなまし量が決定される。

【００４４】そして、ステップＳＤ２０において、上記ステップＳＤ１９により選択されたなまし量がステップＳＤ７或いはＳＤ８により算出された走行負荷係数ＫＦＵＫＡに乗算されることによりなまし処理が実行され、すなわち、ＫＦＵＫＡＳＭ＝ＫＦＵＫＡＳＭ０＋ｎ・（ＫＦＵＫＡ－ＫＦＵＫＡＳＭ０）なる式によりなまし処理後の走行負荷係数ＫＦＵＫＡＳＭが算出される。なお、上式においてＫＦＵＫＡＳＭ０は前回の制御サイクルにおいてステップＳＤ２０により算出されたなまし処理後の走行負荷係数ＫＦＵＫＡＳＭを示し、ｎは上記ステップＳＤ１９により選択されたなまし量を示している。そして、ステップＳＤ２１においてなまし処理後の走行負荷係数ＫＦＵＫＡＳＭがＲＡＭ内の所定の記憶場所に記憶される。このように算出されたなまし処理後の走行負荷係数ＫＦＵＫＡＳＭは、図８に示すように、なまし処理前の走行負荷係数ＫＦＵＫＡに対して大幅に平滑化されている。

【００４５】ここで、図８に示すなまし処理後の走行負荷係数ＫＦＵＫＡＳＭには、上記ステップＳＤ１８によるなまし処理一時停止効果も含まれている。すなわち、車両の発進期間すなわち発進状態判定タイマーＣＨＡＳＳＩＮの計時期間は、加速の影響が大きく走行負荷係数ＫＦＵＫＡＳＭが高負荷側にずれる傾向にあるため、そのような期間では、ステップＳＤ１９およびＳＤ２０をスキップして走行負荷係数ＫＦＵＫＡＳＭの更新を中止しその変化を一時停止することにより、上記の高負荷側へのずれが防止されている。

【００４６】また、図８に示すなまし処理後の走行負荷係数ＫＦＵＫＡＳＭには、さらに前記ステップＳＤ１７によるなまし処理一時停止効果も含まれている。すなわち、なまし量の決定には、加減速状態フラグＸＫＡＳＯＫＵが条件の１つとして用いられているが、そのままの値が用いられると、走行負荷係数ＫＦＵＫＡＳＭにずれが発生するので、応答の速いフラグＸＣＯＡＳＴの反転時点からの所定のディレー区間、すなわちなまし処理前の走行負荷係数ＫＦＵＫＡの反転時からの所定期間ＣＨＡＮＴＥＮでは、ステップＳＤ１９およびＳＤ２０をスキップして走行負荷係数ＫＦＵＫＡＳＭの更新を中止しその変化を一時停止することにより、上記のずれが防止されている。これにより、図９に示すように、走行負荷係数ＫＦＵＫＡの落ち込みに対して、なまし後の走行負荷係数ＫＦＵＫＡＳＭは好適に平滑化される。因に、走行負荷係数ＫＦＵＫＡＳＭの更新を中止するディレー区間が設けられていない場合は、図１０に示すように、なまし後の走行負荷係数ＫＦＵＫＡＳＭも走行負荷係数ＫＦＵＫＡの落ち込みの影響を大きく受ける。

【００４７】そして、上記ステップＳＤ２０のなまし処理により算出される走行負荷係数ＫＦＵＫＡＳＭは、その計算方法に由来して、図１１に示すように、車両の走行負荷に対して上に凸の特性となるので、平坦に近い路面勾配となるほど走行負荷係数ＫＦＵＫＡＳＭが敏感に変化させられる。すなわち、平坦に近い路面勾配となるほど走行負荷係数ＫＦＵＫＡＳＭの感度が高くなる。

【００４８】続くステップＳＤ２２では上記なまし処理後の走行負荷係数ＫＦＵＫＡＳＭが１．００以上の値であるか否かが判断される。このステップＳＤ２２の判断が否定された場合にはステップＳＤ２３においてフラグＸＴＯＨＡＮの内容が「０」にクリアされるが、肯定された場合にはステップＳＤ２４においてフラグＸＴＯＨＡＮの内容が「１」にセットされる。そして、ステップＳＤ２５において、予め設定された図１２に示す関係から、実際のなまし処理後の走行負荷係数ＫＦＵＫＡＳＭに基づいてシフト点補正係数Ｋｓが算出される。この図１２に示す関係は、走行負荷に対してリニヤ感を保つために、シフト点補正係数Ｋｓがなまし処理後の走行負荷係数ＫＦＵＫＡＳＭに対して下に凸となるように設定さ

れている。なお、このシフト点補正係数Ｋｓは、変速線から決定されたシフト点車速に乗算されることにより、車両の走行負荷に応じてそのシフト点車速をずらすためのものである。

【００４９】次に、降坂路走行においてエンジンブレーキを有効に作用させるために、第４速ギヤ段から第２速ギヤ段への自動シフトダウンを示すフラグＸ２ＮＤＤおよび第４速ギヤ段から第３速ギヤ段への自動シフトダウンを示すフラグＸ３ＲＤＤを制御する自動ダウン制御ルーチンを図１３を用いて説明する。この自動ダウン制御ルーチンはメインルーチンと同様のタイミングで実行される。

【００５０】図１３のステップＳＡ１では、第４速ギヤ段から第３速ギヤ段または第２速ギヤ段への自動シフトダウンの開始条件のひとつとして、なまし処理後の走行負荷係数ＫＦＵＫＡＳＭがたとえば０．９５程度の所定の判断基準値以下であるか否かが判断される。この判断基準値は、車両の降坂路走行を判断するための値である。このステップＳＡ１の判断が否定された場合には、ステップＳＡ５およびＳＡ６においてフラグＸ３ＲＤＤおよびＸ２ＮＤＤの内容がクリアされた後、本ルーチンが終了させられる。しかし、上記ステップＳＡ１の判断が肯定された場合には、ステップＳＡ２において、なまし処理前の走行負荷係数ＫＦＵＫＡが１．０５程度の所定の判断基準値よりも小さいか否かが判断される。

【００５１】このステップＳＡ２の判断が否定された場合には、自動シフトダウン制御を解除するために上記ステップＳＡ５以下が実行される。しかし、ステップＳＡ２の判断が肯定された場合には、続くステップＳＡ３において、自動シフトダウンの開始条件のひとつとして、アイドルスイッチがオフ状態であるか否かが判断される。このステップＳＡ３の判断が肯定された場合には、アクセルペダルが踏み込まれているので、続くステップＳＡ４においてアイドルオフディレータイマＣＩＤＬＯＦの内容、すなわちアイドルスイッチのオフからの経過時間が前記ステップＳＨ１９にて算出された判断基準値ＫＯＦＦより短いか否かが判断される。このステップＳＡ４の判断が肯定された場合には前記ステップＳＡ６が実行されてフラグＸ２ＮＤＤがクリアされるが、否定された場合には前記ステップＳＡ５以下が実行されてフラグＸ３ＲＤＤおよびＸ２ＮＤＤがクリアされる。

【００５２】上記ステップＳＡ３の判断が否定された場合、すなわちアクセルペダルが踏み込まれていない場合は、ステップＳＡ７においてフラグＸ３ＲＤＤの内容が「０」であるか否かが判断される。当初はステップＳＡ７の判断が肯定されるので、ステップＳＡ８において、図１４に示す予め設定された関係から実際の車速ＳＰＤに基づいて４→２ダウン判断基準加速度α_{4-2D}が算出された後、ステップＳＡ９において実際の加速度αが上記４→２ダウン判断基準加速度α_{4-2D}より大きいか否かが判断される。このステップＳＡ９の判断が肯定された場合には、ステップＳＡ１６においてフラグＸ２ＮＤＤが「１」にセットされるとともに、ステップＳＡ１２においてフラグＸ３ＲＤＤが「１」にセットされた後、本ルーチンが終了させられる。

【００５３】しかし、上記ステップＳＡ９の判断が否定された場合には、ステップＳＡ１０において、図１４に示す予め設定された関係から実際の車速ＳＰＤに基づいて４→３ダウン判断基準加速度α_{4-3D}が算出された後、ステップＳＡ１１において実際の加速度αが上記４→３ダウン判断基準加速度α_{4-3D}より大きいか否かが判断される。このステップＳＡ１１の判断が肯定された場合には、ステップＳＡ１２においてフラグＸ３ＲＤＤが「１」にセットされて本ルーチンが終了させられるが、否定された場合には直ちに本ルーチンが終了させられる。

【００５４】上記のようにしてフラグＸ３ＲＤＤが「１」にセットされると、続く制御サイクルにおけるステップＳＡ７の判断が否定されるので、ステップＳＡ１３においてフラグＸ２ＮＤＤが「０」であるか否かが判断される。このステップＳＡ１３の判断が肯定された場合には、ステップＳＡ１４において、図１４に示す予め設定された関係から実際の車速ＳＰＤに基づいて３→２ダウン判断基準加速度α_{3-2D}が算出された後、ステップＳＡ１５において実際の加速度αが上記３→２ダウン判断基準加速度α_{3-2D}より大きいか否かが判断される。このステップＳＡ１５の判断が肯定された場合には、ステップＳＡ１６およびＳＡ１２においてフラグＸ２ＮＤＤおよびＸ３ＲＤＤが「１」にセットされるが、否定された場合には直ちに本ルーチンが終了させられる。

【００５５】また、上記ステップＳＡ１３の判断が否定された場合には、ステップＳＡ１７において、図１５に示す予め設定された関係から実際の車速ＳＰＤに基づいて２→３アップ判断基準加速度α_{2-3U}が算出された後、ステップＳＡ１８において実際の加速度αが上記２→３アップ判断基準加速度α_{2-3U}より小さいか否かが判断される。このステップＳＡ１８の判断が肯定された場合には、ステップＳＡ１９においてフラグＸ２ＮＤＤがクリアされるが、否定された場合には直ちに本ルーチンが終了させられる。

【００５６】要するに、本自動ダウン制御ルーチンでは、なまし後の走行負荷係数ＫＦＵＫＡＳＭがたとえば０．９５よりも低い降坂路走行においてアクセルペダルが踏み込まれていないとき、適切なエンジンブレーキ作用を得るために車両の加速度αに応じて４→２ダウン、４→３ダウン、３→２ダウンが実行される。また、アイドルスイッチがオフ状態となったとき、或いは車両の加速度αが２→３アップ判断基準加速度α_{2-3U}より小さくなった場合には第２速ギヤ段への自動ダウンが解除される。また、なまし処理前の走行負荷係数ＫＦＵＫＡが

１．０５以上となったとき、或いは、アイドルオフからの経過時間ＣＩＤＬＯＦが図６の判断基準値ＫＯＦＦを越えると、第３速ギヤ段への自動ダウン制御が解除される。

【００５７】図１６は、第４速ギヤ段へのシフトアップを禁止する第４速禁止制御ルーチンを示している。このルーチンでは、第４速へのシフトアップ禁止の仮解除を表すフラグＸ３ＲＤＨ、第４速ギヤ段へのシフトアップ禁止を表すフラグＸ３ＨＯＬＤの内容が、登坂路走行のように走行負荷が大きい状態では「１」にセットされるが、走行負荷が小さくなると「０」にクリアされて第４速ギヤ段へのシフトアップ禁止が解除されるようになっている。この第４速禁止制御ルーチンは、メインルーチンと同様のタイミングにて実行される。

【００５８】図１６において、ステップＳＥ１では、フラグＸ４３ＤＷＮの内容が「１」であるか否かが判断される。このフラグＸ４３ＤＷＮはその内容が「１」であるときにパワーオンによるシフトダウンの発生を表すものである。このステップＳＥ１の判断が否定された場合には、ステップＳＥ６においてフラグＸ３ＲＤＨの内容がクリアされ、ステップＳＥ７において加速減速サイクルカウンタＣ３ＲＤＨの内容がクリアされてから本ルーチンが終了させられる。しかし、上記ステップＳＥ１の判断が肯定された場合には、続くステップＳＥ２において、フラグＸ３ＲＤＨの内容が「１」であるか否かが判断される。当初はステップＳＥ２の判断が否定されるので、ステップＳＥ３において前記なまし処理された走行負荷係数ＫＦＵＫＡＳＭがたとえば１．２程度の所定の判断基準値以上であるか否かが判断される。この判断基準値は、パワーオンによるシフトダウンの発生時の走行負荷が登坂路走行によるものであるか否かを判定するためのものである。

【００５９】上記ステップＳＥ３の判断が否定された場合は、それほどの走行負荷ではないので、ステップＳＥ４においてフラグＸ３ＨＯＬＤの内容がクリアされ、ステップＳＥ５においてフラグＸ４３ＤＷＮの内容がクリアされた後、ステップＳＥ６においてフラグＸ３ＲＤＨの内容がクリアされ、ステップＳＥ７において加速減速サイクルカウンタＣ３ＲＤＨの内容がクリアされてから本ルーチンが終了させられる。

【００６０】しかし、上記ステップＳＥ３の判断が肯定された場合は、第４速ギヤ段による走行では駆動力不足となってアクセルペダルの踏み込みが予測される状態であるので、ステップＳＥ８においてフラグＸ３ＲＤＨの内容が「１」にセットされ、ステップＳＥ９においてフラグＸ３ＨＯＬＤの内容が「１」にセットされ、ステップＳＥ１０において第４速ギヤ段へのシフトアップ禁止の解除の判断基準値Ｋ３ＨＯＬＤが算出される。この解除の判断基準値Ｋ３ＨＯＬＤは、上記フラグＸ３ＲＤＨおよびフラグＸ３ＨＯＬＤのセット時の走行負荷係数ＫＦＵＫＡＳＭから所定値βが差し引かれることにより求められる。

【００６１】このようにしてフラグＸ３ＲＤＨおよびフラグＸ３ＨＯＬＤの内容が「１」にセットされると、次の制御サイクルでは、ステップＳＥ２の判断が肯定されるので、ステップＳＥ１１において実際の走行負荷係数ＫＦＵＫＡＳＭが前記解除の判断基準値Ｋ３ＨＯＬＤ以上であるか否かが判断される。このステップＳＥ１１の判断が肯定された場合には、未だ走行負荷が大きい状態であるので、ステップＳＥ１２において加速減速サイクルカウンタＣ３ＲＤＨの内容が読み込まれた後、ステップＳＥ１３乃至ＳＥ１８において加速減速サイクルカウンタＣ３ＲＤＨの内容が車両の加減速状態に即して加算される。

【００６２】すなわち、この加速減速サイクルカウンタＣ３ＲＤＨは、計数内容が０乃至３を周期的に繰り返すものであり、その内容が０、２であるときには車両の減速状態を示し、１、３であるときには車両の加速状態を示すものであるので、ステップＳＥ１４において加速減速サイクルカウンタＣ３ＲＤＨの内容が１であると判断された場合には、ステップＳＥ１５において車両の減速状態であるか否かが判断され、このステップＳＥ１５の判断が肯定された場合にはステップＳＥ１８においてその減速状態を表すために加速減速サイクルカウンタＣ３ＲＤＨの内容が１つだけ加算される。また、ステップＳＥ１３、ＳＥ１６において加速減速サイクルカウンタＣ３ＲＤＨの内容が０、２であると判断された場合には、ステップＳＥ１７において車両の加速状態であるか否かが判断され、このステップＳＥ１７の判断が肯定された場合にはステップＳＥ１８においてその加速状態を表すために加速減速サイクルカウンタＣ３ＲＤＨの内容が１つだけ加算される。

【００６３】そして、ステップＳＥ１９において加速減速サイクルカウンタＣ３ＲＤＨの内容が３に到達したか否かが判断される。当初はこのステップＳＥ１９の判断が否定されるので本ルーチンが終了させられるが、加速減速サイクルカウンタＣ３ＲＤＨの内容が３に到達すると、ステップＳＥ１９の判断が肯定されるので、ステップＳＥ６においてフラグＸ３ＲＤＨの内容がクリアされるとともに、ステップＳＥ７において上記加速減速サイクルカウンタＣ３ＲＤＨの内容が「０」にクリアされる。上記ステップＳＥ１３乃至ＳＥ１９では、シフトアップ禁止中において、車速変化による減速から加速への反転が２回検出されると、ステップＳＥ６によりフラグＸ３ＲＤＨをクリアして仮解除を行い、次の制御サイクルではステップＳＥ３の判断が否定されることを条件として解除を行うようにする。

【００６４】以上のステップが繰り返し実行されるうち、走行負荷が小さくなると、前記ステップＳＥ１１の判断が否定されるので、シフトアップ禁止解除のため

に、ステップＳＥ４、ＳＥ５、ＳＥ６、ＳＥ７においてフラグＸ３ＨＯＬＤ、Ｘ４３ＤＷＮ、Ｘ３ＲＤＨ、および加速減速サイクルカウンタＣ３ＲＤＨの内容がそれぞれクリアされる。

【００６５】すなわち、上記図１６の第４速禁止制御ルーチンにおいては、ステップＳＥ１においてパワーオンダウンシフトの発生と判断され、且つステップＳＥ３においてなまし処理後の走行負荷係数ＫＦＵＫＡＳＭが１．２程度の所定値以上となったと判断されたときに、ビジーシフトを防止するために第４速ギヤ段へのシフトアップが禁止される。また、ステップＳＥ１１においてそのシフトアップ禁止判断時の走行負荷係数ＫＦＵＫＡＳＭより所定値βだけ低い解除判断基準値Ｋ３ＨＯＬＤを、なまし処理後の走行負荷係数ＫＦＵＫＡＳＭが下まわったと判断されたとき、および、ステップＳＥ１９において２回目の減速から加速への反転が判断された後、ステップＳＥ３においてなまし処理後の走行負荷係数ＫＦＵＫＡＳＭが１．２程度の所定値を下回ったと判断されたときに、そのシフトアップが解除されるのである。図１７は、上記第４速禁止制御における各フラグの作動例を示すタイムチャートである。

【００６６】図１８は、本実施例のメインルーチンである変速制御ルーチンを示すフローチャートであり、前記走行負荷ＫＦＵＫＡＳＭに基づいて自動変速機６８のギヤ段を変更することにより車両の駆動力を制御する駆動力制御手段に対応している。図において、ステップＳＳ１では、自動変速機６８の現在の変速段を表す変速段Ｇがたとえばトランスミッション用電子制御装置３４からの変速出力に基づいて読み込まれる。続くステップＳＳ２では、上記ステップＳＳ１で読み込んだ変速段Ｇが最高速ギヤ段の「４ｔｈ（第４速ギヤ段）」であるか否かが判断される。このステップＳＳ２の判断が肯定された場合にはアップシフトの可能性がないためステップＳＳ１５以下のシフトダウン制御が実行される。しかし、ステップＳＳ２の判断が否定された場合にはステップＳＳ３以下のシフトアップ制御が実行される。

【００６７】先ず、そのシフトアップ制御作動について説明する。ステップＳＳ３では、自動変速機６８が第３速ギヤ段であるか否かが判断される。このステップＳＳ３の判断が否定された場合には、第１速ギヤ段または第２速ギヤ段であるので、ステップＳＳ７において、図１９に示されているように車速ＳＰＤおよびスロットル弁開度ＴＡの関数である予め記憶された３種類のアップシフト用変速線、すなわち「１ｓｔ→２ｎｄ」，「２ｎｄ→３ｒｄ」，および「３ｒｄ→４ｔｈ」に関する変速線の中から、現在のギヤ段からアップシフトする場合の変速線が選択される。例えば現在のギヤ段が「２ｎｄ（第２速ギヤ段）」である場合には、（ｂ）の「２ｎｄ→３ｒｄ」に関する変速線が選択される。そして、選択された変速線から実際のスロットル弁開度ＴＡに基づいてシフトアップ用変速点車速（シフトアップの変速点）ＳＰＤｕが求められる。

【００６８】反対に、上記ステップＳＳ３の判断が肯定された場合には、続くステップＳＳ４において第２速ギヤ段への自動ダウンを示すフラグＸ２ＮＤＤの内容が「０」であるか否かが判断される。上記ステップＳＳ４の判断が否定されたとき、すなわち第２速ギヤ段への自動ダウンであると判断されたときは、後述のシフトダウン制御ルーチン内のステップＳＳ２３においてシフトダウンが実行される。しかし、上記ステップＳＳ４の判断が肯定されたとき、すなわち第２速ギヤ段への自動ダウンではないと判断されたときは、続くステップＳＳ５においてフラグＸ３ＲＤＨの内容が「０」であるか否かが判断される。このフラグＸ３ＲＤＨはその内容が「０」であるときに第４速ギヤ段へのシフトアップ禁止の仮解除を表すものである。

【００６９】上記ステップＳＳ５の判断が否定された場合、すなわち第４速ギヤ段へのシフトアップ禁止が仮解除されないときは、後述のシフトダウン制御ルーチン内のステップＳＳ１７以下が実行される。しかし、上記ステップＳＳ５の判断が肯定された場合、すなわち第４速ギヤ段へのシフトアップ禁止が仮解除されたときは、続くステップＳＳ６においてフラグＸ３ＨＯＬＤの内容が「１」であるか否かが判断される。このフラグＸ３ＨＯＬＤは、その内容が「１」であるときに第３速ギヤ段の保持すなわち第４速ギヤ段へのシフトアップ禁止を表している。

【００７０】上記ステップＳＳ６の判断が否定された場合、すなわち第４速ギヤ段へのシフトアップ禁止ではないときは、前記ステップＳＳ７においてシフトアップ用変速点車速ＳＰＤｕが算出される。しかし、上記ステップＳＳ６の判断が肯定された場合、すなわち第４速ギヤ段へのシフトアップ禁止の仮解除状態であるときは、ステップＳＳ８において図２０に示すような第３速ギヤ段ホールド中専用の変速線から実際のスロットル弁開度ＴＡに基づいて、第４速ギヤ段へのシフトアップ禁止解除のシフトアップ用変速点車速ＳＰＤｕが算出される。

【００７１】そして、以上のようにしてシフトアップ用変速点車速ＳＰＤｕが算出されると、ステップＳＳ９において、ＳＰＤｕ←ＳＰＤｕ×Ｋｓ式が実行されることにより、シフトアップ用変速点車速ＳＰＤｕの補正が行われる。すなわち、前記ステップＳＤ２５において求められたシフト点補正係数Ｋｓが乗算されることにより補正される。

【００７２】続くステップＳＳ１０では、ステップＳＳ９にて補正されたシフトアップ用変速点車速ＳＰＤｕを実際の車速ＳＰＤが越えたか否か、換言すればシフトアップの変速判断が行われたか否かが判断される。このステップＳＳ１０の判断が否定された場合には、シフトダウン制御のステップＳＳ１７以下が実行されるが、肯定

された場合には、続くステップＳＳ１１において第４速ギヤ段へのシフトアップであるか否かが判断される。このステップＳＳ１１の判断が肯定された場合には、ステップＳＳ１２においてフラグＸ３ＨＯＬＤがクリアされ、ステップＳＳ１３においてフラグＸ４３ＤＷＮがクリアされた後、ステップＳＳ１４においてシフトアップが実行され、それまでのギヤ段を１段だけシフトアップさせる変速出力が自動変速機６８へ供給される。また、上記ステップＳＳ１１の判断が否定された場合にはステップＳＳ１４が直接実行される。

【００７３】前記ステップＳＳ２の判断が肯定された場合には、第４速ギヤ段が成立している状態であるから、ステップＳＳ１５において第３速への自動ダウンを示すフラグＸ３ＲＤＤの内容が「０」であるか否かが判断される。このステップＳＳ１５の判断が否定された場合には第３速への自動ダウンであるので、直ちにステップＳＳ２３において第３速へシフトダウンが実行される。しかし、上記ステップＳＳ１５の判断が肯定された場合には、第３速への自動ダウンではないので、ステップＳＳ１６において第４速へのシフトアップ禁止仮解除フラグＸ３ＲＤＨの内容が「０」であるか否かが判断される。このステップＳＳ１６の判断が否定された場合は、フラグＸ３ＲＤＤの内容が「０」であってもシフトアップ禁止仮解除状態であるので、ステップＳＳ２３において第３速へのシフトダウンが実行される。

【００７４】次いでステップＳＳ１７では、ステップＳ１で読み込まれた現在の変速段Ｇが「１ｓｔ」であるか否かが判断される。このステップＳＳ１７の判断が肯定された場合にはダウンシフトの可能性がないため直ちに本ルーチンが終了させられ、ステップＳ１以下の実行が繰り返される。しかし、ステップＳＳ１７の判断が否定された場合にはステップＳＳ１８において、図２１に示されているように車速ＳＰＤおよびスロットル弁開度ＴＡを変速パラメータとして予め記憶された３種類のダウンシフト側変速線、すなわち「２ｎｄ→１ｓｔ」，「３ｒｄ→２ｎｄ」，および「４ｔｈ→３ｒｄ」に関する変速線の中から、現在のギヤ段からダウンシフトする場合の変速線が選択される。例えば現在のギヤ段が「３ｒｄ」の場合には、（ｂ）の「３ｒｄ→２ｎｄ」に関する変速線が選択される。

【００７５】また、ステップＳＳ１８では、上記選択された変速線と現在のスロットル弁開度ＴＡとからシフトダウン変速点車速ＳＰＤｄが求められ、続くステップＳＳ１９では、ＳＰＤｄ←ＳＰＤｄ×Ｋｓ式が実行されることにより、シフトダウン用変速点車速ＳＰＤｄの補正が行われる。すなわち、前記ステップＳＤ２５において求められたシフト点補正係数Ｋｓが乗算されることにより補正される。

【００７６】次いで、ステップＳＳ２０では、その補正後の変速点車速ＳＰＤｄと現在の車速ＳＰＤとが比較され、ダウンシフトの変速判断が行われる。すなわち、ＳＰＤ≦ＳＰＤｄとなればダウンシフトの変速判断が行われ、パワーオンによる４→３シフトダウンの発生を判定するためのステップＳＳ２１およびＳＳ２２を経てから、ステップＳＳ２３において自動変速機６８の変速段を１段だけシフトダウンさせる変速出力が自動変速機６８へ供給されるが、ＳＰＤｄ＜ＳＰＤの場合には本ルーチンが終了させられて、次の制御サイクルのステップＳ１以下が繰り返される。なお、上記ステップＳＳ２１ではパワーオンにより第３速ギヤ段へのシフトダウンが発生したか否かが判断され、このステップＳＳ２１の判断が肯定されると、ステップＳＳ２２においてパワーオン４→３シフトダウンフラグＸ４３ＤＷＮの内容が「１」にセットされる。

【００７７】ここで、上記シフト点補正係数Ｋｓは、１．０より大きい場合には、シフトアップ用変速点車速ＳＰＤｕやシフトダウン用変速点車速ＳＰＤｄは高車速側に移動してダウンシフトし易くなって駆動力が高められる一方、１．０より小さい場合には、シフトアップ用変速点車速ＳＰＤｕやシフトダウン用変速点車速ＳＰＤｄは低車速側に移動してアップシフトし易くなる。

【００７８】図２２は、上記制御を実行するトランスミッション用電子制御装置３４の制御機能の要部を説明する機能ブロック線図である。図に示すように、本実施例によれば、前記ステップＳＤ４に対応する基準負荷曲線設定手段８０により、車両の定常走行におけるスロットル弁開度ＴＡおよび車速ＳＰＤにより表される基準走行負荷曲線が設定される。前記ステップＳＤ５乃至ＳＤ２０に対応する走行負荷算出手段８２により、スロットル弁開度ＴＡおよび車速ＳＰＤに基づいて表される走行負荷係数ＫＦＵＫＡＳＭの大きさが、上記基準走行負荷曲線を基準として逐次算出される。そして、前記図１８に示すステップＳＳ１乃至ＳＳ２３に対応する駆動力制御手段８４により、上記逐次算出された走行負荷係数ＫＦＵＫＡＳＭに基づいて自動変速機６８のギヤ段すなわち変速比が制御されて車両の駆動力が調節される。

【００７９】したがって、車両の走行領域全域にわたって、実際の走行負荷の大きさに基づいて前記車両の駆動力が調節されるので、路面傾度などによる走行負荷の変化に拘わらず車両の走行領域全域において良好な運転性が得られる。

【００８０】また、本実施例によれば、前記走行負荷算出手段８２は、図３の基準走行負荷曲線からスロットル弁開度ＴＡに基づいて基準走行負荷車速ａを決定するステップＳＤ５と、実際の車速ｃ或いはｂとその基準走行負荷車速ａとに基づいて、走行負荷係数ＫＦＵＫＡ（＝ａ／ｃ或いは２－ｂ／ａ）を逐次算出するステップＳＤ７およびＳＤ９とを含み、その走行負荷係数ＫＦＵＫＡにより実際の走行負荷を表すようにしている。上記基準走行負荷および実際の走行負荷を表すための量としてス

ロットル弁開度を用いて基準走行負荷開度を決定し、実際の開度とその基準走行負荷開度とから走行負荷係数を算出することもできるけれども、このような場合には、スロットル弁開度は車速よりも変動が多く且つ変化が速やかであるため、検出される走行負荷開度が加減速操作の影響を受けて不安定となるのに対し、本実施例のように、実際の車速ｃ或いはｂとその基準走行負荷車速ａとに基づいて走行負荷係数ＫＦＵＫＡを算出する場合には、上記加減速操作の影響が除去される利点がある。上記ステップＳＤ５は基準走行負荷車速決定手段に対応し、上記ステップＳＤ７およびＳＤ９は走行負荷係数算出手段に対応している。

【００８１】また、本実施例では、実際の車速が基準走行負荷車速ａよりも低い値ｂである場合には高走行負荷領域用のＫＦＵＫＡ＝２－（ｂ／ａ）式から走行負荷係数ＫＦＵＫＡを算出するステップＳＤ９を選択し、実際の車速が基準走行負荷車速ａよりも高い値ｃである場合には低走行負荷領域用のＫＦＵＫＡ＝ａ／ｃ式から走行負荷係数ＫＦＵＫＡを算出するステップＳＤ７を選択するステップＳＤ６が備えられているので、一定のスロットル弁開度では、走行負荷係数ＫＦＵＫＡがその値の少なくとも「１」付近では車速ＳＰＤの変化に伴って直線的に変化させられるので、なまし処理によるなましの程度が略均等とされる利点がある。上記ステップＳＤ６は、走行負荷係数ＫＦＵＫＡを算出するための演算式を切り換える演算式変更手段として機能するものであり、前記走行負荷係数算出手段に含まれるものである。

【００８２】また、本実施例では、前記逐次算出された走行負荷係数ＫＦＵＫＡになまし処理を施してなまし処理後走行負荷係数ＫＦＵＫＡＳＭを算出するステップＳＤ２０が設けられ、そのなまし処理後走行負荷係数ＫＦＵＫＡＳＭが実際の走行負荷として用いられるので、アクセルペダルが小刻みに操作されることに関連して変化するなまし処理前の走行負荷係数ＫＦＵＫＡを用いるのに比較して、変速制御が安定化する利点がある。上記ステップＳＤ２０は、逐次求められる走行負荷係数ＫＦＵＫＡをなまし処理により平滑化するなまし処理手段として機能するものであり、前記走行負荷係数算出手段に含まれるものである。

【００８３】また、本実施例では、上記ステップＳＤ２０において走行負荷係数ＫＦＵＫＡになまし処理を施すに先立って、図７に示すように、走行負荷、加速減速状態、スロットル弁がアイドル位置であるかなどの車両の走行条件に従ってなまし量を変更するステップＳＤ１９が設けられているので、一層好適ななまし効果が得られる利点がある。このステップＳＤ１９は、ステップＳＤ２０と共になまし処理手段として機能している。

【００８４】また、本実施例では、なまし処理前の走行負荷係数ＫＦＵＫＡの反転時からの所定期間、すなわちなまし処理前の走行負荷係数ＫＦＵＫＡが１以上の状態と１未満の状態との一方から他方へ変化した時点から所定時間ＣＨＡＮＴＥＮ内は、ステップＳＤ１９およびＳＤ２０をスキップすることによりなまし処理を一時的に停止させてなまし処理後走行負荷係数ＫＦＵＫＡＳＭを実質的に変更しないようにするステップＳＤ１７が設けられている。なまし量の決定に用いられている加減速フラグＸＫＡＳＯＫＵの内容は車速から決定されることから、他の条件に比較して遅れがあり、そのまま用いられると負荷係数ＫＦＵＫＡＳＭにずれが生じるが、ステップＳＤ１７により上記所定期間内はなまし処理後走行負荷係数ＫＦＵＫＡＳＭが実質的に変更されないので、そのずれが解消される。上記ステップＳＤ１７は、なまし処理一時停止手段として機能し、前記走行負荷係数算出手段に含まれる。

【００８５】また、本実施例では、車両の発進時からの所定期間ＣＨＡＳＳＩＮ内は、ステップＳＤ１９およびＳＤ２０をスキップすることによりなまし処理を一時的に中止させてなまし処理後走行負荷係数ＫＦＵＫＡＳＭを実質的に変更しないようにするステップＳＤ１８が設けられている。車両の発進期間は加速の影響が大きく走行負荷係数ＫＦＵＫＡＳＭが高負荷側にずれる傾向があるが、ステップＳＤ１８により上記所定期間内はなまし処理後走行負荷係数ＫＦＵＫＡＳＭが実質的に変更されないので、その高負荷側へのずれが解消される。上記ステップＳＤ１８も、なまし処理一時停止手段として機能し、前記走行負荷係数算出手段に含まれる。

【００８６】また、前記本実施例では、前記駆動力制御手段８４は、実際の走行負荷、すなわちなまし処理後走行負荷係数ＫＦＵＫＡＳＭに基づいて変速線を補正するステップＳＳ９が設けられており、走行負荷に応じた変速制御が得られるので、車両の走行領域全体にわたって燃費と動力性能とが両立できる。このステップＳＳ９は、変速線を補正するための補正手段として機能している。

【００８７】また、本実施例では、上記変速線の補正に用いられるシフト点補正係数Ｋｓを図１２に示す関係からなまし処理後走行負荷係数ＫＦＵＫＡＳＭに基づいて算出するステップＳＤ２５が設けられていることから、なまし処理後走行負荷係数ＫＦＵＫＡＳＭの走行負荷（路面勾配）に対する特性が補正されるので、リニヤ感が十分に得られて運転性が改善される。

【００８８】また、本実施例では、逐次算出されるなまし処理後の走行負荷ＫＦＵＫＡＳＭが１．２０程度の第１の判断基準値を超えたとき、前記自動変速機のシフトアップを禁止するステップＳＥ７乃至ＳＥ９が設けられている。このため、高負荷走行領域において、ダウンシフトにより駆動力が高められるのでアクセルペダルを戻し操作して駆動力を抑えようとするが、そうするとシフトアップが発生して駆動力が不足するため再びアクセルペダルを踏み込み操作するのでダウンシフトが発生する

というビジーシフトが改善される利点がある。上記ステップＳＥ７乃至ＳＥ９は、シフトアップ禁止手段として機能している。

【００８９】また、本実施例では、パワーオンダウンシフト、すなわちアクセルペダルの踏み込み操作によりスロットル弁開度が開かれたことにより最高速の第４速ギヤ段からそれより１段下の第３速ギヤ段へのシフトダウンが発生した直後において、前記ステップＳＥ７乃至ＳＥ９を実行させるステップＳＥ１が設けられているので、ビジーシフトが好適に解消される。

【００９０】また、本実施例では、なまし後の走行負荷ＫＦＵＫＡＳＭが第２の判断基準値Ｋ３ＨＯＬＤ未満となったとき、自動変速機６８のシフトアップの禁止を解除するステップＳＥ１１，ＳＥ４，ＳＥ５が設けられており、その第２の判断基準値Ｋ３ＨＯＬＤは前記第１の判断基準値よりも小さい値、すなわちステップＳＥ３において第１の判断基準値を越えたときの走行負荷ＫＦＵＫＡＳＭから所定値βを差し引いた値に設定されるので、その第２の判断基準値Ｋ３ＨＯＬＤと第１の判断基準値との間のヒステリシスにより、シフトアップ禁止およびその解除が連続的に行われることが解消される。上記ステップＳＥ１１，ＳＥ４，ＳＥ５はシフトアップ禁止解除手段として機能している。

【００９１】また、本実施例では、前記第４速ギヤ段へのシフトアップの禁止制御中において、車速変化による減速から加速への反転が所定回行われる毎に第４速ギヤ段へのシフトアップを実行すべきか否かを判断し、実行すべきであると判断される場合には該シフトアップの禁止を仮解除するステップＳＥ１２乃至ＳＥ１９が設けられている。シフトアップの禁止の解除は高駆動力側から低駆動力側への解除であり、加速時の要求駆動力で判断する必要がある。減速から加速への反転を応答性の遅い車速変化により確実に判定して仮解除を行い、この加速への反転毎に、ステップＳＥ３により高駆動力を維持すべきか否かを判断している。このため、要求駆動力に応じてシフトアップさせることが可能となる。上記ステップＳＥ１２乃至ＳＥ１９も、シフトアップ禁止解除手段として機能している。

【００９２】また、本実施例では、前記第２の判断基準値Ｋ３ＨＯＬＤを、シフトアップの禁止が開始されたときの走行負荷ＫＦＵＫＡＳＭ、またはシフトアップの禁止中に所定回の減速から加速への反転が検出されたときの走行負荷ＫＦＵＫＡＳＭのうち、最新のものよりも所定値βだけ小さい値（ＫＦＵＫＡＳＭ－β）に設定するステップＳＥ１０が設けられている。走行負荷ＫＦＵＫＡＳＭがたとえば１．１５程度の判断基準値以下となったときにシフトアップ禁止を解除する図２３の上段に示す場合には、走行負荷ＫＦＵＫＡＳＭのなまし処理による遅れなどに起因して第４速ギヤ段へのシフトアップの禁止が解除される時点が遅れる問題があったが、上記本実施例によれば、図２３の下段に示すように、シフトアップの禁止の解除の遅れが好適に短縮される利点がある。上記ステップＳＥ１０は、第２の判断基準値設定手段として機能している。

【００９３】また、本実施例では、車両の惰行走行状態、すなわちなまし後の走行負荷ＫＦＵＫＡＳＭが０．９５程度の第１の判断基準値未満且つスロットル弁開度ＴＡが零程度の所定値未満の状態で、車両の加速度αが所定の判断基準値α_{4-2D}、α_{4-3D}、或いはα_{3-2D}以上であるとき、第４速ギヤ段から第２速ギヤ段へのシフトダウン、第４速ギヤ段から第３速ギヤ段へのシフトダウン、或いは第３速ギヤ段から第２速ギヤ段へのシフトダウンを判断するステップＳＡ１乃至ＳＡ４、ＳＡ７乃至ＳＡ１６が設けられている。このため、車両の降坂路走行においてエンジンブレーキを適切に作用させることができる。上記ステップＳＡ１乃至ＳＡ４、ＳＡ７乃至ＳＡ１６は、シフトダウン手段として機能しており、前記駆動力制御手段に含まれる。

【００９４】また、本実施例では、車両の惰行走行状態では、ステップＳＡ８、ＳＡ１０、ＳＡ１４において車速ＳＰＤに応じて判断基準値α_{4-2D}、α_{4-3D}、α_{3-2D}が求められるので、適切なエンジンブレーキ作用が得られる。ステップＳＡ８、ＳＡ１０、ＳＡ１４は、判断基準値決定手段として機能し、上記シフトダウン手段に含まれる。

【００９５】また、本実施例では、なまし処理前走行負荷係数ＫＦＵＫＡが１．０５程度の第２の判断基準値以上となると、自動シフトダウン制御を解除するステップＳＡ２が設けられている。このため、アクセルペダルの操作に応答して直ちに自動シフトダウンが解除される利点がある。上記ステップＳＡ２は、シフトダウン解除手段として機能している。

【００９６】以上、本発明の一実施例を図面に基づいて詳細に説明したが、本発明は他の態様で実施することもできる。

【００９７】例えば、前記実施例の変速線を構成する変数には、エンジン負荷を表す量としてスロットル弁開度ＴＡが用いられていたが、それに替えて、アクセルペダル踏込量、燃料噴射量などが用いられても差し支えない。

【００９８】また、前述の実施例では、変速点車速ＳＰＤｕ、ＳＰＤｄにシフト点補正係数Ｋｓが乗算されることにより、走行負荷に基づく補正が施されていたが、シフト点補正係数Ｋｓが加算されることにより補正が行われてもよいし、吸入空気量と目標吸入空気量との割合などの他の運転状態を考慮した第３，第４，・・の補正値に基づいて補正が加えられてもよい。

【００９９】また、前述の図２の走行負荷検出ルーチンのステップＳＤ１７乃至ＳＤ２０において、走行負荷係数ＫＦＵＫＡの反転からの所定期間および車両の発進期

間では、なまし処理が一時停止されることによりなまし処理後の走行負荷係数ＫＦＵＫＡＳＭの更新が中止されていたが、それに替えて、非常に大きななまし量を用いてなまし処理が行われてもよいのである。

【０１００】また、前述の図２のステップＳＤ１８では、なまし処理後の走行負荷係数ＫＦＵＫＡＳＭの更新を中止させるために、予め設定された設定値が零に減算されるまでの期間を計時する発進状態判定タイマＣＨＡＳＳＩＮが用いられていたが、それに替えて、１０km/h程度の車速で「０」にクリアされ且つ４０km/h程度の車速で「１」にセットされるフラグＸＨＡＳＳＩＮの内容が「０」であり且つ車速ＳＰＤが１０km/h程度の所定値以上で６秒程度の所定時間の未経過であるときには、なまし処理が中止されるようにしてもよい。

【０１０１】また、前述の図１６のステップＳＥ１３乃至ＳＥ１９では、２回の減速から加速への反転が判定されたことを以て第４速ギヤ段へのシフトアップ禁止を仮解除する判定が行われていたが、３回以上であっても差し支えない。

【０１０２】また、前述の図１３のステップＳＡ３では、アイドルスイッチのオフ状態が判定されているが、スロットル弁開度ＴＡが所定値以下であるか否かが判定されてもよい。

【０１０３】また、図１６のステップＳＥ３において１．２なる判断基準値が用いられ、図１３のステップＳＡ１では０．９５なる判断基準値が用いられ、ステップＳＡ２では１．０５なる判断基準値が用いられているが、必ずしもその値でなくてもよい。

【０１０４】また、前述の実施例では、走行負荷係数ＫＦＵＫＡＳＭに基づき、自動変速機６８のギヤ段を切り換える変速線、具体的には変速点車速ＳＰＤu、ＳＰＤdが、走行負荷係数ＫＦＵＫＡＳＭが大きくなるほど、シフトダウンが容易となる方向に制御されて車両の駆動力が調節されていたが、たとえばスロットル弁２０がスロットルアクチュエータにより駆動される形式の車両では、駆動力制御手段８４が、走行負荷係数ＫＦＵＫＡＳＭが大きくなるほど弁開度を増量補正してもよいのである。

【０１０５】また、前記実施例ではエンジン制御用電子制御装置３２およびトランスミッション制御用電子制御装置３４が別体に構成されていたが、単一の電子制御装置にてエンジン１０および自動変速機６８を制御することもできる。

【０１０６】また、前述の実施例では、前進４速の有段式の自動変速機が用いられていたが、たとえば有効径が可変な一対の可変プーリに伝動ベルトが巻き掛けられたベルト式無段変速機に代表される、変速比が連続的に変化させられる無段変速機であっても、本発明が適用され得る。

【０１０７】その他一々例示はしないが、本発明は当業者の知識に基づいて種々の変更，改良を加えた態様で実施することができる。

【図面の簡単な説明】

【図１】本発明の一実施例である駆動力制御装置を備えた自動変速機およびエンジン等の構成を説明する図である。

【図２】図１のトランスミッション用電子制御装置による走行負荷検出作動を説明するフローチャートである。

【図３】図２において、走行負荷ＫＦＵＫＡを算出するために、ステップＳＤ４において設定される基準負荷曲線を示す図である。

【図４】図２において、走行負荷をＫＦＵＫＡを算出するために、低走行負荷領域において用いられる式と高走行負荷領域において用いられる式との関係を示す図である。

【図５】図１のトランスミッション用電子制御装置による発進、加減速状態判定作動を説明するフローチャートである。

【図６】図５のステップＳＨ１９において第３速自動シフトダウン解除ディレイ時間ＫＯＦＦを算出するために用いられる関係を示す図である。

【図７】図２のステップＳＤ１９において負荷係数ＫＦＵＫＡに基づいてなまし量を決定するための関係を示す図である。

【図８】図２のステップＳＤ２０のなまし処理によって得られるなまし処理後の負荷係数ＫＦＵＫＡＳＭをなまし処理前の負荷係数ＫＦＵＫＡと対比して示す図である。

【図９】図２のステップＳＤ２０のなまし処理において、なまし処理前の負荷係数ＫＦＵＫＡが１を境にして反転してから所定のディレー区間で前記なまし量によるなまし処理を中止する効果を説明する図である。

【図１０】ディレー区間で前記なまし量によるなまし処理を中止しない場合を示す図９に相当する図である。

【図１１】図２の走行負荷検出ルーチンが実行された結果得られる走行負荷ＫＦＵＫＡＳＭの路面勾配に対する変化特性を説明する図である。

【図１２】図２のステップＳＤ２５において、シフト点補正係数Ｋｓをなまし処理後の走行負荷係数ＫＦＵＫＡＳＭから求める際に用いられる関係を示す図である。

【図１３】図１のトランスミッション用電子制御装置による、適切なエンジンブレーキを作用させるための自動ダウン制御の作動を説明するフローチャートである。

【図１４】図１３のステップＳＡ８、１０、１４において判断基準加速度α_{4-20}、α_{4-30}、α_{3-20}を求めるために用いられる関係を示す図である。

【図１５】図１３のステップＳＡ１７において判断基準加速度α_{u}を求めるために用いられる関係を示す図である。

【図１６】図１のトランスミッション用電子制御装置に

よる、ビジーシフトを防止するための第４速禁止制御の作動を説明するフローチャートである。

【図１７】図１６の第４速禁止制御の結果得られる作動を説明するタイムチャートである。

【図１８】図１のトランスミッション用電子制御装置による、自動変速機のギヤ段を制御するための変速制御の作動を説明するフローチャートである。

【図１９】図１８の変速制御において用いられるシフトアップ用変速線を示す図であって、(a) は第１速ギヤ段から第２速ギヤ段への変速判断に用いられる変速線、(b)は第２速ギヤ段から第３速ギヤ段への変速判断に用いられる変速線、(c) は第３速ギヤ段から第４速ギヤ段への変速判断に用いられる変速線をそれぞれ示している。

【図２０】図１８のステップＳＳ８において第４速禁止解除のシフトアップ用変速点を求める際に用いられる変速線を示す図である。

【図２１】図１８の変速制御において用いられるシフトダウン用変速線を示す図であって、(a) は第２速ギヤ段から第１速ギヤ段への変速判断に用いられる変速線、(b)は第３速ギヤ段から第２速ギヤ段への変速判断に用いられる変速線、(c) は第４速ギヤ段から第３速ギヤ段への変速判断に用いられる変速線をそれぞれ示している。

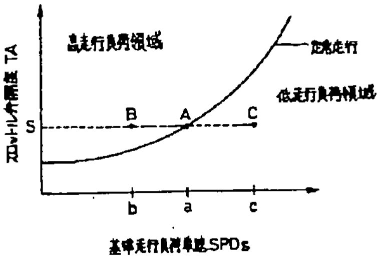
【図２２】図１のトランスミッション用電子制御装置による車両の駆動力制御の作動の要部を説明する機能ブロック線図である。

【図２３】図１６の第４速禁止制御において、第４速禁止解除作動を説明するタイムチャートである。

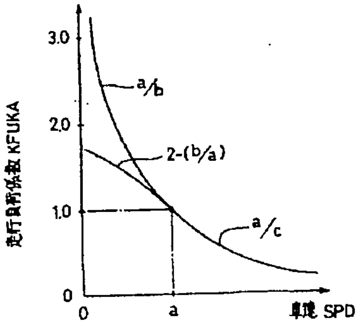
【符号の説明】

６８：自動変速機
８０：基準負荷曲線設定手段
８２：走行負荷算出手段
８４：駆動力制御手段

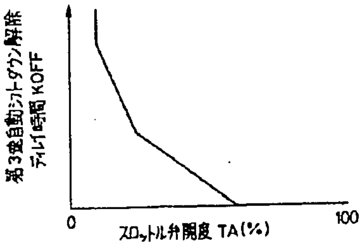
【図３】



【図４】



【図６】

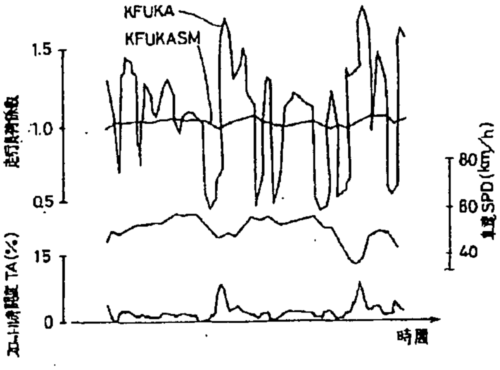


【図７】

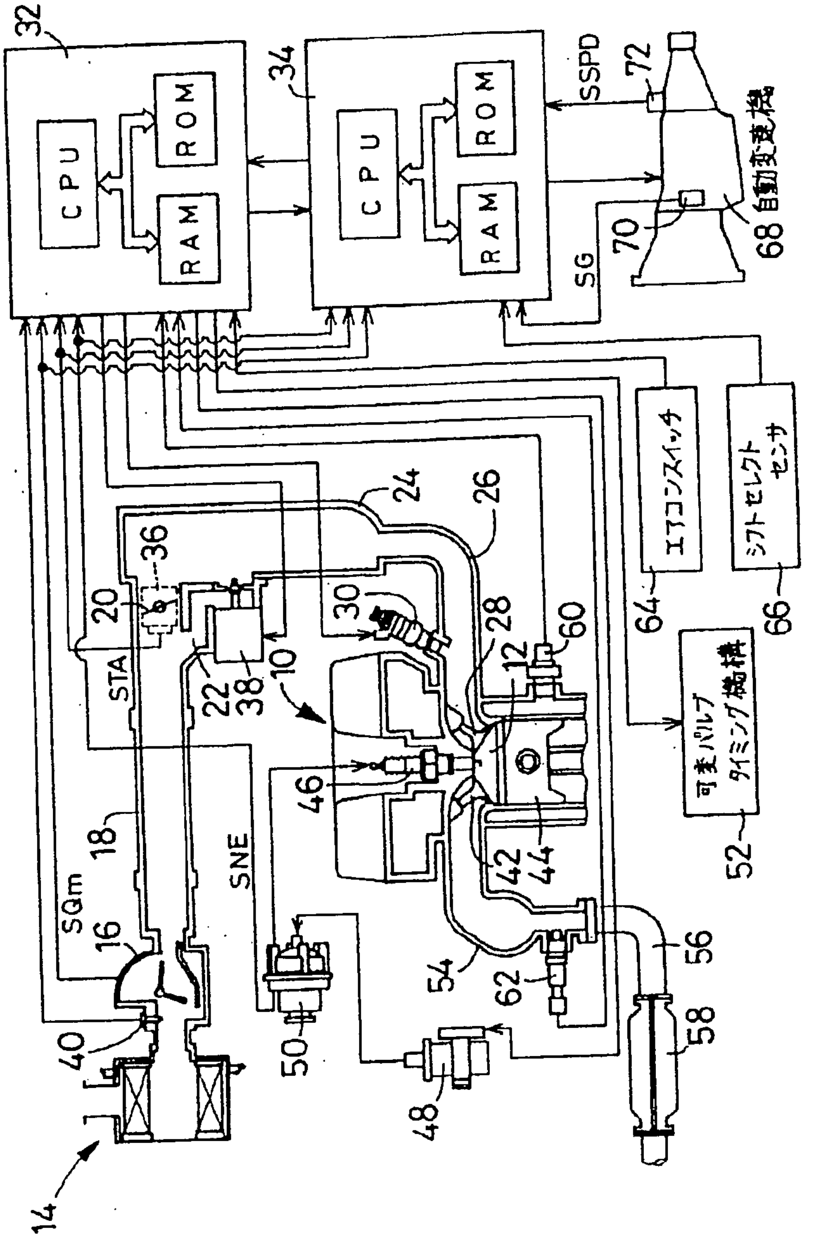
XTOHAN	XCOAST	YIDL	XKASOKU	走行状態	なまし量
*	0	1	*	停止状態	1/128
	1	*	0	惰行走行	1/64
1	0	0	*	＋負荷走行	1/16
	1	*	1	－負荷反転	1/2
0	0	0	*	＋負荷反転	1/2
	1	*	1	－負荷走行	1/16

XTOHAN　：なまし処理後の負荷係数状態（０＝１．０未満　１＝１．０以上）
XCOAST　：なまし処理前の負荷係数状態（１＝１．０未満　０＝１．０以上）
YIDL　　：アイドルスイッチ　（０＝ＯＦＦ　１＝ＯＮ）
XKASOKU：加減速状態　（０＝減速状態　１＝加速状態）

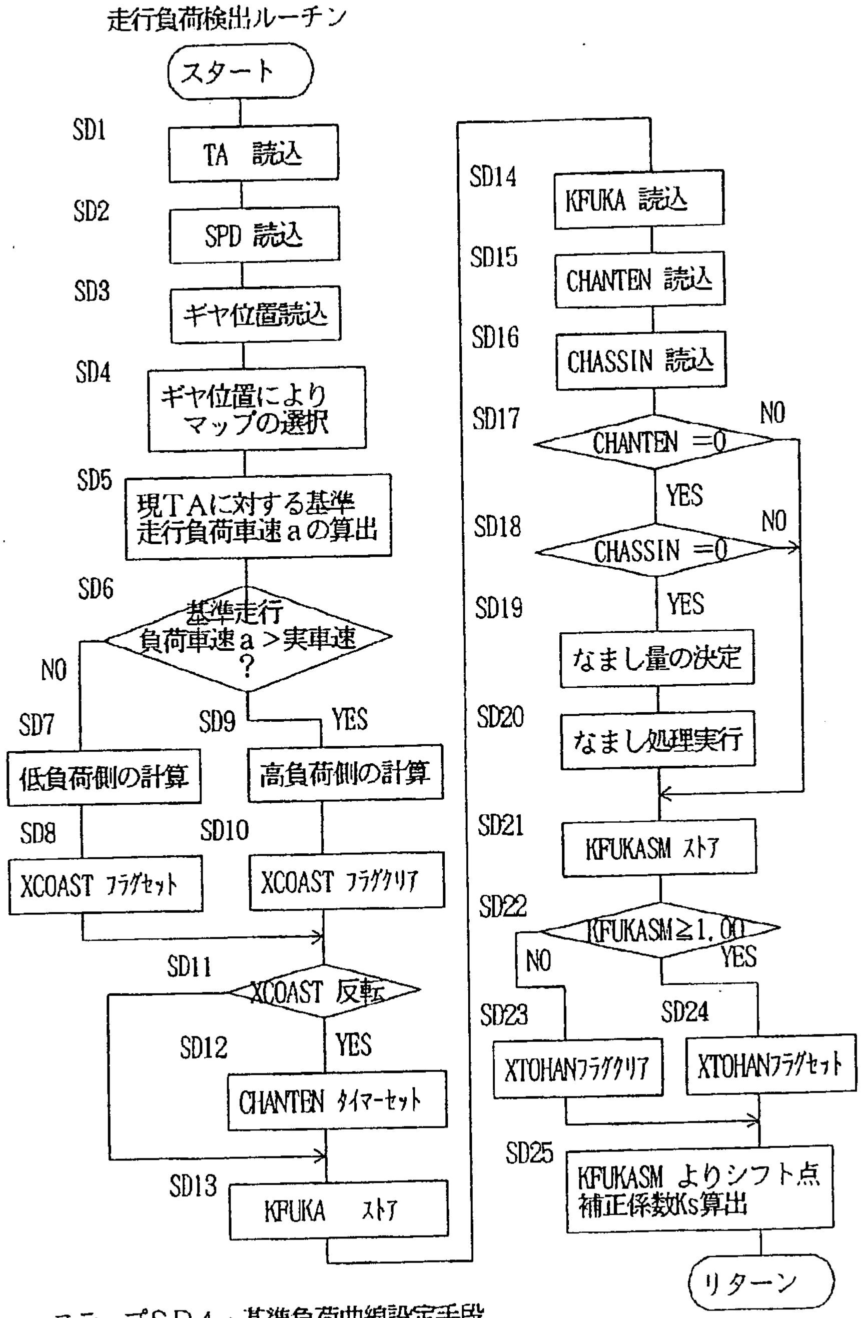
【図８】



【図1】


32
34
CPU
RAM
ROM
CPU
RAM
ROM
SSPD
72
自動変速機
68
70
SG
エアコンスイッチ
64
シフトセレクトセンサ
66
可変バルブタイミング機構
52
24
26
36
20
30
28
12
60
STA
22
38
10
SQm
18
16
SNE
46
42
44
54
56
62
58
40
50
48
14

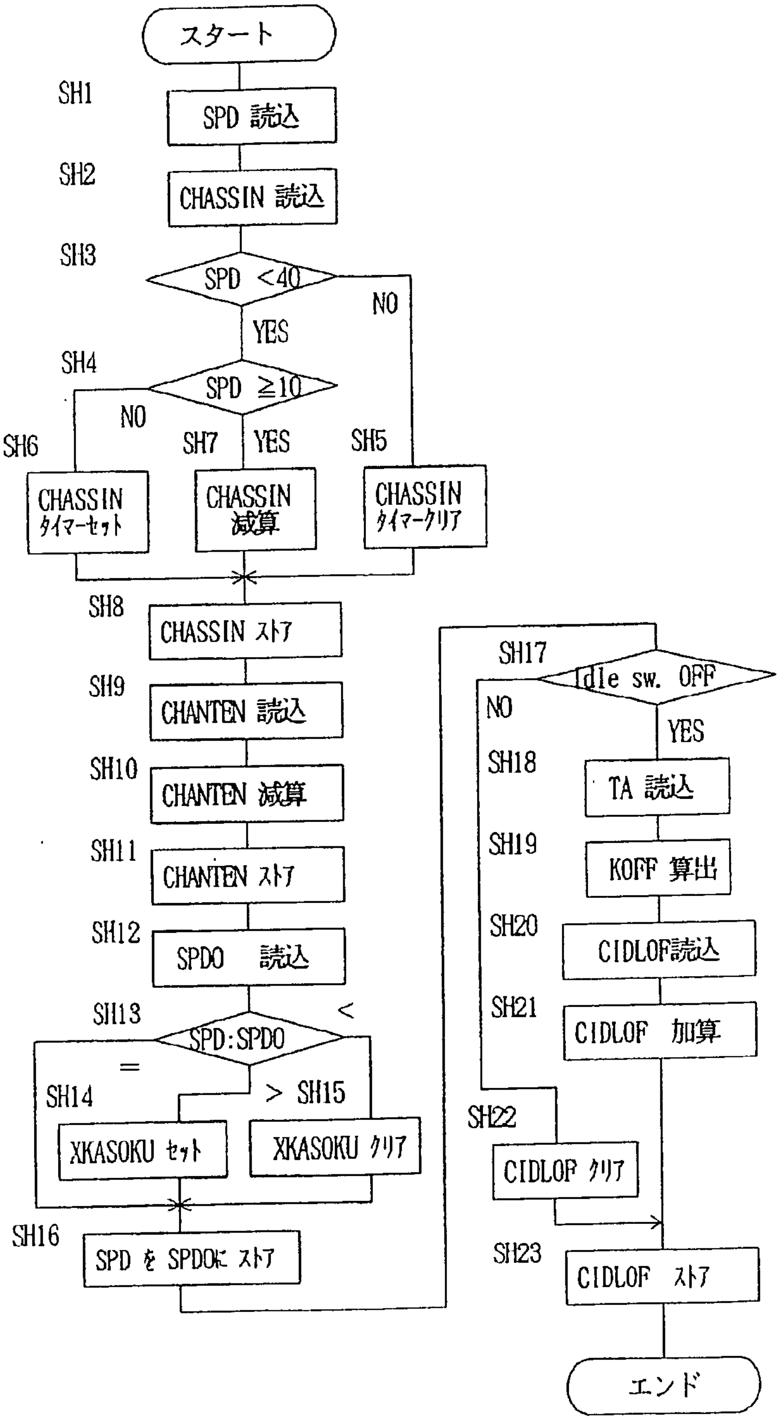
【図２】



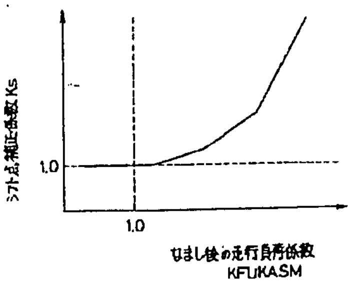
ステップＳＤ４：基準負荷曲線設定手段

ステップＳＤ５乃至ＳＤ２０：走行負荷算出手段

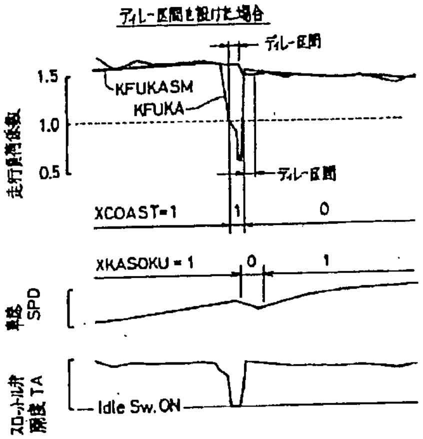
【図5】


スタート
SH1
SPD 読込
SH2
CHASSIN 読込
SH3
SPD <40
NO
YES
SH4
SPD ≧10
NO
YES
SH6
CHASSIN タイマーセット
SH7
CHASSIN 減算
SH5
CHASSIN タイマークリア
SH8
CHASSIN ストア
SH9
CHANTEN 読込
SH10
CHANTEN 減算
SH11
CHANTEN ストア
SH12
SPD0　読込
SH13
SPD:SPD0
<
=
>
SH14
SH15
XKASOKU セット
XKASOKU クリア
SH16
SPD を SPD0に ストア
SH17
Idle sw. OFF
NO
YES
SH18
TA 読込
SH19
KOFF 算出
SH20
CIDLOF読込
SH21
CIDLOF　加算
SH22
CIDLOF クリア
SH23
CIDLOF　ストア
エンド

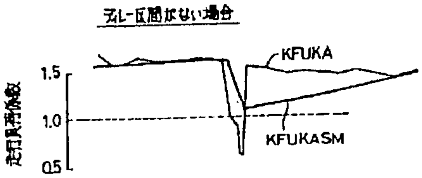
【図12】


シフト点補正係数 Ks
1.0
1.0
なまし後の走行負荷係数
KFUKASM

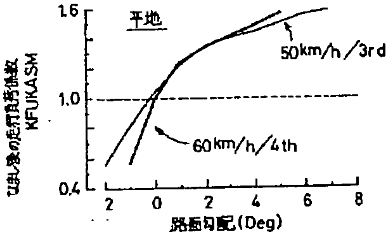
【図9】



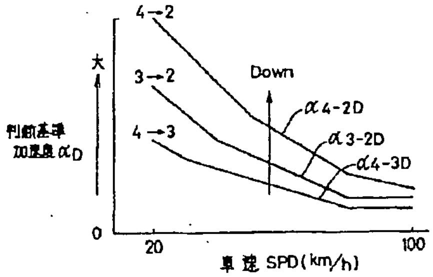
【図10】



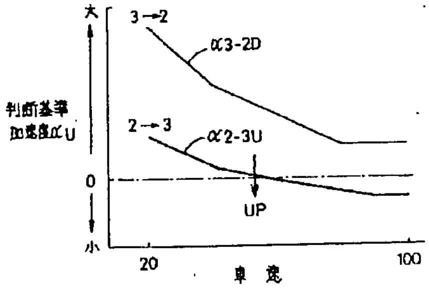
【図11】



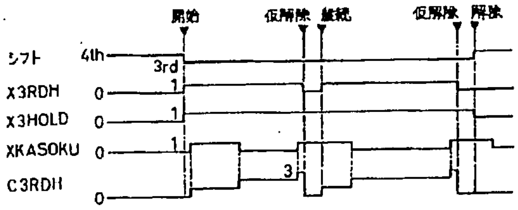
【図14】



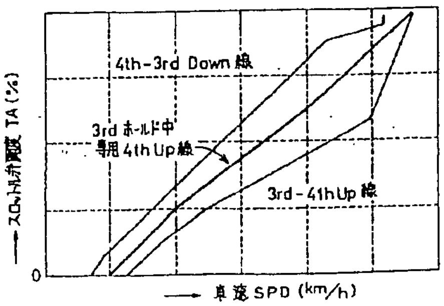
【図15】



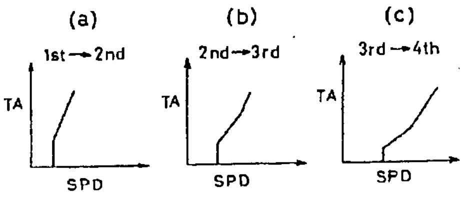
【図17】



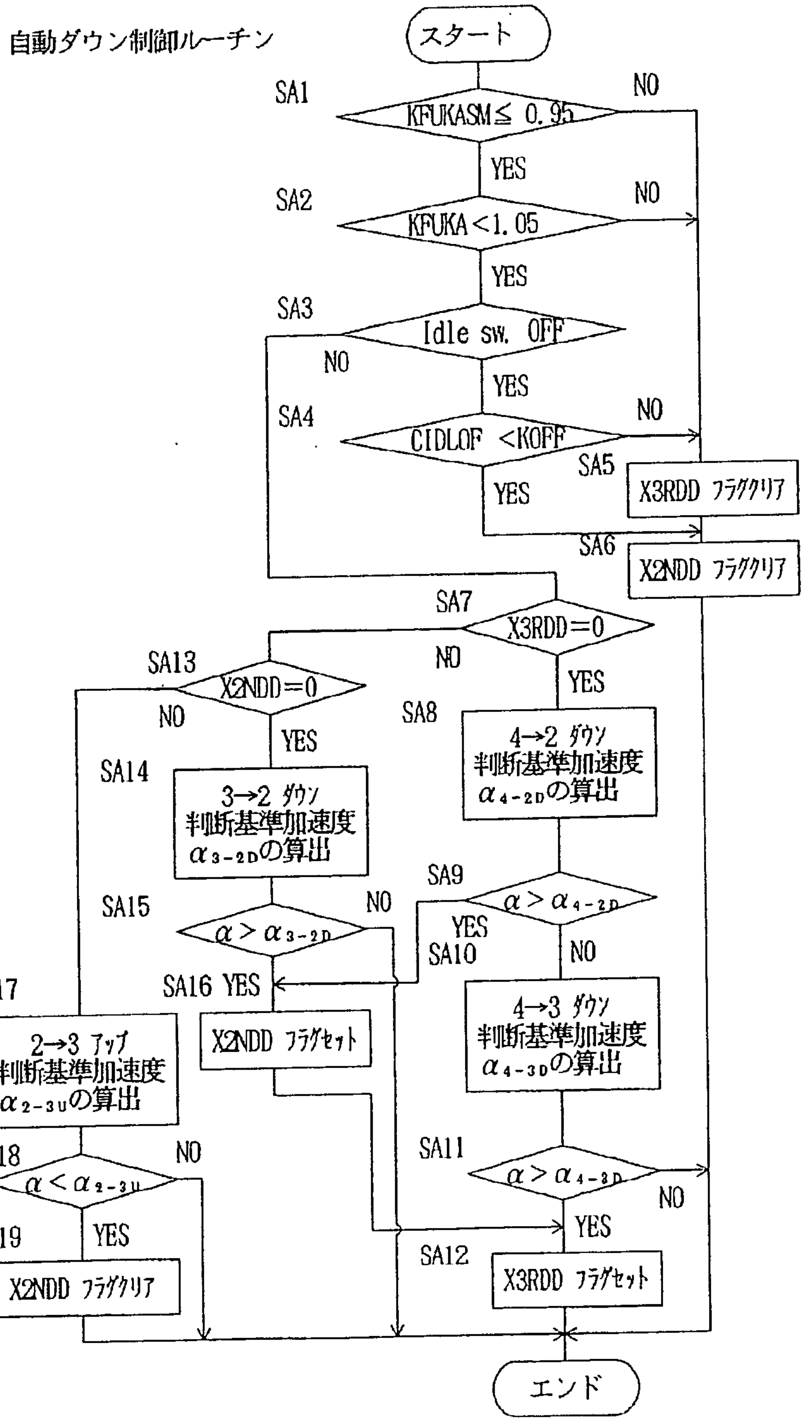
【図20】



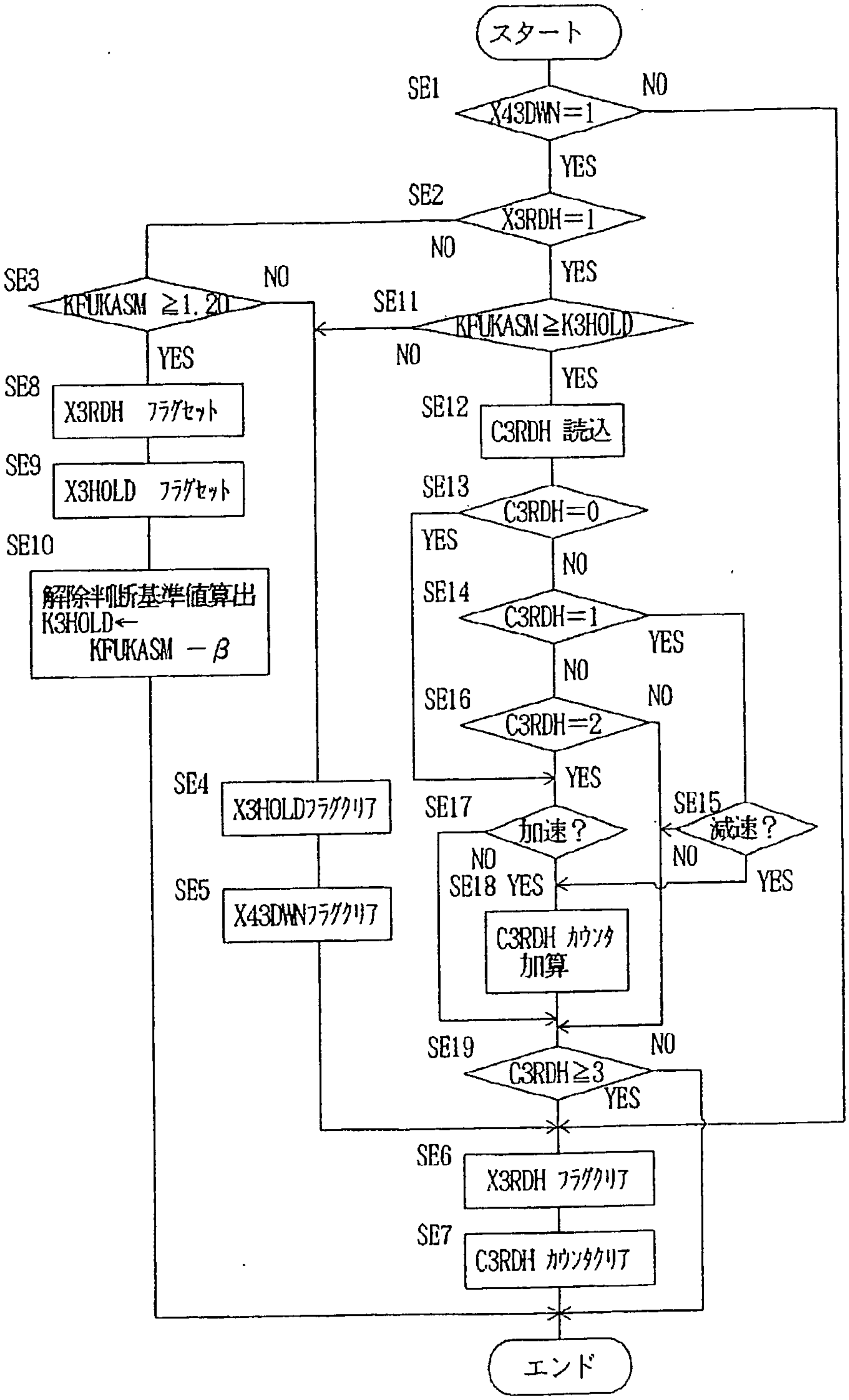
【図19】



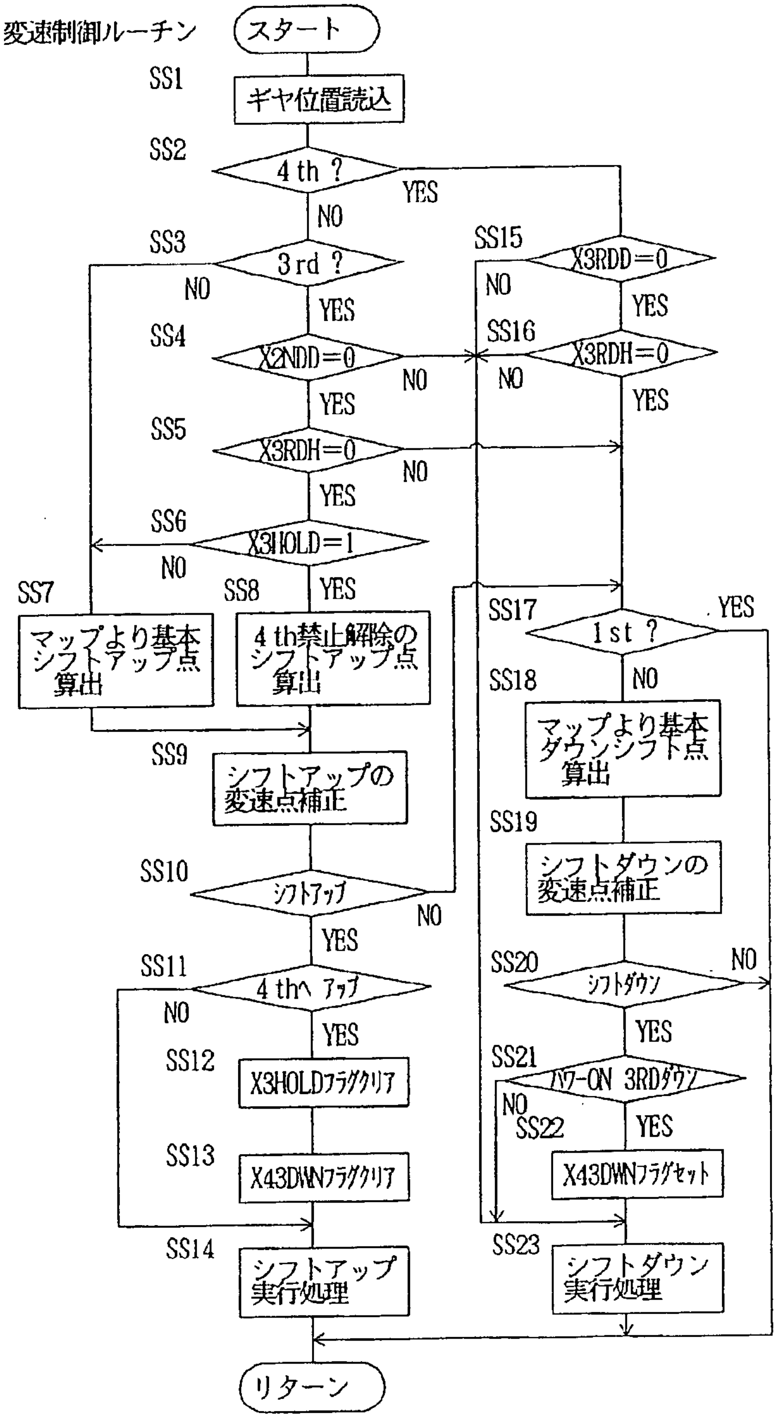
【図13】


自動ダウン制御ルーチン
スタート
SA1
KFUKASM≦0.95
NO
YES
SA2
KFUKA<1.05
NO
YES
SA3
Idle sw. OFF
NO
YES
SA4
CIDLOF <KOFF
NO
YES
SA5
X3RDD フラグクリア
SA6
X2NDD フラグクリア
SA7
X3RDD=0
NO
YES
SA8
4→2 ダウン 判断基準加速度 α4-2Dの算出
SA9
α>α4-2D
YES
NO
SA10
4→3 ダウン 判断基準加速度 α4-3Dの算出
SA11
α>α4-3D
NO
YES
SA12
X3RDD フラグセット
SA13
X2NDD=0
NO
YES
SA14
3→2 ダウン 判断基準加速度 α3-2Dの算出
SA15
α>α3-2D
NO
SA16 YES
X2NDD フラグセット
SA17
2→3 アップ 判断基準加速度 α2-3Uの算出
SA18
α<α2-3U
NO
SA19
YES
X2NDD フラグクリア
エンド

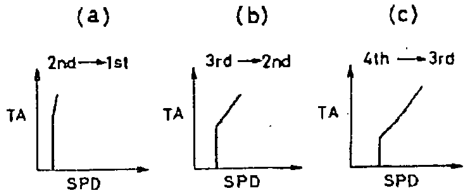
【図16】


スタート
SE1
X43DWN＝1
NO
YES
SE2
X3RDH＝1
NO
YES
SE3
KFUKASM ≧1.20
NO
YES
SE8
X3RDH フラグセット
SE9
X3HOLD フラグセット
SE10
解除判断基準値算出
K3HOLD←
KFUKASM －β
SE11
KFUKASM≧K3HOLD
NO
YES
SE12
C3RDH 読込
SE13
C3RDH＝0
YES
NO
SE14
C3RDH＝1
YES
NO
SE16
C3RDH＝2
NO
YES
SE4
X3HOLDフラグクリア
SE5
X43DWNフラグクリア
SE17
加速？
NO
SE15
減速？
NO
YES
SE18 YES
C3RDH カウンタ
加算
SE19
C3RDH≧3
NO
YES
SE6
X3RDH フラグクリア
SE7
C3RDH カウンタクリア
エンド

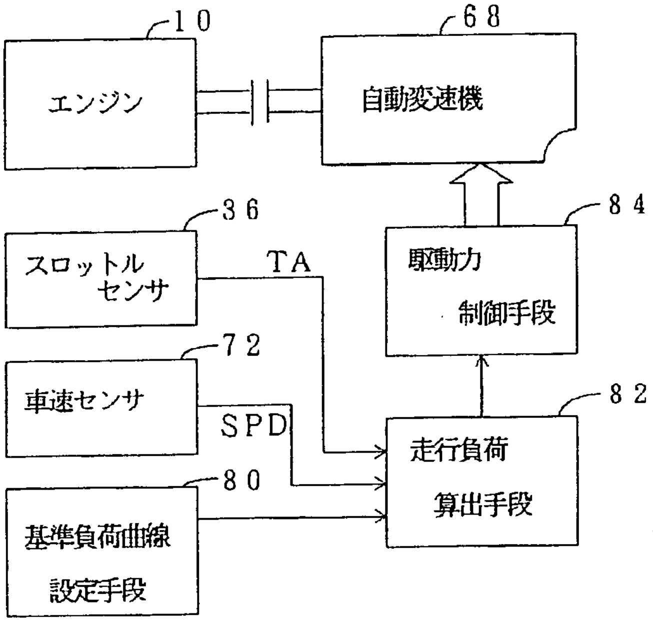
【図18】


変速制御ルーチン
スタート
SS1
ギヤ位置読込
SS2
4 th ?
YES
NO
SS3
3rd ?
NO
YES
SS4
X2NDD=0
NO
YES
SS5
X3RDH=0
NO
YES
SS6
X3HOLD=1
NO
YES
SS7
マップより基本シフトアップ点算出
SS8
4 th禁止解除のシフトアップ点算出
SS9
シフトアップの変速点補正
SS10
ｼﾌﾄｱｯﾌﾟ
NO
YES
SS11
4 thへ ｱｯﾌﾟ
NO
YES
SS12
X3HOLDﾌﾗｸﾞｸﾘｱ
SS13
X43DWNﾌﾗｸﾞｸﾘｱ
SS14
シフトアップ実行処理
SS15
X3RDD=0
NO
YES
SS16
X3RDH=0
NO
YES
SS17
1st ?
YES
NO
SS18
マップより基本ダウンシフト点算出
SS19
シフトダウンの変速点補正
SS20
ｼﾌﾄﾀﾞｳﾝ
NO
YES
SS21
ﾊﾟﾜｰON 3RDﾀﾞｳﾝ
NO
YES
SS22
X43DWNﾌﾗｸﾞｾｯﾄ
SS23
シフトダウン実行処理
リターン

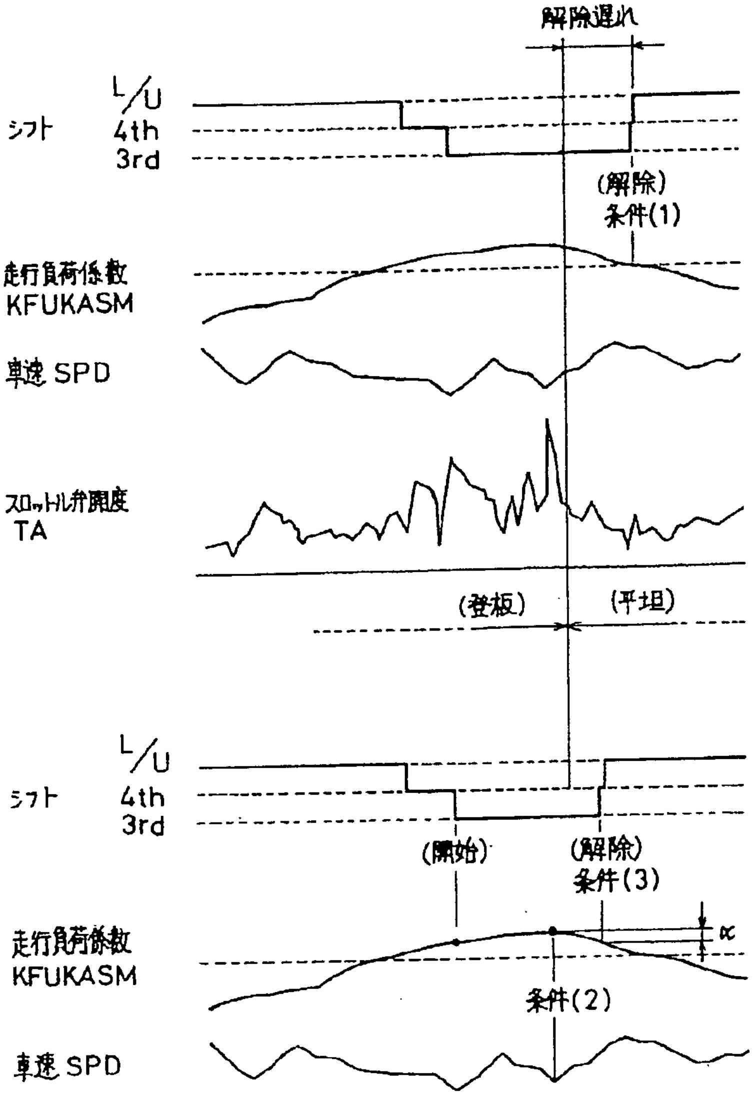
【図21】


(a)
2nd→1st
TA
SPD
(b)
3rd→2nd
TA
SPD
(c)
4th→3rd
TA
SPD

【図22】


10
エンジン
68
自動変速機
36
スロットルセンサ
TA
84
駆動力制御手段
72
車速センサ
SPD
82
走行負荷算出手段
80
基準負荷曲線設定手段

【図２３】


解除遅れ
L/U
4th
3rd
シフト
(解除)
条件(1)
走行負荷係数
KFUKASM
車速 SPD
スロットル弁開度
TA
(登板)
(平坦)
L/U
4th
3rd
シフト
(開始)
(解除)
条件(3)
走行負荷係数
KFUKASM
α
条件(2)
車速 SPD

[Translation]

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59:44				

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(54) Title of the Invention: DRIVING FORCE CONTROL APPARATUS FOR VEHICLE

(57) Abstract

(Purpose) To provide a driving force control apparatus for a vehicle which can obtain good drivability irrespective of the running load over the entire vehicle running range.

(Solution) When the reference running load curve for the steady running condition of a vehicle is set by a reference load curve setting means 80, a running load calculating means 82 successively calculates the running load factor KFUKASM referring to the set curve, wherein the factor KFUKASM has expressed on the basis of the throttle opening angle TA in the vehicle speed SPD. A driving force control means 84 controls the gear positions of an automatic transmission 68 based on the successively calculated factor KFUKASM and adjusts the driving force of the vehicle. Accordingly, the driving force is adjusted on the basis of the size of the actual running load over the entire running range of the car, so that good drivability can be obtained over the entire running range of the vehicle irrespective of varying running loads due to the road surface gradient and like factors.

(CLAIMS)

(Claim 1) A vehicle drive force control apparatus for controlling the drive force of a vehicle wherein the output of an engine is transmitted to a drive wheel, said drive force control apparatus comprising:

a standard running load curve setting means for setting the standard running load curve, which has expressed by the load of the engine in the engine speed when the vehicle is running in a normal state;

a running load calculating means, which successively calculates the running load expressed on the basis of the engine load and vehicle speed using said standard running load curve as a standard;

and a drive force controlling means, which adjusts the drive force of said vehicle based on the running load successively calculated by said running load calculating means.

(Claim 2) A vehicle drive force control apparatus according to claim 1, wherein said running load calculating means further comprises a standard running load vehicle speed determining means, which determines the standard running load vehicle speed on the basis of the engine load amount from said standard running load curve, and a running load coefficient calculating means, which successively calculates a running load coefficient corresponding to the running load on the basis of the vehicle speed and said standard running load vehicle speed, and said running load calculating means outputs said running load coefficient as the running load.

(Claim 3) A vehicle drive force control apparatus according to claim 1 or 2, wherein said vehicle is provided with an automatic transmission, whereby the transmission ratio is changed automatically, and a shifting control means, which controls the shifting ratio of said automatic transmission based on the engine load and vehicle speed, from a shift boundary line in which the shift ratio has been predetermined by said automatic transmission, and said drive force controlling means corrects said shift boundary line based on said running load.

(Claim 4) A vehicle drive force control apparatus according to claim 3, further comprising a upshift inhibiting means, which inhibits shifting up by said automatic transmission when said running load exceeds a first threshold value.

(Claim 5) A vehicle drive force control apparatus according to claim 4, further comprising a upshift inhibition releasing means, which releases the inhibition of shifting up by said automatic transmission when said running load is less than a second threshold value.

(Claim 6) A vehicle drive force control apparatus according to claim 5, wherein said upshift inhibition releasing means determines whether shifting up to the highest gear should be performed when reversal from deceleration to acceleration has occurred a specified number of times while shifting up by said automatic transmission is inhibited, and if determining that shifting up to the highest gear should be performed, releases the inhibition upon shifting up and performs shifting up to set highest gear.

(Claim 7) A vehicle drive force control apparatus according to claim 5 or 6, further comprising a second threshold value setting means, which sets said second threshold value used by said upshift inhibition releasing means that a value lower by a specified value than the newest value of either the running load when inhibition of shifting up was started or the running load when reversal from deceleration to acceleration was detected a specified number of times during upshift inhibition.

(Claim 8) A vehicle drive force control apparatus according to claim 3, wherein said drive force controlling means causes said automatic transmission to shift preferentially to a gear stage at which an engine break operates when the running load calculated by said running load calculating means is less than a specified value, the engine load is at or below a specified threshold value, and the acceleration is at or above a specified threshold value.

(DETAILED DESCRIPTION OF THE INVENTION)

(0001)

1. Industrial Field of Application

The present invention relates in general to an apparatus for controlling a drive force to drive a motor vehicle, and more particularly, to techniques for improving the running stability and drivability of the vehicle, irrespective of a variation in the running load of the vehicle, over the entire ranges of the engine load and the vehicle speed.

(0002)

(Prior Art)

For controlling a drive force to drive a motor vehicle, there is known a drive force control apparatus adapted to change the vehicle drive force by adjusting the opening angle of a throttle valve of a vehicle engine or by controlling the speed ratio of an automatic transmission of the vehicle. For example, a motor vehicle equipped with an automatic transmission which is automatically shifted to change the speed ratio is provided with a shift control apparatus adapted to change the speed ratio of the transmission on the basis of the actually detected engine load and vehicle speed and according to a predetermined shift pattern. The upshift and downshift boundary lines used by such transmission shift control apparatus are generally formulated to achieve not only high running stability and drivability of the vehicle but also high fuel economy of the vehicle, when the vehicle is running on a generally level or flat road surface, since the vehicle usually runs on such flat road surface. Accordingly, the drive force tends to be insufficient for the intended drivability of the vehicle when the vehicle runs uphill.

(0003) In the light of the above-indicated insufficiency of the drive force during uphill running of the vehicle, a transmission shift control apparatus is proposed as disclosed in JP-A-62-180153, wherein an uphill running of the vehicle is detected if the vehicle speed is lowered across the selected upshift boundary line while the throttle opening angle is larger than a predetermined value. When the uphill running is detected, an upshift action of the automatic transmission is inhibited, and the transmission is held in the currently established gear position, whereby running stability and drivability during uphill running of the vehicle are improved.

(0004)

(Problems the Invention is to Solve) However, the known transmission shift control apparatus indicated above is adapted to detect the uphill running of the vehicle under a limited running condition of the vehicle, namely, only if the vehicle speed is lowered across the selected downshift boundary line and if the throttle opening angle is larger than the predetermined lower limit. This arrangement does not provide an improvement in the control of the vehicle drive force depending upon a variation in the load acting on the vehicle, and does not permit satisfactory running stability and drivability of the vehicle over the entire ranges of the vehicle.

(0005) The present invention was created in light of the circumstances described above and has the object of providing a vehicle drive force control apparatus that assures satisfactory running stability and drivability of the vehicle over the entire ranges of the engine load and the vehicle speed, irrespective of a variation in the running load.

(0006)

(Means Used to Solve the Problems)

This object may be accomplished according to the principle of the present invention, which provides an apparatus for controlling a drive force for driving a motor vehicle having an engine and a drive wheel driven by the drive force based on an output of the engine, the apparatus comprising: (a) reference load curve setting means for setting a standard running load curve represented by a load acting on the engine and a running speed of the vehicle when the vehicle is running in a stable mode; (b) running load calculating means for sequentially calculating a running load as represented by the load acting on the engine and the running speed of the vehicle, on the basis of the standard running load curve; and (c) drive force control means for controlling the drive force of the vehicle on the basis of the running load acting on the vehicle sequentially calculated by the running load calculating means.

(0007)

(Operation and Effects of the Invention)

In the vehicle drive force control apparatus of the present invention constructed as described above, the standard running-load curve represented by the engine load and the vehicle running speed during running of the vehicle in the stable mode is determined by the standard load curve setting means, and the vehicle running load as represented by the engine load and the vehicle speed is calculated sequentially on the basis of the aforesaid standard running-load curve. The drive force for driving the vehicle is adjusted by the drive force control means on the basis of the running load of the vehicle sequentially calculated by the running load calculating means. Thus, the vehicle drive force is suitably regulated depending upon the running load of the vehicle over the entire driving range of the vehicle, so as to assure satisfactory drivability of the vehicle irrespective of variations in the running load acting on the vehicle due to factors such as the road gradient.

(0008) In one preferred form of the present invention, the running load calculating means comprises means for determining a standard loaded-vehicle speed on the basis of the engine load according to the standard running load curve, and means for sequentially calculating a running load coefficient KFUKA as the running load of the vehicle, on the basis of the standard loaded-vehicle speed and the detected running speed of the vehicle, and the running load is represented by this running load coefficient KFUKA. In order to represent the standard running load and the running load, the standard running load opening is used using the throttle opening angle which represents the engine load, and the running the coefficient calculated from the actual throttle opening angle in the standard running load opening. In this case, however, the throttle opening angle usually changes at a higher rate than the vehicle speed, and the detected running load opening is greatly influenced by the acceleration and deceleration operations and becomes unstable. By means of the arrangement described above, if the running load coefficient is calculated based on the vehicle speed and the standard running vehicle load speed, it has the advantage of eliminating the above-described influenced of the acceleration and deceleration operations.

(0009) The above-indicated means for calculating the running load coefficient may be adapted to select one of two different equations for calculating the running load coefficient KFUKA, depending upon whether the detected actual vehicle speed is lower or higher than the determined standard loaded-vehicle speed.

(0010) For instance, the 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".

(0011) Preferably, the running load coefficient calculating means includes smoothing means for smoothing the running load coefficient KFUKA calculated successively, to obtain a smoothed running load coefficient KFUKASM, which is used as the running load acting on the vehicle.

(0012) The smoothing means is preferably designed to change the smoothing amount to be applied to the non-smoothed running load coefficient KFUKA, depending upon the running condition of the vehicle.

(0013) Further, it is desirable that the running load coefficient calculating means be constituted so as not to substantially change the smoothed running load coefficient KFUKASM during vehicle starting period.

(0014) It is also for the running load coefficient calculating means to be constituted so that the smoothed running load coefficient KFUKASM is substantially unchanged during the specified interval CHANTEN from the point in time at which the running load coefficient KFUKA before the smoothing process is 1 or above to the point at which it becomes less than 1.

(0015) It is further desirable that the vehicle be equipped with an automatic transmission which changes the speed ratio of the transmission automatically, and a transmission control unit, which controls the speed ratio of this automatic transmission, on the basis of the engine load and the vehicle running speed and according to a predetermined shift boundary line. In this case, the drive force control means includes correcting means for correcting the shift boundary line on the basis of the calculated vehicle running load. This form of the invention using the adjusting means assures high fuel economy and high power performance.

(0016) These correcting means correct the shift boundary line based on the above-described smoothed running load coefficient KFUKASM.

(0017) The correcting means includes means for determining a shift-speed compensating coefficient on the basis of the smoothed running load coefficient KFUKASM, and corrects the shift boundary line on the basis of the determined shift-speed compensating coefficient. The shift boundary line is substantially corrected in accordance with the compensation coefficient determined by the compensation coefficient determining means.

(0018) It is also desirable to provide upshift inhibiting means, which prevents upshifting of the automatic transmission when the sequentially calculated running load exceeds a first threshold value. This has the advantage of solving the phenomenon of frequent shifting, whereby the drive force is restricted by releasing pressure on the accelerator pedal, since the drive force is higher due to downshifting, but in this case of shifting occurs, and the driving force is insufficient, so the accelerator pedal is again depressed, and downshifting occurs.

(0019) The aforementioned upshift inhibiting means also, for example, prevents upshifting of the automatic transmission when the smoothed running load coefficient KFUKASM exceeds the aforementioned first threshold value.

(0020) The aforementioned upshift inhibiting means also prevents upshifting after the throttle opening is increased by depressing the accelerator pedal and downshifting has occurred from the highest gear to a gear one level lower.

(0021) The transmission controller preferably further comprises a upshift inhibition releasing means for releasing the inhibition of the upshift action of the transmission by the upshift inhibiting means when the sequentially calculated running load falls below a second threshold value smaller than the first threshold value. Since there is a suitable amount of difference between the first and second threshold values, it is possible to prevent undesirable alternate inhibition of the upshift action and cancellation of the inhibition due to hysteresis between the first and second threshold values.

(0022) The upshift inhibition releasing means is desirably adapted to determine whether a upshift action of the transmission to the highest-speed position should be effected or not, each time a change of the running condition of the vehicle from a decelerating state to an accelerating state has been repeated a predetermined number of times while the upshift action to the highest-speed position is inhibited by the upshift inhibiting means. If the releasing means determines that the upshift action to the highest-speed position should be effected, the releasing means cancels the inhibition of and allows the upshift action to the highest-speed position. The upshift action to the highest-speed position of the transmission means a shifting of the transmission so as to reduce the vehicle drive force. In this sense, the cancellation of the inhibition of the upshift action must be determined depending on the vehicle drive force required when the vehicle is accelerating. Since the determination as to whether the transmission should be shifted to the highest-speed position is effected when the vehicle is in an accelerating state, the transmission is allowed to be shifted up to the highest-speed position depending upon the vehicle drive force required during acceleration of the vehicle.

(0023) The upshift inhibition releasing means may comprise threshold value determining means for determining the second threshold value such that the second threshold value is smaller by a predetermined value than a value of the running load which is determined at one of the following two moments, whichever is later: the moment when the inhibition of the upshift action is started by the upshift inhibiting means; and the moment when the change of the vehicle running condition from the decelerating state to the accelerating state has been repeated the predetermined number of times. This arrangement advantageously shortens a delay in releasing the inhibition of the upshift action of the transmission. The running load value may be the smoothed running load coefficient KFUKASM discussed above.

(0024) The drive force control means may be adapted to shift down the automatic transmission to a position for applying an engine brake to the vehicle, if the running load acting on the vehicle, calculated by the aforesaid running load calculating means, and the load acting on the engine are smaller than respective predetermined reference values, and if an acceleration value of the vehicle is larger than a predetermined reference value. This arrangement is effective to improve engine brake force.

(0025) In the above arrangement, the drive control means may comprise automatic downshift means for shifting down the automatic transmission to the engine braking position if the smoothed running load coefficient KFUKASM indicated above as the vehicle running load is smaller than a first reference value, if an opening angle of a throttle valve of the engine as the engine load is smaller than a reference value, and if the acceleration value of the vehicle is larger than the reference value.

(0026) In the above case, the drive force control means preferably further comprises means for disabling the automatic downshift means if the successively measured smoothed running load coefficient KFUKASM exceeds a second reference value larger than the first reference value.

(0027)

(Working Examples) A working example of the present invention is next explained in detail referring to the drawings.

(0028) Referring first to FIG. 1, air is introduced into each combustion chamber 12 of a gasoline engine 10 through an air cleaner 14, an air flow meter 16, an intake pipe 18, a throttle valve 20, a by-pass passage 22, a surge tank 24, an intake manifold 26 and an intake valve 28. A fuel is injected by a fuel injector valve 30, into a stream of air flowing through the intake manifold 26 to which the fuel injector valve 30 is attached. Thus, each combustion chamber 12 is supplied with an air-fuel mixture for operating the engine 10. In this embodiment the air flow meter 16 is a movable vane type meter, which functions to sense an actual intake air quantity Qm. This air flow meter 16 generates an intake air quantity signal SQm indicative of the actual intake air quantity Qm which flows through the intake pipe 18. The signal SQm is applied to an engine electronic control unit 32 and a transmission electronic control unit 34. The throttle valve 20 is mechanically linked with an accelerator pedal of the vehicle, as well known in the art, so that the angle of opening TA of the throttle valve 20 changes with the amount of operation of the accelerator pedal, whereby the intake air quantity Qm of the engine 10 can be continuously changed by the accelerator pedal through the throttle valve 20. The throttle valve 20 is provided with a throttle sensor 36 which has an idling position switch. The idling position switch detects the idling position of the throttle valve 20. A signal indicative of this idling position and a throttle opening signal STA indicative of the opening angle TA of the throttle valve 20 are applied to the engine electronic control unit 32 and the transmission electronic control unit 34. The throttle valve 20 is disposed in parallel relationship with the by-pass passage 22, which is provided with an idling control valve 38. The opening of the idling control valve 38 is controlled by the engine electronic control unit 32, to regulate the amount of the air which by-passes the throttle valve 20, so that the idling speed of the engine 10 can be adjusted by the idling control valve 38. The fuel injector valve 30 is also controlled by the engine electronic control unit 32, so that the fuel injection timing and the amount of the fuel injected by the injector valve 30 are suitably controlled. An air temperature sensor 40 is disposed upstream of the air flow meter 16, for sensing the temperature of the air which is admitted into the intake pipe 18. An output signal of the temperature sensor 40 representative of the air temperature is also applied to the engine electronic control unit 32.

(0029) The engine 10 has the intake valve 28, an exhaust valve 42, a piston 44 and a spark plug 46. The spark plug 46 is activated to provide an ignition spark in the combustion chamber 12, by application of a high voltage supplied thereto through a distributor 50 from an ignitor 48 under the control of the engine electronic control unit 32. As a result, the air-fuel mixture in the combustion chamber 12 is ignited by the ignition spark to effect a combustion and expansion stroke of the piston, whereby the piston 44 is reciprocated to rotate the crankshaft. The intake and exhaust valves 28, 42 are opened and closed by rotation of the camshaft, in synchronization with the crankshaft. A mechanism connecting the crankshaft and the camshaft is linked with a valve timing changing device 52, which is controlled by the engine electronic control unit 32, so that the relative rotating phase of the crankshaft and camshaft is changed to adjust the timings at which the intake and exhaust valves 28, 42 are opened and closed. An exhaust gas produced as a result of combustion of the air-fuel mixture in the combustion chamber 12 is discharged into the atmosphere, through the exhaust valve 42, an exhaust manifold 54, an exhaust pipe 56 and a catalytic converter 58. A water temperature sensor 60 is provided for sensing the temperature of a coolant which cools the engine 10. The temperature sensor 60 generates a signal indicative of the engine coolant temperature, which is supplied to the engine electronic control unit 32. The exhaust manifold 54 is provided with an oxygen sensor 62 for detecting an oxygen concentration of the exhaust gas flowing therethrough. An output signal of the sensor 62 indicative of the oxygen concentration is also supplied to the engine electronic control unit 32. The distributor 50 is provided with a speed sensor which generates a pulse signal in synchronization with the rotation of the crankshaft of the engine 10. This pulse signal SNE represents a speed NE of the engine 10 and is supplied to the engine electronic control unit 32 and the transmission electronic control unit 34.

(0030) Each of the engine electronic control unit 32 and the transmission electronic control unit 34 has a central processing unit (CPU), a random-access memory (RAM), a read-only memory (ROM), an input/output interface circuit, an analog/digital (A/D) converter, as provided in an electronic controller using a computer. The CPU operates to perform data processing operations according to various control programs stored in the ROM, while utilizing a temporary data storage function of the RAM. The engine electronic control unit 32 is adapted to signals indicative of ON and OFF states of an air conditioner from an air conditioner switch 64, as well as the signals described above. The transmission electronic control unit 34 receives a signal generated by shift lever sensor 66 representing one of operating positions of the shift lever adjacent to the driver's seat, which consist of: PARKING position P; NEUTRAL position N: DRIVE position D; FIRST position 1; SECOND position 2; and REVERSE position R. The transmission electronic control unit 34 also receives a gear position signal SG from a gear position sensor 70 and a vehicle speed signal SSPD from a vehicle speed sensor 72. The gear position sensor 70 and the vehicle speed sensor 72 are provided on the automatic transmission 68, which has one rear drive position, and four forward drive positions, that is, 1st-gear position, 2nd-gear position, 3rd-gear position and 4th-gear position, for changing the speed NE of the engine 10. Necessary information between the two electronic control units 32 and 34 may be assisted via a communication interface, and the intake air quantity signal SQm, throttle opening signal STA and engine speed signal SNE may be supplied to either of the engine and transmission control units 32, 34. The engine electronic control unit 32 and/or the transmission electronic control unit 34 may be adapted to receive other signals representative of other operating parameters or running conditions of the vehicle, such as on-off states of a brake pedal, steering angle of a steering wheel, gradient of a road surface on which the vehicle runs, and temperature of the exhaust gas, for controlling the engine and/or the transmission.

(0031) The engine electronic control unit 32 operates to control the fuel injector valve 30, ignitor 48, idling control valve 38 and valve timing changing device 52, depending upon the intake air quantity Qm, throttle opening angle TA, engine speed NE, engine 10 coolant temperature, intake air temperature, oxygen concentration in the exhaust passage 56, on-off states of the air conditioner, etc., according to various predetermined arithmetic equations and stored data maps, so as to regulate the amount and timing of the fuel injection by the fuel injector valve 30, timing of ignition by the spark plug 46, idling speed of the engine 10, and opening and closing timings of the intake and exhaust valves 28, 42, so that the engine 10 is controlled to provide a suitable output, with a minimum of fuel consumption and a reduced amount of harmful exhaust emissions.

(0032) The transmission electronic control unit 34 operates to place the automatic transmission 68 in a suitably selected one of the operating positions, according to predetermined shift patterns, depending upon the intake air quantity Qm, throttle opening TA, engine speed signal NE, vehicle speed SPD, gear position of the automatic transmission 68 and shift lever position. Referring to the flow charts, there will be described a basic shift control operation when the vehicle is running with the shift lever placed in the DRIVE position D.

(0033) The flow chart of FIG. 2 shows a routine for detecting a load currently acting on the vehicle. This routine is repeatedly executed with a predetermined cycle time, for example, 32 ms. The routine is initiated with steps SD1, SD2 and SD3 to read the throttle opening angle TA, the vehicle speed SPD and the actual gear position G of the transmission 68. Then, the control flow goes to step SD4 which corresponds to means for setting a standard running load curve. Described more specifically, step SD4 is implemented to select a relation between the throttle opening angle TA and the standard running load curve SPD_S, i.e., the standard load curve relationship which corresponds to the currently selected position G, as shown in FIG. 3. This standard load curve is the relation between the throttle opening angle TA and the standard running load speed SPD_s when the vehicle is running at a relatively constant speed on a flat road surface.

(0034) The control flow then goes to steps SD5 through SD20 which correspond to running load calculating means for determining a running load acting on the vehicle as represented by the engine load and the vehicle speed. That is, steps SD5-SD20 are implemented to calculate a running load coefficient KFUKA, and a smoothed running load coefficient KFUKASM which is obtained by smoothing the calculated running load coefficient KFUKA. SD5, which corresponds to the standard running load speed determining means, is implemented to calculate the standard loaded-vehicle speed SPDs corresponding to the actually detected throttle opening angle TA, according to the relationship which was selected in step SD4 shown in FIG. 3. If the detected throttle opening angle TA is equal to a value indicated at S in FIG. 3, for example, a vehicle speed "a" corresponding to a point "A" on the TA-SPDs curve is determined as the standard loaded-vehicle speed. In step SD6, it is determined whether the value of the standard loaded-vehicle speed SPDs calculated in step SD5 is higher than the actual vehicle speed SPD which is influenced by the load actually acting on the vehicle.

(0035) If a negative decision is obtained in step SD6, for instance, if the actual vehicle running state is as indicated at a point "C" in FIG. 3, the standard loaded-vehicle speed "a" is lower than the actual vehicle speed "c" (a<c), whereby step SD7 is implemented to calculate the running load coefficient KFUKA according to a predetermined equation, KFUKA=a/c. Step SD7 is followed by step SD8 to set a XCOAST flag to "1". If an affirmative decision is obtained in step SD6, on the other hand, for example, if the vehicle is running in a state indicated at a point "B" in FIG. 3, the standard loaded-vehicle speed "a" is higher than the actual vehicle speed "b" (a>b), whereby step SD9 is implemented to calculate the running load coefficient KFUKA according to a predetermined equation, KFUKA=2-(b/a). Step SD9 is followed by step SD10 to reset the XCOAST flag to "0". When the XCOAST flag is set at "0", it means that the not-yet-smoothed coefficient KFUKA has been calculated or determined while the vehicle is running in a high-load state. When the flag is set at "1", it means that the non-smoothed coefficient KFUKA has been determined while the vehicle is running in a low-load state. It will be understood from the graph of FIG. 4 that the running load coefficient KFUKA is equal or close to "1" when the vehicle is running in a stable state on a flat road surface, and that the coefficient KFUKA is smaller and higher than "1" when the vehicle is running in the low-load and high-load states, respectively. The vehicle is considered to be running in the low-load state when the vehicle is running downhill, and in the high-load state when the vehicle is running uphill.

(0036) If the running load coefficient KFUKA during running of the vehicle in the high-load state was calculated according to an equation KFUKA=a/c, the calculated coefficient KFUKA would cause an undesirably large influence on the subsequent smoothing process of the coefficient KFUKA, which would become saturated, and the equation KFUKA=2-(b/a) is used to calculate the coefficient KFUKA when the vehicle is running in the high-load state. Thus, the rate of change of the coefficient KFUKA with the vehicle speed SPD during the vehicle running in the high-load state is almost the same as that in the low-load state, so that the effect of the smoothing process since would become similar irrespective of the effect of the running load..

(0037) Next, step SD11 is performed to determine whether the value of the XCOAST flag has been changed from "1" to "0" or vice versa, namely, whether the running state of the vehicle has been changed from the low-load running state to the high-load running state or vice versa. If an affirmative decision is obtained in step SD11, step SD12 is implemented to set the content of the REVERSE timer CHAN to "0" and the time measurement is started thereby. If a negative decision is obtained in step SD11, than the running load coefficient KFUKA in step SD13 is stored in a specified memory location in the RAM.

(0038) Then, steps SD14, SD15 and SD16 are sequentially implemented to read the coefficient KFUKA, content CHANTEN of the REVERSE timer and a content CHASSIN of a START timer. The REVERSE timer and the START timer are controlled by a routine of FIG. 5 to detect starting and acceleration/deceleration of the vehicle. This routine of FIG. 5 is executed with a cycle time (e.g., 128 ms) longer than the cycle time of the vehicle load detecting routine of FIG. 2.

(0039) The routine of FIG. 5 to is initiated with step SH1 to read the vehicle speed SPD. Step SH1 is followed by step SH2 to read the content CHASSIN of the START timer. The control flow then goes to step SH3 and SH4 to check if the vehicle speed SPD is lower than a predetermined upper limit of 40 km/h and equal to or higher than a predetermined lower limit of 10 km/h. If a negative decision is obtained in step SH3, the START timer CHASSIN is reset to a predetermined initial value in step SH5. If a negative decision is obtained in step SH4, the START timer is started in step SH6. If an affirmative decision is obtained in step SH4, step SH7 is implemented to decrement the content CHASSIN of the START timer. Thus, the START timer CHASSIN is controlled to measure a time lapse after the vehicle has been started. When the vehicle speed exceeds the upper limit of 40 km/h, the START timer is reset to the initial value.

(0040) Next, step SH8 is implemented to store the content CHASSIN of the START timer. Step SH9 is then implemented to read the content CHANTEN of the REVERSE timer. Step SH9 is followed by step SH10 to decrement the content CHANTEN, and step SH11 to store the content CHANTEN. The START timer and the REVERSE timer are decrement timers whose contents CHASSIN, CHANTEN are decremented from the predetermined initial values, and the count is considered completed when the count value reaches 0. In the initial states, the contents START timer CHASSIN and REVERSE time CHANTEN are set at values corresponding to specified durations. For instance, the START timer and the REVERSE timers are initially set to respective initial values of 6.0 sec and 1.2 sec. These initial values correspond to time durations during which the smoothing of the running load coefficient KFUKA is inhibited, as described later.

(0041) The control flow then goes to step SH12 to read the previous vehicle speed SPD0 read in the last control cycle. Step SH13 is then implemented to compare the current vehicle speed SPD with the previous vehicle speed SPD0 read in step SH13. If the current vehicle speed SPD is higher than the previous vehicle speed SPD0, step SH14 is implemented to set the contents of the flag XKASOKU to "1". If the latter is determined to be higher, then step SH15 is implemented to reset the XKASOKU flag to "0". Next, in step SH16, the contents are stored. If the two values are the same, step SH16 is implemented. It will be understood that the content "1" of the XKASOKU flag indicates the accelerating state of the vehicle, while the content "0" of the same indicates the decelerating state.

(0042) Then, the control flow goes to step SH17 to determine whether the idling position switch is in the off state or not. If a negative decision is obtained in step SH17, step SH22 is implemented to reset the idle off delay content CIDLOF. If an affirmative decision is obtained in step SH17, step SH18 is implemented to read the current throttle opening angle TA. Step SH19 is then implemented to calculate a third gear downshift release delay time KOFF, on the basis of the throttle opening angle TA, and according to a predetermined relationship as indicated in FIG. 6 by way of example. Then, steps SH20 and SH21 are implemented to read the idle off delay content CIDLOF, and increment the content CIDLOF. These steps are followed by step SH23 in which the idle off delay content CIDLOF is stored. The idle off delay content CIDLOF is provided to measure a time lapse after the accelerator pedal has been depressed. The third gear downshift release delay time KOFF is used as a threshold for determining the release of automatic downshift action to the 3rd-gear position as described below.

(0043) Referring back to the flow chart of FIG. 2, in step SD17 it is determined whether the content CHANTEN of the REVERSE timer is "0" or not. If an affirmative decision is obtained, step SD18 is implemented to determine whether the content CHASSIN of the START timer is "0" or not. If a negative decision is obtained in step SD17 or SD18, steps SD19 and SD20 so that the smoothing operation to obtain the smoothed running load coefficient KFUKASM is inhibited during respective predetermined time lengths corresponding to the initial contents of the REVERSE and START timers are skipped, and step SD21 is immediately performed. If an affirmative decision is obtained in both steps SH17 and SH18, the control flow goes to step SH19 to determine an amount of smoothing, according to a data table as illustrated in FIG. 7. Described more specifically, the smoothing amount is selected within a range between 1/2 and

1/128, depending upon a specific combination of the values of flags XCOAST, XTOHAN, YIDL and XKASOKU. The XCOAST flag indicates a change of the non-smoothed running load coefficient KFUKA, while the XTOHAN flag indicates a change of the smoothed running load coefficient KFUKASM. The YIDL signal indicates an operating state of the idling position switch of the throttle sensor, which detects that the throttle valve is completely closed. The XKASOKU flag indicates the accelerating and decelerating condition of the vehicle. In the table of FIG. 7, the "*" mark indicates that the appropriate state or value of the flags do not influence the smoothing amount. That is, the smoothing amount is determined by the parameters other than those indicated by the "*" mark.

(0044) Then, the control flow goes to step SD20 in which a smoothing process is performed by multiplying the smoothing amount selected in step SD19 by the running load coefficient KFUKA calculated in step SD7 or SD8, i.e., the smoothed running load coefficient KFUKASM is calculated according to the following equation:

$$KFUKASM=KFUKASM0+n.(KFUKA-KFUKASM0)$$

where, KFUKASM0: KFUKASM calculated in step SD20 in the last cycle of execution of the routine, and n: smoothing amount determined in step SD19. Step SD20 is followed by step SD21 in which the calculated smoothed running load coefficient KFUKASM is stored in a specified location in the RAM. The smoothed coefficient KFUKASM thus obtained is sufficiently smoothed as compared with the non-smoothed coefficient value KFUKA, as shown in FIG. 8.

(0045) It is noted that the smoothed running load coefficient KFUKASM as indicated in FIG. 8 includes the effect of temporarily halting the smoothing as a result of step SD18. That is, since the running load coefficient KFUKA has a tendency to deviate toward the higher load side due to the increased effects of acceleration during starting of the vehicle, i.e., that is, until a predetermined time corresponding to the content CHASSIN of the START timer has passed after the vehicle start, during this period steps SD19 and SD20 are skipped and changing of the smoothed running load coefficient KFUKASM is stopped, and this deviation toward the a higher load is prevented.

(0046) It is noted that the smoothed running load coefficient KFUKASM as indicated in FIG. 8 includes the effect of temporarily halting the smoothing as a result of step SD17. Specifically, although the XKASOKU flag is used as one of the parameters for determining the smoothing amount, if that value alone is used, a deviation will occur in the running load coefficient KFUKASM, so, during the specified delay interval after the value of the more responsive XCOAST flag is reversed, i.e., during the specified interval CHANTEN after reversal of the un smoothed running load coefficient KFUKA, by skipping steps SD19 and SD20, and halting updating in the running load coefficient KFUKASM, and stopping changes therein, the foregoing can be prevented. By this means, as indicated in Figure 9, the smoothed running load coefficient KFUKASM is appropriately smoothed with respect to drops in the running load coefficient KFUKA. This is because, if a delay period during which updating of the running load coefficient KFUKASM is halted is not provided, as shown in FIG. 10, the smoothed value KFUKASM would be excessively lowered together with the non-smoothed value KFUKA.

(0047) The smoothed running load coefficient KFUKASM as calculated in step SD20 varies with the load acting on the vehicle, as indicated in FIG. 11, that is, varies with a change of the road surface gradient. It will be understood that the vehicle load changes with the road surface gradient. The KFUKASM-gradient curves shown in FIG. 11, which are generally upwardly convex, cause the value KFUKASM to change with a higher response to the road surface gradient when the vehicle is running on a flat road surface, than when the vehicle is running uphill or downhill. In other words, the response of the calculated smoothed running load coefficient KFUKASM increases as the road surface gradient (vehicle load) decreases.

(0048) In the following step SD22, it is determined whether the smoothed running load coefficient KFUKASM is equal to or larger than 1.00. If a negative decision is obtained in step SD22, step SD23 is implemented to reset the XTOHAN flag to "0". If an affirmative decision is obtained in step SD22, namely, if the value KFUKASM has increased to 1.00 or higher, step SD24 is implemented to set the XTOHAN flag to "1". These steps are followed by step SD25, in which a shift-speed compensating coefficient Ks for adjusting a shift speed of the vehicle is calculated on the basis of the smoothed running load coefficient KFUKASM and according to a predetermined relationship as represented as indicated in FIG. 12. This relationship shown in FIG. 12 is set so that the compensating coefficient Ks is downwardly convex with respect to the smoothed running load coefficient KFUKASM, in order to maintain a sense of linearity with respect to the running load. The shift-speed compensating coefficient Ks is multiplied by the shift speed determined from a shift pattern so as to adjust the shift speed with respect to the running load of the vehicle.

(0049) Next, there will be described a downshift flag control routine for controlling a X2NDD flag and a X3RDD flag for regulating automatic downshift actions of the transmission from the 4th-gear position to the 2nd-gear position and the 3rd-gear position, restrictively, so as to apply an effective engine brake to the vehicle while the vehicle is running downhill, using FIG. 13. This downshift flag control routine is executed with the same cycle time as a main shift-control routine.

(0050) The downshift flag control routine is initiated with step SA1 (FIG. 13) to determine whether the smoothed running load coefficient KFUKASM is smaller than a predetermined lower limit of 0.95. This special value is the value for determining whether the vehicle is running downhill. If a negative decision is obtained in step SA1, steps SA5 and SA6 are implemented to clear the X3RDD and X2NDD flags, and one cycle of execution of the present routine is terminated. If an affirmative decision is obtained in step SA1, the control flow goes to step SA2 to determine whether the non-smoothed running load coefficient KFUKA is smaller than a predetermined upper limit of 1.05.

(0051) If a negative decision is obtained in step SA2, step SA5 and subsequent steps described above are implemented to release automatic downshift control. If an affirmative decision is obtained in step SA2, the control flow goes to step SA3 to determine whether the idling switch is in the OFF state or not as a condition for starting automatic downshift. If an affirmative decision is obtained in step SA3, it means that the accelerator pedal is depressed. In this case, this step is followed by step SA4 to determine whether the content CIDLOF of the idle off delay timer, i.e., the last time since the idle switch was switched off, is shorter than the time lapse threshold KOFF calculated in step SH19 described above. If an affirmative decision (YES) is obtained in step SA4, step SA6 is implemented to reset the X2NDD flag. If a negative decision (NO) is obtained in step SA4, both steps SA5 and SA6 are implemented to reset both of the X3RDD and X2NDD flags.

(0052) If a negative decision is obtained in step SA3, it means that the accelerator pedal is not depressed. In this instance, the control flow goes to step SA7 to determine whether the X3RDD flag is set at "0" or not. Initially, an affirmative decision is obtained in step SA7, and step SA8 is implemented to calculate a reference 4 →2 down acceleration value $\alpha_{4\text{-}2D}$ on the basis of the vehicle speed SPD and according to a predetermined relationship between SPD and $\alpha_{4\text{-}2D}$ as indicated in FIG. 14. The reference acceleration value $\alpha_{4\text{-}2D}$ is used to determine whether the X2NDD flag should be set to "1" or not. Step SA8 is followed by step SA9 to determine whether an actual acceleration α of the vehicle is higher than the 4 → 2 down reference value $\alpha_{4\text{-}2D}$. If an affirmative decision is obtained in step SA9, the control flow goes to step SA16 to set the X2NDD flag to "1", and step SA12 to set the X3RDD flag to "1", and one cycle of execution of the routine is terminated.

(0053) If a negative decision is obtained in step SA9, step SA10 is implemented to calculate a 4 → 3 down reference acceleration value $\alpha_{4\text{-}3D}$ on the basis of the vehicle speed SPD and according to a predetermined relationship between SPD and $\alpha_{4\text{-}3D}$ as indicated in FIG. 14. The reference acceleration value 4 → 3 down $\alpha_{4\text{-}3D}$ is used to determine whether the X3RDD flag should be set to "1" or not. Step SA10 is followed by step SA11 to determine whether the actual acceleration α of the vehicle is higher than the calculated reference value 4→3 down $\alpha_{4\text{-}3D}$. If an affirmative decision is obtained in step SA11, the control flow goes to step SA12 to set the X3RDD flag to "1", and one cycle of execution of the routine is terminated. If a negative decision is obtained in step SA11, one cycle of the routine is immediately terminated.

(0054) If the X3RDD flag is set to "1" as described above, a negative decision is obtained in step SA7 in the next cycle of execution of the routine, and the control flow goes to step SA13 to determine whether the X2NDD flag is set at "0" or not. If an affirmative decision (YES) is obtained in step SA13, step SA14 is implemented to calculate a 3 → 2 down reference acceleration value $\alpha_{3\text{-}2D}$ on the basis of the vehicle speed SPD and according to a predetermined relationship between SPD and $\alpha_{3\text{-}2D}$ as indicated in FIG. 14. This reference acceleration value $\alpha_{3\text{-}2D}$ is used to determine whether the X2NDD flag should be set to "1" or not. Step SA14 is followed by step SA15 to determine whether the actual acceleration α of the vehicle is higher than the calculated 3 → 2 down reference value $\alpha_{3\text{-}2D}$. If an affirmative decision is obtained in step SA15, the control flow goes to steps SA16 and SA12 to set the X2NDD flag and the X3RDD flag to "1". If a negative decision is obtained in step SA15, one cycle of the routine is immediately terminated.

(0055) If a negative decision is obtained in step SA13, step SA17 is implemented to calculate a 2-3 up reference acceleration value $\alpha_{2\text{-}3U}$ on the basis of the vehicle speed SPD and according to a predetermined relationship between SPD and $\alpha_{2\text{-}3U}$ as indicated in FIG. 15. This 2-3 up reference acceleration value $\alpha_{2\text{-}3U}$ is used to determine whether the X2NDD flag should be reset to "0" or not. Step SA17 is followed by step SA18 to determine whether the actual acceleration α of the vehicle is lower than the calculated 2-3 up reference value $\alpha_{2\text{-}3U}$. If an affirmative decision is obtained in step SA18, the control flow goes to steps SA19 to reset the X2NDD flag to "0". If a negative decision is obtained in step SA18, one cycle of the routine is immediately terminated.

(0056) It will be understood that this automatic down control routine of is formulated so that the transmission 68 is automatically shifted down from the 4th-gear position to the 2nd-gear or 3rd-gear position, or from the 3rd-gear position to the 2nd-gear position, depending upon the detected acceleration α of the vehicle, so as to apply a suitable engine brake to the vehicle when the vehicle is running downhill without the accelerator pedal being depressed, and with the smoothed running load coefficient KFUKASM being 0.95 or smaller. Further, the present routine is adapted to inhibit the automatic downshift action of the transmission to the 2nd-gear position when the accelerator pedal is depressed or when the acceleration α becomes lower than the 2-3 up reference acceleration value $\alpha_{2\text{-}3U}$. The routine is also adapted to release the downshift control of the transmission to the 3rd-gear position when the non-smoothed running load coefficient KFUKA has increased to 1.05 or larger, or when the time lapse CIDLOF after the depression of the accelerator pedal has reached the threshold KOFF determined by the KOFF-TA relationship of FIG. 6.

(0057) Referring next to the flow charts of FIGS. 16, there will be described a routine for inhibiting an upshift action of the transmission to the 4th-gear position. This routine uses a X3RDH flag for provisionally releasing the prevention of the upshift action to the 4th-gear position, and a X3HOLD flag for inhibiting the upshift action to the 4th-gear position. These X3RDH and X3HOLD flags are set to "1" when the load acting on the vehicle is relatively large, for example, when the vehicle is running uphill. When the vehicle load is lowered below a given limit, the X3HOLD flag is reset to "0", whereby the inhibition of the upshift action to the 4th-gear position is cancelled.

(0058) The routine is initiated with step SE1 in FIG. 16 to determine whether a X43DWN flag is set at "1". This X43DWN flag is set to "1" when the transmission has been shifted down. If a negative decision is obtained in step SE1, the control flow goes to step SE6 to clear the X3RDH to "0", and step SE7 to reset a C3RDH counter, and one cycle of execution of the routine is terminated. If an affirmative decision is obtained in step SE1, the control flow goes to step SE2 to determine whether the X3RDH flag is set at "1". Initially, this X3RDH flag is set at "0", and step SE3 is implemented to determine whether the smoothed running load coefficient KFUKASM is equal to or larger than a threshold value of 1.20, or not. This threshold value is determined in order to check if the downshift action of the transmission to the 3rd-gear position with the accelerator pedal being depressed occurred during uphill running of the vehicle or not.

(0059) If a negative decision is obtained in step SE3, it means that the load acting on the vehicle is not so large. In this case, steps SE4 and SE5 are implemented to reset the X3HOLD flag and the X43DWN flag to "0". Step SE5 is followed by steps SE6 and SE7 to reset the X3RDH flag and the C3RDH counter.

(0060) If an affirmative decision is obtained in step SE3, it means a situation in which the vehicle driver is likely to further depress the accelerator pedal due to shortage of the vehicle drive force if the transmission is shifted back up to the 4th-gear position. In this case, steps SE8 and SE9 are implemented to set the X3RDH flag and the X3HOLD flag to "1". Then, the control flow goes to step SE10 to calculate a reference value K3HOLD used to determine whether the inhibition of the upshift action to the 4th-gear position should be cancelled or not. The reference value K3HOLD is obtained by subtracting a predetermined value β from the smoothed running load coefficient KFUKASM when the X3RDH and X3HOLD flags were set.

(0061) With the X3RDH and X3HOLD flags being set to "1" as described above, an affirmative decision is obtained in step SE2 in the next cycle of execution of the routine, and step SE11 is implemented to determine whether the smoothed running load coefficient KFUKASM is equal to or larger than the reference value K3HOLD. If the determination in step SE11 is affirmative, it means that the vehicle load is still relatively large. In this case, the control flow goes to step SE12 to read the content of the acceleration-deceleration cycle counter C3RDH, and steps SE13 through SE18 to increment the acceleration-deceleration cycle counter C3RDH depending upon the accelerating or decelerating condition of the vehicle.

(0062) Described in detail, the content of the acceleration-deceleration cycle counter C3RDH changes sequentially from "0" to "3" each time the counter is incremented. If the counter is incremented when its content is "3", the content changes back to "0". If the content is "0" or "2", it means the deceleration of the vehicle. If the content is "1" or "3", it means the acceleration of the vehicle. If the content of the acceleration-deceleration cycle counter is determined to be “1” in step SE14, step SE15 is implemented to determine whether the vehicle is now decelerating or not. If an affirmative decision is obtained in step SE15, namely, if the vehicle is now decelerating, the control flow goes to step SE18 to increment the acceleration-deceleration cycle counter C3RDH by 1 so that the content indicates the decelerating state of the vehicle. If the content of the acceleration-deceleration cycle counter C3RDH is found to be "0" or "2" in step SE13 or SE16, step SE17 is implemented to determine whether the vehicle is now accelerating or not. If an affirmative decision is obtained in step SE17, the control flow goes to step SE18 to increment the acceleration-deceleration cycle counter C3RDH so that the content indicates the accelerating state of the vehicle.

(0063) Step SE18 is followed by step SE19 to determine whether the content of the acceleration-deceleration cycle counter C3RDH has increased to "3" or not. This step SE19 is also implemented if a negative decision is obtained in step SE16 or SE17. Initially, a negative decision is obtained in step SE19, and one cycle of execution of the routine is terminated. When the acceleration-deceleration cycle counter C3RDH is incremented to "3", the determination in step SE19 is affirmative, so it is followed by step SE6 to reset the X3RDH flag and step SE7 to reset the acceleration-deceleration cycle counter C3RDH to "0". It will be understood that in steps SE13 through SE19, when changes are detected twice in the vehicle running condition from the decelerating state to the accelerating state while upshift action is inhibited, the flag X3RDH is reset in step SE6 to provisionally cancel the inhibition of the upshift action. This causes the negative decision to be obtained in step SE3 in the next cycle of execution of the routine.

(0064) If the vehicle load is reduced to the extent that the negative decision is obtained in step SE11, steps SE4, SE5, SE6 and SE7 are implemented to reset the X3HOLD, X43DWN and X3RDH flags and the acceleration-deceleration cycle counter C3RDH.

(0065) It will be understood that in the 4th-gear inhibition control routine of FIG. 16, in step SE1, if power-on downshift determined to have occurred, and in step SE3 it is determined that the smoothed running load coefficient KFUKASM is at or above a specified value of about 1.2, upshift to fourth gear is prohibited in order to prevent frequent shifting actions. In step SE11, when it is determined that the smoothed running load coefficient KFUKA SM has fallen below the release threshold value K3HOLD by a specified value β lower then the running load coefficient KFUKASM when the upshift inhibition of decision was made, and in step SE19, after return to acceleration from deceleration has been determined to times, if it is determined in step SE3 that the smoothed running load coefficient KFUKASM has fallen below a specified value of about 1.2, upshift is released. A time chart showing operating examples of each flag in fourth gear inhibition control described above is shown in FIG. 17.

(0066) FIG. 18 is a flow chart showing the one station control routine which is the main routine of this working example, and corresponds to the dry fourth control means for controlling the dry fourth of the vehicle by changing the gear level of the automatic transmission 68 based on the above mentioned driving load KFUKASM. The present main routine is initiated with step SS1 to read the currently selected position G of the transmission 68, for example, based on speed-change output from a transmission a transmission electronic control unit 34. Step SS1 is followed by step SS2 to determine whether the currently selected position G is the highest position (4th-gear position) or not. If an affirmative decision is obtained in step SS2, it means that the transmission 68 will not be shifted up. In this case, step SS15 and the subsequent steps are implemented. If a negative decision is obtained in step SS2, step SS3 and the subsequent steps are implemented to control an upshift action of the transmission.

(0067) The operation to control the upshift action of the transmission will be first explained. Step SS3 is initially implemented to determine whether the currently selected position G of the transmission 68 is the 3rd-gear position or not. If a negative decision is obtained in step SS3, it means that the currently selected position G is the 2nd-gear or 1st-gear position. In this instance, step SS7 is implemented to select the shifting boundary line when shifting up from the present speed position from among three types of previously stored upshift boundary lines, as shown in FIG. 19, for shifting up from the 1st-gear position to the 2nd-gear position, from the 2nd-gear position to the 3rd-gear position, and from the 3rd-gear position to the 4th-gear position, respectively. Each of these upshift boundary lines represents a relationship between the throttle opening angle TA and the upshift speed SPD of the vehicle. When the currently selected position G of the transmission 68 is the 2nd-gear position, the upshift boundary line as indicated in (b) is selected in step SS7, and the basic upshift speed SPDu of the vehicle is calculated on the basis of the currently detected throttle opening angle TA and according to the selected upshift boundary line.

(0068) Conversely, if an affirmative decision is obtained in step SS3, step SS4 is implemented to determine whether the X2NDD flag is set at "0" or not. If a negative decision is obtained in step SS4, that is, if it is decided to shift down to the second speed position, the control flow goes to step SS23 in the downshift routine. If an affirmative decision (YES) is obtained in step SS4, that is, if it is decided not to automatically shift down to the second speed position, step SS5 is implemented to determine whether the X3RDH flag is set at "0" or not. The X3RDH flag set at "0" means the provisional cancellation of the inhibition of the upshift action to the 4th-gear position as described above.

(0069) If a negative decision is obtained in step SS5, that is, if the provisional cancellation of the inhibition of the upshift action to the 4th-gear position is not effected, the control flow goes to step SS17 and the subsequent steps to control the downshift action. If an affirmative decision is obtained in step SS5, that is, if the inhibition of the upshift action to the 4th-gear position has been cancelled, step SS6 is implemented to determine whether the X3HOLD flag is set at "1" or not. This X3HOLD flag set at "1" means the holding of the transmission in the 3rd-gear position, namely, the inhibition of the upshift action to the 4th-gear position.

(0070) If a negative decision is obtained in step SS6, that is, if the upshift action to the 4th-gear position is not inhibited, step SS7 is implemented to calculate the upshift speed SPDu of the vehicle as described above. If an affirmative decision is obtained in step SS6, that is, if the upshift action to the 4th-gear position is inhibited, step SS8 is implemented to calculate the upshift speed SPDu of the vehicle on the basis of the throttle opening angle TA and according to a 3-4 upshift boundary line as shown in FIG. 20, which boundary line is exclusively used when the upshift action to the 4th-gear position is inhibited.

(0071) Next, step SS9 is performed to adjust the calculated upshift vehicle speed SPDu by multiplying the value SPDu by the shift-speed compensating coefficient Ks, i.e., SPDu ←SPDu × Ks. Specifically, correction is performed by multiplication by the shift-speed compensating coefficient Ks calculated in step SD25.

(0072) Next, in SS10, it is determined whether the actual vehicle speed SPD is higher than the adjusted upshift vehicle speed SPDu obtained in step SS9, that is, whether the transmission should be shifted up. If a negative decision is obtained in step SS10, the control flow goes to step SS17. If an affirmative decision is obtained in step SS10, the control flow goes to step SS11 to determine whether the transmission is shifted up to the 4th-gear position or not. If an affirmative decision is obtained in step SS11, steps SS12 and SS13 are implemented to reset the X3HOLD flag and the X43DWN flag to "0". This step is followed by step SS14 in which the transmission

68 is shifted up to the 4th-gear position. If a negative decision is obtained in step SS11, step SS11 is directly followed by step SS14.

(0073) If an affirmative decision is obtained in step SS2, that is, if the transmission 68 is now placed in the 4th-gear position, step SS15 is implemented to determine whether the X3RDD flag is set at "0" or not. If a negative decision is obtained in step SS15, the transmission is automatically shifted down to the 3rd-gear position, step SS15 is followed directly by step SS23 in which the transmission is shifted down to the 3rd-gear position. If an affirmative decision is obtained in step SS15, the control flow goes to step SS16 to determine whether the X3RDH flag is set at "0" or not, provisionally releasing the inhibition on shifting to the 4th-gear position. If an affirmative decision is obtained in step SS16, it means that the inhibition of the upshift action to the 4th-gear position is provisionally released, whether X3RDH flag is set at "0" or not. In this case, the control flow goes to step SS23 to shift down the transmission 68 to the 3rd-gear position, even if the X3RDD flag is set at "0".

(0074) Step SS17 is next implemented to determine whether the currently selected position G read in step SS1 is the 1st-gear position or not. If an affirmative decision is obtained in step SS17, one cycle of execution of the present routine is terminated since the transmission cannot be shifted down, and the processes of step S1 and subsequent steps are repeated. If a negative decision is obtained in step SS17, step SS18 is implemented to select the downshift boundary at which the transmission is shifted down from its current speed, from three types of down-shift boundary lines, which already have vehicle speed SPD and throttle opening TA shown in FIG. 21 stored as shift boundary parameters, i.e., the downshift boundary lines used for shifting down the transmission 68 from the 2nd-gear position to the 1st-gear position, from the 3rd-gear position to the 2nd-gear position, and from the 4th-gear position to the 3rd-gear position, respectively. When the currently selected position is the 3rd-gear position, for example, the downshift boundary line from the 3rd-gear position to the 2nd-gear position as indicated in FIG. 21(b) is selected.

(0075) In step SS18 the downshift vehicle speed SPDd is obtained from the boundary line selected above and the current throttle opening TA, followed by step SS9, in which, downshift vehicle speed SPDd is adjusted by performing the equation SPDd ←SPDd × Ks. In other words, adjustment is performed by multiplying the shift-speed compensating coefficient Ks calculated in step SD25.

(0076) Then, the control flow goes to step SS20, where this adjusted downshift vehicle speed SPDd and the current vehicle speed SPD are compared to determine whether the transmission is to be shifted down. Described more specifically, the transmission 68 should be shifted down if the currently detected vehicle speed SPD is equal to or lower than the adjusted downshift vehicle speed SPDd. If so, after step SS21 and step SS22 are implemented to determine whether the transmission 68 has been shifted down from the 4th to the 3rd-gear position, step SS23 is implemented to provide transmission output shifted down by one speed to the transmission 68. If SPDd<SPD, one cycle of execution of the present routine is terminated, and step SS1 and subsequent steps are repeated. If it is determined wall and down to 3rd speed has occurred as a result of power-on in step SS21, the content of the power-on 4 →3 downshift flag X43DWN in step SS22 is set to "1".

(0077) Where the shift-speed compensating coefficient Ks is larger than 1.0, the adjusted upshift and downshift vehicle speeds SPDu and SPDd are increased, whereby the transmission is more likely to be shifted down and the drive force increased. Where the compensating coefficient Ks is smaller than 1.0, on the other hand, the adjusted upshift and downshift vehicle speeds SPDu, SPDd are lowered, whereby the transmission is more likely to be shifted up.

(0078) Referring to the block diagram of FIG. 22, there is illustrated a major portion of the transmission electronic control unit 34. As shown in the diagram, in this embodiment, by means of a reference load curve setting means 80, the standard running load curve, which is represented by the throttle opening angle TA and vehicle speed SPD when the vehicle is running under normal conditions, is set. By means of the running load calculating means 82, which corresponds to steps SD5 and SD 20 described above, the running load coefficient KFUKASM, which is represented on the basis of the throttle opening angle TA and vehicle speed SPD, is successively calculated based on the aforesaid standard running load curve. Next, by means of the drive force control means 84, which corresponds to steps SS1 through SS 23 in FIG. 18, the gear means of the automatic transmission 68, i.e., shifting, is controlled based on the running load coefficient KFUKASM successively calculated above, and the drive force of the vehicle is adjusted.

(0079) Thus, the drive force of the vehicle is adjusted based on the actual running load, so good drivability can be obtained in all running regions of the vehicle irrespective of changes in the running load due to the road gradient or other factors.

(0080) In the present embodiment, the running load calculating means 82 is adapted to implement step SD5 for determining the standard running load-vehicle speed "a" on the basis of the throttle opening angle TA and according to the TA-SPDs relationship as indicated in FIG. 3, and step SD7 or SD9 for calculating a running load coefficient KFUKA (=a/c, or 2-b/a) on the basis of the actually detected vehicle speed "c" or "b" and the determined standard loaded-vehicle speed. The calculated running load coefficient KFUKA represents the running load of the vehicle used to control the vehicle drive force. The standard loaded-vehicle speed and the detected vehicle speed may be replaced by a standard loaded-vehicle throttle opening angle and the detected throttle opening angle. In this case, the running load coefficient KFUKA is calculated on the basis of the standard loaded-vehicle throttle opening angle and the detected throttle opening angle. However, the throttle opening angle usually changes at a higher rate than the vehicle speed, and the determined standard loaded-vehicle throttle opening angle is greatly influenced by a change in the operating position of the accelerator pedal and becomes unstable. In this respect, it is desirable to use the standard loaded-vehicle speed "a" and the detected vehicle speed "b" or "c" in calculating the running load coefficient KFUKA. This arrangement removes influence of the accelerating and decelerating operations described above. It will be understood that step SD5 corresponds to the means for determining the standard loaded-vehicle speed, while steps SD7 and SD9 correspond to load coefficient calculating means for calculating the running load coefficient.

(0081) The illustrated embodiment is also characterized by step SD6, wherein step SD9 is selected to calculate the running load coefficient KFUKA according to the equation KFUKA=2-(b/a), when the detected actual vehicle speed "b" is lower than the standard loaded-vehicle speed "a", and step SD7 is selected to calculate the coefficient KFUKA according to the equation KFUKA=a/c when the detected actual vehicle speed "c" is higher than the standard loaded-vehicle speed "a". The a specified throttle opening angle, the running load coefficient KFUKA approaches the value "1", and changes in a linear relation with changes in the vehicle speed SPD, offering the advantage that a degree of smoothing by the smoothing can be made roughly uniform Step SD6 corresponds to means for selecting the equations for calculating the running load coefficient KFUKA, which means is included in the above-indicated means for calculating the running load coefficient KFUKA.

(0082) Further, the illustrated embodiment is adapted such that the running load coefficient KFUKA calculated successively is subjected to a smoothing operation in step SD20, to obtain the smoothed running load coefficient KFUKASM which is used as the actual vehicle running load, having the advantage that shifting control is stabilized by comparison using the non-smoothed running load coefficient KFUKA which changes in relation to subtle operation of the accelerator pedal. Step SD20 corresponds to means for smoothing the running load coefficient as calculated successively, which means is also included in the load coefficient calculating means.

(0083) In the illustrated embodiment, step SD20 for smoothing the non-smoothed vehicle load KFUKA is preceded by step SD19 in which the smoothing amount is changed depending upon the running conditions of the vehicle, as shown in FIG. 7, such as those represented by the running load, state of acceleration or deceleration, on the throttle valve being in idle position, in which offers the advantage of a better smoothing effect. Step SD19 functions together with step SD20 to provide the smoothing means.

(0084) Further, the illustrated embodiment is adapted to implement step SD17 to skip steps SD19 and SD20 to thereby inhibit the smoothing operation and substantially maintain the last obtained value of the smoothed running load coefficient KFUKASM, for a predetermined period CHANTEN after the non-smoothed running load coefficient KFUKA is changed from a value equal to or larger than 1.0 to a value smaller than 1.0, or vice versa. Since the state of this XKASOKU flag used in determining the amount of smoothing is determined by the speed of the vehicle, a change in the updated value KFUKASM would be delayed with respect to a change in the actual running conditions of the vehicle. To avoid this drawback, in step SD17 the coefficient KFUKASM is not updated or the last value of this coefficient is maintained for the above-indicated period of time. Step SD17 corresponds to means for temporarily inhibiting the operation of the smoothing means, which is also included in the load calculating means.

(0085) The illustrated embodiment is further adapted to implement step SD18 to skip steps SD19 and SD20 to thereby inhibit the smoothing operation and substantially maintain the last obtained value of the smoothed running load coefficient KFUKASM, for a predetermined period CHASSIN after the vehicle has started. In this respect, it is noted that the smoothed vehicle load value KFUKASM is greatly influenced by acceleration during a period following the starting of the vehicle and reduced toward the high-load side. To avoid this drawback, in step SD 18 the coefficient KFUKASM is not updated for the above-indicated period of time after the starting of the vehicle, so deviation to the high load side is eliminated. Step SD18 also corresponds to means for temporarily inhibiting the operation of the smoothing means, which is also included in the load calculating means.

(0086) In this embodiment, the drive force control means 84 is adapted to implement step SS9 to adjust the nominal shift boundary lines on the basis of the determined running load of the vehicle, more specifically, on the basis of the calculated smoothed running load coefficient KFUKASM, so that the transmission is shifted up and down depending upon a change in the load acting on the vehicle, so as to assure not only high fuel economy of the vehicle but also high drivability of the vehicle over the entire ranges of the engine load and the vehicle speed. Steps SS9 corresponds to means for adjusting the nominal shift boundary lines.

(0087) Moreover, in this embodiment, step SD25 is implemented to calculate the shift-speed compensating coefficient Ks on the basis of the smoothed running load coefficient KFUKASM and according to the predetermined relationship as indicated in FIG. 12. This compensating coefficient Ks is used to adjust the shifting boundary lines described above. The characteristics are adjusted with respect to the running load (road gradient) of the smoothed running load coefficient KFUKASM, a linear feel is sufficiently provided and drivability is improved..

(0088) In the illustrated embodiment, steps SE7, SE8 and SE9 are provided to inhibit a upshift action of the automatic transmission when the smoothed running load coefficient KFUKASM exceeds the first threshold value of 1.20. This arrangement is effective to avoid possible frequent alternate downshift and upshift actions of the transmission which would occur due to insufficient driving force upon shifting or a when downshift occurs when the accelerator pedal is depressed due in a high-load state. Thus, steps SE7 through SE9 correspond to upshift inhibiting means for inhibiting an upshift action of the transmission when the smoothed coefficient KFUKASM exceeds 1.20.

(0089) The illustrated embodiment is adapted such that steps SE7, SE8 and SE9 indicated above are implemented when an affirmative decision is obtained in step SE1, namely, immediately after the transmission has been shifted down from the highest-speed, i.e., 4th-gear position to the lower-speed position, i.e., 3rd-gear position, as a result of depression of the accelerator pedal and a consequent increase in the throttle opening angle.

(0090) In this embodiment, moreover, it is also noted that steps SE11, SE4 and SE5 are provided to cancel the inhibition of the upshift action of the transmission 86 when the smoothed running load coefficient KFUKASM is reduced below the second threshold value K3HOLD which is smaller than the first threshold value. More specifically described, in step SE3 the second threshold value K3HOLD is smaller by the predetermined value β than the smoothed coefficient KFUKASM when it exceeds the first threshold value. Since there is a suitable amount of difference between the first threshold value and second threshold value K3HOLD, it is possible to prevent undesirable alternate inhibition of the upshift action and cancellation of the inhibition due to hysteresis which would be caused if the same threshold value was used for inhibiting the upshift action and releasing the prevention. Steps SE11, SE4 and SE5 correspond to releasing means for releasing the prevention of the upshift action.

(0091) In this embodiment, steps SE12 through SE19 are provided to determine whether a change of the running condition of the vehicle from a decelerating state to an accelerating state has been repeated a predetermined number of times while the upshift action to the 4th-gear position is being inhibited by the upshift inhibiting means. Cancellation of the upshift inhibition is cancellation from the high drive force sided to the load drive force side and must be determined by the required force during acceleration. Provisionally, cancellation is performed when is determined that reversal from deceleration to acceleration has occurred by change in the vehicle speed, which is has a delayed responsiveness. In each time or reversal to acceleration occurs, it is determined in step SE3 whether or not the high drive force should be maintained. Thus, the transmission is allowed to be shifted up depending upon the vehicle drive force required during acceleration of the vehicle. Steps SE12-SE19 function as the means for releasing the prevention of the upshift action.

(0092) The second threshold value K3HOLD used in this embodiment to cancel the inhibition of the upshift action is determined in step SE10 such that the second threshold value K3HOLD is equal to KFUKASM - β. The value KFUKASM used to determine the value K3HOLD is the value determined at one of the following two moments, whichever is later: the moment when the inhibition of the upshift action is started, and the moment when the change of the vehicle from the decelerating state to the accelerating state has been repeated the predetermined number of times. In the Shift Example I shown in the upper part of FIG. 23, the inhibition is cancelled when the smoothed running load coefficient KFUKASM is lowered below a predetermined threshold value of about 1.15, the prevention of shifting up to the 4th speed position due to factors such as delay in the smoothing process of the load coefficient KFUKASM was a problem, but according to this embodiment, as shown in the lower part of FIG. 23, there is a damage that this delay in cancellation of the shift up inhibition can be shortened. Step SE10 corresponds to means for determining the second threshold value for releasing the prevention of the upshift action to the 4th-gear position.

(0093) In the illustrated embodiment, steps SA1 through SA4 and steps SA7 through SA16 are provided to shift down the transmission from the 4th-gear position to the 3rd-gear or 2nd-gear position, or from the 3rd-gear position to the 2nd-gear position, under a given condition of the vehicle while the vehicle is coasting, that is, when the following conditions are satisfied: the smoothed running load coefficient KFUKASM is smaller than the reference value of 0.95, the throttle opening angle TA is smaller than a reference value zero corresponding to the idling position of the throttle valve, and the detected acceleration value α of the vehicle is larger than the appropriate reference value $\alpha_{4\text{-}2D}$, $\alpha_{4\text{-}3D}$ or $\alpha_{3\text{-}2D}$. This arrangement is effective to apply an engine brake to the vehicle during downhill running of the vehicle. Steps SA1-SA4 and SA7-SA16 correspond to downshift means for shifting down the transmission, which means is a part of the drive force control means.

(0094) In this embodiment, moreover, the reference values $\alpha_{4\text{-}2D}$, $\alpha_{4\text{-}3D}$ or $\alpha_{3\text{-}2D}$ are determined in steps SA8, SA10 and SA14, on the basis of the vehicle speed SPD during coasting of the vehicle, providing an appropriate engine braking effect. Steps SA8, SA10 and SA14 are included in the downshift means, functioning as means for determining reference values.

(0095) In this embodiment, step SA2 is provided so that when the non-smoothed running load coefficient KFUKA has increased to the second reverence value of 1.05 or larger, the automatic downshift control is released. This offers the advantage of allowing the automatic downshift to be cancelled immediately in response to depression of the accelerator pedal. Step SA2 functions as the downshift release means.

(0096) An embodiment has been explained above in detail referring to the drawings, but other embodiments of the present invention are possible.

(0097) For example, the throttle opening angle TA is used as a quantity expressing the engine load in the variable making up the shifting boundary in the embodiment described above, but another value such as the amount of depression of the accelerator pedal or the fuel injection amount may be used in its stead.

(0098) In addition, in the embodiment described above compensation is performed based on the running load by multiplying the shifting vehicle speeds SPDu and SPDd by the shift-speed compensating coefficient Ks, but compensation may also be effected by adding a shift-speed compensating coefficient Ks, or by adding compensation based on 3rd, 4th, ... compensation values considering other driving conditions such as the air intake amount and target air intake amount.

(0099) Also, in the steps SD17 through SD20 of the running load detection routine shown in FIG. 2, updating of the smoothed running load coefficient KFUKASM was halted by temporarily halting the smoothing process for specified interval after reversal of the running load coefficient KFUKA and during the vehicle starting time, but the smoothing process that uses an extremely large smoothing amount may also be used.

(0100) Further, in step SD18 in FIG. 2 above, the start status determination timer content CHASSIN, which measures the period until a preset value that has been preset is decremented to zero, is used to prevent the updating of the smoothed running load coefficient KFUKASM, but instead, the smoothing process can be halted while a specified period of about 6 seconds has not elapsed while the content of the flag XHASSIN, which is cleared to "0" at a speed of around 10 km/h and is set to "1" at a vehicle speed of about 40 km/h, is "zero", and the vehicle speed SPD is a specified value of about 10 km/h or above.

(0101) Moreover, in steps SE13 through SE19 shown in FIG. 16 described above, a decision to provisionally cancel the upshift inhibition to the 4th speed position is made based on the judgment that reversal from deceleration to acceleration has occurred twice, but a standard of three times or more may also be used.

(0102) In addition, in step SA3 in FIG. 13 described above, is determined whether the idle switch is in OFF status, but determination may be made as to whether or not the throttle opening angle TA is a specified value or below.

(0103) Also, in step SE3 in FIG. 16, to reference value of 1.2 is used, in step SA1 and in step SA2 in FIG. 13, reference values of 0.95 and 1.05 are used, respectively, but these values need not necessarily be used.

(0104) Also, in the embodiment described above, based on the running load coefficient KFUKASM, the boundary lines for shifting the gears in the automatic transmission 68, or specifically, the shifting-point vehicle speeds SPDu and SPDd are controlled so that shifting down can be performed more easily as the running load coefficient KFUKASM increases. However, with vehicles, for example, of a type in which the throttle 20 is driven by a straw actuator, the drive force control means 84 may be modified to adjust the throttle opening angle such that the adjusted angle increases with an increase in the running load coefficient KFUKASM.

(0105) The separate control units 32, 34 for controlling the engine 10 and the transmission 68 in the first and second embodiments may be replaced by a single electronic control device designed to control the engine 10 and the transmission 68.

(0106) While the drive force control apparatus according to the illustrated embodiments is used for controlling the automatic transmission 68 having four forward drive positions, the present invention is applicable to a continuously variable transmission whose speed ratio is continuously variable, such as a belt-and-pulley type in which a pair of variable-diameter pulleys whose effective diameters are variable are connected by a power transmission belt.

(017) It is further to be understood that the present invention may be embodied with various other changes, modifications and improvements, which may occur to those skilled in the art, without departing from the spirit and scope of the invention defined in the following claims.

(BRIEF DESCRIPTION OF THE DRAWINGS)

FIG. 1 is a schematic view showing an engine assembly and an automatic transmission of a motor vehicle, and a control system for controlling the engine and transmission, which control system incorporates a vehicle drive force control apparatus according to a first embodiment of the present invention;

FIG. 2 is a flow chart illustrating a running load detection routine executed by a transmission electronic control unit to detect a running load coefficient in FIG. 1;

FIG. 3 is a graph indicating an example of a standard load curve selected in step SD4 to calculate the running load coefficient KFUKA in FIG. 2;

FIG. 4 is a graph indicating a change of the running load coefficient KFUKA calculated in a routine of FIG. 2, according to predetermined equations during vehicle running in low-load and high-load states;

FIG. 5 is a flow chart illustrating a start and acceleration/deceleration status determining routine executed by the electronic transmission control unit shown in FIG. 1;

FIG. 6 is a graph indicating a relationship used in step SH19 of the routine of FIG. 5 to calculate a delay time KOFF by which the cancellation of inhibition of transmission upshift to the 3rd-gear position is delayed;

FIG. 7 is a view indicating a relationship used in step SD19 of the routine of FIG. 2 to determine the amount of smoothing based on the running load coefficient KFUKA;

FIG. 8 is a view comparing depicting a waveform of the smoothed running load coefficient KFUKASM obtained in step SD20 of the routine of FIG. 2, in comparison with a waveform of the non-smoothed value KFUKA;

FIG. 9 is a view for explaining an effect obtained by inhibiting the smoothing in step SD20 of the running load coefficient KFUKA for a predetermined delay time following a change of the value KFUKA across the level of 1 in FIG. 2;

FIG. 10 is a graph corresponding to the top graph of FIG. 9, in the case where the smoothing of the running load coefficient KFUKA for the delay time is not inhibited;

FIG. 11 is a graph for explaining a change in the smoothed running load coefficient KFUKASM of FIG. 2 in relation to the gradient of the road surface on which the vehicle runs;

FIG. 12 is a graph indicating a relationship used in step SD25 of the routine of FIG. 2 to calculate a shift-speed compensating coefficient Ks on the basis of the smoothed running load coefficient KFUKASM;

FIG. 13 is a flow chart illustrating an automatic downshift control routine executed by the transmission control unit to control downshift flags for regulating automatic downshift actions of the transmission so as to provide an adequate engine-braking effect;

FIG. 14 is a graph indicating relationships used in steps SA8, SA10 and SA14 of the routine of FIGS. 13A and 13B to calculate reference acceleration values $\alpha_{4\text{-}2D}$, $\alpha_{4\text{-}3D}$ and $\alpha_{3\text{-}2D}$;

FIG. 15 is a graph indicating relationships used in step SA17 of the routine of FIG. 13 to calculate a reference acceleration α_U;

FIG. 16 is a flow chart illustrating a routine executed by the transmission electronic control unit in FIG. 1 to inhibit an upshift action of the transmission to the 4th-gear position, for avoiding frequent shifting actions of the transmission;

FIG. 17 is a time chart illustrating varying states of flags and a counter used in the routine of FIGS. 16A and 16B;

FIG. 18 is a flow chart illustrating a main shift control routine executed by the transmission electronic control unit to control shifting actions of the transmission;

FIGS. 19(a), 19(b) and 19(c) are graphs indicating upshift boundary lines for shifting up the transmission used in the transmission control in FIG. 18 (a) from the 1st-gear position to the 2nd-gear position, (b) from the 2nd-gear position to the 3rd-gear position, and (c) from the 3rd-gear position to the 4th-gear position, respectively;

FIG. 20 is a graph indicating shift boundary lines including a upshift boundary line used in step SS8 of the routine of FIG. 18 to calculate a upshift vehicle speed after the inhibition of this upshift action to the 4th-speed position is released;

FIGS. 21(a), 21(b) and 21(c) are graphs indicating downshift boundary lines for shifting down the transmission used in the transmission control in FIG. 18 (a) from the 2nd-gear position to the 1st-gear position, (b) from the 3rd-gear position to the 2nd-gear position, and (c) from the 4th-gear position to the 3rd-gear position, respectively;

FIG. 22 is a block diagram illustrating major functional components of the vehicle drive force control apparatus according to the transmission electronic control unit of FIG. 1;

FIG. 23 is a timing chart for explaining an operation according to the routine of FIG. 16 to cancel the inhibition of the transmission upshift to the 4th-gear position.

(EXPLANATION OF THE REFERENCE NUMERALS)

68: automatic transmission

80: reference load curve setting means

82: running load calculating means

84: drive force control means

FIG. 1

52: variable valve timing mechanism
64: air-conditioners which
66: shift lever sensor
68: automatic transmission

FIG. 2

Running load detection routine
Start
SD1 Reading TA
SD2 Reading SPD
SD3 Reading gear position
SD4 Selecting appropriate map according to gear position
SD5 Calculating standard running load vehicle speed "a" corresponding to present TA
SD6 Standard running load vehicle speed "a" > detected vehicle speed?
SD7 Calculation on low-load side
SD8 Setting XCOAST flag
SD9 Calculation on high-load side
SD10 Clearing XCOAST flag
SD11 XCOAST reversed?
SD12 Setting CHANTEN timer
SD13 Storing KFUKA
SD14 Reading KFUKA
SD15 Reading CHANTEN
SD16 Reading CHASSIN
SD17 CHANTEN = 0?
SD18 CHASSIN = 0?
SD19 Determining smoothing amount
SD20 Performing smoothing process
SD21 Storing KFUKASM
SD22 KFUKASM ≥ 1.00?
SD23 Clearing XTOHAN flag
SD24 Setting XTOHAN flag
SD25 Calculating compensation coefficient Ks based on KFUKASM
Return

Step SD4: standard load curve setting means
Step SD5 through SD20: running load calculating means

FIG. 3

Throttle opening angle TA High-load zone Normal flat road running

Low-load zone

Standard running load vehicle speed SPDs

FIG. 4

Running load coefficient KFUKA

Vehicle speed SPD

FIG. 5

Start
SH1 Reading SPD
SH2 Reading CHASSIN
SH3 $\mathrm{SPD} < 40$?
SH4 $\mathrm{SPD} \geq 10$?
SH5 Clearing CHASSIN timer
SH6 Starting CHASSIN timer
SH7 Decrementing CHASSIN
SH8 Storing CHASSIN
SH9 Reading CHANTEN
SH10 Decrementing CHANTEN
SH11 Storing CHANTEN
SH12 Reading SPD0
SH13 SPD:SPD0
SH14 Setting XKASOKU
SH15 Clearing XKASOKU
SH16 Storing SPD as SPD0
SH17 Idle SW. OFF?
SH18 Reading TA
SH19 Calculating threshold KOFF
SH20 Reading CIDLOF
SH21 Incrementing CIDLOF I timer
SH22 Clearing CIDLOF
SH23 Storing CIDLOF
End

FIG. 6

Third gear automatic shift down release delay time KOFF
Throttle opening TA (%)

FIG. 7

XTOHAN	XCOAST	YIDL	XKASOKU	Running state	Smoothing amount
*	0	1	*	Stopped	1/128
	1	*	0	Coasting	1/64
1	0	1	*	Positive load run	1/16
	1	*	0	Load changed to positive	1/2
0	0	1	*	Negative load run	1/2
	1	*	0	Load changed to negative	1/16

XTOHAN: status of smoothed load coefficient
(0 = less than 1.0, 1 = 1.0 or greater)
XCOAST: status of non-smoothed load coefficient
(0 = less than 1.0, 1 = 1.0 or greater)
YIDL: idle switch (0 = OFF, 1 = ON)
XKASOKU: acceleration/deceleration status (0 = deceleration, 1 = acceleration)

FIG. 8

[Left]
Running load coefficient
Throttle opening TA (%)
[Right]
Vehicle speed SPD (km/h)
[Bottom]
Time

FIG. 9
When delay interval is provided
[left] running load coefficient
[right] delay interval
delay interval
[left] vehicle speed SPD
Throttle opening TA

FIG. 10

When no delay interval is provided
Running load coefficient

FIG. 11

[top] Flat
[left] Smoothed load coefficient KFUKASM
[bottom] Road surface gradient (deg.)

FIG. 12

Shift speed compensating coefficient Ks
Smoothed running load coefficient KFUKASM

FIG. 13

Automatic downshift control routine

START
SA1 KFUKASM ≤ 0.95?
SA2 KFUKA < 1.05?
SA3 Idle sw. OFF?
SA4 CIDLOF < KOFF?
SA5 Clearing "X3RDD" flag
SA6 Clearing "X3NDD" flag
SA7 X3RDD = 0?
SA8 4 → 2 down
Calculating reference acceleration $\alpha_{4\text{-}2D}$
SA9 $\alpha > \alpha_{4\text{-}3D}$?
SA10 4 → 3 down
Calculating reference acceleration $\alpha_{4\text{-}3D}$
SA11 $\alpha > \alpha_{4\text{-}3D}$?
SA12 Setting X3RDD flag
SA13 X3NDD = 0?
SA14 3 → 2 down
Calculating reference acceleration $\alpha_{3\text{-}2D}$
SA15 $\alpha > \alpha_{3\text{-}2D}$?
SA16 Setting X2NDD flag
SA17 2 → 3 up
Calculating reference acceleration $\alpha_{2\text{-}3U}$
SA18 $\alpha < \alpha_{2\text{-}3U}$?
SA19 Setting X2NDD flag
END

FIG. 14

Reference acceleration α_D
0 → large
Vehicle speed SPD (km/h)

FIG. 15

Reference acceleration α_U
Small →0 → large
Vehicle speed

FIG. 16

START
SE1 X43DWN = 1?
SE2 X3RDH + 1?
SE3 KFUKASM ≥ 1.20?
SE4 Clearing X3HOLD flag
SE5 Setting X43DWN flag
SE6 Clearing X3RDH flag
SE7 Clearing C3RDH counter
SE8 Setting X3RDH flag
SE9 Setting X3HOLD flag
SE10 Calculating release threshold value K3HOLD ←KFUSASM - β
SE11 KFUKASM ≥ K3HOLD?
SE12 Reading C3RDH
SE13 C3RDH = 0?
SE14 C3RDH = 1?
SE15 Deceleration?
SE16 C3RDH = 2?
SE17 Acceleration
SE18 Increment C3RDH counter
SE19 C3RDH ≥ 3
END

FIG. 17

Shift action	4th	3rd	Initial states	Provisional release	Inhibition continued	Provisional cancellation	Cancelled
X3RDH	0	1					
XEHOLD	0	1					
XKASOKU	0	1		3			
C3RDH	0						

FIG. 18

Shift control routine

START
SS1 Reading gear position
SS2 4th?
SS3 3rd?
SS4 X2NDD = 0?
SS5 X3RDH = 0?
SS6 X3HOLD = 1?
SS7 Calculating basic upshift speed
SS8 Calculating upshift vehicle speed for canceling inhibition of upshift to 4th
SS9 Compensation of upshift shifting speed
SS10 Upshift
SS11 Up to 4th
SS12 Clear X3HOLD flag
SS13 Clear X43DWN flag
SS14 Upshift execution process
SS15 X3RDD = 0?
SS16 X3RDH = 0?
SS17 1st?
SS18 Calculation of basic downshift speed from map
SS19 Correction of downshift shifting point
SS20 Shift down
SS21 Power-on 3rd down?
SS22 Set X43DWN flag
SS23 Downshift execution process
RETURN

FIG. 19

(a)	(b)	(c)
1st →2nd	2nd →3rd	3rd →4th
TA	TA	TA
SPD	SPD	SPD

FIG. 20

[left] throttle opening TA (%)
[in graph] 4th-3rd downshift boundary line
2nd-4th upshift boundary line used only while 3rd hold in progress
3rd-4th boundary upshift boundary line
[bottom] →vehicle speed SPD (km/h)

FIG. 21

(a)
2nd →1st
TA

SPD

(b)
3rd →2nd
TA

SPD

(c)
4th →3rd
TA

SPD

FIG. 22

10: engine
36: throttle sensor
72: vehicle speed sensor
80: standard load curve setting means
68: automatic transmission
84: drive force controlling means
82: running load calculating means

FIG. 23

release delay

Shift L/U
4th
3rd

(release) (1)

Running load coefficient
KFUKASM

Vehicle speed SPD

Throttle opening angle (TA)

(uphill) (flat)

Shift L/U
4th
3rd

(start) (release)
condition (3)

Running load coefficient
KFUKASM

condition (2)

Vehicle speed SPD

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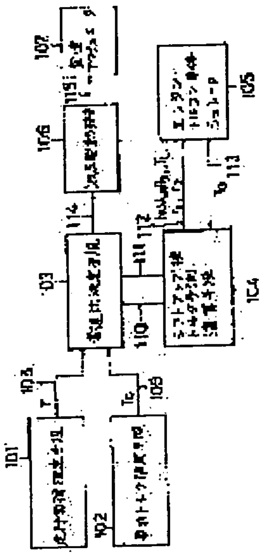
(54) SHIFT CONTROLLER FOR AUTOMATIC TRANSMISSION

(57)Abstract:
PURPOSE: To provide such an automatic transmission shift controller that secures the shift control of an automatic transmission accurately reflected to a driving state in a positive manner, and makes a sufficient fuel consumption so as to be promoted.
CONSTITUTION: This shift controller is provided with a transmission gear ratio changed torque predicting means for predicting and operating the extent of torque after changing the gear ratio, and on the basis of the predicated operational result by this transmission gear ratio changed torque predicating operation means, a transmission gear ratio of the automatic transmission is controlled.



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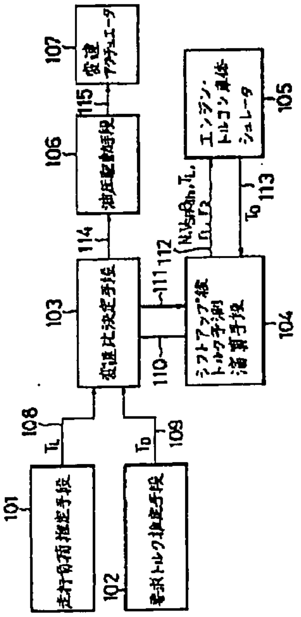
(54)【発明の名称】　自動変速機の変速制御装置

(57)【要約】

【目的】運転状況を的確に反映した自動変速機の変速制御が確実に得られ、充分な燃費向上が図れるようにした自動変速機の変速制御装置を提供すること。

【構成】変速比変更後のトルクを予測演算する変速比変更後トルク予測演算手段を設け、この変速比変更後トルク予測演算手段による予測演算結果に基づいて自動変速機の変速比を制御するようしたもの。

【図1】



【特許請求の範囲】

【請求項１】　制御信号によって段階的に変速比が決定される車両用自動変速機において、変速比変更後のトルクを予測演算する変速比変更後トルク予測演算手段を設け、この変速比変更後トルク予測演算手段による予測演算結果に基づいて上記制御信号を演算するように構成したことを特徴とする自動変速機の変速制御装置。

【請求項２】　請求項１の発明において、変速比の変更に伴うトルク変動をシミュレーション処理により演算するトルク変動シミュレーション手段を設け、上記変速比変更後トルク予測演算手段が、このトルク変動シミュレーション手段によるシミュレーション結果に基づいて上記制御信号を演算するように構成されていることを特徴とする自動変速機の変速制御装置。

【請求項３】　請求項２の発明において、車両の走行負荷を推定する走行負荷推定手段と、運転者により要求されているトルクを推定する要求トルク推定手段とを設け、上記走行負荷推定手段による推定結果と、上記要求トルク推定手段による推定結果と、上記変速比変更後トルク予測演算手段による予測演算結果とに基づいて上記制御信号を演算するように構成したことを特徴とする自動変速機の変速制御装置。

【請求項４】　請求項３の発明において、上記走行負荷推定手段が、上記自動変速機の出力トルクの検出結果と、車両に現れる加速度の検出結果とに基づいて車両の走行負荷を推定するように構成されていることを特徴とする自動変速機の変速制御装置。

【請求項５】　請求項４の発明において、上記車両に現れる加速度の検出結果が、独立して車両に取付けられた加速度センサによって与えられるように構成したことを特徴とする自動変速機の変速制御装置。

【請求項６】　請求項３の発明において、上記要求トルク推定手段が、エンジンのスロットルバルブ開度と車両の走行速度による要求トルクマップの検索により、運転者が要求するトルクを推定するように構成されていることを特徴とする自動変速機の変速制御装置。

【請求項７】　請求項２の発明において、上記トルク変動シミュレーション手段が、エンジン回転速度とスロットルバルブ開度によるエンジントルクマップの検索により求めたエンジントルクと、上記自動変速機のトルクコンバータの入力軸回転速度と出力軸回転速度からトルクコンバータ性能曲線マップの検索により求めたトルクコンバータのタービントルク及びポンプトルクとを用い、エンジンと車両の２自由度をもつ運動モデルからシミュレーション結果を与えるように構成されていることを特徴とする自動変速機の変速制御装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】

【０００２】

【産業上の利用分野】本発明は、トルクコンバータを備えた車両用の自動変速機に係り、特に自動車の自動変速機に好適な変速制御装置に関する。

【０００３】

【従来の技術】従来の自動変速機の変速制御装置は、例えば、特開昭６１－２２６７０６号公報に記載のように、車速及びスロツトル開度を電気信号として検知し、車速及びスロツトル(バルブ)開度を変数とし、予め設定されている変速パターンに基づいて、現在の車速及びスロツトル開度に対応する所定の変速段(比)を選択するようになっている。そして、このときの変速パターンは複数組設定されており、運転者によるパターン選択操作により切換えられるようになっている。なお、この変速パターンの選択は、パターン選択操作を特に行わなくても、運転者の運転操作状態により自動的に切換えられるようにしたものもある。

【０００４】

【発明が解決しようとする課題】上記従来技術は、自動変速機の変速パターンの多様化について配慮がされておらず、変速パターンが代表的な２～３の運転状況に基づいてだけ決められてしまうため、運転状況を的確に反映した変速が充分に得られず、その結果、燃費の悪化を招いてしまうことが多いという問題があった。

【０００５】本発明の目的は、運転状況を的確に反映した自動変速機の変速制御が確実に得られ、充分な燃費向上が図れるようにした自動変速機の変速制御装置を提供することにある。

【０００６】

【課題を解決するための手段】上記目的を達成するために、本発明は、変速比変更後のトルクを予測演算する変速比変更後トルク予測演算手段を設け、この変速比変更後トルク予測演算手段による予測演算結果に基づいて自動変速機の変速比が制御されるようにしたものである。

【０００７】具体的に、特定の一実施例に即していえば、走行負荷を推定する走行負荷推定手段と、要求トルクを検知する要求トルク推定手段と、変速比を算出する変速比決定手段と、シフトアツプ後(変速比変更後)のトルクを予測演算するシフトアツプ後トルク予測演算手段と、シフトアツプ後のトルクを予測演算するためのエンジン・トルコン・車体シミユレータ(トルク変動シミュレーション手段)と、変速機の制御油圧を変速アクチユエータに出力する油圧駆動手段とを有し、運転状況を的確に反映した変速を実行するようにしたものである。

【０００８】

【作用】シフトアツプ後トルク予測演算手段からは、現在の車速とエンジン回転数(回転速度)、現在の変速比、それにシフトアツプ後の変速比とがエンジン・トルコン・車体シミユレータに入力され、このエンジン・トルコン・車体シミユレータから変速後の発生トルクが出力され、シフトアツプ後トルク予測演算手段に送られる。走

行負荷推定手段と要求駆動力検知手段で検知された信号と、シフトアツプ後トルク予測演算手段とエンジン・トルコン・車体シミユレータで演算されたシフトアツプ後の発生トルク信号は変速比決定手段に入力され、ここで所定の変速比が決定される。

【０００９】

【実施例】以下、本発明による自動変速機の変速制御装置について、図示の実施例により詳細に説明する。なお以下の説明では、本発明を自動車の自動変速機に適用した場合について説明し、このため、変速比又はギア比については、自動車のトランスミツシヨンのギア比とファイナルギア比が乗算されたものとする。

【００１０】図１は、本発明の一実施例で、図において、１０１は走行負荷を推定する走行負荷推定手段で、その出力１０８からは走行負荷T_Lが変速比決定手段１０３に入力される。また、１０２は要求トルクを推定する要求トルク推定手段で、その出力１０９からは推定要求トルクT_Dが変速比決定手段１０３に入力される。

【００１１】そこで、変速比決定手段１０３からは、出力１１１として、現在の車速V_{SP}とエンジン回転数Ｎ、スロツトル開度θth、走行負荷T_L、現在の変速比r_1、それにシフトアツプ後の変速比r_2などのデータが、シフトアツプ後のトルクを予測演算するシフトアツプ後トルク予測演算手段１０４に入力され、この結果、このシフトアツプ後トルク予測演算手段１０４の出力１１２からは、現在の車速V_{SP}、エンジン回転数Ｎ、スロツトル開度θth、走行負荷T_L、現在の変速比r_1、それにシフトアツプ後の変速比r_2などのデータが出力され、エンジン・トルコン・車体シミユレータ１０５に入力される。

【００１２】そして、このエンジン・トルコン・車体シミユレータ１０５は、シフトアツプ後のトルクT_Oをシミユレーシヨンによつて演算し、その出力１１３からシフトアツプ後トルク予測演算手段１０４を介して変速比決定手段１０３に、このトルクT_Oを入力する。

【００１３】そこで、この変速比決定手段１０３では、以上の入力をもとに変速比の決定が行われ、変速指令信号１１４が油圧駆動手段１０６を介して変速アクチユエータ１０７に出力され、自動変速機の変速比が切換えられる。

【００１４】上記したように、従来の自動変速機の制御では、車速及びスロツトル開度だけを変数とし、予め設定されている変速パターンに基づいて、現在の車速及びスロツトル開度に対応する所定の変速段を選択するようにしてあり、従って、この方法では運転状況の変動、特に走行負荷の変化に対して的確な変速を行うことが困難であつた。例えば、平坦路や緩い下り坂などでは、登り坂に比べて早めにシフトアツプすることにより、運転性を損なうことなく、しかも燃費が向上すると考えられるが、従来はアクセル開度と車速のみから変速を行つていたので、このような変速は行えなかつた。

【００１５】そこで、この実施例のように、走行負荷を推定し走行負荷に応じた変速を行うようにしてやれば、燃費の向上が得られ、しかも運転状況に応じた的確な変速が得られることになるのである。

【００１６】図２は、本発明の一実施例が適用された自動車のエンジン駆動系とその制御ユニットを示したもので、エンジン２０１及びトランスミツシヨン（自動変速機）２０２からは、それぞれの運転状態を示す信号がＡ／Ｔコントロールユニット２０３に出力され、同様に、車両信号２０７及びＡＳＣＤコントロールユニット信号２０８も、Ａ／Ｔコントロールユニット２０３に出力される。そしてＡ／Ｔコントロールユニット２０３では、これらの信号から変速比を決定し、トランスミツシヨン２０２に変速指令信号２０６を出力する。

【００１７】図３は、図２に示されている各種の信号の詳細な説明で、信号３０４から信号３０７までがエンジンからの信号２０４に対応し、信号３０８から信号３１０までがトランスミツシヨンからの信号２０５に対応し、信号３１１から信号３１４までが車両信号２０７に対応し、信号３１５、３１６がＡＳＣＤコントロールユニツト信号２０８に対応し、信号３１７から信号３２１までがＡ／Ｔコントロールユニツト信号２０６に対応する。これらの信号は入力信号処理ユニツト３０２を介してＡ／Ｔコントロールユニツト２０３に入力され、このＡ／Ｔコントロールユニツト２０３から出力信号処理ユニツト３０３を介して出力される。

【００１８】図４は、図１の変速比決定手段１０３において行われている処理の流れを示したもので、以下、この流れ図により変速比決定手段１０３の処理について説明する。

ステップ４０１：走行負荷T_Lを計算する。

ステップ４０２：要求トルクT_Dを計算する。

ステップ４０３：シフトアツプ後の推定トルクT_Oを計算する。

ステップ４０４：$T_O > T_L + T_D$ならばステップ４０５に移る。

そうでなければステップ４０６に移る。

ステップ４０５：シフトアツプする。そしてステップ４０１に戻る。

ステップ４０６：シフトダウンの判定をした後、ステップ４０１に戻る。

なお、シフトダウンについては、従来の車速とスロツトル開度から予め定められた変速パターンにしたがつて変速を行う方法を用いても良いし、シフトアツプと同様の処理を行なうようにしても良い。

【００１９】ここで、要求トルクT_Dについてみると、これは運転者が求めている加速度に相当すると考えてよい。一方、$T_O - T_L$は、ギアがシフトアツプした後に発生すると予想されるトルクである。そこで、ステップ４

04では、これらの値を比較することにより、シフトアップの判定を行つているのである。

【0020】次に、図5により、走行負荷推定手段101について説明する。まず、加速度検出手段501は、加速度αを、信号507として走行負荷推定手段101に出力する。この信号507は図3の加速度センサからの信号314に対応する。タービン回転数N_tはトルクコンバータ(トルコン)のタービンの回転数で、これは、図3の車速センサ1の信号310からギア比r倍することにより求めても良いし、車速センサ2からの信号311から求めても良い。なお、車速センサ1の信号は変速機の出力軸に取り付けられた回転センサからの信号であり、車速センサ2の信号は車速メーターからの信号である。このエンジン回転数Nの信号506は図3のエンジン回転信号307に対応する。タービン回転数信号505及びエンジン回転数信号506はトルコン出力トルク推定手段502に入力される。

【0021】トルコン出力トルク推定手段502では、トルコンの入力軸と出力軸の回転比eを$e=N_t/N$で求め、トルコン特性テーブル504に出力する。トルコン特性テーブル504は、トルコンの回転比eからポンプトルクの係数τ、トルク比tを検索し、それぞれ信号511と512としてトルコン出力トルク推定手段502に出力する。そこで、このトルコン出力トルク推定手段502では、これらトルコンのポンプトルク係数τ、トルク比t、それにエンジン回転数Nの各データから、トルコンのポンプトルク、タービントルクと入力軸、出力軸の回転数の関係により、タービントルクT_tを、$T_p=\tau\cdot(N/1000)^2$、$T_t=T_p\cdot t$の関係式で求め、走行負荷推定手段101に出力する。なお、このタービントルクT_tはトルコン出力トルクT_tと同意義であり、これはトルクセンサを用いて直接測定してもよい。

【0022】そこで、走行負荷推定手段101では、このトルコン出力トルクT_tにギア比rを乗算して、車輪に発生するトルクT_mを算出し、加速抵抗を、車重Mと車輪の有効半径r_Wと、それに加速度αから、$M\cdot r_W\cdot\alpha$の関係式で算出し、走行負荷T_Lを、$T_L=T_m-M\cdot r\cdot\alpha$の関係式で算出する。以上の計算の流れを図6に示す。

【0023】図6において、

ステップ601：車速V_{SP}とエンジン回転数N、ギア比r、それに加速度α

のそれぞれのデータの読み込みを行う。

ステップ602：タービン回転数N_tを次式で演算する。

$N_t=V_{SP}/120\pi/r_W\cdot r\times1000$

ステップ603：トルコンの回転比eを求め、ポンプトルクの係数τとトルク比tを検索する。

$e=N_t/N$、$\tau=f_1(e)$、$t=f_2(e)$

ステップ604：ポンプトルクT_pとタービントルクT_tを計算する。

$T_p=\tau\cdot(N/1000)^2$、$T_t=t\cdot T_p$

ステップ605：トルクT_mの演算。$T_m=T_p\cdot r$

ステップ606：走行負荷T_Lの演算。$T_L=T_m-M\cdot r\cdot\alpha$

次に、要求トルク推定手段102の構成を図7に示す。この図7に示すように、要求トルク推定手段102にはスロツトル開度θ_{th}と車速V_{SP}が入力され、この要求トルク推定手段102から、さらに要求トルクテーブル702にスロツトル開度θ_{th}及び車速V_{SP}が出力される。この要求トルクテーブル702は、図8に示すように、これらスロツトル開度θ_{th}および車速V_{SP}から要求トルクT_Dを検索するようになつており、検索した要求トルクT_Dを要求トルク推定手段102に出力する。こうして、要求トルク推定手段102から推定要求トルクT_Dが出力される。

【0024】次に、図9は、エンジン・トルコン・車体シミュレータ(トルク変動シミュレーション手段)105の概要を示したもので、この図9から明らかなように、このシミュレーター105は、エンジンのトルク特性901、エンジンの慣性モーメント902、トルクコンバータのモデル903、変速機のモデル904、車両の重量905、それに走行負荷906を含んだシミユレータとなつており、このシミユレータに現在のエンジン回転数N、車速V_{SP}、現在のギア比r_1、シフトアツプ後のギア比r_2、走行負荷T_Lを与え、変速時の出力トルクT_mの変化を、シミユレーシヨンを行つて推定し、これによりシフトアツプ後の出力トルクを正確に推定することが可能となる。

【0025】変速の前後では一般にトルコンの入力軸と出力軸の回転比eが変化し、従つてトルコンの入力トルクと出力トルクのトルク比も変化する。つまり変速後の出力トルクをエンジン特性、及びギア比の変化だけから求めるようにしたのでは、大きな誤差を伴う。しかしこの回転比eの変化は運転状況によりまちまちである。そこで、変速時のトルコンの入出力の回転とトルクの伝達の様子をシミユレーシヨンによつて正確に求めることにより、変速時の出力トルクをかなり正確に推測でき、この変速後の出力トルクと要求トルクおよび走行負荷の関係からシフトアツプの判定を行うことによつて、運転状況に応じた的確な変速が可能になるのである。

【0026】図10は、変速時の出力トルクT_mの変化を模式的に示したもので、ギア比rは、変速時には図のように連続的に変化するのが一般的である。また、一方、出力トルクT_mは、図示のように変速シヨツクを伴つて変化し、変速直後は出力トルクが急変する。そこで、このシミユレータ105では、変速開始時刻をギア比の変化し始める時刻とし、変速終了時刻をギア比が一定になつてからある程度の時間がたつた後として、その

間の時間のシミュレーションを行なうようになっている。なお、以下の説明では、変速開始時刻をｔ＝０とし、変速終了時刻をｔ＝ｔendとしている。

【００２７】図１１はシミュレータのブロック図を示したもので、この図において、ブロック１１０１はスロットル開度θth とエンジン回転数ＮからエンジントルクT_0 を求めるテーブルであり、ブロック１１１１はトルコンの入力軸と出力軸の回転の比ｅからポンプトルク係数τとポンプトルクとタービントルクのトルク比ｔを求めるテーブルである。まず、ブロック１１１９ではポンプトルクTp が求められ、ブロック１１１８ではタービントルクTt が求められる。ブロック１１１０はエンジン慣性モーメントや変数の単位の変換のためのブロックであり、Te －Tp に乗算される。ブロック１１０９は積分要素で、ブロック１１１０の出力を積分してエンジン回転数Ｎが計算される。ブロック１１０２、ブロック１１０６は変速機のギア比で、与えられた時間変化にしたがつて変化する。ブロック１１０２の出力が出力トルクT_m であり、シミュレーション終了後、この値が出力される。ブロック１１２１では出力トルクT_m と走行負荷T_L の差を求めている。ブロック１１０３は車重と車輪の有効半径および変数の単位変換のためのブロックである。ブロック１１０４は積分要素で、車速V_{SP}が求められる。ブロック１１０５は車速からトランスミツシヨンの出力軸回転数を求めるためのブロックである。ブロック１１０７では、エンジン回転数Ｎ（＝トルコン入力軸回転数）とタービン回転数Nt から回転数の比ｅ＝Nt ／Ｎを求めている。

【００２８】図１２はトルコンの回転比ｅとポンプトルク係数τの関係を示したもので、図１３はトルコンの回転比ｅとトルク比ｔの関係を表わしたものである。また、図１４はエンジン回転数Ｎ、スロツトル開度θthとエンジントルクとの関係を表わしたものである。

【００２９】図１５は、このシミュレーションの処理の流れを表わしたもので、以下に処理の流れの詳細を示す。

【００３０】ステップ１５０１：現在のエンジン回転数Ｎ、車速V_{SP}をシミュレーションの初期値Ｎ（０）、Ｖ（０）として設定し、Ｔを積分計算ステツプ幅とし、ｎをシミュレーション終了までのステツプ数とする。すなわち、Ｎ（０）＝Ｎ、Ｖ（０）＝V_{SP}、ｉ＝０、ｎ＝ｔend／Ｎ　とする。ステップ１５０２：変速ギア比の時系列変化を、ｒ(０)＝r_1、ｒ(ｎＴ)＝r_2として、ｒ（ｉ）（ｉ＝１，２，３……（ｎ－１）Ｔ）に設定する。

ステップ１５０３：タービン回転数Nt(ｉ)を次式で計算する。

Nt(ｉ)＝Ｖ（ｉ）／１２０π／rw・ｒ(ｉ)×１０００

ステップ１５０４：トルクコンバータの入力軸と出力軸の回転比ｅを計算し、ポンプトルク係数τを図１２のトルコン特性マツプから検索して求め、トルコンのトルク

比ｔを図１３のトルコン特性マツプから検索して求める。つまり、ｅ＝Nt(ｉ)／Ｎ(ｉ)、τ＝f_1(ｅ)、ｔ＝f_2(ｅ)となる。

【００３１】

ステップ１５０５：ポンプトルクTp 、タービントルクTt を次式で求める。

Tp ＝τ・(Ｎ(ｉ)／１０００)^2、Tt ＝ｔ・Tp

ステップ１５０６：エンジントルクTe を図１４のエンジントルク特性マツプから求める。従って、Te ＝f_3(θth、Ｎ(ｉ)) となる。

ステップ１５０７：積分の係数を次式から求める。

ｘ＝(Te－Tp)×９.８／Ie ×６０／２π

ステップ１５０８：(ｉ＋１)Ｔでのエンジン回転数Ｎ(ｉ＋１)を求める。

Ｎ（ｉ+１）＝Ｎ（ｉ）＋Ｔ・ｘ

ステップ１５０９：出力トルクTe を求める。

Te ＝Tt・ｒ(ｉ)

ステップ１５１０：積分の係数ｘを求める。

ｘ＝(T_m－T_L)×９.８／Ｍ／rw ×３.６

ステップ１５１１：(ｉ＋１)Ｔでの車速Ｖ(ｉ＋１)を求める。

Ｖ(ｉ＋１)＝Ｖ(ｉ)＋Ｔ・ｘ

ステップ１５１２：(ｉ＋１)Ｔ＝ｔend ならばステップ１５１３でT_m を出力し、そうでなければステップ１５１４で　ｉをｉ＋１　としてステップ１５０３に戻る。

【００３２】従って、この実施例によれば、変速時のトルコンの入出力の回転状態と、トルクの伝達の様子がシミュレーシヨンによつて正確に求められ、この結果、変速時の出力トルクをかなり正確に推測でき、この変速後の出力トルクと要求トルクおよび走行負荷の関係からシフトアツプの判定が行えることになり、運転状況に応じた的確な変速が可能となる。

【００３３】

【発明の効果】本発明によれば、走行負荷を充分に正確に推定でき、この結果、走行負荷に充分に対応した変速が行えることになり、運転者の意向が充分に反映された状態のもとで、運転状況に応じた的確な変速が得られ、充分な燃費向上が図れると共に、良好な乗り心地を保った車両の運転が容易にえられることができる。

【図面の簡単な説明】

【図１】本発明による自動変速機の変速制御装置の一実施例を示すブロック図である。

【図２】本発明の一実施例が適用された自動車のエンジン駆動系とその制御ユニツトを示した構成図である。

【図３】本発明の一実施例におけるＡ／Ｔコントロールユニツトへの入力信号と出力信号の詳細を示す説明図である。

【図４】本発明の一実施例における変速比決定手段の処理の流れを説明するためのフローチャートである。

【図５】本発明の一実施例における走行負荷推定手段の

ブロック図である。

【図６】本発明の一実施例における走行負荷推定手段の処理の流れを説明するためのフローチャートである。

【図７】本発明の一実施例における要求トルク推定手段のブロック図である。

【図８】本発明の一実施例における要求トルク推定手段で使用されている要求トルクテーブルの説明図である。

【図９】本発明の一実施例におけるエンジン・トルコン・車体シミユレータを概念的に示した模式図である。

【図１０】本発明の一実施例における変速時の出力トルクの変化を模式的に示した説明図である。

【図１１】本発明の一実施例におけるエンジン・トルコン・車体シミユレータのブロック図である。

【図１２】本発明の一実施例におけるトルコンの回転比とポンプトルク係数の関係を表わす特性図である。

【図１３】本発明の一実施例におけるトルコンの回転比とトルク比の関係を表わす特性図である。

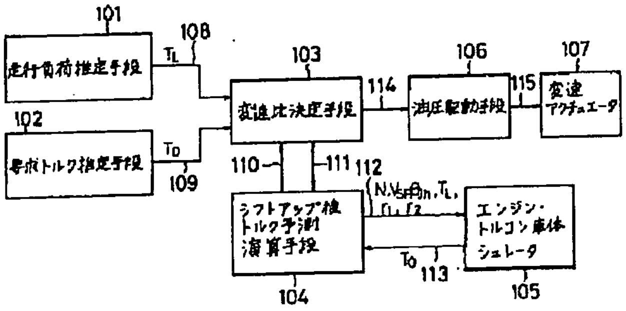
【図１４】本発明の一実施例におけるエンジン回転数とスロツトル開度及びエンジントルクとの関係を表わす特性図である。

【図１５】本発明の一実施例におけるエンジン・トルコン・車体シミユレータの処理の流れを説明するためのフローチャートである。

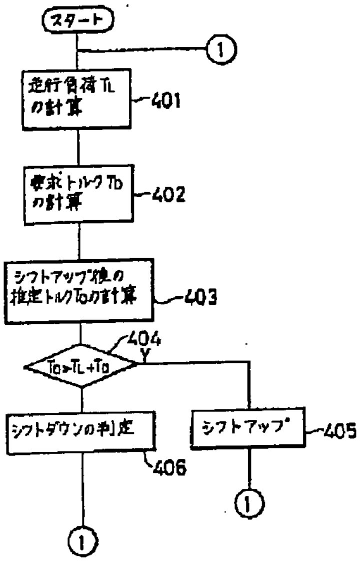
【符号の説明】

１０１	走行負荷推定手段
１０２	要求トルク推定手段
１０３	変速比決定手段
１０４	シフトアツプ後トルク予測演算手段
１０５	エンジン・トルコン・車体シミユレータ（トルク変動シミュレーション手段）

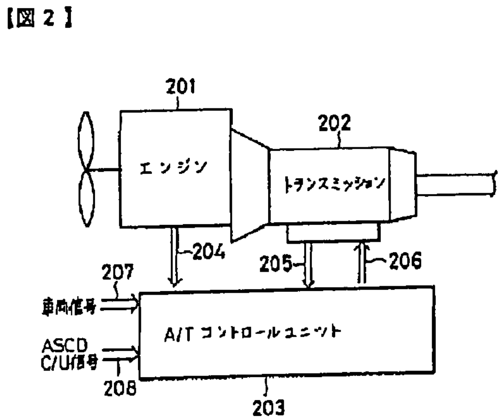
【図１】



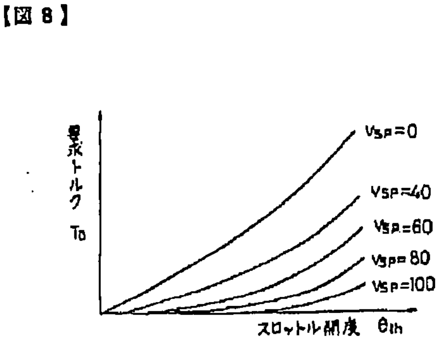
【図４】



【図２】

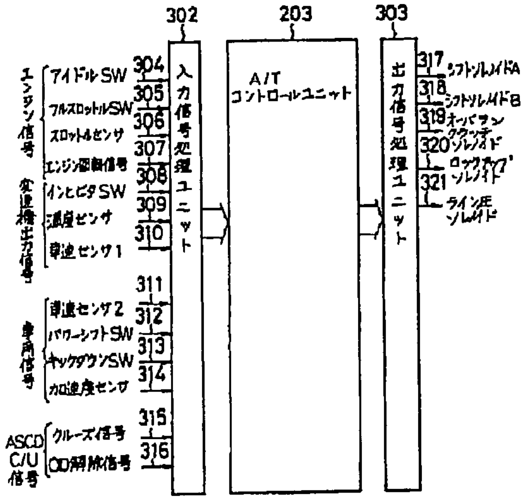


【図８】



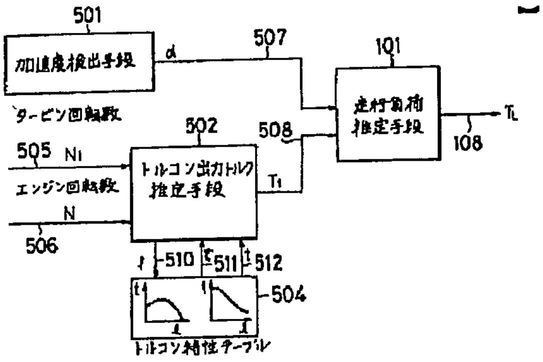
【図3】

【図 3】



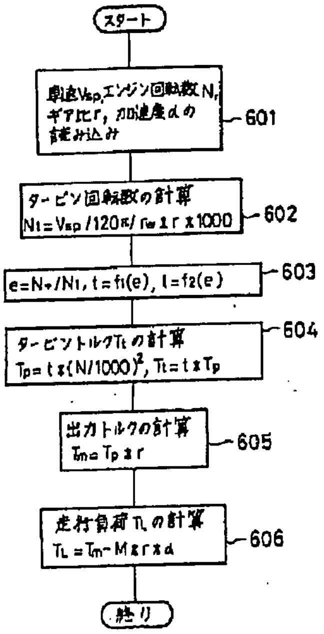
【図5】

【図 5】



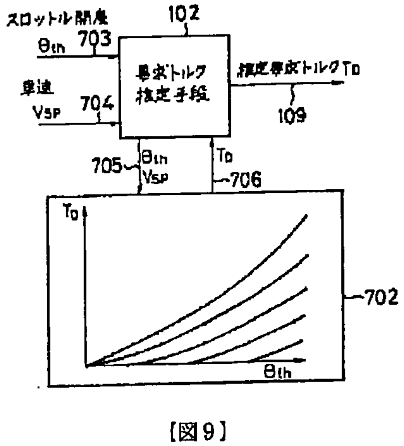
【図6】

【図 6】



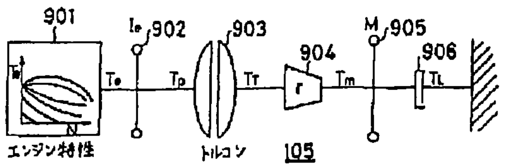
【図7】

【図 7】



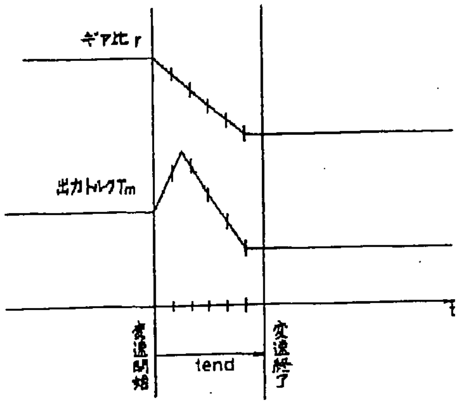
【図9】

【図 9】



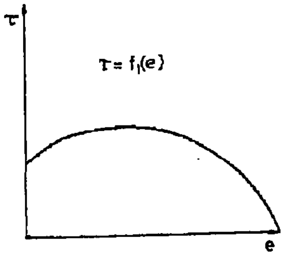
【図１０】

【図10】



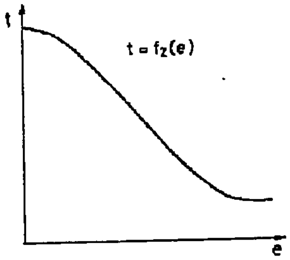
【図１２】

【図12】



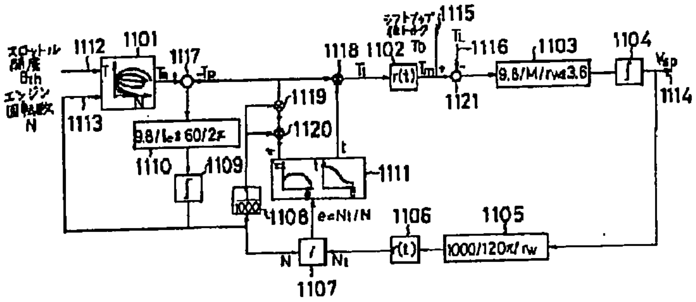
【図１３】

【図13】



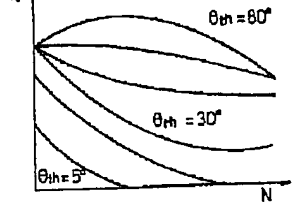
【図１１】

【図11】



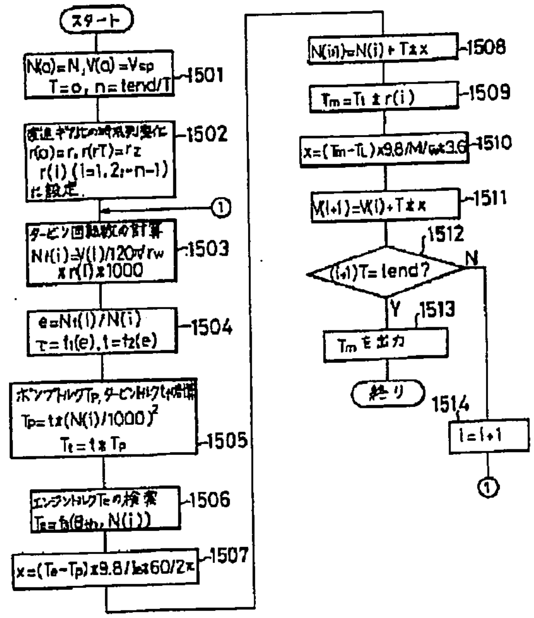
【図１４】

【図14】



【図１５】

【図15】



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(54) Title of the Invention: SHIFT CONTROLLER FOR AUTOMATIC TRANSMISSION

(57) Abstract

(Purpose) To provide a shift controller for an automatic transmission which obtains automatic transmission shift control that accurately reflects driving conditions and significantly improves fuel consumption.

(Solution) Controller is provided with a post-shifting torque predictive calculation means, which performs predictive calculation of the torque after the transmission ratio has been changed, and the transmission ratio is controlled based on the predictive calculation results obtained by this post-shifting torque predictive calculation means.

(CLAIMS)

(Claim 1) An automatic transmission shift controller wherein the transmission ratio is determined in stages according to a control a control signal, said automatic transmission shift controller characterized as comprising a post-shifting torque predictive calculation means, which performs predictive calculation of the torque after the transmission ratio has been changed, and being constituted so that said control signal is calculated based on said predictive calculation results obtained by said post-shifting torque predictive calculation means.

(Claim 2) An automatic transmission shift controller according to the invention of claim 1, further characterized as being constituted to comprise a torque change simulation means, which calculates change in torque accompanying a change in the transmission ratio, and so that said post-shifting torque predictive calculation means calculates said control signal based on the simulation results obtained by said torque change simulation means.

(Claim 3) An automatic transmission shift controller according to the invention of claim 2, further characterized as comprising a running load estimating means for estimating the running load of the vehicle and a required torque estimating means for estimating the torque required by the driver, and as being constituted so that said control signal is calculated on the basis of the estimation results by said running load estimating means, the estimation results by said required for estimating means, and the predictive calculation results by said post-shifting torque predictive calculation means.

(Claim 4) An automatic transmission shift controller according to the invention of claim 3, further characterized in that said running load estimating means is constituted so as to estimate the running load of the vehicle on the basis of the detection results of output torque by said automatic transmission in the detection results for acceleration manifested by the vehicle.

(Claim 5) An automatic transmission shift controller according to the invention of claim 4, further characterized as being constituted so that said detection results for acceleration manifested by the vehicle are provided by an acceleration sensor independently attached to the vehicle.

(Claim 6) An automatic transmission shift controller according to the invention of claim 3, further characterized as being constituted so that said required torque estimating means estimates the torque required by the driver by referring to a required torque map according to the throttle valve opening of the engine and the running speed of the vehicle.

(Claim 7) An automatic transmission shift controller according to the invention of claim 2, further characterized as being constituted so that said torque change simulation means provides simulation results from an operating model of the engine and vehicle having two degrees of freedom, using the engine torque obtained by referring to the engine torque map based on the engine RPM's and throttle valve opening, and turbine torque and pump torque of the torque converter obtained from the torque converter input rotational speed and output rotational speed of said automatic transmission by referring to a torque converter performance curve map.

(DETAILED DESCRIPTION OF THE INVENTION)

(0001)

(Industrial Field of Application)

(0002)

(Industrial Field of Application) The present invention relates to an automatic transmission shift controller for vehicles provided with torque converters, more particularly, an automatic transmission shift controller suitable for automatic transmission in automobiles.

(0003)

(Prior Art) A conventional automatic transmission shift controller, for example, as described in JPA Sho 61-226706, is constituted so that the vehicle speed and throttle opening are detected as an electrical signal, and using the vehicle speed and throttle (valve) opening as variables, a specified transmission stage (ratio) corresponding to the current vehicle speed and throttle opening is selected based on a preset gearshift pattern. At this time multiple gearshift patterns are set, and switching among these patterns is performed based on a pattern selection operation by the driver. The selection of these gearshift patterns can be effective by automatic switching according to the driving operation status of the driver without performing any special pattern selection operation.

(0004)

(Problems the Invention Is to Solve) In the prior art described above, since the gearshift pattern is based merely on a representative two or three driving states without taking into account the various aspects of gearshift patterns of an automatic transmission, shifting that accurately reflects the driving conditions is not fully realized, which leads to the problem of poor fuel economy.

(0005) The object of the present invention is to provide a shift controller for an automatic transmission which obtains automatic transmission shift control that accurately reflects driving conditions and thus significantly improves fuel consumption.

(0006)

(Means Used to Solve the Problems) In order to achieve the aforesaid object, in the present invention a post-shifting torque predictive calculation means, which performs predictive calculation of the torque after the transmission ratio has been changed, is provided, and the transmission ratio is controlled based on the predictive calculation results obtained by this post-shifting torque predictive calculation means.

(0007) Specifically, to cite one specific embodiment, the present invention is provided with a running load estimating means, which estimates the running load, a required torque estimating means, which detects the required torque, a shift ratio determining means, which calculates the transmission ratio, a post-upshift torque predictive calculation means, which performs predictive calculation of the torque after upshift (after gear change), and engine-torque converter-vehicle body simulator (torque change simulation means) for predictive calculation of the torque after upshifting, and an oil pressure driving means, which outputs control oil pressure for the transmission to the shifting actuator, and thereby transmission control that accurately reflects the driving conditions can be realized.

(0008)

(Operation) The present vehicle speed and engine rpm's (rotational speed), present gear ratio, and gear ratio after upshifting are input from the post-upshift torque predictive calculating means to the engine-torque converter-vehicle body simulator, and the generated torque after shifting is sent from this engine-torque converter-vehicle body simulator to the post-upshift torque predictive calculating means. Signals detected by the running load estimating means and required the drive force estimating means and the post-upshift generated torque signal calculated by the engine-torque converter-vehicle body simulator are input to the shift ratio determining means, where a specified transmission ratio is determined.

(0009)

(Embodiments) Next, the automatic transmission shift controller of the present invention is explained in further detailed by means of working examples shown in the drawings. In the following explanation, cases are cited where the present invention is applied in automatic transmissions for automobiles, and for this reason the product of the transmission gear ratio and final gear ratio is used with respect to the speed change ratio or gear ratio.

(0010) FIG. 1 shows an embodiment of the present invention. In the drawing, 101 indicates the running load estimating means, which estimates the running load. The running load T_L from the output 108 thereof is input to the shift ratio determining means 103. 102 is the required torque estimating means, which estimates the required torque. The estimated required torque T_D from the output 109 thereof is input to the shift ratio determining means 103.

(0011) As output 111 from the shift ratio determining means 103, data such as the current vehicle speed V_{SP} and engine rotational speed N, the throttle opening θth, the running load T_L, the present transmission ratio r_1, and the post-upshift transmission ratio r_2 are input to the post-upshift torque predictive calculating means 104, and as a result, data such as the current vehicle speed V_{SP} and engine rotational speed N, the throttle opening θth, the running load T_L, the present transmission ratio r_1, and the post-upshift transmission ratio r_2 are output from the output 112 of the post-upshift torque predictive calculating means 104 and input to the engine-torque converter-vehicle body simulator 105.

(0012) The engine-torque converter-vehicle body simulator 105 calculates the post-upshift torque T_0 by simulation and inputs this torque T_0 from its output 113 to the shift ratio determining means 103 via the post-upshift torque predictive calculating means 104.

(0013) Next, the transmission ratio is determined by the shift ratio determining means 103 based on the input described above, and a shift command signal 114 is issued via the oil pressure driving means 106 to a gearshift actuator 107, and the transmission ratio of the automatic transmission is shifted.

(0014) As described above, in conventional automatic transmission control, only the vehicle speed and throttle opening are used as variables, and a specified shift position is selected corresponding to a current vehicle speed and throttle opening. Thus, using this method it has been difficult to achieve shifting that accurately reflects changes in driving conditions, particularly, changes in the running load. For example, by upshifting earlier when running on a flat road surface or slight downward slope than when driving uphill, fuel consumption is believed to be improved without any loss of drivability, but in the past, since shifting is performed only based on the accelerator opening ~~in~~ and vehicle speed, it has not been possible to perform shifting in the desired manner.

(0015) As shown in this embodiment, by estimating the running load and shifting gears in accordance with the estimated running load, improvement in fuel consumption can be obtained in shifting control that accurately reflects driving conditions can also be obtained.

(0016) FIG. 2 shows an engine driving system for an automobile in which an embodiment of the present invention is applied and the control unit thereof. Signals indicating the respective driving are output to an automatic transmission control unit 203 from an engine 201 and transmission (automatic transmission) 202, and similarly a vehicle signal 207 and ASCD control unit signal 208 are output to the automatic transmission control unit 203. The automatic transmission control unit 203 thereupon determines the transmission ratio from the signals and outputs a shift command 206 to the transmission 202.

(0017) FIG. 3 provides a detailed explanation of the various signals shown in FIG. 2. The portion from signal 304 to signal 307 corresponds to the signal 204 from the engine, the portion from signal 308 to signal 310 corresponds to signal 205 from the transmission, the portion from signal 311 to signal 314 corresponds to the vehicle signal 207, signals 315 and 316 corresponds to the ASCD control unit signal 208, and the portion from signal 317 to signal 321 corresponds to the automatic transmission control unit signal 206. The signals are input via an input signal processing unit 302 to the automatic transmission control unit 203, and are output via the output signal processing unit from the automatic transmission control unit 203.

(0018) FIG. 4 shows the process flow performed by the shift ratio determining means 103 in FIG. 1. The process performed by the shift ratio determining means 103 is explained below in accordance with these flow charts.

Step 401: Calculate running load T_L.

Step 402: Calculate required torque T_D.

Step 403: Calculate post-upshift estimated torque T_0.

Step 404: If $T_0 > T_L + T_D$, then go to step 405.

If not, go to step 406.

Step 405: Upshift. Then return to step 401.

Step 406: After determining downshift, return to step 401.

With respect to downshifting, a conventional method whereby shifting is performed in accordance with a gearshift pattern predetermined from the vehicle speed and throttle opening may be used, or similar processing to upshifting may be used.

(0019) Here, the required torque T_D can be considered as equivalent to the acceleration required by the driver. On the other hand, $T_0 - T_L$ is the torque predicted to occur after upshifting. In step 404, the upshift decision is made by comparing these values.

(0020) In FIG. 5, the running load estimating means 101 is explained. First, an acceleration detecting means 501 outputs the acceleration α as a signal 507 to the running load estimating means 101. This signal 507 corresponds to the signal 314 from the acceleration sensor shown in FIG. 3. The turbine speed Nt is the rotational speed of the turbine of the torque converter, and may be calculated by multiplication by the gear ratio "r" from the signal 310 of the vehicle speed sensor 1 in FIG. 3, or from the signal 311 from the vehicle speed sensor 2. The signal from the vehicle speed sensor 1 is a signal from a rotation sensor placed on the output shaft of the transmission, and the signal of the vehicle speed sensor 2 is the signal from the vehicle speedometer. The signal 506 which is the engine rotational speed N corresponds to the engine rotational signal 307 in FIG. 3. A turbine rotational speed signal 505 and engine rotational speed signal 506 are input to the torque converter output torque estimating means 502.

(0021) The torque converter output torque estimating means 502 determines the rotational ratio "e" of the input shaft and output shaft of the torque converter by the formula $e = Nt/N$ and outputs this the torque converter characteristic table 504. The torque characteristic table 504 searches a pump torque coefficient τ and torque ratio "t" from the torque rotational ratio "e", and outputs these as signals 511 and 512 to the torque converter output torque estimating means 502. The torque converter output torque estimating means 502, from various data of the pump torque coefficient τ and for ratio "t" torque converter pump torque, as well as the engine rotational speed N, based on the torque converter pump for and turbine torque and the relationship between the input shaft and output rotational speed, calculates the turbine torque Tt by the relational formula $Tp = \tau \cdot (N/1000)^2$. $Tt = Tp \cdot t$, and sends the result to the running load estimating means 101. This turbine torque Tt has the same meaning as the torque converter output torque Tt and also may be directly estimated using a torque sensor.

(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 $T_L = Tm - M \cdot rw \cdot \alpha$ 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. $T_L = Tm - M \cdot r \cdot \alpha$

Next, the configuration of the required torque estimating means 102 is shown in FIG. 7. As shown in FIG. 7, the throttle opening θth and vehicle speed V_{SP} are provided as input to the required torque estimating means 102 and then the throttle opening θth and vehicle speed V_{SP} are output to the required torque table 702 from the required torque estimating means 102. This required torque table 702 is constructed so that the required torque T_D is retrieved from the throttle opening θth and vehicle speed V_{SP}, and the retrieved required torque T_D is then sent as output to the required torque estimating means 102. Thus, the estimated required torque T_D is provided as output from the required torque estimating means 102.

(0024) Next, FIG. 9 shows an overview of the engine-torque converter-vehicle body simulator (torque change simulation means) 105. As is apparent from FIG. 9, this simulator 105 includes the engine torque characteristics 901, engine torque inertial moment 902, torque converter model 903, transmission model 904, vehicle weight 905 and running load 906. The current vehicle speed V_{SP} and engine rotational speed N, the vehicle speed V_{SP}, the present transmission ratio r_1, the post-upshift transmission ratio r_2 and running load T_L are provided to this simulator, and changes in the output torque Tm upon shifting are estimated by performing simulation, thereby making it possible to estimate output torque after upshifting accurately.

(0025) The rotational ratio between the input shaft and output shaft of the torque converter generally differs before and after shifting, and the torque ratio of the input torque and output torque of the torque converter also changes accordingly. In other words, if the output torque after shifting is calculated solely from changes in the gear ratio and engine characteristics, significant error will result. However, the changes in this rotational ratio "e" are various according to the driving conditions. For this reason, it is possible to estimate the output torque upon shifting with considerable accuracy by accurately calculating the input and output rotation of the torque converter during shifting and the transfer of torque based on simulations. By determining upshifting based on the coefficients of the output torque after shifting, the required torque and the vehicle load, it is possible to perform shifting that accurately reflects the driving conditions.

(0026) FIG. 10 shows schematically shows changes in the output torque Tm when shifting. The gear ratio "r" generally changes continuously as shown in the figure when shifting is performed. Meanwhile, the output torque Tm changes in accordance with shifting shock as shown in the figure and the output torque undergoes sudden change immediately after shifting. Thus, in this simulator 105, the shifting start time is made the time at which change in the gear ratio begins and the shifting completion time is made the time at which a specified period has elapsed after the gear ratio has become stable. The simulation is performed during this interval. In the following explanation, the shifting start time is made $t = 0$, and the shifting completion time is made $t = t_{end}$.

(0027) FIG. 11 shows a block diagram of a simulator. In this diagram, the block 1101 is a table for obtaining the engine torque T_0 from the throttle opening θth and the engine rotational speed N. The block 1111 is a table for obtaining the pump torque coefficient τ, and the torque ratio "t" of the pump torque and turbine torque from the rotational ratio "e" of the input shaft and output shaft of the torque converter. The pump torque Tp is obtained in block 1119, and the turbine torque Tt is obtained in block 1118. Block 1110 is a block for conversion of engine inertial moment and variable units, multiplied by Te – Tp. block 1109 , the output of block 1110 is an integration element, and the engine rotational speed N is calculated by integration of the output of the block 1110. Block 1102 and block 1106 or the gear ratios of the transmission and change in accordance with the time changes provided. The output of block 1102 is the output torque Tm, which value is issued as output after completion of a simulation. In block 1121, the difference between the output torque Tm and the running load T_L is obtained. Block 1103 is a block for unit conversion of the vehicle weight and effective radius of the wheels and variables. Block 1104 is an integration element that is used to obtain the vehicle speed V_{SP}. Block 1105 is the block for obtaining the output shaft rotational speed of the transmission from the vehicle speed. In block 1107, the ratio e = Nt/N rotational speed is obtained from the engine rotational speed N (= torque input shaft rotational speed) and turbine rotational speed Nt.

(0028) FIG. 12 shows the relation between the torque converter rotational ratio "e" and the pump torque coefficient τ. FIG. 13 shows the relation between the torque converter rotational ratio "e" and torque ratio "t". FIG. 14 shows the relation among the engine rotational speed N, the throttle opening θth and the engine torque.

(0029) FIG. 15 shows the process flow in the simulation, which flow is explained in detail below.

(0030) Step 1501: The present engine rotational speed N and vehicle speed V_{SP} are set as the initial values N (0) and V (0) in the simulation, T is made the integration calculation step width and *n* the number of steps until completion of the simulation. Specifically, N (0) = N, V (0) = V_{SP}, $i = 0$, and $n = t_{end}/N$. Step 1502: Time-series changes in the transmission gear ratio are set as $r(0) = r_1$, $r(nT) = r_2$, r (i) (i = 1, 2, 3... (n – 1) T). Step 1503: the turbine rotational speed Nt (i) is calculated based on the following formula:

$$Nt(i) = V(i)/120\pi/rw \cdot r(i) \times 1000$$

Step 1504: The rotational ratio "e" of the input shaft and output shaft of the torque converter is calculated, the pump torque coefficient τ is obtained by searching from the torque characteristic map of FIG. 12, the torque ratio "t" of the torque converter is obtained by searching from the torque converter characteristic map shown in FIG. 13. Specifically, $e = Nt(i)/N(i)$, $\tau = f_1(e)$, $t = f_2(e)$.

(0031)

Step 1505: The pump torque Tp and turbine torque Tt are calculated by the following equations:

$$Tp = \tau \cdot (N(i)/1000)^2,\ Tt = t \cdot Tp$$

Step 1506: The engine torque Te is obtained from the engine torque characteristic map in FIG. 14. Accordingly, $Te = f_3(\theta th, N(i))$.

Step 1507: The coefficient of integration is calculated from the following equation:

$$x = (Te - Tp) \times 9.8/Ie \times 60/2\pi$$

Step 1508: The engine rotational speed N(i + 1) is obtained from (i + 1)T:

$$N(i+1) = N(i) + T \cdot x$$

Step 1509: The output torque Te is obtained:

$$Te = Tt \cdot r(i)$$

Step 1510: The integration coefficient x is obtained:

$$x = (Tm - T_L) \times 9.8/M/rw \times 3.6$$

Step 1511: The vehicle speed V (i + 1) is obtained at (i + 1)T:

$$V(i+1) = V(i) + T \cdot x$$

Step 1512: If (i + 1)T = t_{end}, then in step 1513 Tm is output, and if not, in step 1514 "i" is made "i + 1" and the process flow is returned to step 1503.

(0032) Thus, according to this embodiment, the state of rotation of the input and output of the torque converter when shifting is performed in the state of transfer of torque can be accurately obtained by simulation. As a result, the output torque when shifting is performed can be accurately predicted, and an upshift decision can be made based on the relation among this output torque during shifting, the required torque and the running load, shifting which accurately reflects the driving condition can be performed.

(0033)

(Effects of the Invention) By means of the present invention, it is possible to predict the running load with sufficient accuracy, and as a result, shifting can be performed that is sufficiently responsive to the running load, and under conditions which sufficiently reflect the intentions of the driver, shifting which accurately respect the driving condition can be obtained, fuel economy can be sufficiently improved, and the vehicle can be driven with enjoyment.

(BRIEF EXPLANATION OF THE DRAWINGS)

FIG. 1 is a block diagram showing an embodiment of the automatic transmission shifts controller of the present invention.

FIG. 2 is a block diagram showing an automobile engine drive system and control unit in which an embodiment of the present invention is applied.

FIG. 3 is an explanatory diagram showing in detail the input signal and output signal to the automatic transmission control unit in an embodiment of the present invention.

FIG. 4 is a flow chart explaining the process flow of the shift ratio determining means in an embodiment of the present invention.

FIG. 5 is a block diagram showing a running load estimating means in an embodiment of the present invention.

FIG. 6 is a flow chart explaining the process flow of the running load estimating means in an embodiment of the present invention.

FIG. 7 is a block diagram of a required torque estimating means in an embodiment of the present invention.

FIG. 8 is a diagram explaining the required torque table used by the required torque estimating means in an embodiment of the present invention.

FIG. 9 is a schematic drawing showing an engine-torque converter-vehicle body simulator in an embodiment of the present invention.

FIG. 10 is an explanatory diagram schematically showing changes in the output torque during shifting in an embodiment of the present invention.

FIG. 11 is a block diagram of the engine-torque converter-vehicle body simulator in an embodiment of the present invention.

FIG. 12 is a characteristic graph showing the relationship between the rotational ratio of the torque converter and the pump torque coefficient in an embodiment of the present invention.

FIG. 13 is a characteristic graph showing the relation between the rotational ratio of the torque converter and torque ratio in an embodiment of the present invention.

FIG. 14 is a characteristic graph showing the relationship among engine rotational speed, throttle opening and engine torque in an embodiment of the present invention.

FIG. 15 is a flow chart explaining the process flow of the engine-torque converter-vehicle body simulator in an embodiment of the present invention.

(Explanation of the Reference Numerals)

101: running load estimating means
102: required torque estimating means.
103: shift ratio determining means
104: post-upshift torque predictive calculating means
105: engine-torque converter-vehicle body simulator (torque change simulation means)

FIG. 1

101: running load estimating means
102: required torque estimating means.
103: shift ratio determining means
104: post-upshift torque predictive calculating means
105: engine-torque converter-vehicle body simulator (torque change simulation means)
106: oil pressure driving means
107: shifting actuator

FIG. 2

201: engine
202: transmission
203: automatic transmission control unit
207: vehicle signal
208: ASCD C/U signal

FIG. 3

[far left, top to bottom]
engine signals
transmission output signals
vehicle signals
ASCD C/U signals
203: automatic transmission control unit
302: input signal processing unit
303: output signal processing unit
304: idle switch
305: full throttle to which
306: throttle sensor
307: engine speed signal
308: inhibitor switch
309: temperature sensor

310: speed sensor 1

311: speed sensor 2

312: power shift switch

313: kickdown switch

314: acceleration sensor

315: cruise signal

316: OD release signal

317: shift solenoid A

318: shift solenoid B

319: overrun clutch solenoid

320: lockup solenoid

321: line pressure solenoid

FIG. 4

START

401: calculate running load T_L

402: calculate required torque T_D

403: calculate post-upshift estimated torque T_0

404: $T_0 > T_L + T_D$?

405: upshift

406: downshift decision

FIG. 5

101: running load estimating means

501: acceleration detecting means

[under 501:] turbine rotational speed N_t

502: torque converter output torque estimating means

504: torque converter characteristic table

505: engine rotational speed N

FIG. 6

START

601: Reading of vehicle speed V_{SP} and engine rotational speed N, gear ratio "r" an acceleration α

602: Calculation of turbine rotational speed:

$Nt = V_{SP}/120\pi/rw \cdot r \times 1000$

603: $e = Nt/N$, $\tau = f_1(e)$, $t = f_2(e)$

604: Calculation of turbine torque Tt:

$Tp = \tau \cdot (N/1000)^2$. $Tt = t \cdot Tp$

605: Calculation of torque

$Tm = Tp \cdot r$

606: Calculation of running load

T_L. $T_L = Tm - M \cdot r \cdot \alpha$

END

FIG. 7

102: required torque estimating means.

109: estimated required torque Tp

703: throttle opening θth

704: vehicle speed V_{SP}

FIG. 8

[vertical axis] required torque T_D

[horizontal axis] throttle opening θth

FIG. 9

901: engine characteristics

903: torque converter

FIG. 10

gear ratio r

output torque Tm

start shift complete shift

FIG. 11

1112: throttle opening θth

1113: engine rotational speed N

1115: post-upshift torque

FIGS. 12-14: see original

FIG. 15

START

1501: N (0) = N, V (0) = V_{SP}, *i* = 0, and *n* = t_{end}/N.

1502: Time-series changes in the transmission gear ratio set as r (0) = r_1, r (nT) = r_2, r (i) (i = 1, 2, 3... (n – 1) T)

1503: Calculation of turbine rotational speed:

$Nt(i) = V(i)/120\pi/rw \cdot r(i) \times 1000$

1504: $e = Nt(i)/N(i)$, $\tau = f_1(e)$, $t = f_2(e)$

1505: Calculation of pump torque Tp and turbine torque Tt:

$Tp = \tau \cdot (N(i)/1000)^2$, $Tt = t \cdot Tp$

1506: Engine torque Te obtained:

$Te = f_3(\theta th, N(i))$

1507: $x = (Te - Tp) \times 9.8/Ie \times 60/2\pi$

1508: $N(i+1) = N(i) + T \cdot x$

1509: $Te = Tt \cdot r(i)$

1510: $x = (Tm - T_L) \times 9.8/M/rw \times 3.6$

1511: $V(i+1) = V(i) + T \cdot x$

1512: If $(i+1)T = t_{end}$?

1513: Tm is output.

1514: i = I+1

END

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(21)Application number :	09-290483	(71)Applicant :	NISSAN MOTOR CO LTD
(22)Date of filing :	07.10.1997	(72)Inventor :	MORITA HIROSHI

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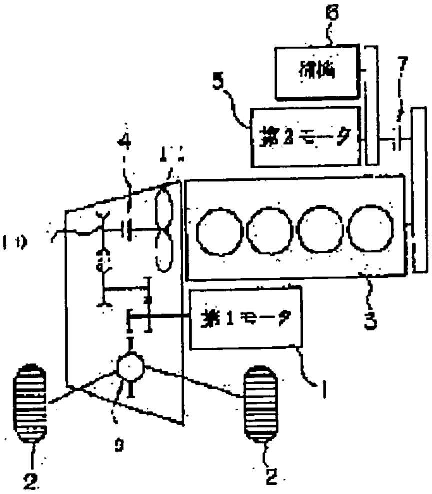
(54) CONTROLLER FOR HYBRID CAR

(57)Abstract:
PROBLEM TO BE SOLVED: To enhance acceleration at the time of reacceleration after deceleration.
SOLUTION: An engine 3 and a first motor 1 are provided as prime movers for a car. When it is detected that a brake becomes nonoperative from an operating state, when a first clutch 4 which cuts the linkage of the output shaft of the engine 3 to driving wheels 2 selectively is in a disconnected state, a second clutch 7 which disconnects the linkage of a second motor 5 to the output shaft of the engine 3 selectively is connected, and the engine 3 is driven/ rotated by a second motor 5 preparatorily. And at the point of time when an accelerator is operated, fuel is supplied and the engine 3 is caused to operate autonomously. And the first clutch 4 is connected, and the driving wheels 2 are driven/rotated by the engine 3 and the first motor 1.



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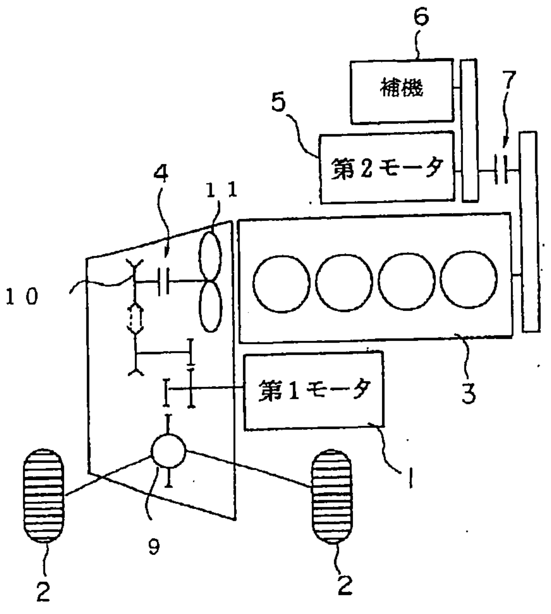
(54)【発明の名称】　ハイブリッド自動車の制御装置

(57)【要約】

【課題】減速再加速時における加速性能を向上することである。

【解決手段】車両の原動機としてエンジン3及び第1モータ1を備えている。第2モータ5により、エンジン3の出力軸を回転駆動することができる。エンジン3の出力軸と駆動輪2との連結を選択的に切断する第1クラッチ4が切断状態で、ブレーキが作動から非作動になったことが検出されたときに、第2モータ5とエンジン3の出力軸との連結を選択的に切断する第2クラッチ7を接続して、第2モータ5によりエンジン3を予備的に回転駆動し、アクセルが作動された時点で、燃料を供給してエンジン3を自律的に作動せしめ、第1クラッチ4を接続して、エンジン3及び第1モータ1によって駆動輪2を回転駆動する。



【特許請求の範囲】

【請求項１】　車両の駆動輪を回転駆動するエンジンと、前記駆動輪を回転駆動する第１モータと、前記エンジンの出力軸と前記駆動輪との連結を選択的に切断するクラッチとを備えたハイブリッド自動車において、
前記エンジンの出力軸を回転駆動する第２モータと、
ブレーキの状態を検出するブレーキ状態検出手段と、
ブレーキが作動状態にあるとき前記クラッチを切断状態とし、ブレーキが作動状態から非作動状態になったことが検出されたときに、前記第２モータにより前記エンジンを回転駆動する第１制御を実施する制御手段とを備えたことを特徴とするハイブリッド自動車の制御装置。

【請求項２】　前記エンジン及び前記第１モータの回転数を検出する回転数検出手段と、
アクセルの状態を検出するアクセル状態検出手段とをさらに備え、
前記エンジンは、電子制御式のスロットル弁及び燃料噴射弁を有し、
前記制御手段は、前記第１制御を実施中に前記アクセル状態検出手段によりアクセルが非作動状態から作動状態になったことが検出されたときに、前記第１モータにより前記駆動輪を回転駆動するとともに、前記クラッチを接続状態とし、車両の要求トルクと第１モータのトルクとの差に基づき、前記スロットル弁の開度及び前記燃料噴射弁による燃料噴射量を制御する第２制御をさらに実施することを特徴とする請求項１記載のハイブリッド自動車の制御装置。

【請求項３】　前記制御手段は、前記第１及び第２制御を実施中に前記スロットル弁の開度が所定開度か否かを判断し、該開度が所定開度より小さくなったと判断した場合には、前記第１及び第２制御を中止することを特徴とする請求項２記載のハイブリッド自動車の制御装置。

【請求項４】　アクセルの状態を検出するアクセル状態検出手段と、
前記エンジンの回転数を検出する回転数検出手段とをさらに備え、
前記制御手段は、前記第１制御を実施中に前記アクセル状態検出手段によりアクセルが非作動状態であることが検出され、且つ前記回転数検出手段により検出された前記エンジンの回転数が予め設定された所定値に達していると判断した場合には、前記第２モータを制御して前記エンジンの回転数を該所定値に維持する第３制御をさらに実施することを特徴とする請求項１記載のハイブリッド自動車の制御装置。

【請求項５】　前記制御手段は、前記ブレーキ状態検出手段によりブレーキが非作動状態から作動状態になったことが検出された場合には、前記第１制御を中止することを特徴とする請求項１記載のハイブリッド自動車の制御装置。

【請求項６】　前記エンジンは、電子制御式のスロットル弁を有し、
前記制御手段は、前記第１制御を行うときに、前記スロットル弁の開度を全開とすることを特徴とする請求項１記載のハイブリッド自動車の制御装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、車両の原動機としてモータ及びエンジンを備えたハイブリッド自動車の制御装置に関し、特に、減速中にエンジンを切り離した状態で再加速する場合における加速性能を向上するための技術に関する。

【０００２】

【従来の技術】車両の原動機としてモータとエンジンを備えたハイブリッド自動車に関する従来技術としては各種のものが知られている。

【０００３】この種のハイブリッド自動車においては、エンジン及びモータのそれぞれの出力軸はクラッチを介して駆動輪の車軸に連結されており、各クラッチの接続又は切断を制御して、エンジン及びモータのいずれか一方又は双方の駆動力によって、走行するようにしている。そして、燃費の向上等の観点から、減速時には該モータをジェネレータとして用いて、車両の運動エネルギを回生することが行われている。

【０００４】また、都市部においては電気自動車として、郊外においては内燃機関式の自動車として使用する形態のハイブリッド自動車として、特開平３－３１９２０６号公報に記載されているものも知られている。このものは、都市部で、エンジンを停止し、モータについてのクラッチのみを接続して該モータの駆動力によって走行している場合において、アクセルの作動が解除（オフ）され、且つブレーキが作動（オン）されたときには、エンジンについてのクラッチ（エンジンクラッチ）を接続し、車両の制動力を利用して強制的にエンジンを回転駆動することにより、エンジンが長期間停止した状態が維持されるのを防止している。

【０００５】

【発明が解決しようとする課題】ところで、制動中にエンジンクラッチを接続して該エンジンを強制的に回転駆動する従来技術では、エンジンブレーキとして消費されるエネルギに相当する分だけ、エネルギの回生量が減少し、非効率的であるという問題がある。

【０００６】一方、モータによるエネルギの回生量を増加するため、減速時にエンジンを切り離して（エンジンクラッチを切断して）、モータによりエネルギの回生を行うようにした場合、減速した後に再加速するとき（減速再加速時）、エンジンが再始動される迄に時間を要し、加速性能が悪いという問題がある。

【０００７】本発明は、このような従来技術の問題点に鑑みてなされたものであり、減速再加速時における応答性、加速性を向上するとともに、高効率的なエネルギの

回生を行うことができるハイブリッド自動車の制御装置を提供することを目的とする。

【0008】

【課題を解決するための手段】上記目的を達成するために、請求項1記載の本発明のハイブリッド自動車の制御装置は、車両の駆動輪を回転駆動するエンジンと、前記駆動輪を回転駆動する第1モータと、前記エンジンの出力軸と前記駆動輪との連結を選択的に切断するクラッチとを備えたハイブリッド自動車において、前記エンジンの出力軸を回転駆動する第2モータと、ブレーキの状態を検出するブレーキ状態検出手段と、ブレーキが作動状態にあるとき前記クラッチを切断状態とし、ブレーキが作動状態から非作動状態になったことが検出されたときに、前記第2モータにより前記エンジンを回転駆動する第1制御を実施する制御手段とを備えたことを特徴とする。

【0009】減速後に再加速を行う場合には、ブレーキを作動して制動し、ブレーキの作動を解除した後に、アクセルを作動して再加速を行う蓋然性が高いので、この点に着目して、この請求項1記載のハイブリッド自動車の制御装置では、ブレーキが作動状態から非作動状態になったときに、次にアクセルが作動されるであろうことを先取りして、第2モータによってエンジンを予備的に回転駆動（モータリング）するようにしている。

【0010】従って、後にアクセルが作動された場合に、エンジンに対する燃料の供給等を行うことにより、エンジンは第2モータによって既に回転されているから、素早く立ち上がり、再加速の応答性を向上することができる。

【0011】また、ブレーキが作動状態から非作動状態になったときに、第2モータによりエンジンを回転駆動するようにしたから、前述した従来技術のようにブレーキの作動中にエンジンについてのクラッチを接続して該エンジンを強制的に回転駆動する必要がないので、第1モータによって車両の運動エネルギの回生を行う場合に、エンジンブレーキとして消費されるエネルギに相当する分だけ、エネルギの回生量を増加することができ、大幅に燃費の向上を図ることができる。

【0012】また、上記目的を達成するために、請求項2記載のハイブリッド自動車の制御装置は、請求項1記載のハイブリッド自動車の制御装置において、車両の速度を検出する車速検出手段と、前記エンジン及び前記第1モータの回転数を検出する回転数検出手段と、アクセルの状態を検出するアクセル状態検出手段とをさらに備え、前記エンジンは、電子制御式のスロットル弁及び燃料噴射弁を有し、前記制御手段は、前記第1制御を実施中に前記アクセル状態検出手段によりアクセルが非作動状態から作動状態になったことが検出されたときに、前記第1モータにより前記駆動輪を回転駆動するとともに、前記クラッチを接続状態とし、車両の要求トルクと前記第1モータのトルクとの差に基づき、前記スロットル弁の開度及び前記燃料噴射弁による燃料噴射量を制御する第2制御をさらに実施することを特徴とする。

【0013】この請求項2記載のハイブリッド自動車の制御装置では、前記第1制御を実施中、即ち、第2モータによるエンジンの予備的な回転駆動がなされている状態で、アクセルが作動された場合に、エンジンを自律的に作動（始動）せしめ、クラッチを接続状態として、エンジン及び第1モータの両方の駆動力によって加速するようにしたから、比較的に低出力のモータや小容量のバッテリを用いた場合であっても、減速再加速時の加速性を高く維持することができる。

【0014】また、エンジンの自律的な作動に先立ち、第2モータによりエンジンを予備的に回転駆動するようにしたから、再加速時の立ち上がりの遅れが少なく、応答性が良好である。さらに、必要とされる要求トルクと第1モータのトルク（実際のトルクであり、通常は最大発生トルク）との差に基づき、スロットル開度及び燃料噴射量（エンジントルク）を制御する、即ち、必要とされる要求トルクのうち第1モータのトルクで不足する部分をエンジントルクで補うようにしたから、加速性能を維持しつつ、第1モータとして比較的に低出力のモータを採用することができるようになる。

【0015】上記目的を達成するために、請求項3記載のハイブリッド自動車の制御装置は、請求項2記載のハイブリッド自動車の制御装置において、前記制御手段は、前記第1及び第2制御を実施中に前記スロットル弁の開度が所定開度か否かを判断し、該開度が所定開度より小さくなったと判断した場合には、前記第1及び第2制御を中止することを特徴とする。

【0016】この請求項3記載のハイブリッド自動車の制御装置では、スロットル弁の開度が所定開度より小さくなった場合には、第1制御を中止（第2クラッチの切断、第2モータの作動の停止）及び第2制御を中止するようにしており、これは、スロットル弁の開度が所定開度である場合には要求トルクが満たされていないが、所定開度より小さくなった場合には要求トルクが満たされたと判断することができ、要求トルクが満たされた場合には、第1モータによる補助を行う必要はないためであり、かかる制御を中止した方が、効率が良いためである。

【0017】上記目的を達成するために、請求項4記載のハイブリッド自動車の制御装置は、請求項1記載のハイブリッド自動車の制御装置において、アクセルの状態を検出するアクセル状態検出手段と、前記エンジンの回転数を検出する回転数検出手段とをさらに備え、前記制御手段は、前記第1制御を実施中に前記アクセル状態検出手段によりアクセルが非作動状態であることが検出され、且つ前記回転数検出手段により検出された前記エンジンの回転数が予め設定された所定値に達していると判

断した場合には、前記第２モータを制御して前記エンジンの回転数を該所定値に維持する第３制御をさらに実施することを特徴とする。

【００１８】この請求項４記載のハイブリッド自動車の制御装置は、例えば、最大出力で第２モータによりエンジンの予備的な回転駆動を行った場合であって、その後にアクセルが作動されない状態、即ち再加速されない状態が継続した場合に、最大出力でエンジンを回転駆動し続けることは非効率的であるため、第２モータを制御してエンジンの回転数を予め決められた所定値に制限して、電力消費量の低下を図りつつ、再加速時の応答性、加速性を維持するようにしたものである。

【００１９】上記目的を達成するために、請求項５記載のハイブリッド自動車の制御装置は、請求項１記載のハイブリッド自動車の制御装置において、前記制御手段は、前記ブレーキ状態検出手段によりブレーキが非作動状態から作動状態になったことが検出された場合には、前記第１制御を中止することを特徴とする。

【００２０】この請求項５記載のハイブリッド自動車の制御装置は、ブレーキが作動状態となった場合には、第２モータによるエンジンの予備的な回転駆動を継続することは無駄なので、この制御を中止して、高効率化を図るようにしたものである。

【００２１】上記目的を達成するために、請求項６記載のハイブリッド自動車の制御装置は、請求項１記載のハイブリッド自動車の制御装置において、前記エンジンは、電子制御式のスロットル弁を有し、前記制御手段は、前記第１制御を行うときに、前記スロットル弁の開度を全開とすることを特徴とする。

【００２２】この請求項６記載のハイブリッド自動車の制御装置では、第２モータによりエンジンの回転駆動を行う場合には、スロットル弁が閉じていると負荷となるため、これを全開として負荷を最小限にしているから、エンジン回転数の上昇時間を短縮することができる。また、後にアクセルが作動された場合に、既にスロットル弁が開いているので空気が円滑に流通しており、従って、ただちに燃料の供給や点火を開始することができ、加速応答性も向上することができる。

【００２３】

【発明の効果】請求項１記載のハイブリッド自動車の制御装置によれば、減速後に再加速を行う場合に応答性、加速性を向上することができるという効果がある。また、モータによりエネルギの回生を行う場合に、エネルギの回生量を従来よりも大きくでき、燃費を大幅に向上することができるという効果もある。

【００２４】請求項２記載のハイブリッド自動車の制御装置によれば、請求項１についての前記効果に加えて、減速再加速時の加速性能を維持しつつ、駆動輪を回転駆動するモータ（第１モータ）として比較的に小型、低出力のモータや小容量のバッテリを採用することができるようになり、全体として小型・軽量化を図れるとともに、低コスト化を図ることができるという効果がある。

【００２５】請求項３記載のハイブリッド自動車の制御装置によれば、請求項２についての前記効果に加えて、スロットル開度が全開でなくなった場合に要求トルクが満たされたと判断して制御を中止するようにしたから、制御の高効率化を達成できるという効果がある。

【００２６】請求項４記載のハイブリッド自動車の制御装置によれば、請求項１についての前記効果に加えて、第２モータによりエンジンの予備的な回転駆動を行った場合の該第２モータの電力消費量を抑制しつつ、再加速時の応答性、加速性をある程度高く維持できるという効果がある。

【００２７】請求項５記載のハイブリッド自動車の制御装置によれば、請求項１についての前記効果に加えて、減速後に再加速されない場合の効率の低下を防止できるという効果がある。

【００２８】請求項６記載のハイブリッド自動車の制御装置によれば、請求項１についての前記効果に加えて、第２モータによるエンジンの回転駆動について、その負荷を軽減することができ、エンジン回転数の上昇時間を短縮することができるとともに、再加速時の加速応答性をさらに向上することができるという効果がある。

【００２９】

【発明の実施の形態】以下、本発明の実施形態を図面に基づいて説明する。図１は、本発明の実施形態のハイブリッド自動車の要部構成を示す図、図２は本発明の実施形態の制御手段の各種信号の入出力を示す図である。

【００３０】図１において、１は車両駆動及びエネルギの回生に用いられる第１モータ（電気モータ）であり、この第１モータ１の出力軸は差動装置９を介して駆動輪２の車軸に連結されている。

【００３１】３は電子制御式のスロットル弁及び燃料噴射弁を有するエンジンであり、エンジン３の出力軸（クランク軸）はトルクコンバータ１１、無段変速機１０（ＣＶＴ）を介して第１モータ１の出力軸に連結されている。エンジン３の出力軸と該無段変速機１０の入力軸は第１クラッチ４を介して連結されており、これらの間を選択的に接続又は切断できるようになっている。

【００３２】５はエアコン等の補機６の駆動及びエンジン３を回転駆動するための第２モータ（電気モータ）である。第２モータ５の出力軸は減速機を介してエンジンの出力軸（クランク軸）に連結されている。第２モータ５の出力軸と該減速機の入力軸は第２クラッチ７を介して連結されており、これらの間を選択的に接続又は切断できるようになっている。

【００３３】また、図示は省略しているが、このハイブリッド自動車は、エンジン３の回転数を検出するエンジン回転数検出手段、第１モータ１の回転数を検出する第１モータ回転数検出手段、第２モータ５の回転数を検出

する第２モータ回転数検出手段、ブレーキのオン（作動）又はオフ（非作動）を検出するブレーキ状態検出手段（ブレーキセンサ）、アクセルの作動状態を検出するアクセル状態検出手段（アクセルセンサ）、車両の速度を検出する車速検出手段、第１クラッチ４のオン（接続）又はオフ（切断）を検出する第１クラッチ状態検出手段、第２クラッチ７のオン（接続）又はオフ（切断）を検出する第２クラッチ状態検出手段を備えている。

【００３４】これらの各手段からの信号は、図２に示されているように、車両走行状態判別手段、各部指令モード判定手段を含む制御手段８に入力される。即ち、エンジン回転数検出手段によるエンジン回転数Ｎｅ、第１モータ回転数検出手段による第１モータ回転数Ｎｍａ、第２モータ回転数検出手段による第２モータ回転数Ｎｍｂ、ブレーキ状態検出手段によるブレーキセンサ信号ＢＲ、アクセル状態検出手段によるアクセルセンサ信号ＡＣ、車速検出手段による車速ＶＳＰ、第１クラッチ状態検出手段による第１クラッチ断接信号ＣＬ１、第２クラッチ状態検出手段による第２クラッチ断接信号ＣＬ２は、それぞれ制御手段８に入力される。

【００３５】制御手段８は、これらの信号及びその他の信号やデータ等に基づき、第１クラッチ４、第２クラッチ７、第１モータ１、第２モータ５、及びエンジン（スロットル弁や燃料噴射弁等）３に対して指令信号を出力し、これらを制御する。ここで、第１クラッチ４の作動を簡単に説明すると、車両減速時、第１モータ１による回生エネルギを増加するため、アクセルペダルがＯＦＦされ、且つブレーキペダルが踏み込まれると、第１クラッチ４は切断され、エンジン３は、車輪から切り離される。一方、ブレーキペダルがＯＦＦされると、再加速する蓋然性が高いので、アクセルペダルが踏み込まれる迄の間に第１クラッチ４を接続する。具体的には、次に説明する図３のフローチャートに従って動作する。

【００３６】図３は本発明の実施形態の制御手段による処理を示すフローチャートである。まず、制御手段８は各部（各手段）からの信号を読み込む（Ｓ１）。即ち、エンジン回転数Ｎｅ、第１モータ回転数Ｎｍａ、第２モータ回転数Ｎｍｂ、ブレーキセンサ信号ＢＲ、アクセルセンサ信号ＡＣ、車速信号ＶＳＰ、第１クラッチ断接信号ＣＬ１及び第２クラッチ断接信号ＣＬ２を読み込む。

【００３７】次いで、検出した運転状態に応じて第１モータ１の出力（要求トルク）を演算し（Ｓ２）、第１モータ１に対して出力を指令する（Ｓ３）。第１クラッチ断接信号ＣＬ１＝ＯＦＦ（エンジンが切り離されている）か否かを判断し（Ｓ４）、第１クラッチ断接信号ＣＬ１＝ＯＦＦの場合（Ｙｅｓの場合)には、ブレーキセンサ信号ＢＲ＝０（ブレーキ非作動）か否かを判断する（Ｓ５）。

【００３８】Ｓ５において、ブレーキセンサ信号ＢＲ＝０の場合（Ｙｅｓの場合)には、前回（直前）のブレーキセンサ信号ＢＲＯ＝０（ブレーキ非作動）か否かを判断し（Ｓ６）、前回のブレーキセンサ信号ＢＲＯ＝１（ブレーキ作動）である場合（Ｎｏの場合）には、制御フラグＦＭＧ＝１とする（Ｓ７）。その後、ＴＶＯ（エンジン３のスロットル弁の開度）が全開となるように制御し、第２クラッチ７を接続するための指令信号ＭＣＬ２＝１を出力して、第２モータ５の出力軸とエンジン３の出力軸を接続する（Ｓ８）。

【００３９】次いで、第２モータ５に対して最大トルクを発生するように指令信号を出力して、エンジン３の回転数を上昇せしめ（Ｓ９）、アクセルセンサ信号ＡＣ＝０（アクセル非作動）か否かを判断し（Ｓ１０）、アクセルセンサ信号ＡＣ＝１（アクセル作動）の場合（Ｎｏの場合）には、第１クラッチ４を接続するための指令信号ＭＣＬ１＝１を出力して、エンジン３の出力軸と駆動輪２の車軸を接続する（Ｓ１１）。

【００４０】その後、目標エンジントルクＴＭｅ、車両の要求トルクＴＭａ、第２モータの最大発生トルクＴＪａとして、ＴＭｅ＝ＴＭａ－ＴＪａを演算し（Ｓ１２）、この目標エンジントルクＴＭｅに基づき、燃料噴射弁による燃料噴射量及びＴＶＯ（スロットル弁の開度）を演算し（Ｓ１３）、Ｓ１３で演算された燃料噴射量及びＴＶＯの指令信号等を出力して、エンジン３の自律的な運転を開始する（Ｓ１４）。

【００４１】次いで、ＴＶＯが全開（所定開度）か否かを判断し（Ｓ１５）、ＴＶＯが全開である場合（Ｙｅｓの場合）にはエンジンが要求トルクを満たしていないと判断して以降のステップ（Ｓ１６～Ｓ１８）をスキップし、ＴＶＯが全開でない（所定開度よりも小さい）場合（Ｎｏの場合）には、要求トルクが満たされたので、第２クラッチ７を切り離すための指令信号ＭＣＬ２＝０を出力して、第２モータ５の出力軸とエンジン３の出力軸との接続を解除（切断）する（Ｓ１６）。その後、第２モータトルク＝０とするための指令信号を出力し（Ｓ１７）、制御フラグＦＭＧ＝０とする（Ｓ１８）。

【００４２】Ｓ４において、第１クラッチ断接信号ＣＬ１＝ＯＮ（接続）の場合（Ｎｏの場合)には、制御フラグＦＭＧ＝１か否かを判断し（Ｓ２０）、制御フラグＦＭＧ＝１の場合（Ｙｅｓの場合）には、Ｓ５に進み、制御フラグＦＭＧ＝０の場合（Ｎｏの場合）にはこの処理を終了する。

【００４３】Ｓ５において、ブレーキセンサ信号ＢＲ＝１（作動）の場合（Ｎｏの場合）には、制御フラグＦＭＧ＝１か否かを判断し（Ｓ２１）、制御フラグＦＭＧ＝０の場合（Ｎｏの場合）にはこの処理を終了する。Ｓ２１において、制御フラグＦＭＧ＝１の場合（Ｙｅｓの場合）には、第２クラッチ７を切り離すための指令信号ＭＣＬ２＝０を出力して、第２モータ５の出力軸とエンジン３の出力軸との接続を解除（切断）し（Ｓ２２）、第２モータトルク＝０とするための指令信号を出力し（Ｓ

２３）、第２モータ５によるエンジンのモータリングを中止する。

【００４４】その後、フューエルカットフラグＦＦＣ＝０か否か、即ち燃料の供給を実施しているか否かを判断し（Ｓ２４）、フューエルカットフラグＦＦＣ＝０（供給）の場合（Ｙｅｓの場合）には、フューエルカットフラグＦＦＣ＝１を出力して燃料の供給を停止し（Ｓ２５）、制御フラグＦＭＧ＝０とし（Ｓ２６）、この処理を終了する。Ｓ２４において、フューエルカットフラグＦＦＣ＝１の場合（Ｎｏの場合）には、制御フラグＦＭＧ＝０とし（Ｓ２６）、この処理を終了する。

【００４５】Ｓ６において、前回のブレーキセンサ信号ＢＲＯ＝０（ブレーキ非作動）の場合（Ｙｅｓの場合）には、制御フラグＦＭＧ＝１か否かを判断し（Ｓ２７）、制御フラグＦＭＧ＝１の場合（Ｙｅｓの場合）には、Ｓ８に進み、制御フラグＦＭＧ＝０の場合（Ｎｏの場合）にはこの処理を終了する。

【００４６】Ｓ１０において、アクセルセンサ信号ＡＣ＝０（アクセル非作動）の場合（Ｙｅｓの場合）には、エンジン回転数Ｎｅが予め設定された所定値Ｎｉｄｌに達しているか否かを判断し（Ｓ２８）、エンジン回転数Ｎｅが予め設定された所定値Ｎｉｄｌに達していない場合（Ｎｏの場合）にはこの処理を終了し、エンジン回転数Ｎｅが予め設定された所定値Ｎｉｄｌに達している場合（Ｙｅｓの場合）には、第２モータ回転数Ｎｍｂ＝Ｃｂ×Ｎｉｄｌとなるように指令信号を出力して、エンジン回転数Ｎｅを所定値Ｎｉｄｌに維持し（Ｓ２９）、この処理を終了する。なお、Ｃｂは第２モータ５とエンジン３との間の減速比である。

【００４７】図４は本発明の実施形態の各部の作動とトルクや回転数の変化等の関係を示す図である。上から順に、（ａ）はアクセル開度又はアクセルのオン・オフ、（ｂ）はブレーキのオン・オフ、（ｃ）は車速の変化、（ｄ）は第１モータトルクの変化、（ｅ）はエンジントルクの変化、（ｆ）はエンジン回転数の変化、（ｇ）は第２モータトルクの変化、（ｈ）は第２モータ回転数の変化、（ｉ）は第１クラッチのオン・オフ、（ｊ）は第２クラッチのオン・オフ、（ｋ）はエアコンのオン・オフを示している。なお、横軸は時間（ｔ）を示している。

【００４８】簡単に説明すると、アクセル開度が０とされ（（ａ）のｔ１）、次いで、ブレーキがオン（作動）されると（（ｂ）のｔ２）、第１クラッチ４がオフ（切断）となり（（ｉ）のｔ２）、エンジン３への燃料供給は停止されてエンジン回転数が降下し（（ｆ）のｔ２）、第１モータ１によるエネルギの回生が大となる（（ｄ）のｔ２）。

【００４９】この状態から、ブレーキがオフ（作動解除）されると（（ｂ）のｔ３）、第２クラッチ７がオン（接続）され（（ｊ）のｔ３）、第２モータ５はエンジンを最大トルクでモータリングし（（ｇ）のｔ３）、エンジン回転数が上昇する（（ｆ）のｔ３）。

【００５０】この状態で、アクセル開度が大とされると（（ａ）のｔ４）、第１クラッチ４がオン（接続）されるとともに（（ｉ）のｔ４）、エンジン３に燃料が供給されて自律運転が開始され（（ｅ）のｔ４）、その後に第２クラッチ７がオフ（切断）される（（ｊ）参照）。

【００５１】これにより、エンジン３は素早く立ち上がり、エンジン３及び第１モータ１の両方の駆動力によって加速される（（ｃ）参照）。なお、第２モータ５の駆動力を全てエンジン３の予備的な回転（モータリング）に用いるため、ブレーキがオフ（作動解除）されて以降、エンジンが自律運転を開始してしばらく経過するまでの間、エアコンの作動は停止している（（ｋ）のｔ３）。

【００５２】上述した本発明の実施形態によると、ブレーキがオン（作動）からオフ（作動解除）になったときに、次にアクセルが作動されるであろうことを先取りして、第２モータ５によってエンジン３を予備的に回転駆動（モータリング）し、後にアクセルが作動された時点で、エンジン３に対する燃料の供給を行ってエンジン３を自律運転するようにしたから、エンジン３は燃料供給開始時において第２モータ５によって既に回転されており、従って素早く立ち上がり、再加速の応答性が非常に良好となる。

【００５３】また、加速時にエンジン３と第１モータ１の両方によって駆動するようにしているから、加速性能が高いとともに、加速性能を維持しつつ、第１モータ１として比較的に小型で低出力のモータを採用することができるようになり、搭載されるバッテリも小型で小容量のものを採用することもできるから、ハイブリッド自動車の小型化、軽量化、低コスト化を図ることが可能である。

【００５４】さらに、ブレーキの作動時にはエンジン３を切り離しているから、エンジンブレーキとして消費されるエネルギを回生することが可能であり、これと上述した軽量化等により、大幅に燃費を向上することができる。

【００５５】なお、以上説明した実施形態は、本発明の理解を容易にするために記載されたものであって、本発明を限定するために記載されたものではない。したがって、上記の実施形態に開示された各要素は、本発明の技術的範囲に属する全ての設計変更や均等物をも含む趣旨である。

【図面の簡単な説明】

【図１】本発明の実施形態のハイブリッド自動車の要部構成を示す図である。

【図２】本発明の実施形態のハイブリッド自動車の制御手段の各種信号の入出力を示す図である。

【図３】本発明の実施形態の制御手段の処理を示すフロ

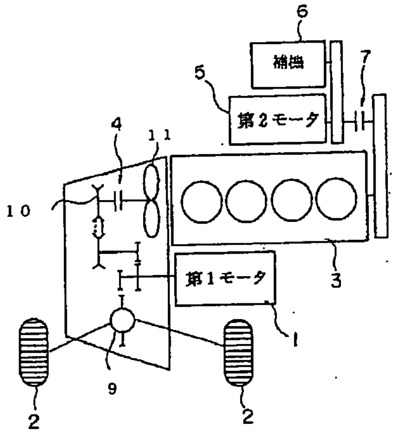
ーチャートである。

【図4】本発明の実施形態の各部の作動とトルクや回転数の変化等の関係を示す図である。

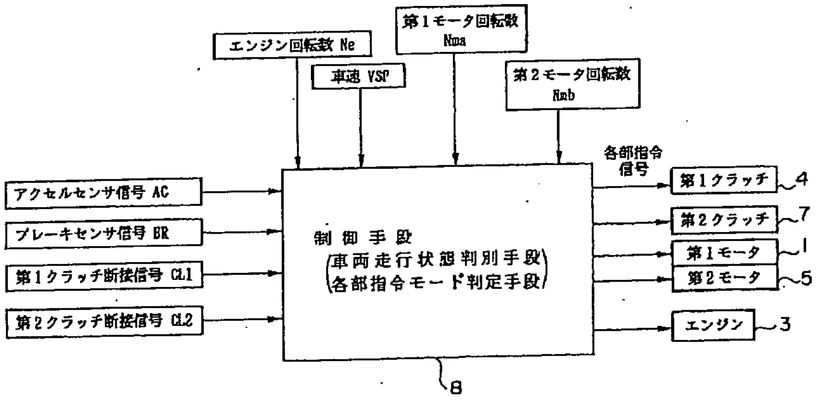
【符号の説明】

1…第1モータ
2…駆動輪
＊3…エンジン
4…第1クラッチ
5…第2モータ
7…第2クラッチ
8…制御手段
＊

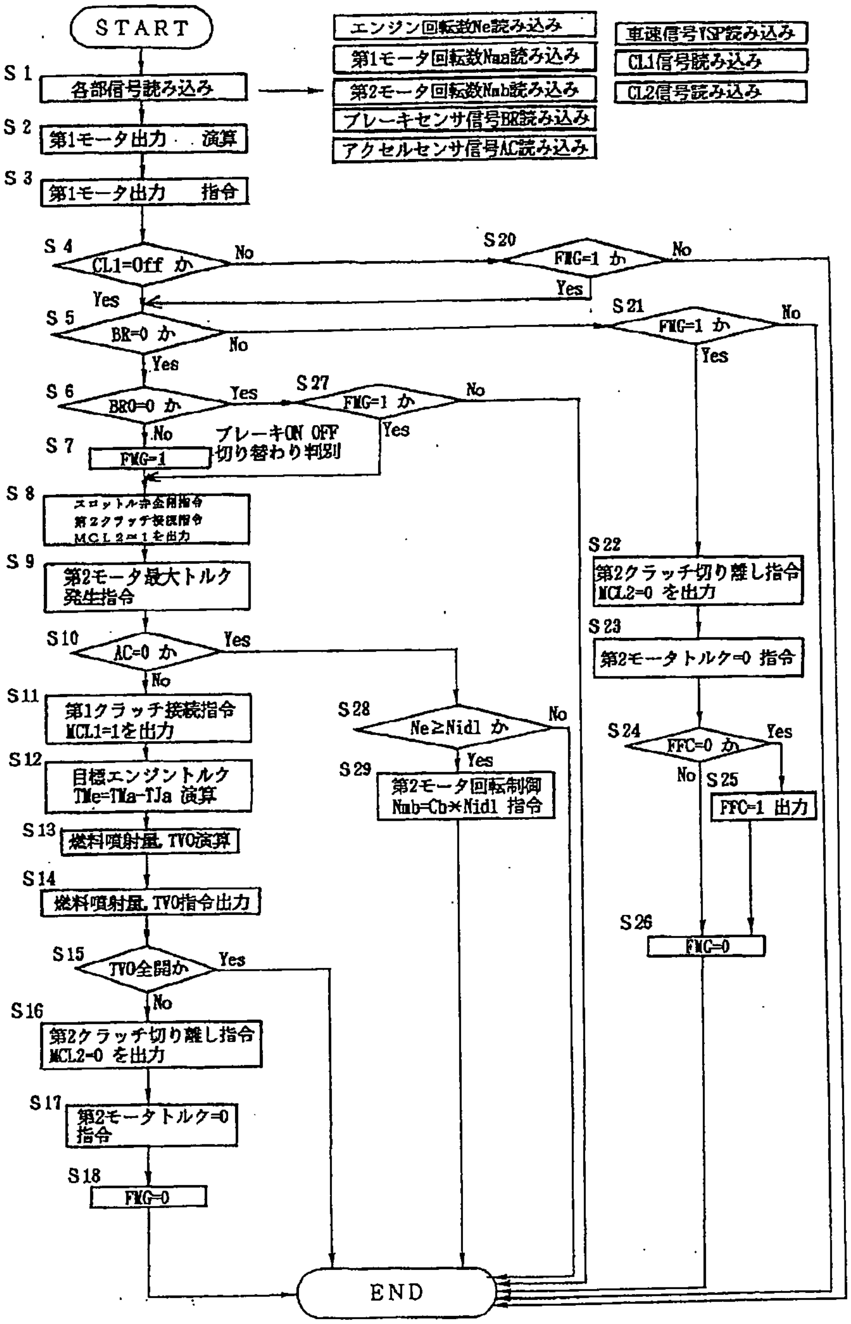
【図1】



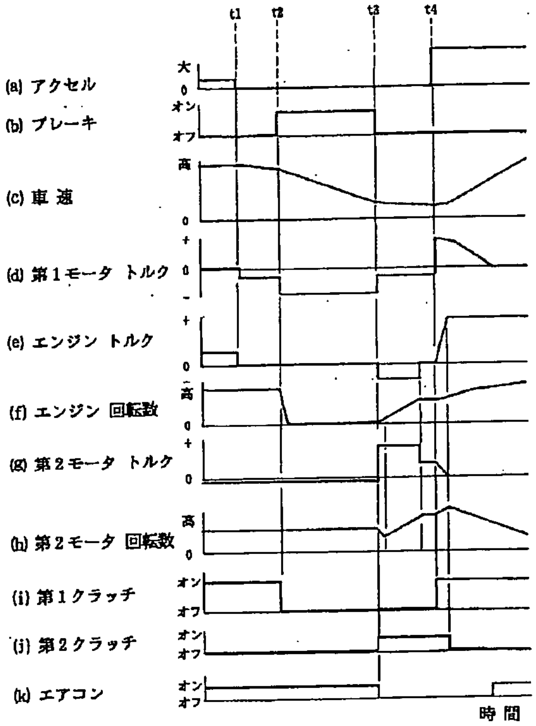
【図2】



【図３】


START
S１
各部信号読み込み
エンジン回転数Ne読み込み
第1モータ回転数Nma読み込み
第2モータ回転数Nmb読み込み
ブレーキセンサ信号BR読み込み
アクセルセンサ信号AC読み込み
車速信号VSP読み込み
CL1信号読み込み
CL2信号読み込み
S２
第1モータ出力　演算
S３
第1モータ出力　指令
S４
CL1=Off か
No
Yes
S20
FMG=1 か
No
Yes
S５
BR=0 か
No
Yes
S21
FMG=1 か
No
Yes
S６
BR0=0 か
Yes
No
S27
FMG=1 か
No
Yes
S７
FMG=1
ブレーキON OFF
切り替わり判別
S８
スロットル弁全開指令
第2クラッチ接続指令
MCL2=1を出力
S９
第2モータ最大トルク
発生指令
S10
AC=0 か
Yes
No
S11
第1クラッチ接続指令
MCL1=1を出力
S12
目標エンジントルク
TMe=TMa-TJa 演算
S13
燃料噴射量, TVO演算
S14
燃料噴射量, TVO指令出力
S15
TVO全開か
Yes
No
S16
第2クラッチ切り離し指令
MCL2=0 を出力
S17
第2モータトルク=0
指令
S18
FMG=0
S22
第2クラッチ切り離し指令
MCL2=0 を出力
S23
第2モータトルク=0 指令
S24
FFC=0 か
Yes
No
S25
FFC=1 出力
S26
FMG=0
S28
Ne≧Nidl か
No
Yes
S29
第2モータ回転制御
Nmb=Cb*Nidl 指令
END

【図４】


t1
t2
t3
t4
(a) アクセル
大
0
(b) ブレーキ
オン
オフ
(c) 車 速
高
0
(d) 第1モータ トルク
+
0
−
(e) エンジン トルク
+
0
−
(f) エンジン 回転数
高
0
(g) 第2モータ トルク
+
0
(h) 第2モータ 回転数
高
0
(i) 第1クラッチ
オン
オフ
(j) 第2クラッチ
オン
オフ
(k) エアコン
オン
オフ
時 間

[Translation]

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(54) Title of the Invention: CONTROL SYSTEM FOR HYBRID CAR

(57) Abstract
(Purpose)
(Solution)

(CLAIMS) [omitted]

(DETAILED DESCRIPTION OF THE INVENTION)

(0001)

(Technical Field of the Invention)

The present invention relates to a control system for hybrid automobiles which are equipped with a motor [here and hereinafter referring to an electric motor] and engine [here and hereinafter referring to an internal combustion engine] as the sources of motive force of the vehicle. More specifically, the present invention relates to a technique for improving acceleration performance when the vehicle reaccelerates while the engine is disengaged upon deceleration.

(0002)

(Prior Art)

Various types of hybrid automobiles equipped with both a motor and an engine as motive power source are known in prior art.

(0003) In hybrid automobiles of this type, the respective output shafts of the engine and motor are connected to the axle of the drive wheels via a clutch. By controlling the connection or disconnection of each clutch, the vehicle is driven by the driving force of either the motor or the engine or both. From the standpoint of improving fuel consumption, during deceleration the motor is used as a generator, allowing the drive energy of the vehicle to be recovered.

(0004) JPA Hei 3-319206 describes a vehicle that can be used as an electric automobile in metropolitan areas and a hybrid automobile that can be used as an automobile with an internal combustion engine in suburban areas. With this vehicle, when the vehicle is driven in metropolitan areas with engine stopped, engaging only the clutch with respect to the electric motor and running the vehicle with said motor only, when the accelerator at all is released (off), and the brake is operated (on), the clutch (engine clutch) is connected with respect to the engine, and the engine is forcibly driven in rotation using the braking force of the vehicle, thereby preventing the engine from being kept in an idle state for long periods of time.

(0005)

(Problems the Invention Is to Solve)

It should be noted that, however, in the prior art whereby the engine is forcibly driven in rotation by connection of the engine clutch during braking, energy recovery is lost in an amount equivalent to the energy expended in engine braking, and to that extent the system is inefficient.

(0006) On the other hand, in systems where energy is recovered by the motor by disengaging the engine during deceleration (disengaging the engine clutch) in order to increase the amount of energy recovered by the motor, when reaccelerating after deceleration (when decelerating and reaccelerating), time is required to restart the engine and acceleration performance is poor.

(0007) The present invention was produced in light of these problems in prior art and has the object of offering a control system for a hybrid automobile that is able to improve responsiveness and acceleration when reaccelerating after deceleration, and can recover energy with high efficiency.

(0008)

(Means Used to Solve the Problems) In order to achieve the objects described above, the control system for hybrid automobiles according to the present invention as described in claim 1 is a control system in a hybrid automobile provided with an engine, which drives the rotation of the drive wheels of the vehicle, a first motor, which drives the rotation of said drive wheels, and a clutch, which selectively disengages the output shaft of said engine and said drive wheels, and is characterized as comprising a second motor, which drives the rotation of the output shaft of said engine, a braking state detecting means, which detects the state of braking, and a controller, which places said clutch in a disengaged state when the brake is in an applied state, and drives the rotation of said engine by means of said second motor when it is detected that the brake has shifted from an applied state to a non-applied state.

(0009) When the vehicle reaccelerating after deceleration, after braking has been performed by applying the brake and then the application of the brake is released, there is a high probability that the accelerator will be applied and reacceleration performed. In light of this point, in a control system for hybrid automobiles as described in this first claim, when the brake has changed from an applied state to a non-applied state, the engine is next driven in rotation in preparation ("motoring") by the second motor in anticipation that the accelerator will probably next be applied.

(0010) Accordingly, when the accelerator is subsequently applied, since the engine is already being turned by the second motor, when fuel is fed to the engine, it quickly starts and responsiveness in reacceleration can be improved.

(0011) When the brake is changed from an applied state to a non-applied state, since the engine is driven in rotation by the second motor, it is not necessary to engage the clutch with respect to the engine while the brake is engaged and to forcibly drive the rotation of the engine as described in the prior art above. Therefore, the energy recovery amount can be increased to the extent of energy applied in engine braking when running energy of the vehicle is recovered by the first motor, and fuel consumption can be greatly improved.

(0012) In addition, in order to achieve the purpose described above, the hybrid automobile control system of the second claim is characterized in that, in the hybrid automobile control system of the first claim, a vehicle speed detecting means, which detects the speed of the vehicle, and a rotational speed detecting means, which detects the rotational speed of said first motor, and an accelerator detecting means, which detects the state of accelerator, are provided, said engine has electronically controlled type throttle valves and fuel injection valves, said controller, when it has been detected by said accelerator detecting means that the accelerator has shifted from a non-applied state to an applied state, while said first control process is being implemented, performs a second control process to drive the rotation of said drive wheels by means of said first motor, places the clutch in a state of engagement, and, based on the required torque of the vehicle in the torque of the first motor, controls the opening of said throttle valves and the fuel injection amount injected by said fuel injection valves.

(0013) In the hybrid automobile control system of this second claim, when the accelerator is applied while the rotation of the engine is being driven in preparation by the second motor, i.e., in a state in which preparatory rotational driving of the engine is being performed by the second motor, autonomous operation (starting) of the engine is implemented, and since acceleration is performed by the drive force of both the engine and first motor with the clutch in an engaged state, even if a motor with comparatively low output or a small-capacity battery is used, the acceleration upon reacceleration after deceleration can be maintained at a high level.

(0014) Moreover, since the rotation of the engine is being driven in preparation by the second motor prior to start autonomous operation of the engine, there is no delay in starting upon reacceleration, and responsiveness is good. Moreover, based on the difference between the required torque and the torque of the first motor (the actual torque, normally the maximum generated torque), the throttle opening and fuel injection amount (engine four) are controlled, i.e., the insufficiency in the torque of the first motor in relation to the total torque required is made up for by engine torque, so that a motor having a comparatively low output can be used as the first motor while maintaining acceleration performance.

(0015) In order to achieve the objects described above, the hybrid automobile control system described in claim 3 is characterized in that, in the hybrid automobile control system described in claim 2, when determining whether the opening of the throttle valve is a specified opening well the aforementioned first and second control processes are in progress, if it is determined that said opening is smaller than a specified opening, the aforesaid first and second control processes are halted.

(0016) In the hybrid vehicle control system described in this third claim, when the opening of the throttle valve is smaller than a specified opening, the first control process is halted (disengagement of the second clutch and halting of the operation of the second motor) and the second control process is halted. This process is performed for the following reason: When the throttle valve opening is at a specified opening, the required torque is not satisfied, but it can be determined that when it is smaller than the specified opening, the required torque has been satisfied, and when the required torque has been satisfied, assistance by the first motor becomes unnecessary, and efficiency is improved if this control process is halted.

(0017) In order to achieve the objective described above, the hybrid automobile control system described in claim 4 is characterized in that, in the hybrid automobile control system of claim 1, an accelerator state detecting means, which detects the state of the accelerator, and a rotational speed detecting device, which detects the rotational speed of the aforesaid engine, are also provided, and the aforesaid controller is constituted so that, when it is detected by the aforesaid accelerator state detecting means that the accelerator is in a non-applied state while the aforesaid first control process is in progress, and it is determined that the rotational speed of the engine detected by the aforesaid rotational speed detecting device has reached a set value that has been previously established, a third control process is performed whereby the engine rotational speed is maintained at a specified level by controlling the second motor.

(0018) The hydraulic automobile control system described in this fourth claim is constituted so that, when, for example, the engine is driven in rotation in preparation by the second motor at maximum output, and the accelerator is not thereafter applied, i.e., a state continues in which reacceleration does not occur, since it is inefficient for the engine to continue to be driven and maximum output, the rotational speed of the engine is restricted to a predetermined set value by controlling the second motor, and the responsiveness and acceleration performance upon reacceleration can be maintained while reducing the amount electrical power consumed.

(0019) In order to achieve the aforementioned objective, the hybrid automobile control system described in claim 5 is characterized by the fact that, in the hybrid automobile control system described in claim 1, the aforementioned controller halts the aforementioned first control process when the aforementioned braking state detecting means is detected that the brake has shifted from a non-applied state to an applied state.

(0020) The hybrid automobile control system described in this fifth claim is able to improve efficiency by halting the control process when the brake is in an applied state, since continuation of preparatory driving of the engine by the second motor would be wasteful.

(0021) In order to achieve the aforesaid purpose, the hybrid automobile control system described in claim 6 is characterized in that, in a hybrid automobile control system described in claim 1, the engine has an electronically controlled throttle valve, and the controller fully opens the opening of this throttle valve when performing the aforementioned first control process.

(0022) With the hybrid automobile control system described in this sixth claim, when the rotation of the engine is driven by the second motor, the throttle valve constitutes a load when it is closed, so the load is minimized by completely opening the throttle, allowing the startup time for the engine rotational speed to be shortened. However, when the accelerator is subsequently applied, air is able to flow smoothly since throttle is opened, and accordingly feeding fuel and ignition can be started and acceleration responsiveness can be improved.

(0023)

(Effects of the Invention) By means of the hybrid automobile control system described in claim 1, the responsiveness and acceleration performance can be improved when reaccelerating after deceleration. In addition, when energy is recovered by the motor, the amount of energy recovered is greater than that in the past, thus having effect of greatly improving fuel efficiency.

(0024) By means of the hybrid automobile control system described in claim 2, in addition to the effects mentioned above with respect to claim 1, it is also possible to use a comparatively small-size and low-output motor and low-capacity battery for the motor (first motor) that drives rotation of the drive wheels while maintaining good acceleration performance when reaccelerating after deceleration, thereby achieving an overall reduction in size and weight and having effect of reducing costs.

(0025) By means of the hybrid automobile control system described in claim 3, in addition to the effects mentioned above with respect to claim 2, since the control process is discontinued when it is determined that torque has been satisfied when the throttle opening is not fully opened, the effect of achieving higher efficiency in control is obtained.

(0026) The hybrid automobile control system described in claim 4, besides the effects mentioned above with respect to claim 3, has the additional the effect of maintaining a certain degree of responsiveness and acceleration performance at a high level upon reacceleration while restraining power consumption by the second motor when preparatory rotation of the engine is driven by the second motor.

(0027) The hybrid automobile control system described in claim 5, in addition to the effects described with respect to claim 1, offers the effect of being able to prevent a loss of efficiency upon reacceleration after deceleration.

(0028) The hybrid automobile control system described in claim 6, in addition to the effects described with respect to claim 1, offers the effect of being able to reduce the load with respect to the rotational driving of the engine by the second motor, and to be able to increase acceleration responsive upon reacceleration.

(0029)

(Embodiments on of the Invention) An embodiment of the present invention is explained below referring to the drawings. Figure 1 is a drawing for the essential constitution of a hybrid automobile in an embodiment of the present invention, and Figure 2 is a diagram training input and output of various signals by the controller in an embodiment of the present invention.

(0030) In Figure 1, the reference numeral 1 represents the first motor (electric motor) use for the driving the vehicle and recovery of energy, and the output shaft of this first motor 1 is linked to the axle of the drive wheels 2 via a differential device 9.

(0031) 3 is the engine, which has an electronic control type throttle valve and fuel injection valve. The output shaft (crankshaft) of the engine 3 is linked with the output shaft of the first motor 1 via a torque converter 11 and the input shaft of a continuously variable transmission 10, and is able to selectively engage with and disengage from these parts.

(0032) 5 is a second motor (electric motor), which drives the ancillary equipment 6 such as the air-conditioner and drives the rotation of the engine 3. The output shaft of the second motor 5 is connected to the output shaft (crankshaft) of the engine via a reducer. The output shaft of the second motor 5 and input shaft of the reducer are linked via a second clutch 7, and can be selectively engaged and disengaged.

(0033) Although omitted from the drawings, this hybrid automobile is provided with an engine rotational speed detecting means for detecting the rotational speed to the engine 3, a first motor rotational speed detecting means for detecting the rotational speed of the first motor 1, a second motor rotational speed detecting means for detecting the rotational speed of the second motor 5, a braking state detecting means (brake sensor), which detects whether the brake is on (applied) or off (not applied), and an accelerator state detecting means (accelerator sensor), which detects the operating state of the accelerator, a first clutch state detecting means, which detects whether the first clutch 4 is on (engaged) or off (disengaged), and a second clutch state detecting means, which detects whether the second clutch 7 is on (engaged) or off (disengaged).

(0034) The signals from each of these means are input to a controller 8, which includes a command mode deciding means for each part. Specifically, the engine rotational speed Ne obtained by the engine rotational speed detecting means, the first motor rotational speed Nma detected by the first motor rotational speed detecting means, the second motor rotational speed Nmb obtained by the second motor rotational speed detecting means, a brake sensor signal BR obtained by the braking state detecting means, an accelerator sensor signal AC obtained by the accelerator state detecting means, the vehicle speed VSP obtained by the vehicle speed detecting means, a first clutch engagement signal CL1 obtained by the first clutch state detecting means, and a second clutch engagement signal CL2 obtained by the second clutch state detecting means are input to the controller 8.

(0035) The controller 8, based on these signals and other signals and data, outputs command signals to and controls the first clutch 4, second clutch 7, first motor 1, second motor 5 and engine (throttle valve, fuel injection valve, etc.) 3. Here, to explain the operation of the first clutch 4 briefly, upon deceleration of the vehicle since the recovered energy produced by the first motor 1 is increased, when the operator's foot has been removed from the accelerator pedal and the brake pedal is depressed, the first clutch 4 is disengaged, the engine 3 is disengaged from the wheels. On the other hand, when the operator's foot has been removed from the brake pedal, since the probability of reacceleration is high, the first clutch 4 is engaged during the period until the accelerator pedal is depressed. Specifically, the operation indicated in the flowchart of Figure 3, explained below, is performed.

(0036) Figure 3 is a flowchart showing the process performed by the controller in an embodiment of the present invention. First, the controller 8 reads the signals from each part (each means) (S1). Specifically, it reads the engine rotational speed Ne, the first motor rotational speed Nma, the second motor rotational speed Nmb, the brake sensor signal BR, the accelerator sensor signal AC, the vehicle speed signal VSP, a first clutch engagement signal CL1 and the second clutch engagement signal CL2.

(0037) Next, the output (required toward) a first motor 1 is calculated in accordance with the driving state detecting (S2), and output is directed to the first motor 1 (S3). It is next determined whether the first clutch engagement signal CL1 = OFF (engine is disengaged) (S4), and if the first clutch engagement signal CL1 = OFF (if YES), then is determined whether the brake sensor signal BR = 0 (brake is not applied) (S5).

(0038) In S5, if the brake sensor signal BR = 0 (if YES), it is determined whether the previous (immediately previous) brake sensor signal BRO = 0 (brake not applied) (S6), if the brake sensor signal BRO = 1 (if NO), the full flag FMG is made FMG = 1 (S7). Next, control is performed so that the TVO (engine 3 throttle opening) is made completely open, a command signal MCL2 = 1 is output in order to engage the second clutch 7, and the output shaft of the second motor 5 and the output shaft of the engine 3 are engaged (S8).

(0039) Next, a command signal to generate maximum torque is output to the second motor 5, and the rotational speed of the engine 3 is increased (S9), it is determined whether or not the accelerator sensor signal AC = 0 (accelerator not applied) (S10), and if the accelerator sensor signal AC = 1 (accelerator applied) (if NO), a command signal MCL1 = 1 is output to engage the first clutch 4, and the output shaft of the engine 3 and the output shaft of the drive wheels 2 are engaged (S11).

(0040) The target engine torque TMe is then calculated by Tme = Tma – TJa based on the required vehicle torque TMa and maximum torque TJa of the second motor (S12). Based on this target engine torque TMe, the fuel injection amount according to the fuel injector valve and TVO (throttle valve opening) are calculated (S13), and a command signal for the fuel injection amount and TVO calculated in S13 is ended, and the autonomous operation of the engine is started (S14).

(0041) Next, it is determined whether the TVO is fully open (specified opening) (S15), and if the TVO is fully open (if YES), and if it is determined if the engine has not satisfied the required torque, and subsequent steps (S16-S18) are skipped, and if the TVO is not fully open (is smaller than the specified opening) (if NO), the required torque is not satisfied. Therefore a command signal MCL2 = 0 is issued to disengaged the second clutch 7, and the engagement of the output shaft of the second motor 5 and the output shaft of the engine 3 is released (disengaged) (S16). Next, a command signal for second motor torque = 0 is issued (S17), and the control flag FMG is made 0 (S18).

(0042) In S4, if the first clutch engagement signal CL1 = ON (engaged) (if NO), it is determined whether the control flag FMG = 1 (S20), and if the control flag FMG = 1 (if YES) the process sequence advances to S5, while if the control flag FMG = 0 (if NO), this process is ended.

(0043) In S5, if the brake sensor signal BR = 1 (applied) (if NO), then it is determined whether the control flag FMG = 1 (S21), and if the control flag FMG = 0 (if NO), this process is ended. In S21, if the control flag FMG = 1 (if YES), then a command signal MCL for disengaged in the second clutch 7 is issued, the engagement of the output shaft of the second motor 5 and the output shaft of the engine 3 is released (disengaged) (S22), a command signal for making the second motor torque = 0 is issued (S23), and the motoring of the engine by the second motor 5 is stopped.

(0044) Next it is determined whether the fuel cut flag FFC = 0, i.e., whether or not fuel is being supplied (S24), and if the fuel cut flag FFC = 0 (supplied) (if YES), fuel cut flag FFC = 1 is issued, the feeding of the fuel is halted (S25), the control flag FMG is made 0 (S26) and the process is ended.

(0045) In S6, if the previous brake sensor signal BRO = 0 (brake not applied)) (if YES), it is determined whether the control flag FMG = 1 (S27), and if the control flag FMG = 1 (if YES), the process advances to S8, while if control flag FMG = 0 (if NO), this process is ended.

(0046) In S10, if the accelerator sensor signal AC = 0 (accelerator not applied) (if YES), it is determined whether the engine rotational speed Ne has reached a predetermined set value Nid1 (S28), and if the engine rotational speed Ne has not reached a predetermined set value Nid1 (if NO), this process is ended, while if the engine rotational speed Ne has reached a predetermined set value Nid1 (if YES), a command signal is issued such that the second motor rotational speed

$Nmb = Cb \times Nid1$, the engine rotational speed Ne is maintained at the specified value Nid1 (S29), and this process is ended. Cb here is the deceleration ratio between the second motor 5 and engine 3.

(0047) Figure 4 is a diagram showing the relation between operation of different parts in the employment of the present invention and changes in torque, rotational speed and the like. In order from the top, (a) shows the accelerator opening or accelerator on/off status, (b) the brake on/off status, (c) changes in vehicle speed, (d) changes in first motor torque, (e) changes in engine torque, (f) changes in engine rotational speed, (g) changes in second motor torque, (h) changes in second motor rotational speed, (i) first clutch on/off status, (j) second clutch on/off status, and (k) air-conditioner on/off status. The horizontal axis shows time (t).

(0048) Explained briefly, the accelerator opening is made 0 (t1 of (a)), next the brake is switched on (applied) (t2 of (b)), the first clutch 4 is switched off (disengaged) (t2 of (i)), feeding of fuel to the engine 3 is halted and the engine rotational speed is reduced (t2 of (f)), and the recovery of energy by the first motor 1 is increased (t2 of (d)).

(0049) From this state, when the brake is switched off (application released), (t3 of (b)), the second clutch 7 is switched on (engaged) (t3 of (j)), the second motor 5 motors the engine at maximum torque (t3 of (g)), and the engine rotational speed is increased (t3 of (f)).

(0050) In this state, when the accelerator opening is increased (t4 of (a)), the first clutch 4 is switched on (engaged) (t4 of (i)) and the autonomous operation of the engine 3 is started by feeding fuel (t4 of (e)), then the second clutch 7 is switched off (disengaged) (see (j)).

(0051) By this means, the engine 3 starts up quickly, and the vehicle is accelerated by the drive force of both the engine 3 and the first motor 1 (see (c)). Since all of the drive force of the second motor 5 is used in the preparatory rotation (motoring) of the engine 3, after the brake has been switched off (released), for the short interval until autonomous running of the engine is started, the operation of the air-conditioner ceases (t3 of (k)).

(0052) According to this embodiment of the present invention, when the brake has been switched from on (applied) to off (released), it is anticipated that the accelerator will be applied, the preparatory rotation (motoring) of the engine 3 is performed by the second motor 5, and when the accelerator is then applied, fuel is applied to the engine 3 in the engine is able to operate autonomously, so that the engine is already being rotated by the second motor 5 when the feeding of fuel is begun and accordingly is able to start quickly, so that reacceleration responsiveness is extremely good.

(0053) Since the vehicle is driven by both the engine 3 and first motor 1 when accelerating, acceleration performance is high, it is possible to use a motor having a comparatively small size and low output as the first motor 1 while maintaining good acceleration performance, and since the battery carried also can be made lightweight and reduced in size, reduction in the size, weight and cost of the hybrid automobile as a whole is possible.

(0054) Further, since the engine 3 is disengaged when the brake is applied, the energy consumed in engine braking can be recovered, and by means of this recovery along with the weight reduction described above, fuel efficiency can be greatly improved.

(0055) The embodiment explained above is described in order to facilitate understanding of the present invention and is not described in order to restrict the present invention. Accordingly, the various elements developed in the embodiment described above include any and all design changes or equivalent items within the technical scope of the invention.

(Brief Explanation of the Drawings)

Figure 1 is a drawing showing the main constituent parts of a hybrid automobile according to an embodiment of the invention.

Figure 2 is a diagram showing the input and output of various signals of the controller in a hybrid automobile according to an embodiment of the present invention.

Figure 3 is a flowchart showing the process performed by the controller according to an embodiment of the present invention.

Figure 4 is a diagram showing the relation between the operation of various parts and changes in torque, rotational speed and the like in an embodiment of the present invention.

(Explanation of the Reference Numerals)

1... first motor
2... drive wheels
3... engine
4... first clutch
5... second motor
7... second clutch
8... controller

Figure 1

1: first motor

5: second motor

6: ancillary equipment

Figure 2

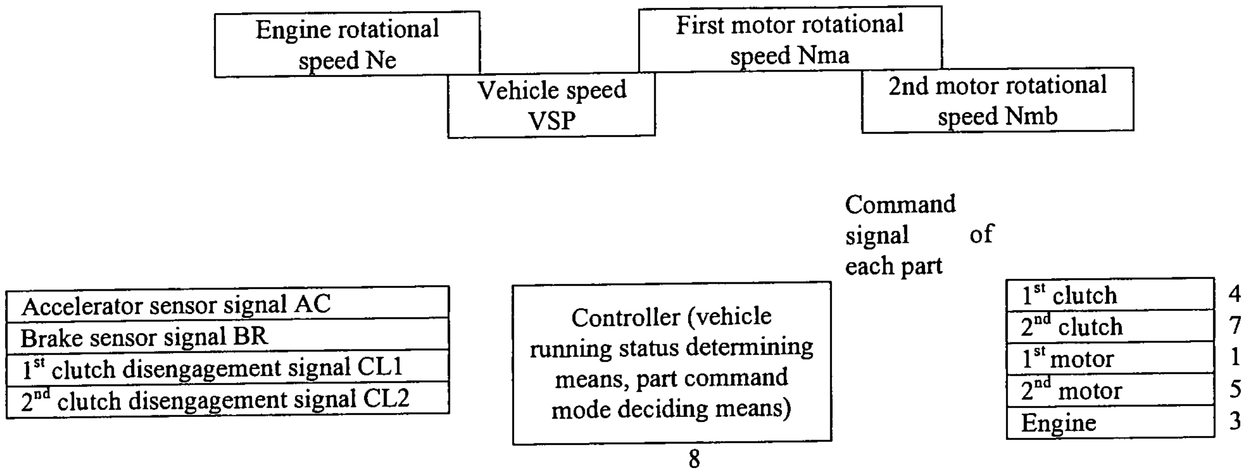

Figure 3

START

S1: Read each part's signal

S2: Calculate 1st motor output

S3: Command 1st motor output
S4: CL1 = Off?
S5: BR = 0?
S6: BR = 0?
S7: FMG = 1

S8: Throttle valve full open command, 2nd clutch engagement command, MCL 2= 1 issued
S9: 2nd motor maximum torque generation command

S10: AC= 0?

S11: 1st clutch engagement command MCL1 = 1 issued
S12: Target engine torque TMe = Tma – TJa calculation

S13: Fuel injection amount TVO calculation
S14: Fuel injection amount, TVO command issued
S15: TVO fully open?
S16: 2nd clutch disengagement command MCL2 = 0 issued
S17: 2nd motor torque = 0 command
S18: FMG = 0

Read engine rpm Ne
Read 1st motor rpm Nma
Read 2nd motor rpm Nmb
Read brake sensor signal BR
Read accelerator sensor signal AC

Read vehicle speed signal VSP
Read CL1 signal
Read CL2 signal

S20: FMG = 1?

S27: FMG = 1?
Brake on/off
Switch discrimination

S28: Ne ≥ Nidl?

S29: 2nd motor rotation control Nmb = Cb*Nid1 command

END

S21: SMG = 1

S22: 2nd clutch disengaged command MCL2 = 0 issued
S23: 2nd motor torque = 0 command
S24: FFC=0?

S25: FFC= 1 issued

S26: FMG=0

Figure 4

(a) Accelerator large
0
on
(b) Brake off
high
(c) Vehicle speed

(d) 1st motor torque

(e) Engine torque
high
(f) Engine rotational speed

(g) 2nd engine torque
high
(h) 2nd motor rotational speed
on
(i) 1st clutch off

(j) 2nd clutch on
off
(k) air-conditioner on
off

Time

PATENT ABSTRACTS OF JAPAN

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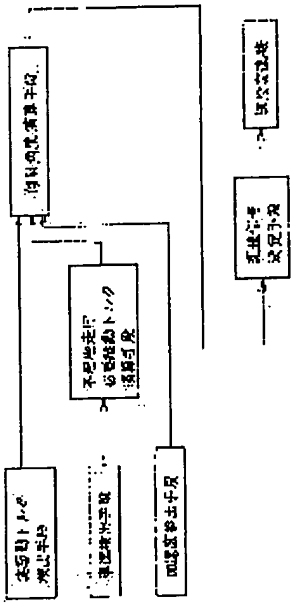
(54) CONTROL DEVICE FOR CONTINUOUSLY VARIABLE TRANSMISSION



(57)Abstract:
PURPOSE: To always keep an engine brake effect optimum, by calculating the value which corresponds to the angle of inclination of a road surface traveled over, and varying automatically a change gear ratio pattern according to said calculated value.

CONSTITUTION: An actual driving torque detecting means, which detects an actually generated driving torque on the output side of a continuously variable transmission, and an acceleration detecting means which detects the actual acceleration of a vehicle, are installed. Then, a calculating means for driving torque required for the flat land travel which calculates the flat land driving torque, which is required when it is assumed that the vehicle travels on the flat land at the detected speed, is also installed. Moreover, an angle of inclination calculating means, which calculates the angle of inclination of a road surface, from the flat land driving torque and the detected acceleration, is installed, and a speed change signal deciding means, which decides the control target change gear ratio or the control target input rotating speed, according to the output of said angle of inclination calculating means, is installed. With this constitution, an engine brake effect can be always kept optimum.

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(54)発明の名称　無段変速機の制御装置

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明細書

1．発明の名称

無段変速機の制御装置

2．特許請求の範囲

1.無段変速機の出力側の実際の発生駆動トルクを検出する実駆動トルク検出手段と、車両の走行速度を検出する車速検出手段と、車両の実際の加速度を検出する加速度検出手段と、検出された車速で平坦地を走行するとした場合に必要とされる平坦地駆動トルクを演算する平坦地走行必要駆動トルク演算手段と、実駆動トルク検出手段によって検出される実駆動トルクと平坦地走行必要駆動トルク演算手段によって演算される平坦地駆動トルクと加速度検出手段によって検出される車両の実加速度とに基づいて路面の傾斜角度を演算する傾斜角度演算手段と、傾斜角度演算手段によって演算された傾斜角度に基づいて制御目標変速比又は制御目標入力回転速度を決定する変速信号決定手段と、を有することを特徴とする無段変速機の制御装置。

2.上記変速信号決定手段は、スロットル全閉運転状態では、傾斜角度演算手段によって演算される傾斜角度が、登り坂では小さくなるにしたがって、また下り坂では大きくなるにしたがって、制御目標変速比又は制御目標入力回転速度を変速比大側に決定する特許請求の範囲第1項記載の無段変速機の制御装置。

3.上記変速信号決定手段は、スロットル全閉以外の運転条件では、傾斜角度演算手段によって演算される傾斜角度が、登り坂では大きくなるにしたがって、また下り坂では小さくなるにしたがって、制御目標変速比又は制御目標入力回転速度を変速比大側に決定する特許請求の範囲第1又は2項記載の無段変速機の制御装置。

3．発明の詳細な説明

（イ）産業上の利用分野

本発明は、無段変速機の制御装置に関するものである。

（ロ）従来の技術

従来の無段変速機の制御装置としては、例えば

特開昭５８－１８０８６４号公報に示されるものがある。この無段変速機の制御装置は、車速の変化から実加速度を算出し、所定の比較基準加速度と実加速度とを比較し、実加速度の方が小さい場合にはそうでない場合の基準変速比よりも大きい修正変速比を指令するようにしたものである。これにより登坂走行時などに駆動力が不足した運転状態となったとき変速比が増大してエンジン回転速度が上昇するので、Ｌレンジにセレクトすることなく良好な走行フィーリングを得ることができる。

（ハ）発明が解決しようとする問題点

しかし、上記のような従来の無段変速機の制御装置は、比較基準加速度と実加速度とを比較するように構成されているため、比較基準加速度のデータが膨大となって、データの作成及び処理が面倒で実際的でないという問題点がある。すなわち、傾斜角度の異なる様々な坂道において最適な運転状態を得るようにするためには、細かく区分した傾斜角度ごとに比較基準加速度を設定し、これに対応して車速及びスロットル開度によって決定される変速指令信号を設定する必要があり、精度のよい制御を行なうためには膨大なデータを必要とする。このようなデータを作成するためには各傾斜角度ごとに実際に実験又は計算を行って最適な値を決定する必要があり、多大な労力を必要とする。また、このような膨大なデータを記憶装置内に格納するために容量の非常に大きな記憶装置を必要とする。本発明は、このような問題点を解決することを目的としている。

（ニ）問題点を解決するための手段

本発明は、エンジンの性能データから計算によって走行中の坂道の傾斜角度を算出し、これに応じて変速信号を決定することにより、上記問題点を解決する。すなわち、本発明による無段変速機の制御装置は、無段変速機の出力側の実際の発生駆動トルクを検出する実駆動トルク検出手段と、車両の走行速度を検出する車速検出手段と、車両の実際の加速度を検出する加速度検出手段と、検出された車速で平坦地を走行するとした場合に必要とされる平坦地駆動トルクを演算する平坦地走行必要駆動トルク演算手段と、実駆動トルク検出手段によって検出される実駆動トルクと平坦地走行必要駆動トルク演算手段によって演算される平坦地駆動トルクと加速度検出手段によって検出される車両の実加速度とに基づいて路面の傾斜角度を演算する傾斜角度演算手段と、傾斜角度演算手段によって演算された傾斜角度に基づいて制御目標変速比又は制御目標入力回転速度を決定する変速信号決定手段と、有している。

（ホ）作用

傾斜角度演算手段によって演算された傾斜角度は、実際に走行している路面の傾斜角度に対応している。すなわち、実駆動トルク検出手段によって検出される実駆動トルクと、平坦地走行必要駆動トルク演算手段によって演算される平坦地駆動トルクとの差、すなわち余裕トルク（又は不足トルク）を演算し、これと車両の実際の加速度（正確には、この加速度を得るためのトルク）との差から傾斜角度が演算される。こうして求められた傾斜角度に応じて変速パターンを制御することにより、登り坂に応じて必要な駆動トルクを得るようにすることができ、また下り坂の場合には適度なエンジンブレーキ効果を得るようにすることができる。例えば、登り坂の場合には、演算された傾斜角度が大きいほど変速比を大側に設定する。また、下り坂の場合には、演算された傾斜角度が大きいほど変速比大側に設定する。

（ヘ）実施例

第２図に無段変速機の動力伝達機構を示す。この無段変速機はフルードカップリング１２、前後進切換機構１５、Ｖベルト式無段変速機構２９、差動装置５６等を有しており、フューエルカット装置１１付きのエンジン１０の出力軸１０ａの回転を所定の変速比及び回転方向で出力軸６６及び６８に伝達することができる。なお、フューエルカット装置１１は、所定の運転状態、すなわちスロットルが全閉でエンジン回転速度（又は車速）が所定値以上の場合に、燃料の供給を停止することができる装置である。この無段変速機は、

フルードカップリング１２（ロックアップ油室１２ａ、ポンプインペラー１２ｂ、タービンランナ１２ｃ等を有している）、回転軸１３、駆動軸１４、前後進切換機構１５、駆動プーリ１６（固定円すい板１８、駆動プーリシリンダ室２０（室２０ａ、室２０ｂ）、可動円すい板２２、みぞ２２ａ等からなる）、遊星歯車機構１７（サンギア１９、ピニオンギア２１、ピニオンギア２３、ピニオンキャリア２５、インターナルギア２７等から成る）、Ｖベルト２４、従動プーリ２６（固定円すい板３０、従動プーリシリンダ室３２、可動円すい板３４等から成る）、従動軸２８、前進用クラッチ４０、駆動ギア４６、アイドラギア４８、後進用ブレーキ５０、アイドラ軸５２、ピニオンギア５４、ファイナルギア４４、ピニオンギア５８、ピニオンギア６０、サイドギア６２、サイドギア６４、出力軸６６、出力軸６８などから構成されているが、これらについての詳細な説明は省略する。なお、説明を省略した部分の構成については本出願人の出願に係る特願昭５９－２２６７０６号に記載されている。

第３図に無段変速機の油圧制御装置を示す。この油圧制御装置は、オイルポンプ１０１、ライン圧調圧弁１０２、マニアル弁１０４、変速制御弁１０６、調整圧切換弁１０８、変速モータ（ステップモータ）１１０、変速操作機構１１２、スロットル弁１１４、一定圧調圧弁１１６、電磁弁１１８、カップリング圧調圧弁１２０、ロックアップ制御弁１２２等を有しており、これらは互いに図示のように接続されており、また前進用クラッチ４０、後進用ブレーキ５０、フルードカップリング１２、ロックアップ油室１２ａ、駆動プーリシリンダ室２０及び従動プーリシリンダ室３２とも図示のように接続されている。これらの弁等についての詳細な説明は省略する。説明を省略した部分については前述の特願昭５９－２２６７０６号に記載されている。なお、第３図中の各参照符号は次の部材を示す。ピニオンギア１１０ａ、タンク１３０、ストレーナ１３１、油路１３２、リリーフ弁１３３、弁穴１３４、ポート１３４ａ～ｅ、スプール１３６、ランド１３６ａ～ｂ、油路１３８、一方向オリフィス１３９、油路１４０、油路１４２、一方向オリフィス１４３、弁穴１４６、ポート１４６ａ～ｇ、スプール１４８、ランド１４８ａ～ｅ、スリーブ１５０、スプリング１５２、スプリング１５４、押圧部材１５８、油路１６４、油路１６５、オリフィス１６６、オリフィス１７０、弁穴１７２、ポート１７２ａ～ｅ、スプール１７４、ランド１７４ａ～ｃ、スプリング１７５、油路１７６、オリフィス１７７、レバー１７８、油路１７９、ピン１８１、ロッド１８２、ランド１８２ａ～ｂ、ラック１８２ｃ、ピン１８３、ピン１８５、弁穴１８６、ポート１８６ａ～ｄ、油路１８８、油路１８９、油路１９０、弁穴１９２、ポート１９２ａ～ｇ、スプール１９４、ランド１９４ａ～ｅ、負圧ダイヤフラム１９８、オリフィス１９９、オリフィス２０２、オリフィス２０３、弁穴２０４、ポート２０４ａ～ｅ、スプール２０６、ランド２０６ａ～ｂ、スプリング２０８、油路２０９、フィルター２１１、オリフィス２１６、ポート２２２、ソレノイド２２４、プランジャ２２４ａ、スプリング２２５、弁穴２３０、ポート２３０ａ～ｅ、スプール２３２、ランド２３２ａ～ｂ、スプリング２３４、油路２３５、オリフィス２３６、弁穴２４０、ポート２４０ａ～ｈ、スプール２４２、ランド２４２ａ～ｅ、油路２４３、油路２４５、オリフィス２４６、オリフィス２４７、オリフィス２４８、オリフィス２４９、チョーク形絞り弁２５０、リリーフバルブ２５１、チョーク形絞り弁２５２、保圧弁２５３、油路２５４、クーラー２５６、クーラー保圧弁２５８、オリフィス２５９、切換検出スイッチ２７８。

第４図にステップモータ１１０及びソレノイド２２４の作動を制御する変速制御装置３００を示す。変速制御装置３００は、入力インターフェース３１１、基準パルス発生器３１２、ＣＰＵ（中央処理装置）３１３、ＲＯＭ（リードオンリメモ

リ）３１４、ＲＡＭ（ランダムアクセスメモリ）３１５及び出力インターフェース３１６を有しており、これらはアドレスバス３１９及びデータバス３２０によって連絡されている。この変速制御装置３００には、エンジン回転速度センサー３０１、車速センサー３０２、スロットル開度センサー３０３、シフトポジションスイッチ３０４、タービン回転速度センサー３０５、エンジン冷却水温センサー３０６、ブレーキセンサー３０７及び切換検出スイッチ２９８からの信号が直接又は波形成形器３０８、３０９及び３２２、及びＡＤ変換器３１０を通して入力され、一方増幅器３１７及び線３１７ａ～ｄを通してステップモータ１１０へ信号が出力され、またソレノイド２２４へも信号が出力されるが、これらについての詳細な説明は省略する。なお、説明を省略した部分の構成については、前述の特願昭５９－２２６７０６号に記載されている。

第５～８図に変速制御装置３００によって行われる制御内容を示す。このうちソレノイド２２４を制御することによるクラッチの完全締結制御及びフルードカップリング１２のロックアップ制御については、前述の特願昭５９－２２６７０６号に記載されたものと同様であるので説明を省略する。

第６～８図にはステップモータ制御ルーチンが示してある。ステップ６０２で実際の車速Ｖｓが所定の小さい値V_0よりも大きい場合にはステップ６２４に進んでシフトポジションがＤレンジにあるかどうかを判断し、Ｄレンジにある場合にはステップ８０２に進む。ステップ８０２ではVs_1の値として現在ルーチンよりも一回前のルーチンにおけるVs_0の値を設定し、次いでステップ８０４でVs_0として現在のルーチンで読み込んだ車速Ｖｓを設定する。次いで、同様にステップ８０６でTH_1として現在のルーチンよりも一回前のルーチンにおける値TH_0を設定し、次いでステップ８０８でTH_0として現在のルーチンにおけるＴＨを設定する。次いで、Vs_0がVs_1よりも大きいかどうかを判断し（同８１０）、$Vs_0 \leqq Vs_1$のときにはΔＶの値を０に設定し（同８１２）、ステップ８１６に進み、また$Vs_0 > Vs_1$のときにはΔＶの値として$Vs_0 - Vs_1$の値を設定し（同８１４）、ステップ８１６に進む。ΔＶは速度の変化、すなわち加速度を示す値となる。ステップ８１６ではエンジン回転速度N_e及びスロットル開度TH_1の値に基づいて、あらかじめ記憶させてあるエンジン性能のデータから補間法によりトルク値Ｔｒを求める。次いで、ステップ８１８で車速Ｖｓに基づいて駆動トルクＴｆを求める。駆動トルクＴｆとしては車速Ｖｓで平坦地を走行する場合の平坦地駆動トルクが設定されているが、これについても走行性能のデータから補間法により求められる。次いで、ステップ８２０で傾斜角度Ｓの値として、$C_1\ (C_2 \times i \times Tr - \Delta V \times C_3 - Tf)$の値を演算する。次いで、ステップ８２２でスロットルが全閉であるかどうかを判断し、全閉でない場合には傾斜角度Ｓの値に応じて変速パターンＡを決定し（同８２４）、またスロットル全閉の場合には傾斜角度Ｓの値に応じて変速パターンＢを決定し（同８２６）、次いで変速パターンの検索を行ない（同８２８）、ステップ９０２に進む。変速パターンＡ及びＢとしては、例えば第９図に示すように傾斜角度Ｓに応じてA_0～A_5、及びB_0～B_5が設定されている。変速パターンＡは第１０図に示すようにエンジン回転速度とスロットル開度とを関連づける。また変速パターンＢは車速とエンジン回転速度とを第１１図に示すように関連づける。

前述のステップ６２４でＤレンジにはないと判断され、ステップ６３９でＬレンジにあると判断された場合にはＬレンジ変速パターンの検索を行ない、Ｒレンジにあると判断された場合にはＲレンジ変速パターンの検索を行なう（同６４０）。前述のステップ８２８、ステップ６２８、及びステップ６４０からはステップ９０２に進むが、ステップ９０２以下の内容は特願昭６０－４２８８１号に記載されており、また本発明とは直接関連しないので、説明を省略する。なお、こ

のフローチャートでステップ６０４、９０６のTH_2は小さなスロットル開度に相当する所定値であり、ステップ９０８のV_1は低車速相当の所定値である。また、ステップ６０２からステップ６０４に進んだ場合の制御についても同様の理由で説明を省略する。

結局、ステップ８０２からステップ８２８までの制御によって次のような動作が行なわれることになる。エンジン回転速度N_E及びスロットル開度TH_1からエンジンの実駆動トルクTrが算出され、またその時点の車速で平坦地を走行する場合に必要な平坦地駆動トルクTfが演算される（ステップ８１６及び８１８）。次いで、$C_1(C_2 \times i \times Tr - \Delta V \times C_3 - Tf)$を演算することにより傾斜角度Ｓを算出する。この傾斜角度Ｓに基づいて、スロットルが開いている場合にはＡパターンが選択され、その変速パターンに基づいて変速比が制御される。変速パターンＡは、第１０図に示すようにスロットル開度に対応する目標制御エンジン（入力）回転速度が与えられており、また傾斜角度Ｓに応じてA_0～A_5を選択することにより、傾斜角度にかかわらず同一スロットル開度ではほぼ同一の加速力が得られるように設定されている。また、スロットル全閉の場合には、変速パターンＢが選択され、これに基づいて変速制御が行なわれるが、変速パターンＢは、車速に応じて目標制御エンジン（入力）回転速度が与えられており、またB_0～B_6を選択することにより、傾斜角度にかかわらず車速を一定、すなわち加速度をほぼ０とするようにあらかじめ設定されている。このようにこの実施例では変速パターンとして加速側及びコースティング側にそれぞれ複数種類用意してあり、算出される傾斜角度Ｓに応じてパターンの切換えが行なわれることになる。なお、パターン選択のハンチングが発生することを防止するために、パターン切換えに用いる傾斜角度Ｓの値の間にはヒステリシスが付けられている。

（第２実施例）

第１２図に本発明の第２実施例を示す。この第２実施例は前述の第１実施例の第６図に示すステップ８１６～８２０をステップ８１７及び８１９に変更したものである。すなわち、ステップ８１７ではスロットル開度ＴＨに対応して$N_E \times Tr$を検索する。すなわち、第１３図に示すようなパターンがあらかじめ作られており、これに基づいて$N_E \times Tr$を検索する。次いで、ステップ８１９では$C_1(C_2 \times N_E \times Tr / Vs - \Delta V \times C_3 - T_s)$を傾斜角度Ｓの値として設定する。こうすることによって前述の第１実施例と同様の作用を得ることができる。なお、変速パターンＡとして、パターンA_0及びパターンA_5のみを設定し、傾斜角度Ｓの値に応じて補間法により中間のパターンを求めるようにすることもできる。変速パターンＢについても同様である。

（第３実施例）

第１４～１６図に本発明の第３実施例を示す。この第３実施例は、第１実施例に対してステップ８１６とステップ８１８との間にステップ８４０及び８４２が挿入されていること、及びステップ８２２～８２８をステップ８５０～８８８に置き換えていること、だけが相違している。この第３実施例は登り坂に対してのみ第１実施例とほぼ同様の作用を行う。すなわち、傾斜角度Ｓの値が基準となるS_0よりも大きい場合には大きな変速比を設定したパワーパターンが選択されて十分な駆動トルクが得られ、傾斜角度ＳがS_0よりも小さい場合には小さな変速比を設定したエコノミーパターンが選択される。なお、S_0の値は車速及びスロットル開度の増大に応じて減少するように設定される。これは駆動トルクの余裕がないときはパワーパターンを選択しやすくするためである。なお、ステップ８６２及び８６４は$S > S_0$の状態が所定時間継続した場合にパワーパターンが選択されるようにして誤判断を防止するためのものである。また、ステップ８７０～８８２は、パワーパターンで走行中に短時間だけアクセルペダルを戻したときにはパワーパターンを維持するように作用するもので、ステップ

872のTH_3及びステップ876のV_2はそれぞれ低開度及び低車速（TH_2及びV_0よりは大きい）に相当する所定値である。

（ト）発明の効果

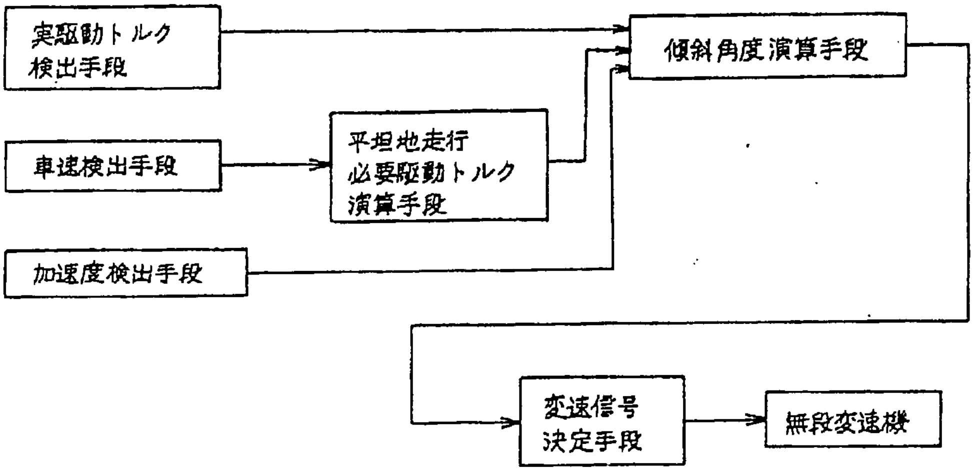
以上説明してきたように、本発明によると、走行路面の傾斜角度に相当する値を算出し、この値に応じて変速パターンを自動的に変化させるようにしたので、登り坂における加速力及び下り坂におけるエンジンブレーキ効果が常に最適な状態に制御される。また、車両の積載重量が変化した場合にも同様に加速力及びエンジンブレーキ効果が変化するため運転性が大幅に向上する。また、記憶装置に入力するデータはエンジン性能に関するものだけでよくなり、データの入力作業が大幅に簡素化される。

4．図面の簡単な説明

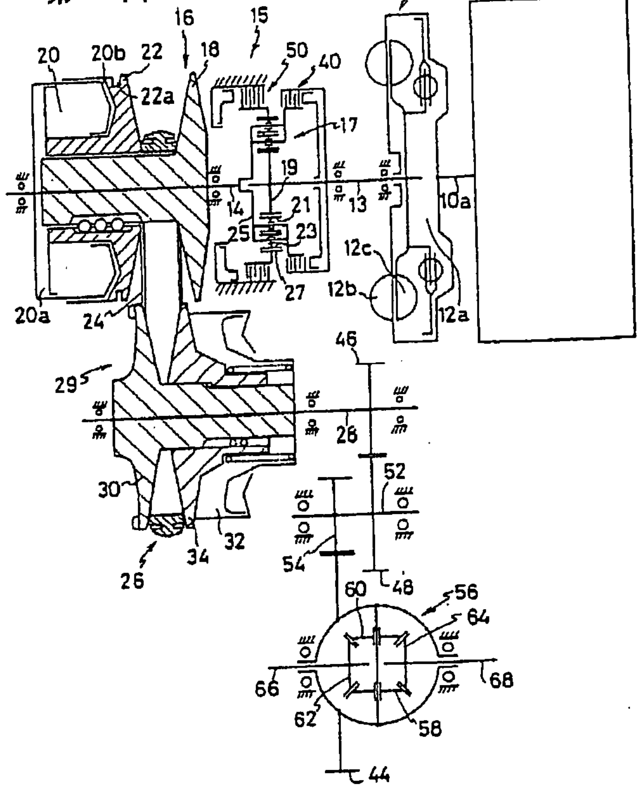
第1図は本発明の構成要素間の関係を示す図、第2図は無段変速機の骨組図、第3図は油圧制御装置を示す図、第4図は変速制御装置を示す図、第5、6、7及び8図は制御ルーチンを示す図、第9図は傾斜角度に対する変速パターンの設定を示す図、第10図は変速パターンAを示す図、第11図は変速パターンBを示す図、第12図は本発明の第2実施例を示す図、第13図はスロットル開度に対する$N_e \times Tr$の関係を示す図、第14、15及び16図は本発明の第3実施例の制御ルーチンを示す図である。

特許出願人　日産自動車株式会社
代理人　弁理士　宮内利行

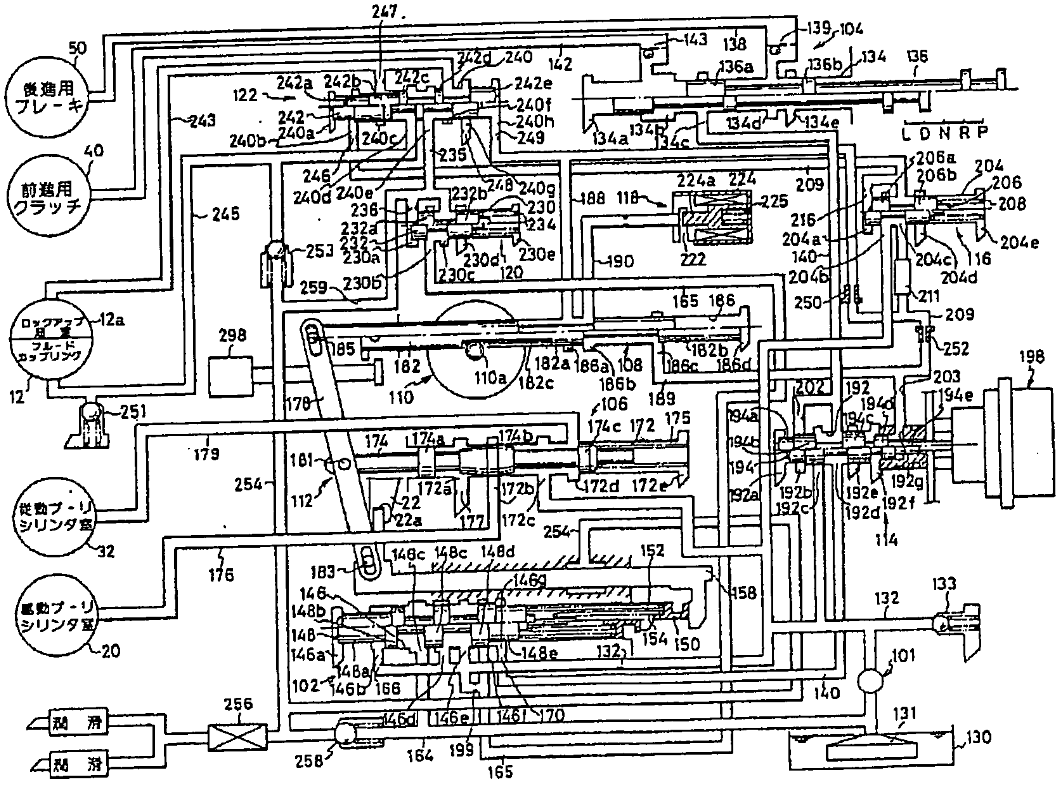
第1図



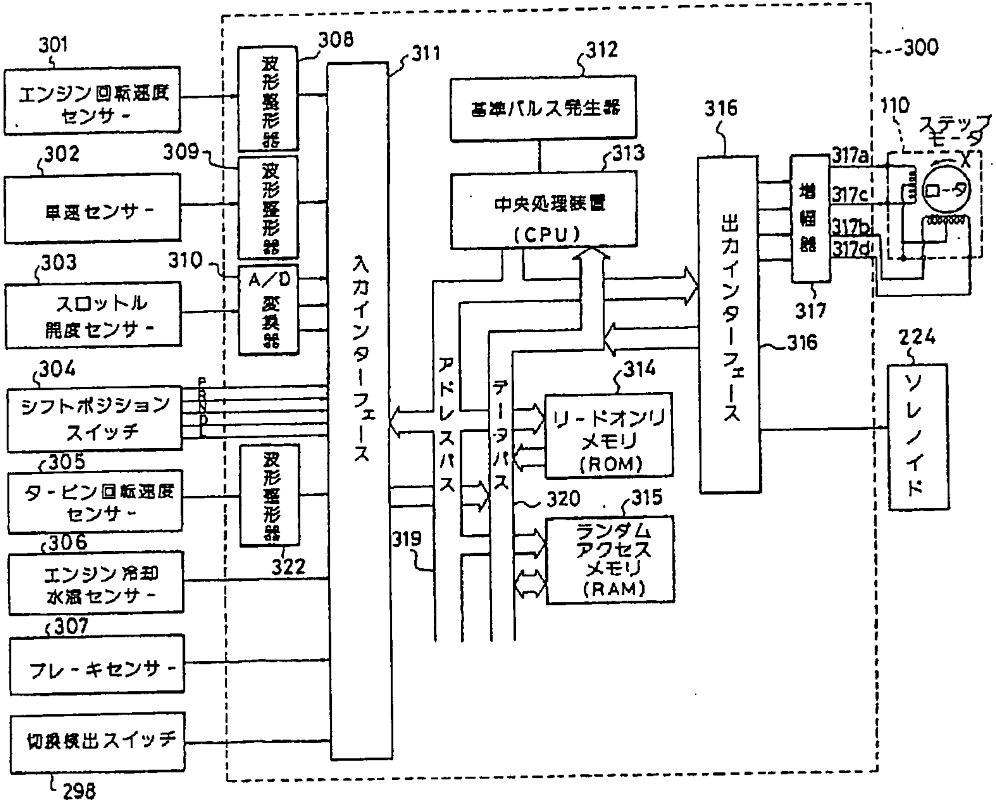
第2図


16
15
12
10
11
20
20b
22
18
50
40
22a
17
19
14
13
10a
21
25
23
12c
12b
12a
27
20a
24
46
29
28
30
52
32
34
26
54
48
56
60
64
66
68
62
58
44

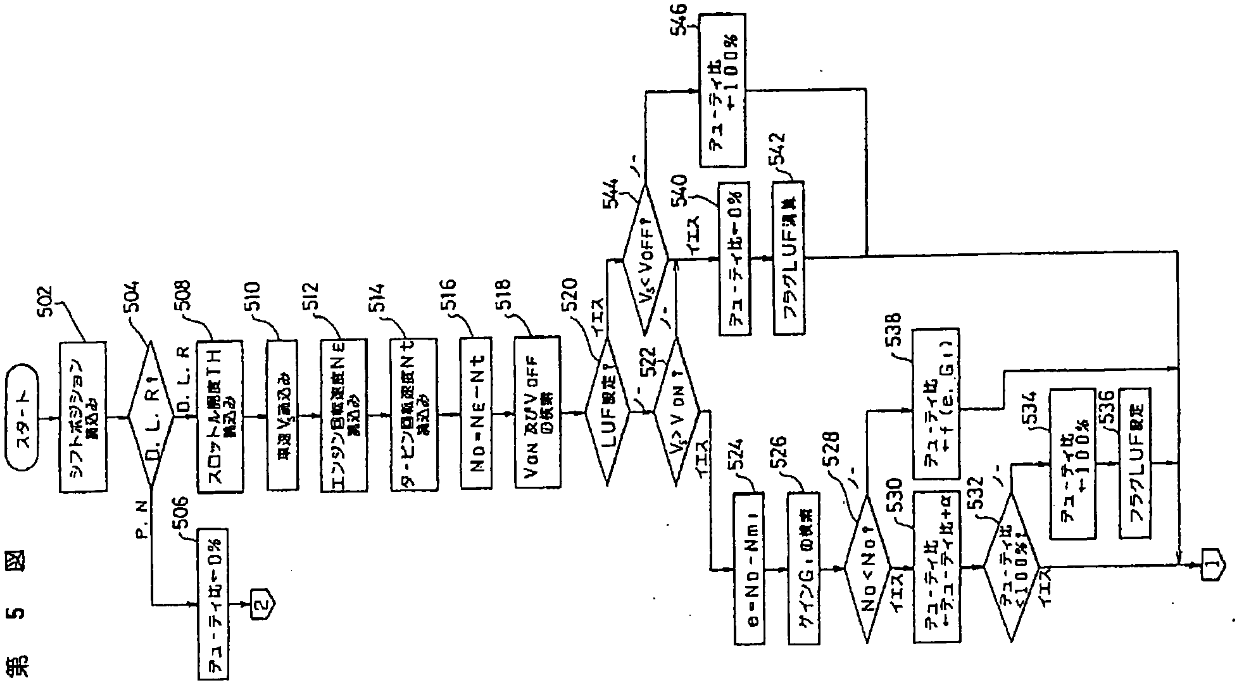
第3図


後進用ブレーキ
50
前進用クラッチ
40
ロックアップ室
フルードカップリング
12a
12
従動プーリシリンダ室
32
駆動プーリシリンダ室
20
潤滑
潤滑
247
139
104
134
136
138
143
136a
136b
142
122
240
242
242a
242b
242c
242d
242e
240a
240b
240c
240d
240e
240f
240g
240h
249
134a
134b
134c
134d
134e
L D N R P
243
245
246
235
248
236
230
232
232a
232b
230a
230b
230c
230d
230e
234
120
188
118
224
224a
225
222
190
209
216
206
206a
206b
204
204a
204b
204c
204d
204e
208
140
116
253
259
250
211
252
165
186
185
182
182a
182b
182c
186a
186b
186c
186d
108
110
110a
189
298
251
106
174
174a
174b
174c
172
172a
172b
172c
172d
172e
175
177
178
179
181
112
22
22a
254
176
183
146
146a
146b
146c
146d
146e
146f
146g
148
148a
148b
148c
148d
148e
152
154
150
158
132
133
101
131
130
102
166
170
164
199
256
258
114
192
192a
192b
192c
192d
192e
192f
192g
194
194a
194b
194c
194d
194e
198
202
203

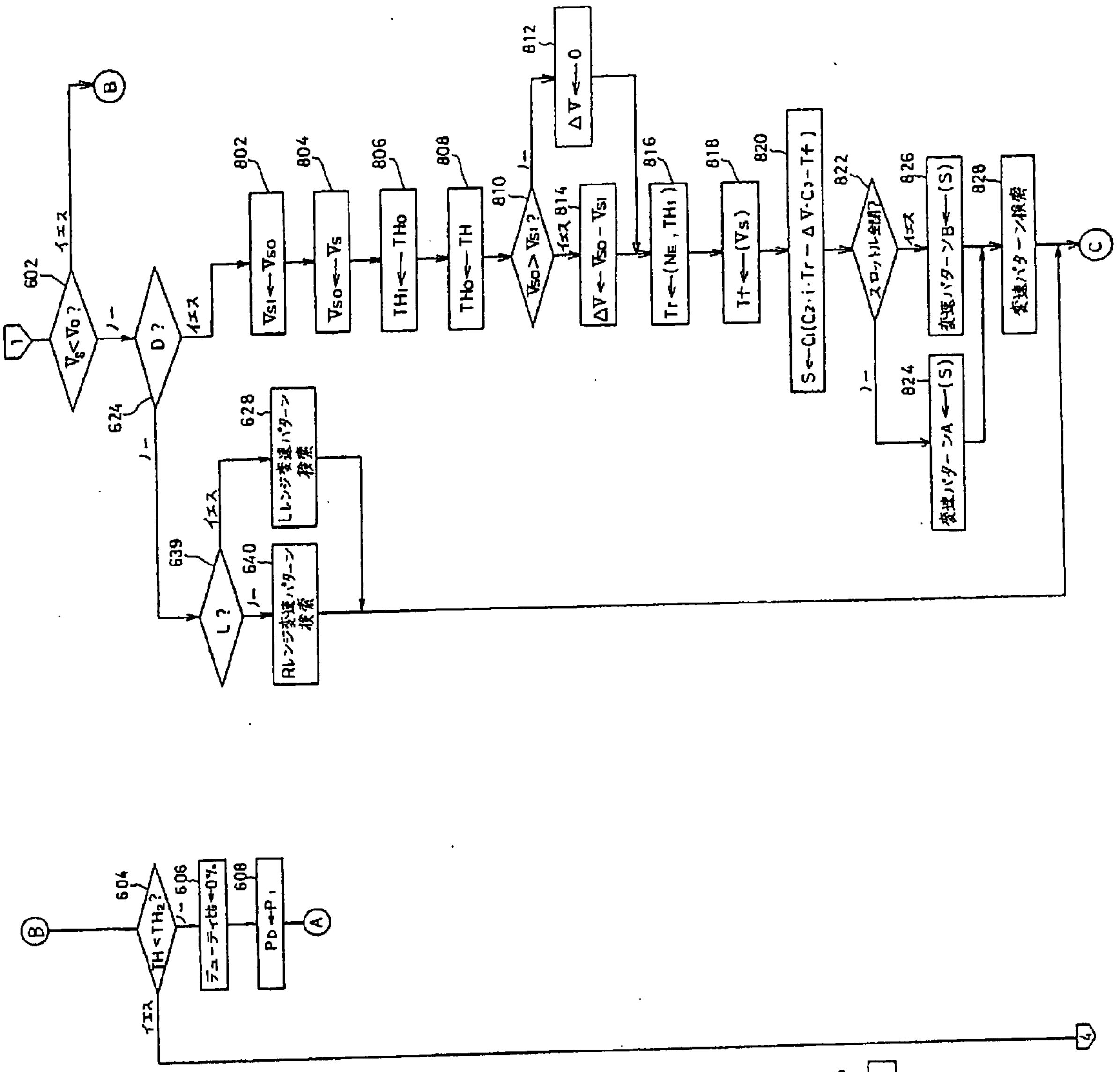
第４図


300
301
エンジン回転速度センサー
302
車速センサー
303
スロットル開度センサー
304
シフトポジションスイッチ
P
R
N
D
2
L
305
タービン回転速度センサー
306
エンジン冷却水温センサー
307
ブレーキセンサー
切換検出スイッチ
298
308
波形整形器
309
波形整形器
310
A/D変換器
波形整形器
322
311
入力インターフェース
319
アドレスバス
データバス
320
312
基準パルス発生器
313
中央処理装置 (CPU)
314
リードオンリメモリ (ROM)
315
ランダムアクセスメモリ (RAM)
316
出力インターフェース
317
増幅器
317a
317c
317b
317d
110
ステップモータ
ロータ
224
ソレノイド

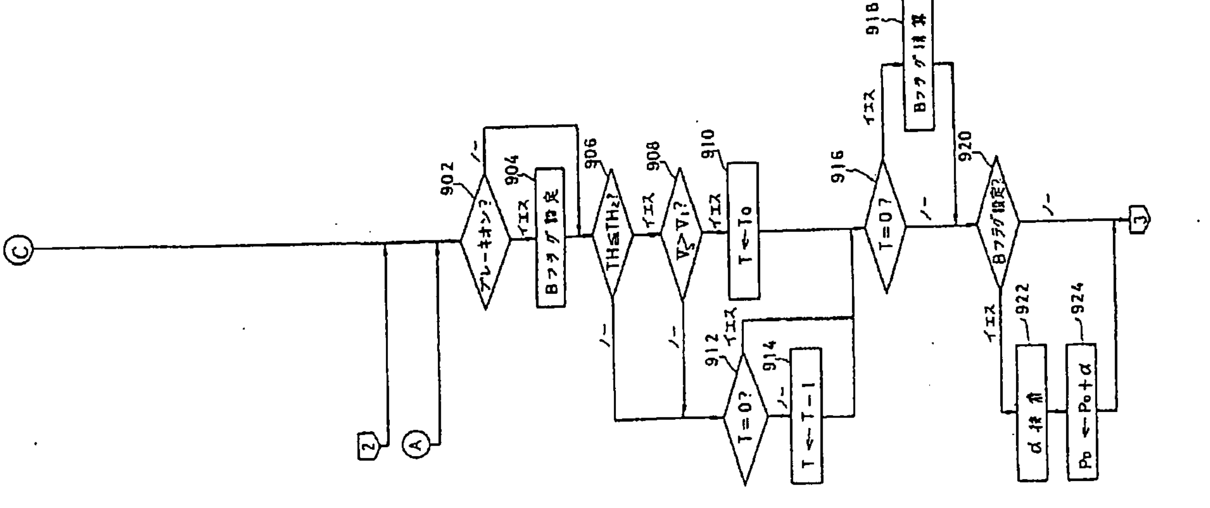
第５図


スタート
502
シフトポジション読込み
504
D.L.R?
P.N
506
デューティ比←0%
2
D.L.R
508
スロットル開度TH読込み
510
車速Vs読込み
512
エンジン回転速度NE読込み
514
タービン回転速度Nt読込み
516
No=NE−Nt
518
VON及びVOFFの検索
520
LUF設定?
イエス
ノー
522
Vs>VON?
ノー
イエス
544
Vs<VOFF?
ノー
イエス
546
デューティ比←100%
540
デューティ比←0%
542
フラグLUF消去
524
e=No−Nm1
526
ゲインG1の検索
528
No<No?
ノー
イエス
530
デューティ比←デューティ比+α
538
デューティ比←f(e, G1)
532
デューティ比<100%?
ノー
イエス
534
デューティ比←100%
536
フラグLUF設定
1

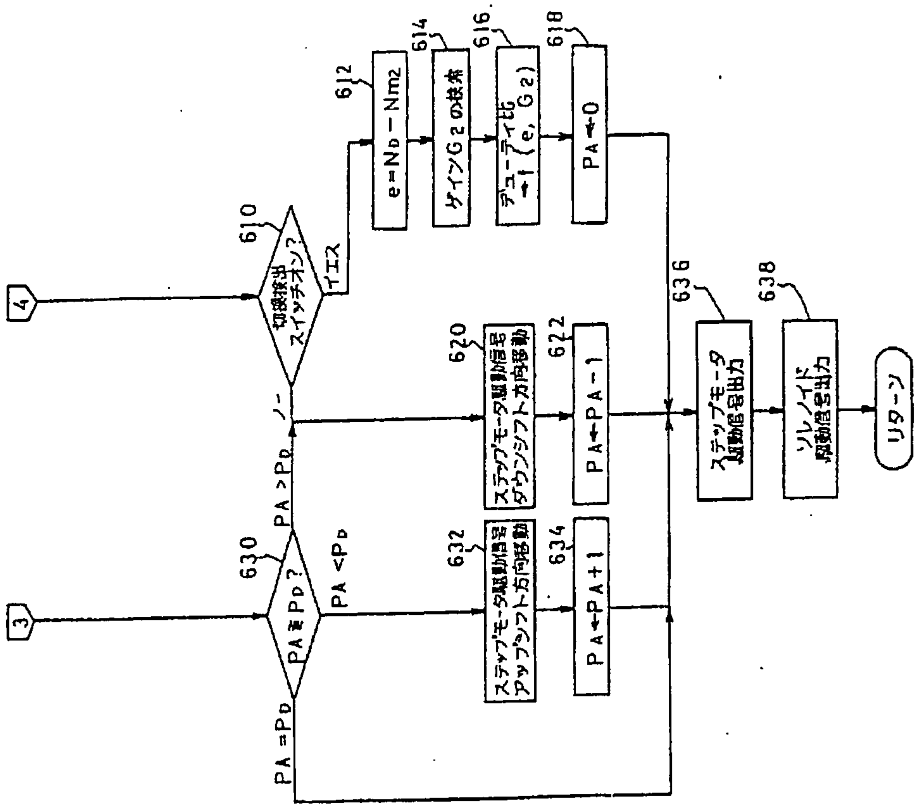
第6図


1
V_s<V_0?
602
イエス
B
ノー
D?
624
イエス
ノー
802
V_S1←V_S0
804
V_S0←V_S
806
TH1←TH0
808
TH0←TH
810
V_S0>V_S1?
イエス
ノー
812
ΔV←0
814
ΔV←V_S0−V_S1
816
Tr←(N_E, TH1)
818
Tf←(V_S)
820
S←C1(C2·i·Tr−ΔV·C3−Tf)
822
スロットル全開?
イエス
ノー
824
変速パターンA←(S)
826
変速パターンB←(S)
828
変速パターン検索
C
639
L?
イエス
ノー
628
Lレンジ変速パターン検索
640
Rレンジ変速パターン検索
B
604
TH<TH2?
ノー
606
デューティ比←0%
608
P_D←P_1
A
イエス
4

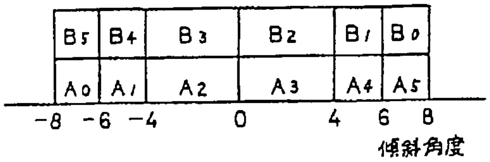
第7図


C
902
ブレーキオン?
ノー
イエス
904
Bフラグ設定
906
TH≦TH2?
イエス
ノー
908
V_S>V_1?
イエス
ノー
910
T←T0
912
T=0?
イエス
ノー
914
T←T−1
916
T=0?
イエス
ノー
918
Bフラグ消去
920
Bフラグ設定?
ノー
イエス
3
922
α検索
924
P_D←P_D+α
2
A

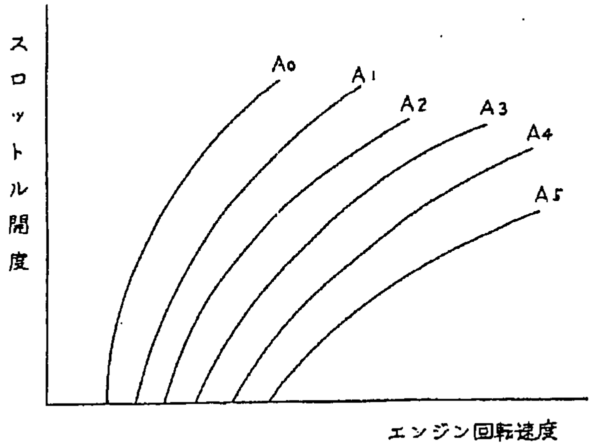
第8図



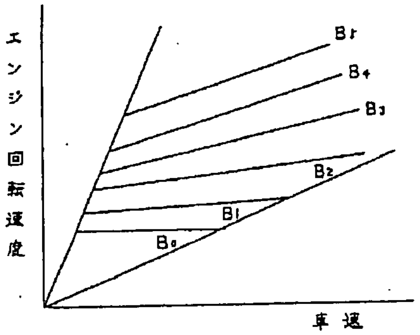
第9図



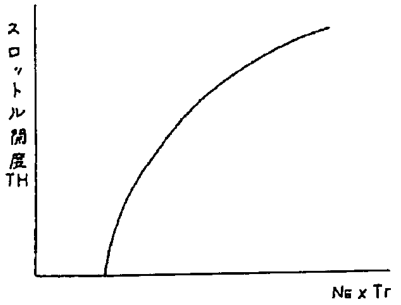
第10図



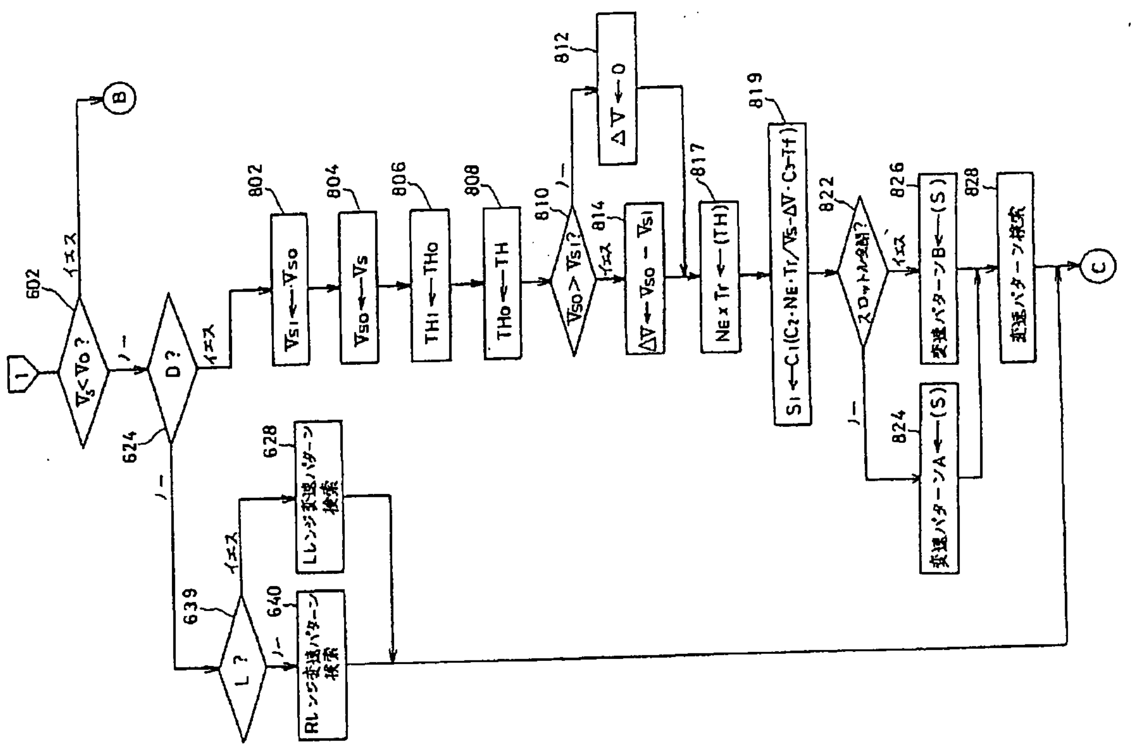
第11図



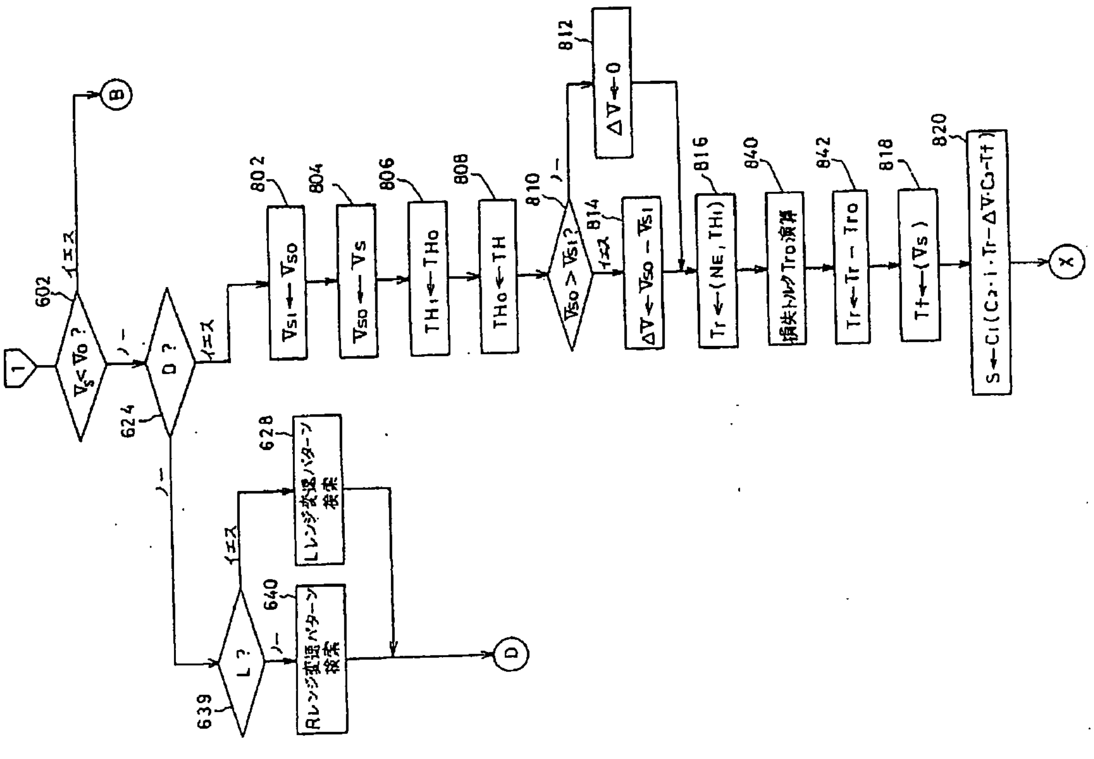
第13図



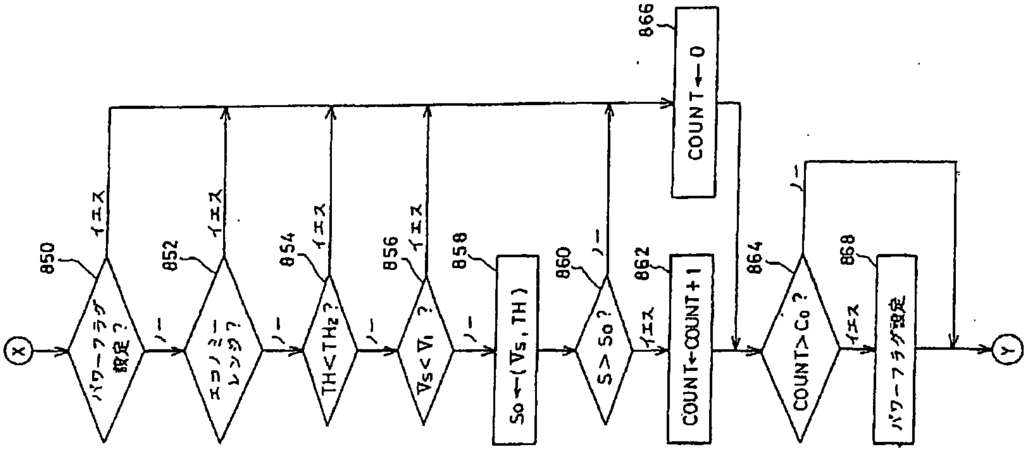
第12図


1
602
Vs<Vo?
イエス
B
ノー
D?
624
イエス
802
VS1←VS0
804
VS0←VS
806
TH1←TH0
808
TH0←TH
810
VS0>VS1?
ノー
812
ΔV←0
イエス
814
ΔV←VS0−VS1
817
NE×Tr←(TH)
819
S1←C1(C2·NE·Tr/VS−ΔV·C3−Tf)
822
スロットル全閉?
イエス
826
変速パターンB←(S)
ノー
824
変速パターンA←(S)
828
変速パターン検索
C
ノー
639
L?
イエス
628
Lレンジ変速パターン検索
ノー
640
RLレンジ変速パターン検索

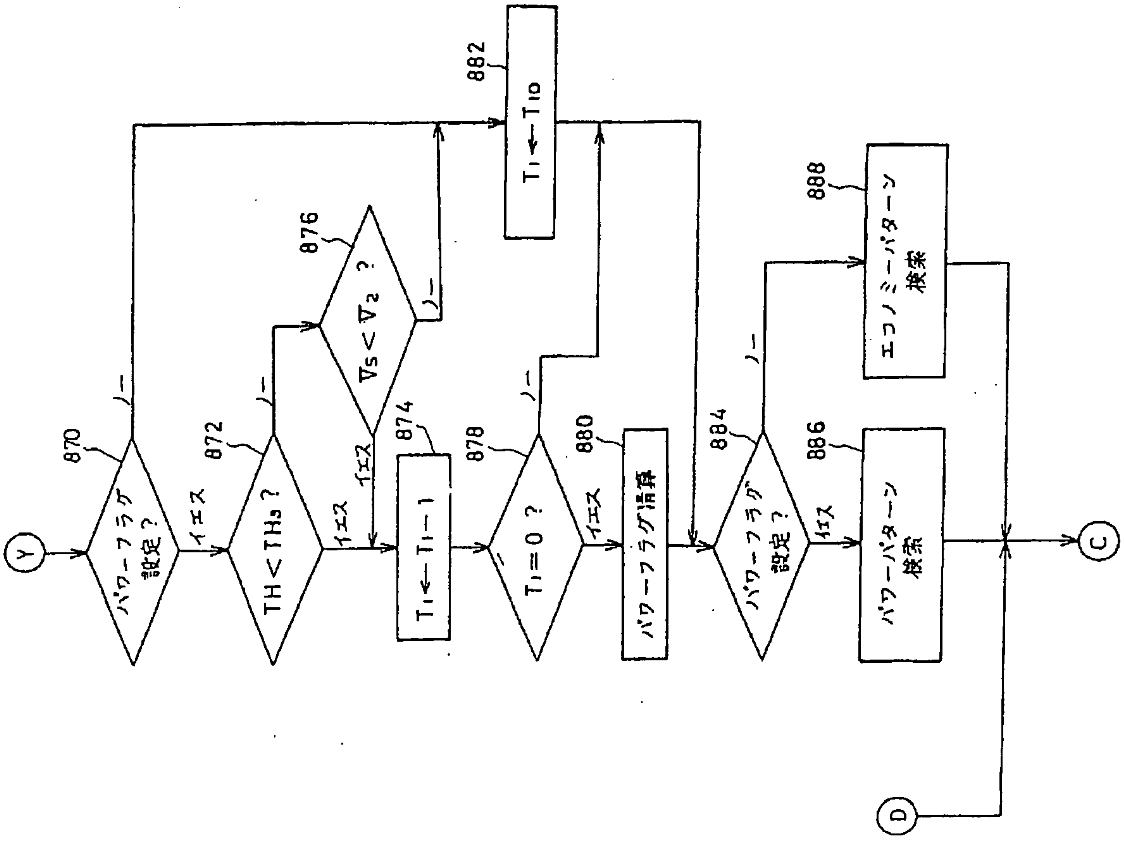
第14図


1
602
Vs<Vo?
イエス
B
ノー
D?
624
イエス
802
VS1←VS0
804
VS0←VS
806
TH1←TH0
808
TH0←TH
810
VS0>VS1?
ノー
812
ΔV←0
イエス
814
ΔV←VS0−VS1
816
Tr←(NE, TH1)
840
損失トルクTro演算
842
Tr←Tr−Tro
818
Tf←(VS)
820
S←C1(C2·i·Tr−ΔV·C3−Tf)
X
ノー
639
L?
イエス
628
Lレンジ変速パターン検索
ノー
640
Rレンジ変速パターン検索
D

第15図


X
850
パワーフラグ設定？
イエス
ノー
852
エコノミーレンジ？
イエス
ノー
854
TH<TH2？
イエス
ノー
856
Vs<V1？
イエス
ノー
858
So←(Vs, TH)
860
S>So？
ノー
イエス
862
COUNT←COUNT+1
866
COUNT←0
864
COUNT>Co？
ノー
イエス
868
パワーフラグ設定
Y

第16図


Y
870
パワーフラグ設定？
イエス
ノー
872
TH<TH3？
イエス
ノー
876
Vs<V2？
ノー
イエス
874
T1←T1−1
878
T1=0？
ノー
イエス
880
パワーフラグ消去
882
T1←T10
884
パワーフラグ設定？
イエス
ノー
886
パワーパターン検索
888
エコノミーパターン検索
C
D

[Translation]

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Examination Request: Not Filed Number of Inventions: 1 (total 12 pages [original])

(54) Title of the Invention: Control Device for Continuously Variable Transmission

(21) Application No.: Sho 60-253730

(22) Filing date: November 14, 1985

(72) Inventor: HISAMURA, Haruyoshi

c/o Nissan Motor Co. Ltd., No. 2 Muromachi, Kanagawa-ku, Yokohama-shi

(71) Applicant: Nissan Motor Co. Ltd.

No. 2 Muromachi, Kanagawa-ku, Yokohama-shi

(74) Agent: Noriyuki Miyauchi, Patent Attorney

SPECIFICATION

1. Title of the Invention

Control Device for Continuously Variable Transmission

2. Claims

[Omitted]

3. Detailed Description of the Invention

(A) Industrial Field of Application

The present invention relates to a control device for a continuous variable transmission.

(B) Prior Art

The invention disclosed in JPA Sho 58-180864 can be cited as a representative example of a control device for continuously variable transmissions used heretofore. This control device for continuously variable transmissions calculates the actual acceleration from changes in the vehicle speed, compares a specified comparison standard acceleration and the actual acceleration, and if the actual acceleration is smaller, orders a corrected shift ratio that is greater than the standard shift ratio when the actual acceleration is not smaller. By this means, when the vehicle is in a driving state where the drive torque is insufficient, such as when climbing a slope, by increasing the shift ratio the engine rotational speed can be increased, so that a good driving sensation can be obtained without selecting in the L range.

(C) Problems the Invention Is to Solve

Nevertheless, since such prior control devices for continuously variable transmissions are constituted so as to compare a comparison standard acceleration and the actual acceleration, there is a problem that the comparison standard acceleration data expands, making preparation and processing of the data difficult and impractical. More specifically, in order to obtain the optimal driving state on roads having various angles of inclination, it is necessary to set the standard comparison acceleration for each of many finely divided angles of inclination and to set the shift command signal that is determined by the vehicle speed and throttle opening so as to correspond therewith, and an extremely large amount of data is necessary in order to perform control with good precision. In order to create such data, the optimal value must be determined by actual testing and calculation of the slope, requiring extensive labor. The object of the present invention is to solve such problems.

(D) Means Used to Solve the Problems

The present invention solves the aforementioned problems by calculating the slope of inclined roads while driving by means of calculation from engine performance data and determines a shifting signal in accordance therewith. Specifically, the continuously variable transmission control device according to the present invention comprises an actual drive torque detecting means, which detects the actual drive torque generated on the output side of the variable transmission, a vehicle speed detecting means, which detects the traveling speed of the vehicle, an acceleration detecting means, which detects the actual acceleration of the vehicle, a flatland traveling required drive torque calculating means, which calculates the flatland drive torque required when traveling on a flat surface at the detected vehicle speed, a slope calculating means, which calculates the slope of the road based on the actual drive torque detected by the actual drive torque detector, the flatland drive torque calculated by the flatland traveling required drive torque calculating means, and the actual acceleration of the vehicle detected by the acceleration detecting means, and a shift signal deciding means, which decides the shift ratio to be controlled or input rotational speed to be controlled based on the slope calculated by the slope calculating means.

(E) Operation

The slope calculated by the slope calculating means corresponds to the slope of the road on which the vehicle is actually traveling. In other words, the difference between the actual drive torque detected by the actual drive torque detecting means and the flatland drive torque calculated by the flatland traveling required drive torque calculating means, i.e., the torque margin (or insufficient torque), is calculated and the slope is calculated from the difference between this and the actual acceleration of the vehicle (more precisely, the torque obtained from this acceleration). By controlling the shift pattern in accordance with the slope thus obtained, it is possible to obtain the required drive torque in accordance with the uphill slope, and in the case of a downhill slope to obtain an appropriate engine-brake effect. For example, in the case of an uphill slope, the shift ratio is set at a larger value as the calculated slope increases. In the case of a downhill slope, the shift ratio is set at a larger value as the calculated slope increases.

(F) Working Examples

Figure 2 shows a power transfer mechanism of a continuously variable transmission. This continuously variable transmission comprises a fluid coupling 12, a forward and reverse switching mechanism 15, a V-belt type continuously variable transmission 29, a differential apparatus 56, and the like. The rotation of an output shaft 10a of the engine 10, which is equipped with a fuel cut device 11, can be transferred to output shafts 66 and 68 at a specified shift ratio and rotational direction. The fuel cut device 11 is an apparatus for preventing the feeding of fuel in specified driving status, i.e., when the engine rotational speed (or vehicle speed) exceeds a specified value and the throttle is completely closed. This continuously variable transmission comprises a fluid coupling 12 (having a lockup oil chamber 12a, a pump impeller 12b, a turbine runner 12c, etc.), rotary shaft 13, drive shaft 14, forward/reverse switching mechanism 15, drive pulley 16 (comprising a fixed conical plate 18, drive pulley cylinder chambers 20 (chambers 20a and 20b), a movable conical plate 22, a channel 22a, etc.), a planetary gear mechanism 17 (comprising a sun gear 19, pinion gear 21, pinion gear 23, pinion carrier 25, internal gear 27, etc.), a V-belt 24, a slave pulley 26 (comprising a fixed conical plate 30, slave pulley cylinder chamber 32, movable conical plate 34, etc.), a slave shaft 28, a forward clutch 40, a drive gear 46, and idle gear 48, a reverse brake 50, and idle shaft 52, a pinion gear 54, a final gear 44, a pinion gear 58, a pinion gear 60, a side gear 62, a side gear 64, an output shaft 66, an output shaft 68, and other parts, but detailed explanation thereof is omitted. The constitution of these parts of which discussion is omitted here is described in Japanese Patent Application Sho 59-226706, which was filed by the present inventor.

Figure 3 shows a hydraulic control apparatus of the continuously variable transmission. This hydraulic control apparatus comprises an oil pump 101, line pressure adjustment valve 102, manual valve 104, shift control valve 106, adjustment pressure switching valve 108, shifting motor (step motor) 110, shifting operation mechanism 112, while valve 114, fixed pressure adjustment valve 116, solenoid 118, coupling pressure adjustment valve 120, lockup control valve 122, and the like. These are interconnected as shown in figure and are also connected with the clutch 40, reverse brake 50, fluid coupling 12, lockup oil chamber 12a, drive pulley cylinder chamber 20, and slave pulley cylinder chamber 32, as shown in figure. The detailed explanation of these valves and the like is omitted. The parts of which discussion is omitted here are described in the aforementioned Japanese Patent Application Sho 59-226706. The reference numerals in Figure 3 refer to the following members: pinion gear 110a, tank 130, strainer 131, oil passage 132, relief valve 133, valve hole 134, ports 134a-e, spool 136, lands 136a-b, oil passage 138, one-way orifice 139, oil passage 140, oil passage 142, one-way orifice 143, valve hole 146, ports 146a-g, spool 148, lands 148a-e, sleeve 150, spring 152, spring 154, pressure member 158, oil passage 164, oil passage 165, orifice 166, orifice 170, valve hole 172, ports 172a-e, spool 174, lands 174a-c, spring 175, oil passage 176, orifice 177, lever 178, oil passage 179, pin 181, rod 182, lands 182a-b, rack 182c, pin 183, pin 185, valve hole 186, ports 186a-d, oil passage 188, oil passage 189, oil passage 190, valve hole 192, ports 192a-g, spool 194, lands 194a-e, negative pressure diaphragm 198, orifice 199, orifice 202, orifice 203, valve hole 204, ports 204a-e, spool 206, lands 206a-b, spring 208, oil passage 209, filter 211, orifice 216, port 222, solenoid 224, plunger 224a, spring 225, valve hole 230, ports 230a-e, spool 332, lands 332a-b, spring 234, oil passage 235, orifice 236, valve hole 240, ports 240a-b, spool 242, lands 242a-e, oil passage 243, oil passage 245, orifice 246, orifice 247, orifice 248, orifice 249, choke type throttle valve 252, pressure keeping valve 253, oil passage 254, cooler 256, cooler pressure keeping valve 258, orifice 259 and changeover detecting switch 278.

Figure 4 shows a shift controller 300, which controls the operation of the step motor 110 and solenoid 224. The shift controller 300 includes an input interface 311, a standard pulse generator 312, a CPU (central processing unit) 313, a ROM (read-only memory) 314, a RAM (random access memory) 315 and an output interface 316, and these are linked by means of an address bus 319 and data bus 320. In this shift controller 300, from an engine rotational speed sensor 301, vehicle speed sensor 302, throttle opening sensor 303, shift position switch 304, turbine rotational speed sensor 305, engine cooling water temperature sensor 306, brake sensor 307 and changeover detecting switch 298 are input via direct or waveform fabricators 308, 309 and 322 and an AD converter 310, pass through an amplifier 317 and lines 317a-d, and are output to the step motor 110 or to the solenoid 224. Detailed description of these matters is omitted here, but a detailed description of the parts explanation of which has been omitted may be found in the aforementioned Japanese Patent Application Sho 59-226706.

The content of the control process performed by the shift controller 300 is shown in Figures 5 through 8. The complete conclusive control process of the clutch and the lockup control process of the fluid coupling 12 by means that the solenoid 224 is likewise described in the aforementioned Japanese Patent Application Sho 59-226706, and is omitted here.

Figures 6 through 8 illustrate the step motor control routine. In step 602, if the actual vehicle speed Vs is greater than a specified small value V_0, then the routine advances to step 624, it is determined whether the shift position is in the D range, and if it is in the D range, the routine advances to step 802. In step 802, the value of Vs_0, in the immediately preceding routine from the present routine is set as the value of the Vs_1, and next, in step 804, the vehicle speed Vs which has been read in the current routine is set as Vs_0. Next, similarly in step 806, the value TH_0 in the routine immediately previous to the current routine is set as TH_1, and in the following step 808, TH in the present routine is set as TH_0. Next, it is determined whether Vs_0 is larger than Vs_1 (step 810), and if $Vs_0 \geq Vs_1$, then the value of ΔV is set at 0 (step 812), and the routine advances to step 816. If $Vs_0 < Vs_1$, then the value of ΔV is set at the value of $Vs_0 - Vs_1$ (step 814), and the routine advances to step 816. ΔV represents the change in the vehicle speed i.e., the value of acceleration. In step 816, based on the values of the engine rotational speed N_E and the throttle opening TH_1, the torque value Tr is obtained by interpolation from previously stored data on engine performance. Next, in step 818, the drive torque Tf is calculated based on the vehicle speed Vs. The flatland drive torque is set as the drive torque at traveling on a flat surface at the vehicle speed Vs, but this value can also be obtained from the running performance data by interpolation. Next, in step 820, the value of C_1 $(C_2 \times i \times Tr - \Delta V \times C_3 - Tf)$ is calculated as the value of the slope S. Next, in step 822, it is determined whether the throttle is completely closed, and if it is not completely closed, a shift pattern A is determined in accordance with the value of the slope S (step 824), and if the throttle is completely closed, a shift pattern B is determined in accordance with the value of the slope S (step 826). Shift pattern retrieval is next performed (step 828), and the procedure then advances to step 902. As shift patterns A and B, for example, A_0-A_S and B_0-B_S can be set in accordance with the slope S, is shown in Figure 9. The engine rotational speed and throttle opening are correlated, as shown in Figure 10. Additionally, the shift pattern B is correlated as shown in Figure 11 with the engine rotational speed.

If it is determined in step 624 described above that the shift position is not in D range, then in step 639, if it is determined that the position is in the L range, retrieval of L range shift pattern is performed, and if the position is determined to be in the R range, then R range shift patterns are retrieved (step 640). The routine then advances from the above-described step 828, step 628 and step 640 to step 902, but the contents of step 902 and subsequent steps are described in Japanese Patent Application Sho 60-42881 and are not directly relevant to the present invention, so explanation thereof is omitted. In this flowchart, TH_2 of steps 604 and 906 is a specified value corresponding to a small throttle opening, and V_1 in step 908 is a specified value corresponding to a low vehicle speed. Description of the control process when proceeding from step 602 to step 604 is omitted for similar reasons.

Ultimately, following operation is effected by the control procedure from step 822 to step 828. The actual torque Tr of the engine is calculated from the engine rotational speed N_E and the throttle opening TH_1, and the flatland drive torque Tf required in the case of driving on a flat road at the vehicle speed at that point in time is calculated (steps 816 and 818). Next, the slope S is calculated by computation of C_1 $(C_2 \times i \times Tr - \Delta V \times C_3 - Tf)$. Based on this slope S, if the throttle is open, then pattern A is selected in the shift ratio is adjusted based on this shift pattern. The shift pattern A provides a target control engine (input) rotational speed corresponding to the throttle opening, as shown in Figure 10, and by selecting A_0-A_S in accordance with this slope S, setting can be performed so that nearly the same acceleration is obtained at the same throttle opening irrespective of the slope. If the throttle is completely closed, then the shift pattern B is selected, and shift control is performed based thereon. The shift pattern B provides a target control engine (input) rotational speed in accordance with the vehicle speed and by selecting B_0-B_S in accordance, the vehicle speed can be fixed, i.e., can be set in advance so that acceleration is roughly 0, irrespective of the slope. Thus, in this working example multiple types of shift patterns can be prepared on both the acceleration and coasting sides, and the patterns can be switched in accordance with the calculated slope S. In order to prevent the occurrence of hunting in the pattern selection, hysteresis is provided between the values of the slope S used in pattern switching.

(Working Example 2)

Working Example 2 of the present invention is shown in Figure 12. In this second working example, the steps 816 through 820 shown in Figure 6 in Working Example 1 are changed to steps 817 and 819. Described specifically, in step 817 $N_E \times Tr$ is retrieved corresponding to the throttle opening TH. In other words, a pattern similar to that shown in Figure 13 is prepared in advance and $N_E \times Tr$ is retrieved based on this pattern. Next, in step 819, C_1 $(C_2 \times N_E \times Tr/Vs - \Delta V \times C_3 - T_S)$ is set as the slope S. By this means, a similar action can be obtained as that described in Working Example 1 above. Here, only pattern A_0 and pattern A_S are set as the shift pattern A, and intermediate patterns can be obtained by interpolation in accordance with the value of the slope S. The same is true with respect to the shift pattern B.

(Working Example 3)

Working Example 3 of the present invention is shown in Figures 14 through 16. This third working example differs from Working Example 1 merely in the fact that steps 840 and 842 are inserted between step 816 and step 818 and steps 822 through 828 are replaced by steps 850 through 888. This third working example performs a nearly similar operation to that of Working Example 1 only with respect to uphill slopes. Specifically, if the value of the slope S is greater than a standard value S_0, then a sufficient drive torque is obtained by selecting a power pattern in which a large shift ratio is set, and if the slope S is smaller than S_0, an economy pattern is selected in which the shift ratio is set so as to be small. This is in order to facilitate selection of a power pattern when the drive torque is insufficient. Steps 682 and 684 are so that a power pattern will be selected for preventing a misjudgment when the condition of $S > S_0$ has continued for more than a specified length of time. In addition, steps 870 through 882 are performed in order to maintain a power pattern when depression of the accelerator pedal has been resumed for a short period of time during driving in a power pattern, and TH_3 in step 872 and V_2 in step 876 are set values corresponding to the low opening and low vehicle speed (greater than TH_2 and V_0).

(G) Effects of the Invention

As explained above, by means of the present invention, since the value corresponding to the slope of the road on which the vehicle is driving is calculated and the shift pattern is automatically changed in accordance with this value, the accelerating power on uphill slopes and the engine brake effect on downhill slopes can always be controlled to optimal conditions. In addition, since the accelerating force and engine brake effect likewise change when the loaded vehicle weight changes, drivability is greatly improved. Moreover, since data that is stored in the memory device need only be data concerning the engine performance, the data input operation is greatly simplified.

4. Brief Explanation of the Drawings.

Figure 1 is a diagram showing the relationship between the constituent elements of the present invention, Figure 2 is a schematic drawing of a day continuously variable transmission, Figure 3 is a diagram showing the hydraulic control apparatus therein, Figure 4 is a diagram showing a shift controller, Figures 5, 6, 7 and 8 are diagrams showing control routines, Figure 9 is a diagram showing the setting of a shift pattern corresponding to slope, Figure 10 is a diagram showing shift pattern A, Figure 11 is a diagram showing shift pattern B, Figure 12 is a diagram showing Working Example 2 of the present invention, Figure 13 is a diagram showing the relationship of NE × Tr to the throttle opening, and Figures 14, 15 and 16 are diagrams showing a control routine in Working Example 3 of the present invention.

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Figure 1

Actual drive torque detecting means

Slope calculating means

Vehicle speed detecting means

Flatland traveling required drive torque calculating means

Acceleration detecting means

Shift signal determining means

Continuously variable transmission

Figure 3

50: reverse brake
40: forward clutch
12a: lockup oil chamber.
12: fluid coupling
32: slave pulley cylinder chamber
20: drive pulley cylinder chambers
lubrication
lubrication

Figure 4

301: engine rotational speed sensor

302: vehicle speed sensor

303: throttle opening sensor

304: shift position switch

305: turbine rotational speed sensor

306: engine cooling water temperature sensor

307: brake sensor

298: changeover detecting switch

308, 309 and 322: waveform fabricators

310: AD converter

311: input interface

312: standard pulse generator

313: central processing unit (CPU)

314: read-only memory (ROM)

315: random access memory (RAM)

316: output interface

319: address bus 319

320: data bus 320

317: amplifier

110: step motor

224: solenoid

Figure 5

START
502: read shift position
504: D. L. R?
506: duty ratio ←0%
508: read throttle opening TH
510: read vehicle speed VS
512: read engine rotational speed N_E
514: read turbine rotational speed Nt
516: $N_D = N_E - N_T$
518: retrieve V_{ON} and V_{OFF}
520: LUF set? Yes
No
522: V_S > V ON? No
Yes
524e = ND-Nm_1
526: retrieve gain G_1
528: $N_D < N_0$? No
Yes
530: duty ratio ←duty ratio + α
532: duty ratio < 100%? No
Yes
534: duty ratio ←100%
536: set flag LUF
538: duty ratio ←f (e, G_1)
540: duty ratio ←0%
542: clear flag LUF
544: Vs < V_{OFF}? No
Yes
546: duty ratio ←100%

Figure 6

602: $Vs < V_0^?$ Yes
No
624: D?
No Yes
639: L? Yes
No
628: retrieve L range shift pattern
640: retrieve R range shift pattern
802: $V_{S1} \leftarrow V_{S0}$
804: $V_{S0} \leftarrow V_S$
806: $TH_1 \leftarrow TH_0$
808: $TH_0 \leftarrow TH$
810: $V_{S0} > V_{S1}$? No
Yes
812: $\Delta V \leftarrow 0$
814: $\Delta V \leftarrow V_{S0} - V_{S1}$
816: $Tr \leftarrow (N_E, T_{H1})$
818: $Tf \leftarrow (V_S)$
820: $S \leftarrow C_1 (C_2 \times i \times Tr - \Delta V \times C_3 - Tf)$
822: throttle fully open?
No Yes
824: shift pattern A $\leftarrow$(S)
826: shift pattern B $\leftarrow$(S)
828: retrieve shift pattern

Figure 7

604: TH $<$ TH_2
Yes No
606: duty ratio ←0%
608: P_D ←P_1
902: brake on? No
Yes
904: B flag set
906: TH $\leq$ TH_2?
No Yes
908: $V_S \leq V_1$?
No Yes
910: T ←T_0
912: T = 0? Yes
No
914: T ←T-1
916: T = 0? Yes
No
918: clear B flag
920: B flag set?
Yes No
922: retrieve α
924: PD ←PD + α

Figure 8

610: changeover detecting switch on?
No Yes
612: $e = N_D - Nm_2$
614: retrieve gain G_2
616: duty ratio $\leftarrow f(e, G_2)$
618: $P_A \leftarrow 0$
620: move step motor drive signal in downshift direction
622: $P_A \leftarrow P_A\text{-}1$
630: $P_A \geq P_D$?
632: move step motor drive signal in upshift direction
634: $P_A \leftarrow P_A+1$
636: step motor drive signal output
638: solenoid drive signal output
return

Figure 9

[See original for graph]
Slope

Figure 10
[vertical axis] throttle opening
[horizontal axis] engine rotational speed

Figure 11
[vertical axis] engine rotational speed
[horizontal axis] vehicle speed

Figure 13
[vertical axis] throttle opening
[horizontal axis] $N_E \times T_R$

Figure 12
602: Vs < $V_0^?$ Yes
No
624: D?
No Yes
639: L? Yes
No
628: retrieve L range shift pattern
640: retrieve R range shift pattern
802: $V_{S1} \leftarrow V_{S0}$
804: $V_{S0} \leftarrow V_S$
806: $TH_1 \leftarrow TH_0$
808: $TH_0 \leftarrow TH$
810: $V_{S0} > V_{S1}$? No
Yes
812: $\Delta V \leftarrow 0$
814: $\Delta V \leftarrow V_{S0} - V_{S1}$
817: $Tr \leftarrow (TH)$
819: $S \leftarrow C_1 (C_2 \times i \times Tr/V_S - \Delta V \times C_3 - Tf)$
822: throttle fully open?
No Yes
824: shift pattern A ←(S)
826: shift pattern B ←(S)
828: retrieve shift pattern

Figure 14

602: Vs < V_0? Yes
No
624: D?
No Yes
639: L? Yes
No
628: retrieve L range shift pattern
640: retrieve R range shift pattern
802: $V_{S1} \leftarrow V_{S0}$
804: $V_{S0} \leftarrow V_S$
806: $TH_1 \leftarrow TH_0$
808: $TH_0 \leftarrow TH$
810: $V_{SO} > V_{SI}$? No
Yes
812: $\Delta V \leftarrow 0$
814: $\Delta V \leftarrow V_{S0} - V_{S1}$
816: $Tr \leftarrow (N_E, T_{HI})$
840: Calculate torque loss Tr_0
842: $Tr \leftarrow Tr - Tr_0$
818: $Tf \leftarrow (V_S)$
820: $S \leftarrow C_1 (C_2 \times i \times Tr - \Delta V \times C_3 - Tf)$

Figure 15

850: power flag set? Yes
No
852: economy range? Yes
No
854: TH < TH_2? Yes
No
856: $V_S < V_1$? Yes
No
858: $S_0 \leftarrow (V_S, TH)$
860: $S > S_0$? No
Yes
862: COUNT ← COUNT+1
864: COUNT >Co? No
Yes
866: COUNT ← 0
868: set power flag

Figure 16

870: power flag set? No
Yes
872: $TH < TH_3$? No
Yes
874: $T_1 \leftarrow T_1 - 1$
876: $Vs < V_2$?
Yes No
878: $T_1 + 0$? No
Yes
880: clear power flag
882: $T_I < T_{10}$
884: power flag set? No
Yes
886: retrieve power pattern
888: retrieve economy pattern

D1

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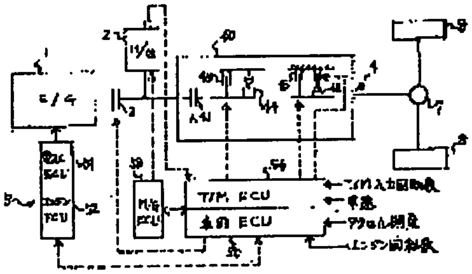
(54) ON-VEHICLE HYBRID DRIVE DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To improve response of restarting while running to reduce decelerating shock.

SOLUTION: This on-vehicle hybrid drive device is provided with an engine 1, a motor generator 2, an input clutch 3, a transmission 4, a second clutch 41, and their controller. A control device 5 starts the engine 1 by means of a power of the motor generator 2 by engaging the input clutch 3 in the condition where a torque transmission through the transmission 4 is shut off by an operation of the second clutches 41 or 42 when shifting from motor generator running to engine running.



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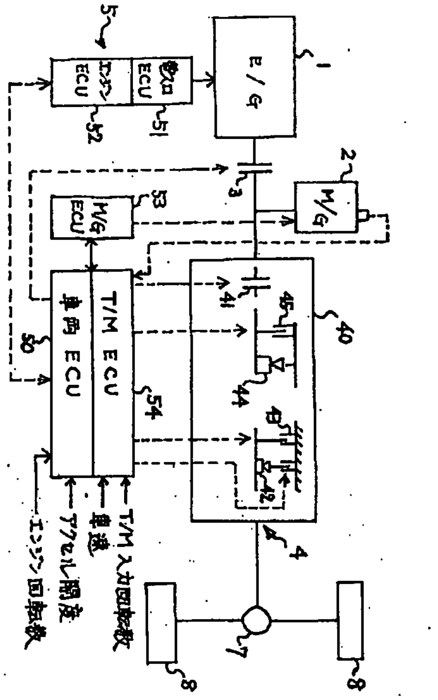
(54)【発明の名称】車両用ハイブリッド駆動装置

(57)【要約】

【課題】　走行中エンジン再始動のレスポンスを向上させ、減速ショックを低減する。

【解決手段】　車両用ハイブリッド駆動装置は、エンジン１、モータジェネレータ２、入力クラッチ３、伝動装置４、第２のクラッチ４１及びそれらの制御装置を備える。制御装置５は、モータジェネレータ走行からエンジン走行に移る際に、第２のクラッチ４１又は４２の作動で伝動装置４を介するトルク伝達が遮断される状態で、入力クラッチ３を係合させてモータジェネレータ２の動力によりエンジン１を始動させる。



【特許請求の範囲】

【請求項１】　エンジンと、モータジェネレータと、前記エンジン及びモータジェネレータ相互間の動力伝達を制御可能な入力クラッチと、前記エンジンとモータジェネレータの動力を車輪に伝達する伝動装置と、該伝動装置による動力の伝達を制御可能な第２のクラッチと、前記エンジン、モータジェネレータ及び入力クラッチを制御する制御装置と、を備える車両用ハイブリッド駆動装置において、

前記制御装置は、

エンジンを停止させ、モータジェネレータの動力を車輪へ伝達しているモータ走行時に、アクセル操作を検出して、前記第２のクラッチの作動で伝動装置を介するトルク伝達が遮断される状態で、入力クラッチを係合させてモータジェネレータの動力によりエンジンを始動させる始動制御手段を有する、ことを特徴とする、車両用ハイブリッド駆動装置。

【請求項２】　前記第２のクラッチは、前記制御装置により制御される摩擦クラッチとされ、

前記始動制御手段は、第２のクラッチを解放させて伝動装置を介するトルク伝達を遮断する、請求項１記載の車両用ハイブリッド駆動装置。

【請求項３】　前記伝動装置は、複数の変速段を達成する変速機を含み、

前記第２のクラッチは、変速機内に配設され、所定の変速段達成時にモータジェネレータから車輪へのトルク伝達のみ可能とするワンウェイクラッチとされ、

前記始動制御手段は、変速機を前記所定の変速段に変速する変速制御手段を含む、請求項１記載の車両用ハイブリッド駆動装置。

【請求項４】　前記始動制御手段は、入力クラッチの係合によりモータジェネレータの回転が減少したときに、モータトルクを増大させるトルク増大手段を含む、請求項１又は２記載の車両用ハイブリッド駆動装置。

【請求項５】　前記始動制御手段は、モータジェネレータの回転に応じてモータトルクを制御するトルク制御手段を含む、請求項１、２又は４記載の車両用ハイブリッド駆動装置。

【請求項６】　前記変速機は、ワンウェイクラッチに併設され、車輪からモータジェネレータへのトルク伝達を可能とするエンジンブレーキ用係合要素を有し、

前記変速制御手段は、前記所定の変速段でエンジンブレーキ用係合要素を解放する、請求項３記載の車両用ハイブリッド駆動装置。

【請求項７】　前記変速機は、ワンウェイクラッチに併設され、車輪からモータジェネレータへのトルク伝達を可能とするエンジンブレーキ用係合要素を有し、

前記変速制御手段は、変速機を他の変速段からダウンシフトさせて前記所定の変速段に変速する、請求項３記載の車両用ハイブリッド駆動装置。

【請求項８】　前記制御装置は、入力クラッチの係合圧をスイープアップさせ、モータジェネレータ回転の減少時に、入力クラッチを完全係合させるスイープアップ手段を有する、請求項１～５のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項９】　前記始動制御手段は、モータジェネレータにエンジンのクランキングトルクの平均値を出力させるトルク制御手段を含む、請求項１～８のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項１０】　前記制御装置は、入力クラッチの係合圧をピストンストロークを詰めた後、エンジンをクランキング開始位置まで回転させる係合圧にするスタンバイ制御手段を有する、請求項１～９のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項１１】　前記制御装置は、モータ走行領域とエンジン走行領域との間にクラッチスタンバイ領域を設定された、請求項１～１０のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項１２】　前記始動制御手段は、エンジン回転が所定回転になったとき、エンジンに燃料を供給し点火させる、請求項１～１１のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項１３】　前記始動制御手段は、エンジン回転とモータジェネレータ回転の同期後に第２のクラッチを完全係合させる、請求項１～１２のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項１４】　前記始動制御手段は、エンジン始動後、モータジェネレータの出力トルクをスイープダウンさせ、エンジンのスロットル開度を開く終了制御手段を含む、請求項１～１３のいずれか１項記載の車両用ハイブリッド駆動装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、エンジンとモータジェネレータを動力とする車両用ハイブリッド駆動装置に関し、特に、燃費節減のために車両走行中に停止させたエンジンをモータジェネレータ駆動による走行下で再始動させる技術に関する。

【０００２】

【従来の技術】車両用駆動装置として、燃焼機関（本明細書において、エンジンという）と電動発電機（同じく、モータジェネレータという）を動力源とするハイブリッド駆動装置がある。こうした装置における一方の動力源としてのエンジンは、その特性として、低負荷側で負荷の減少量に対して急激に効率の減少割合が大きくなる傾向がある。

【０００３】そこで、燃費性能を改善して省エネルギを図るため、低負荷すなわちアクセル操作量（同じく、アクセル開度という）が小さい状態での走行時に、エンジンを自動的に停止させ、モータジェネレータ駆動で走行

する方式の駆動装置が提案されている。この方式では、アクセル開度が所定の低開度領域を出るとき、エンジンを自動的に再始動させなければならないが、その際に、走行のための駆動トルクを出力しているモータジェネレータの駆動力を一部エンジン始動に割くことになるため、エンジンのクランキング負荷による駆動力の低下で、大きな減速感が生じる。したがって、この方式では、エンジン再始動時の減速ショックを如何に軽減するかが解決しなければならない大きな問題点となる。

【０００４】こうした減速ショックの発生に対する対策として、従来、エンジン再始動時に、モータジェネレータの出力トルクをエンジンに伝達するクラッチの係合圧をスイープアップさせながら、入力クラッチの係合の進行に伴うトルク伝達力の増加につれて生じるモータジェネレータの微小回転変化率を認識し、その出力トルクを補足（ブースト）する制御を行う技術がある。

【０００５】ところで、エンジン始動時のクランキング負荷は、その停止状態からの加速に必要なイナーシャトルクの他に、各シリンダで吸入、圧縮、排気が生じることに伴う抵抗、機械的引きずり抵抗分のトルク、エアコン、オルタネータ、ウォータポンプ、オイルポンプ等の補機類の駆動トルク等の合成トルクとなる。これらのうち、特に吸排気動作による負荷は、例えば６気筒エンジンでは、図１１に各気筒ごとに異なる記号付の線で示すように周期的な変動トルクとなり、上記各トルクの合計値は、実線で示すような特性となる。

【０００６】しかしながら、実際のクランキングトルクは、一旦エンジンの回転が始まると、当初回転の抵抗となっていたイナーシャトルクが、フライホイールイナーシャの発生により、逆にトルク変動を抑制する要素として働くようになるため、図１２に示すように、回転の立ち上がり時のみ極端に大きく、その後はほぼ一定の値となる特性を有する。したがって、トルク変動は残るものの、一定速度の回転を維持するために外部より平均的に与えなければならないクランキングトルクは、変動トルクの平均値でよいようになる。

【０００７】そこで、こうしたクランキングトルクの特性に合わせて、再始動時にエンジンがある程度の回転数に達して、回転の立ち上げのための慣性力負荷が低減するまで吸排気動作に伴う負荷が生じないようにすることで、トルク負荷のピーク値を下げて、モータジェネレータにかかるクランキングトルクを軽減する技術が提案されている。

【０００８】

【発明が解決しようとする課題】しかしながら、後者の技術は、エンジンの改変を要するばかりでなく、複雑な制御を必要とし、実用までには未だ多くの解決すべき問題点があると考えられる。他方、前者の技術にも、上記クランキングトルクの特性に伴う問題点がある。すなわち、クランキングトルクの立ち上がり特性は、前記の周期的な変動トルク成分があることで、エンジン停止時のクランクシャフトの位置により、図１３に一点鎖線と実線で対比して示すようにピーク位置がずれて特性が異なってくる。このようにピークトルク発生タイミングがずれることで、クラッチの伝達トルク容量を異ならせるべく、クラッチ係合油圧もそれに合わせて変化させる必要が生じ、モータジェネレータ出力トルク増分をそれに応じて異ならせる極めてきめの細かな制御が必要となる。こうした精密な制御は、マップ制御のような簡易制御では困難である。また、この制御では、シリンダの圧縮、膨張で発生する変動トルク成分が正確に推定できないため、エンジン始動初期にショックが発生しやすい。更に、制御スピードが十分でない。

【０００９】ところで、エンジン再始動の際の駆動力の低下によるショックを軽減するには、出力トルクに十分余裕のある大容量のモータジェネレータを用い、クランキング負荷に応じてその出力トルクを増大させる制御を行えばよいことになるが、エンジン始動のためだけに備えて、そうした大容量のモータジェネレータを搭載することは、自体の大型化を招くばかりでなく、それを制御するインバータの高容量化、更にはバッテリの高容量化を招き、有効な解決策とはなりえない。

【００１０】そこで本発明は、モータジェネレータによる走行中に、エンジン再始動のためのトルク負荷の増加でモータジェネレータの回転が低下しても、それが伝動装置を介して車輪に及ばないようにして、エンジン再始動時の減速によるショックを防ぐことができる車両用ハイブリッド駆動装置を提供することを第１の目的とする。

【００１１】次に、本発明は、上記エンジン再始動時の減速によるショックの防止を伝動装置のクラッチの制御で実現することを第２の目的とする。

【００１２】また、本発明は、上記エンジン再始動時の減速によるショックの防止を伝動装置の変速機の制御で格別の付加的な手段を用いることなく実現することを第３の目的とする。

【００１３】次に、本発明は、上記エンジン再始動のためのクランキングを簡単な方法で、しかも適正なタイミングで開始させることを第４の目的とする。

【００１４】更に、本発明は、上記エンジン再始動のためのクランキングを適性なモータトルクで行うことを第５の目的とする。

【００１５】また、本発明は、上記変速機の制御でエンジン再始動時の減速によるショックを防止するものにおいて、そのための具体的制御手段を得ることを第６の目的とする。

【００１６】また、本発明は、上記エンジン再始動の際の減速によるショックを変速機の制御で防止するものにおいて、再始動時の変速状態に応じた具体的制御手段を得ることを第７の目的とする。

【００１７】また、本発明は、上記エンジン再始動のためにモータトルクをエンジンに伝達する入力クラッチを簡単な係合圧の制御で迅速かつ的確に係合させることを第８の目的とする。

【００１８】また、本発明は、エンジン再始動制御時のモータジェネレータのトルクを低減することを第９の目的とする。

【００１９】また、本発明は、エンジン再始動を一定の短期間でレスポンス良く行うことを第１０の目的とする。

【００２０】ところで、従来ハイブリッド駆動装置における走行モードの切り換えは、制御装置のマイクロコンピュータにメモリされ、アクセル開度と車速の関係から走行領域を定めた走行モードマップを参照しながら、各時点のアクセル開度と車速の関係に応じてなされる。そこで、本発明は、上記スタンバイ制御の開始時期をマップ上に設定することで、簡易なマップ制御で確実にエンジン再始動を行うことを第１１の目的とする。

【００２１】また、本発明は、適切な燃料供給の再開と点火により始動制御の最終段階でタイミング良くエンジンを自力回転させることを第１２の目的とする。

【００２２】また、本発明は、モータジェネレータによるエンジン始動制御を円滑に終了させることを第１３の目的とする。

【００２３】また、本発明は、エンジン始動後のモータ走行からエンジン走行への移行を円滑に行うことを第１４の目的とする。

【００２４】

【課題を解決するための手段】上記第１の目的を達成するため、本発明は、エンジンと、モータジェネレータと、前記エンジン及びモータジェネレータ相互間の動力伝達を制御可能な入力クラッチと、前記エンジンとモータジェネレータの動力を車輪に伝達する伝動装置と、該伝動装置による動力の伝達を制御可能な第２のクラッチと、前記エンジン、モータジェネレータ及び入力クラッチを制御する制御装置と、を備える車両用ハイブリッド駆動装置において、前記制御装置は、エンジンを停止させ、モータジェネレータの動力を車輪へ伝達しているモータ走行時に、アクセル操作を検出して、前記第２のクラッチの作動で伝動装置を介するトルク伝達が遮断される状態で、入力クラッチを係合させてモータジェネレータの動力によりエンジンを始動させる始動制御手段を有する、ことを特徴とする。

【００２５】次に、第２の目的を達成するため、前記第２のクラッチは、前記制御装置により制御される摩擦クラッチとされ、前記始動制御手段は、第２のクラッチを解放させて伝動装置を介するトルク伝達を遮断する構成とされる。

【００２６】また、第３の目的を達成するため、前記伝動装置は、複数の変速段を達成する変速機を含み、前記第２のクラッチは、変速機内に配設され、所定の変速段達成時にモータジェネレータから車輪へのトルク伝達のみ可能とするワンウェイクラッチとされ、前記始動制御手段は、変速機を前記所定の変速段に変速する変速制御手段を含む構成とされる。

【００２７】更に、第４の目的を達成するため、前記始動制御手段は、入力クラッチの係合によりモータジェネレータの回転が減少したときに、モータトルクを増大させるトルク増大手段を含む構成とされる。

【００２８】次に、第５の目的を達成するため、前記始動制御手段は、モータジェネレータの回転に応じてモータトルクを制御するトルク制御手段を含む構成とされる。

【００２９】次に、第６の目的を達成するため、前記変速機は、ワンウェイクラッチに併設され、車輪からモータジェネレータへのトルク伝達を可能とするエンジンブレーキ用係合要素を有し、前記変速制御手段は、前記所定の変速段でエンジンブレーキ用係合要素を解放する構成とされる。

【００３０】更に、第７の目的を達成するため、前記変速機は、ワンウェイクラッチに併設され、車輪からモータジェネレータへのトルク伝達を可能とするエンジンブレーキ用係合要素を有し、前記変速制御手段は、変速機を他の変速段からダウンシフトさせて前記所定の変速段に変速する構成とされる。

【００３１】次に、第８の目的を達成するため、前記制御装置は、入力クラッチの係合圧をスイープアップさせ、モータジェネレータ回転の減少時に、入力クラッチを完全係合させるスイープアップ手段を有する構成とされる。

【００３２】次に、第９の目的を達成するため、前記始動制御手段は、モータジェネレータにエンジンのクランキングトルクの平均値を出力させるトルク制御手段を含む構成とされる。

【００３３】次に、第１０の目的を達成するため、前記制御装置は、入力クラッチの係合圧をピストンストロークを詰めた後、エンジンをクランキング開始位置まで回転させる係合圧にするスタンバイ制御手段を有する構成とされる。

【００３４】次に、第１１の目的を達成するため、前記制御装置は、モータ走行領域とエンジン走行領域との間にクラッチスタンバイ領域を設定された構成とされる。

【００３５】次に、第１２の目的を達成するため、前記始動制御手段は、エンジン回転が所定回転になったとき、エンジンに燃料を供給し点火させる構成とされる。

【００３６】次に、第１３の目的を達成するため、前記始動制御手段は、エンジン回転とモータジェネレータ回転の同期後に第２のクラッチを完全係合させる構成とされる。

【００３７】次に、第１４の目的を達成するため、前記

始動制御手段は、エンジン始動後、モータジェネレータの出力トルクをスイープダウンさせ、エンジンのスロットル開度を開く終了制御手段を含む構成とされる。

【0038】

【発明の作用及び効果】上記の構成を採る請求項1記載の車両用ハイブリッド駆動装置では、モータ走行時に、第2のクラッチの作動で伝動装置を介する車輪への動力伝達が遮断される状態で、入力クラッチを係合させてエンジンを始動させる制御が行われるので、モータジェネレータの回転がエンジンのクランキング負荷のために低下しても、それにより車輪の回転が低下することがなくなる。したがって、この構成によれば、車両の惰行状態でエンジン再始動が行われることになるので、エンジン再始動時の減速によるショックを防ぐことができる。また、モータジェネレータの出力トルクを専らエンジン始動に用いることで、レスポンスの良いエンジン再始動を行うことができる。

【0039】次に、請求項2記載の構成では、伝動装置を介する車輪への動力伝達が遮断される状態を、始動制御手段による第2のクラッチの解放制御で実現することができる。

【0040】また、請求項3に記載の構成では、伝動装置を変速機を含むものとすることで、変速機に通常配設されているワンウェイクラッチを第2のクラッチとして利用して、伝動装置を介する車輪への動力伝達が一方向遮断される状態を得ることができる。

【0041】更に、請求項4に記載の構成では、始動制御手段によりモータジェネレータの回転の減少で入力クラッチの係合を判断してモータトルクを増大させる制御を行なうことができるので、本来検出精度の高いモータジェネレータ回転数の変化によりタイミング良くモータトルクを増大させてエンジンのクランキングを開始させることができる。したがって、この構成によれば、エンジン再始動レスポンスを向上させることができる。

【0042】更に、請求項5に記載の構成では、トルク制御手段によりモータジェネレータの回転に応じてモータトルクを制御することで、再始動終了時のエンジン回転を簡単にモータジェネレータ回転に同期させる制御が可能となる。したがって、この構成によれば、単純な制御で始動制御を終了させることができる。

【0043】更に、請求項6に記載の構成では、所定の変速段がエンジンブレーキ用係合要素の係合される変速段であっても、変速制御手段でエンジンブレーキ用係合要素を解放することで、ワンウェイクラッチの作動により伝動装置を介する車輪への動力伝達が一方向遮断される状態を得ることができる。

【0044】次に、請求項7に記載の構成では、エンジン再始動時の変速段がワンウェイクラッチの作動が関与しない直結段等の変速段であっても、変速制御手段で所定の変速段にシフトダウンすることでワンウェイクラッチの作動により伝動装置を介する車輪への動力伝達が一方向遮断される状態を得ることができる。

【0045】更に、請求項8に記載の構成では、スイープアップ手段により入力クラッチの係合圧を単にスイープアップさせ、モータジェネレータの回転が減少するところで完全係合する係合圧とする制御で、入力クラッチ係合圧の簡易な制御でクランキングを開始させることができる。

【0046】更に、請求項9に記載の構成では、トルク制御手段によりモータジェネレータの出力トルクがクランキングトルクの平均値に制御されるので、比較的低いトルクでのエンジンクランキングが可能となる。したがって、この構成によれば、出力の小さなモータジェネレータによるエンジン再始動が可能となる。

【0047】更に、請求項10に記載の構成では、始動制御に先行するスタンバイ制御によりクランキング開始位置を常に一定にすることができ、それにより、その後の簡易な入力クラッチ係合制御とモータトルク制御で、レスポンス良くエンジン再始動を行うことができる。

【0048】更に、請求項11に記載の構成では、スタンバイ制御の開始時期を領域判断で簡単に行うことができるので、スタンバイ制御のロジックを単純化しながら、迅速にスタンバイ制御を実行することができる。

【0049】更に、請求項12に記載の構成では、エンジン回転が所定の回転数になったところで始動のためにエンジンに燃料を供給し、点火する制御が行われるので、的確なエンジン始動が可能となる。

【0050】更に、請求項13に記載の構成では、エンジン回転とモータジェネレータ回転が同期したところで、伝動装置を介する動力伝達が再開されるので、エンジン始動後のモータ走行からエンジン走行への移行時のショックを防ぐことができる。

【0051】更に、請求項14に記載の構成では、終了制御手段による単純なトルク制御とスロットル制御で、エンジン始動後のモータ走行からエンジン走行への移行を円滑に行うことができる。

【0052】

【発明の実施の形態】以下、図面に沿い、本発明の実施形態について説明する。図1は車両用ハイブリッド駆動装置のシステム構成を示すもので、この装置は、エンジン（E／G）1と、モータジェネレータ（M／G）2と、エンジン1及びモータジェネレータ2相互間の動力伝達を制御可能な入力クラッチ（以下、実施形態の説明において、他のクラッチと区別する意味でCiクラッチという）3と、エンジン1とモータジェネレータ2の動力を車輪に伝達可能な伝動装置4と、エンジン1、モータジェネレータ2及び入力クラッチ3を制御する制御装置5（ECU）とを備えている。

【0053】モータジェネレータ2は、そのロータが入力クラッチ3を介してエンジン1に連結され、更に、伝

動装置４を構成する自動変速機（Ｔ／Ｍ）４０に、他のクラッチ（同じく、実施形態の説明においてＣ１クラッチという）４１を介して連結されている。本形態では、自動変速機（Ｔ／Ｍ）４０の入力クラッチとしてのＣ１クラッチ４１は、伝動装置４による動力の伝達を制御可能な第２のクラッチを構成する。

【００５４】自動変速機４０は、複数の変速段を達成する所定のギヤトレインを備えるものとされ、その出力軸は、ディファレンシャル装置７を介して左右の駆動輪８に連結されている。この自動変速機４０は、所定の変速段達成時にモータジェネレータ２から車輪８へのトルク伝達のみ可能とするワンウェイクラッチ４２又は他のワンウェイクラッチ４４と、これらワンウェイクラッチ４２，４４に併設され、車輪８からモータジェネレータ２へのトルク伝達を可能とするエンジンブレーキ用係合要素４３又はクラッチ４５とを有する。

【００５５】制御装置５は、エンジン１のスロットルを電子スロットルアクチュエータを介して制御する電子スロットル制御部（電スロＥＣＵ）５１、エンジン制御部（Ｅ／Ｇ－ＥＣＵ）５２、モータジェネレータ２を図示しないインバータを介して制御するモータジェネレータ制御部（Ｍ／Ｇ－ＥＣＵ）５３と、自動変速機４０の油圧コントロールユニットをソレノイドを介して制御するトランスミッション系制御部（Ｔ／Ｍ－ＥＣＵ）５４、それら各制御部を統括制御する車両制御部（車両ＥＣＵ）５０とから構成されている。これら各制御部は、マイクロコンピュータを主体とする電子制御装置を構成している。そして、制御装置５へは、車両の各部に通常配置される各図示しないセンサからのアクセル開度信号、車速信号、トランスミッション入力回転数信号及びエンジン回転数信号が取込み可能とされている。

【００５６】本発明に従い、制御装置５は、エンジン１を停止させ、Ｃｉクラッチ３を解放させてモータジェネレータ２の動力を車輪８へ伝達している車両走行時に、アクセル開度を検出して、エンジン１を始動させる制御装置内の処理プロセスとしての始動制御手段を有している。更に、制御装置５は、始動制御手段によるエンジン１の始動に先行させて、エンジン１をクランキング開始位置まで回転させる制御を行う同じく処理プロセスとしてのスタンバイ制御手段を有する。

【００５７】更に、制御装置５は、そのマイクロコンピュータのメモリ上に走行モードマップを備えている。図２はこのマップデータを図式化して示すもので、車速と、アクセル開度との関係から、アクセルオン時の負（後進）高車速側にエンジン走行領域、車速０を挟む正負（前進及び後進）両低車速側にエンジン及びモータ走行領域、低アクセル開度を除く正（前進）高車速側にエンジン走行領域、そして低アクセル開度側にモータ走行領域、更に、アクセルオフの正（ホイール駆動の前進）車速側に回生領域を設定されている。そして、本形態では、特に、エンジン走行領域に隣接するモータ走行領域に、後に詳記するＣｉクラッチスタンバイ制御領域が設定されている。

【００５８】次に、上記走行モードマップを参照して行われる本発明の主題に係る制御内容を具体的に説明する。まず、エンジン停止判断は、本発明の主題とは直接関係ないが、例えば、図２に示す走行モードマップに従い、アクセル開度が所定時間以上モータ走行領域にあるとき、制御装置５のエンジン停止可の判断により行われる。そしてこうしたエンジン停止下での走行状態において、上記エンジン停止判断と逆に、アクセル開度が所定時間以上エンジン走行領域にあるとき、制御装置５によりエンジン始動必要と判断することで、エンジン再始動判断がなされる。そして、このエンジン再始動判断により、Ｃｉクラッチ３のスタンバイ制御と、エンジン始動制御と、完爆判断と、終了制御が実行される。更に、エンジン始動制御は、クランキングの前半部分のエンジン回転の立ち上げ制御と、後半部分の加速制御と、燃料供給及び点火で構成されている。

【００５９】まず、Ｃｉクラッチのスタンバイ制御は、次の三つのタイミングで実行可能である。第１は、上記再始動判断が成立したときであり、第２は、アクセル開度が図２に示す走行モードマップのＣｉクラッチスタンバイ制御領域に入ったときであり、第３は、エンジン停止制御が終了した後の所定時間の間である。これらのうち、第２の判断方法が最も効果的である。なお、本形態では、これらを併用している。

【００６０】以下、図３に示すタイムチャートに基づき、図１を併せて参照しながら、順次制御内容を説明する。当初、エンジン回転数（Ｎｅ）は停止状態の０、モータ回転数（Ｎｍ）は車速の増加に連れて漸増、エンジントルク（Ｔｅ）は停止状態の０、モータトルク（Ｔｍ）は、アクセル開度に応じてあらかじめ設定された出力制御マップに基づき出力されるトルク（Ｔａｃｃ）で加速状態の漸増、Ｃｉクラッチ圧（Ｐｃｉ）は解放状態の０、Ｃ１クラッチ圧（Ｐｃ１）は係合状態のライン圧、出力軸トルク（Ｔｏｕｔ）はモータトルク駆動力に見合ったトルク漸増状態となっている。

【００６１】ここで、モータ走行領域から、アクセル開度がＣｉクラッチスタンバイ制御領域に入ると、トランスミッション系制御部５４から油圧コントロールユニットへのソレノイド信号出力で、Ｃ１クラッチ圧（Ｐｃ１）を０としてＣ１クラッチ４１を解放させるとともに、Ｃｉクラッチ圧（Ｐｃｉ）をファーストフィル圧（Ｐｆ）としてファーストフィル時間（ｔｆ）だけＣｉクラッチ３の油圧サーボへ供給する制御が行われる。このファーストフィル圧（Ｐｆ）とファーストフィル時間（ｔｆ）は、素早くクラッチピストンをストロークさせ、Ｃｉクラッチ油圧サーボのシリンダ内がオイルで充満できる程度の値に設定される。一方、モータジェネレ

ータ２の出力トルク（Tm）は０とされる。

【００６２】次に、同様の手順で、スタンバイ圧（Ｐｓｔｂｙ）の供給がスタンバイ時間（ｔｓｔｂｙ）だけ行われる。スタンバイ圧（Ｐｓｔｂｙ）は、Ｃｉクラッチ３が少しトルクを伝え、エンジン１のクランクシャフトが少し回転し、圧縮トルクを必要とする直前の角度位置で停止する程度の圧力（例えば１００～２００ｋＰａ程度）とする。スタンバイ時間（ｔｓｔｂｙ）は、第１又は第３の判断方法によるときは、例えば数１００ｍｓｅｃ程度必要であり、第１の判断方法の場合は、その後直ちにスイープアップ制御に移り、第３の判断方法の場合は、その後Ｃｉクラッチオフでモータ走行に移る。また、第２の判断方法の場合は、スタンバイ時間（ｔｓｔｂｙ）は、Ｃｉクラッチ圧の次の制御（スイープアップ制御）が始まるまで続けられる。

【００６３】このように、Ｃｉクラッチスタンバイ制御を実行することで、Ｃｉクラッチ３を介してモータジェネレータ２のイナーシャトルクがエンジン１に伝達され、エンジン１は回転するが、最初のシリンダの圧縮行程に入るところで、所要トルクが大きくなることでＣｉクラッチ３はスリップし、エンジン１はそのクランク角位置で停止してクランキング前のスタンバイ状態となる。この回転角は、６気筒エンジンで最大でも１００°程度である。かくして、クランク角位置を常にクランキングのピークトルクが発生する手前に置くことで、制御開始時のクランキングトルクの立ち上がり特性を同じにすることができる。

【００６４】このようにしてスタンバイ状態が達成されるスタンバイ時間（ｔｓｔｂｙ）が経過すると、今度は、始動制御手段によるエンジン始動が行われる。この場合、まずＣｉクラッチ圧（Ｐｃｉ）のスイープアップが行われる。そして、これによるＣｉクラッチ３の係合の進行でトルク伝達力が次第に増加して、エンジンのクランキングが開始される。このとき、モータ回転数（Ｎｍ）がクランキング負荷で低下し始めるので、Ｃｉクラッチ圧（Ｐｃｉ）を一気にライン圧まで上昇させるとともに、モータトルク（Tm）の出力を再開させる。このときのモータトルク（Tm）は、エンジンのクランキングに必要なトルク（Ｔｃｒｕｎｋ）とされ、トルク伝達容量を増したＣｉクラッチ３を介するトルク伝達で、エンジン１はその回転の立ち上がり時のイナーシャトルクによるピークトルクを乗り越えて回転を始める。その後もクランキングトルク出力は継続され、この場合は、エンジン回転（Ne）が所定回転数になることで点火タイミングが図られる。そして点火と同時にモータトルク（Tm）は、車両走行に必要な駆動に必要なトルク（Ｔａｃｃ）に戻される。

【００６５】エンジン１の始動（エンジンが自力で回転を持続できる状態）を確認する完爆判断は、下記の方法により行うことができる。その第１は、通常の空燃比制御に使用するエグゾースト側に設けたO_2（酸素）センサの出力を用いる方法である。この方法では、シリンダ内での燃焼が全シリンダで連続して生じるようになると、排ガス中の酸素濃度が極めて少なくなるので、エンジン完爆判定が可能となる。また、第２は、排ガス温度又は排ガス処理用触媒コンバータの温度をみる方法である。そして、第３は、シリンダ内の燃焼圧力をみる方法である。上記方法のうち、第１の方法が最も効果的であり、特に排ガス温度が低い状態のときでもセンサ性能（感度）が安定するようにしたヒータ付O_2センサを用いると更に有効である。これに対して、第３の方法は、リーンバーンエンジンでしか使用しないセンサを用いることになるため、通常のエンジンに適用した場合、センサは完爆判定以外には使用しないものとなってしまう点でコスト上は不利となる。

【００６６】こうしてエンジン完爆を判断した時点で、エンジン１の電磁制御スロットルバルブを、その時々のアクセル開度に応じた開度に開き、同じくアクセル開度に応じた出力トルク（Ｔａｃｃ）によりモータ駆動されているトランスミッション入力回転数にエンジン１の回転数を近付けていく。そして、エンジン回転数とトランスミッション入力回転数すなわちモータ回転数が等しくなったとき、Ｃ１クラッチ係合圧のスイープアップとともに、モータ出力トルク（Tm）をアクセル開度に応じた所定勾配でスイープダウンさせる。

【００６７】次に、上記制御を実行する具体的な手順をフローで説明する。図４は、走行中エンジン始動制御メインフローを示す。まず、ステップＳ１のアクセル開度読み込みと、ステップＳ２の車速読み込みにより、ステップＳ３で、走行マップ（図２参照）から現在の走行状態がエンジン走行領域にあるか否かを判断する。また、ステップＳ４では、同じく走行マップからＣｉクラッチスタンバイ領域にあるか否かを判断する。これらステップＳ３とステップＳ４の何れかの判断が成立（Ｙｅｓ）する場合に、スタンバイ制御手段を構成するステップＳ５で、Ｃｉクラッチスタンバイ制御を実行し、次いで、始動制御手段を構成するステップＳ６によるエンジン始動制御を実行することになる。

【００６８】図５は、図４に示すステップＳ５のＣｉクラッチスタンバイ制御のサブルーチンを示す。このルーチンでは、当初のステップＳ２１で、Ｃ１クラッチを解放する。これにより車両は慣性走行となる。次に、ステップＳ２２によりＣｉクラッチ圧（Ｐｃｉ）を初期値（Ｐｆ）にして出力し、クラッチのピストンストロークを詰める処理を行う。この処理によるＣｉクラッチ３の作動は、ステップＳ２３によるタイマ判断で、油圧出力から時間（ｔｆ）が経過したことにより確認される。

【００６９】この時間経過を待って、ステップＳ２４で、Ｃｉクラッチ圧（Ｐｃｉ）をエンジンがクランキング開始位置になるように、所定のスタンバイ圧（Ｐｓｔ ｂｙ）に設定し、出力する。これにより、エンジン１のクランク軸が微小回転し、クランキング開始位置（圧縮行程手前）になる。このクランキング開始位置の確認は、ステップＳ２５で、スタンバイ圧（Ｐｓｔｂｙ）を出力してからの時間が所定のスタンバイ時間（ｔｓｔｂｙ）経過したかの判断で行われる。次に、ステップＳ２６で、エンジン走行領域になったかを判断する。そして、この判断が成立（Ｙｅｓ）の場合には、エンジン始動制御サブルーチンに入る。一方、ステップＳ２６で、エンジン走行領域判断が不成立（Ｎｏ）の場合には、更に、ステップＳ２７で、Ｃｉクラッチスタンバイ領域にあるかを判断し、これが成立（Ｙｅｓ）の場合は、ステップＳ２４に戻って、Ｃｉクラッチ圧（Ｐｃｉ）をスタンバイ圧（Ｐｓｔｂｙ）状態に保持する。また、ステップＳ２７のＣｉクラッチスタンバイ領域判断が不成立（Ｎｏ）の場合は、モータ走行領域に戻ったとして本制御を中止すべく、ステップＳ２８で、Ｃｉクラッチ圧（Ｐｃｉ）を0にする処理を行う。そして最後に、ステップＳ２９でＣ１クラッチを再係合させる。

【００７０】このようにしてスタンバイ状態になった後のエンジン始動制御は、大別して２つの形態を採ることができる。まず第１実施形態として、Ｃ１クラッチ４１を第２のクラッチとして用いる制御について説明する。

【００７１】この場合、図６及び図７に示すエンジン始動制御サブルーチンに入ると、ステップＳ３１で、Ｃｉクラッチ圧（Ｐｃｉ）をスイープアップさせながら、ステップＳ３２で、モータ回転数（Nm）の変化率（Ｘ２＝ｄNm／ｄｔ）を求める。そして、ステップＳ３３で、変化率（Ｘ２）が所定変化率（Ｘ１）を上回ったかをみる。すなわち、Ｃｉクラッチ３の係合の進行でクランキングが開始されてモータ回転がエンジン１により引き下げられ始めたかをみる。この判断が成立（Ｙｅｓ）すると、ステップＳ３４で、Ｃｉクラッチ圧（Ｐｃｉ）を１００％の圧、すなわちＰ１００にし、Ｃｉクラッチ３を完全係合させる。上記ステップＳ３１～Ｓ３４は、本発明にいうスイープアップ手段を構成する。そして、トルク増大手段を構成するステップＳ３５で、モータトルク（Tm）をエンジンの始動トルク（Ｔｃｒｕｎｋ）を出力するように設定する。更に、ステップＳ３６で、モータ回転数（Nm）と変速機の入力回転数（Ｎｉｎ）との偏差（dN）を求める。そして、ステップＳ３７で、偏差（dN）より微小トルク（ｄTm）を決定する。かくして、ステップＳ３８で、フィードバックを実行する。この場合、Ｃ１クラッチ４１が解放されており、モータトルク（Tm）は全てエンジン１をクランキングするために使われるので、モータトルクを一定に維持すると、エンジン回転が必要以上に上昇してしまい、Ｃ１クラッチ４１を再係合させる際に支障が生じる可能性がある。そこで、モータ回転と変速機の入力回転の偏差に応じてモータトルクをフィードバック制御するわけである。上記ステップＳ３６～Ｓ３８は、本発明にいうトルク制御手段を構成する。

【００７２】更に、ステップＳ３９で、エンジン回転が所定回転数（例えば、５００ｒpm、すなわち燃料供給と点火によりエンジンが自力回転可能な完爆状態となる回転数）になったかを判断する。そして、ステップＳ４０でエンジン点火済みかを判定し、未点火（Ｎｏ）の場合は、ステップＳ４１でエンジンに燃料を噴射し、点火させ、エンジンを始動させる。また、点火済みの場合は、ステップＳ４１を跳ばして、次のステップに進む。

【００７３】かくして、エンジン１が始動したら、ステップＳ４２で、エンジン回転数（Ｎｅ）が変速機４０の入力回転数（Ｎｉｎ）と同期したかを、±Ｎａの幅の範囲で判断する。これによる同期の判断が成立（Ｙｅｓ）したところで、ステップＳ４３により、Ｃ１クラッチ４１を係合させる。この場合、エンジン回転数（Ｎｅ）が変速機４０の入力回転数（Ｎｉｎ）とすでに同期しているので、係合時のショックは発生しない。かくしてＣ１クラッチ４１の係合でエンジン１のトルクが車輪８に伝達可能となるので、次のステップＳ４４では、モータトルク（Tm）を減少させていく処理を行う。併せて、ステップＳ４５で、モータトルク（Tm）のスイープダウンにより減少した分をエンジン１に出力させる（Ｔｅ＝Ｔａｃｃ－Tm）処理を行う。具体的には、電子スロットルへの信号出力でスロットルを開いて行く。最後に、ステップＳ４６でモータトルク（Tm）が0になったかを判断する。この判断が成立（Ｙｅｓ）することで、モータ走行からエンジン走行の切換えが終了する。以上のステップＳ４４，Ｓ４５は、終了制御手段を構成する。

【００７４】上記実施形態によれば、モータジェネレータ２の出力トルクを全てクランキングトルクとして使用できるので、従来のように車両の駆動トルクに加えたクランキングトルク分を出力できるように性能を見積もる必要がないので、モータジェネレータ２の大型化を防ぐことができる。

【００７５】次に、前記第１実施形態では、車輪８からモータジェネレータ２への伝動装置４を介するトルク伝達の遮断状態を得る第２のクラッチとしてＣ１クラッチ４１を用いる形態を採ったが、Ｃ１クラッチ４１に代えてワンウェイクラッチ４２（又はワンウェイクラッチ４４）を使用する形態を採ることもできる。次に、こうした形態を採る第２実施形態について図８に示すタイムチャートを参照しながら説明する。

【００７６】この形態におけるＣｉクラッチ圧（Ｐｃｉ）の制御は、前形態と同様となるので説明を省略する。一方、モータトルク（Tm）の制御については、前形態と同様とすることもできるが、この第２実施形態では、当初の状態からスタンバイ制御期間を通じて、車両の駆動に必要なアクセル開度に応じたそれまでのトルク（Ｔａｃｃ）に維持される。そして、この場合の動力遮

断手段は、所定の変速段達成時にモータジェネレータ２から車輪８へのトルク伝達のみ可能とするワンウェイクラッチ４２（又はワンウェイクラッチ４４）となるので、制御開始時の変速段が所定の変速段にあるか否かにより変速制御を必要とし、更にワンウェイクラッチ４２（又はワンウェイクラッチ４４）と併設されてトルク伝達を有効とするエンジンブレーキ用係合要素４３（又はクラッチ４５）の解放制御を必要とする。したがって、この制御では、制御開始時の変速段が図に示すように例えば直結段の第４速の場合には、第３速へのシフトダウンによりワンウェイクラッチ４２（又はワンウェイクラッチ４４）による逆駆動トルクの遮断が得られるようにしなければならない。また、その状態でも、エンジンブレーキ用係合要素４３（又はクラッチ４５）の係合によりエンジンブレーキが達成される場合、エンジンブレーキ用係合要素４３（又はクラッチ４５）を解放して逆駆動トルクが伝わらないようにすることになる。

【００７７】次のエンジン始動制御時は、制御内容自体は同様であるが、モータトルク（Tm）は、それまでの車両の駆動に必要なアクセル開度の応じたトルク（Ｔａｃｃ）にクランキングトルク（Ｔｃｒｕｎｋ）分を加えたトルク出力とされる。その余の点は、同期確認時に変速段を元の変速段に戻し、あるいはエンジンブレーキ用係合要素４３を解放させる点を除いて前形態と同様である。

【００７８】この第２実施形態のクラッチスタンバイ制御サブルーチンは、図９に示すフローとなる。この場合のフローは、前記第１実施形態と概ね共通となるので、異なる箇所のみ異なるステップ番号を付して説明する。まず変速制御手段としのステップＳ２１−１で、ワンウェイクラッチ（ＯＷＣ）の効く変速段、すなわち車輪８からモータジェネレータ２へのトルク伝達を無効とする作動が生じる変速段に変速させる。なお、この場合、制御開始時の変速段がすでにワンウェイクラッチ（ＯＷＣ）の効く変速段であるときは、エンジンブレーキ用係合要素４３（又はクラッチ４５）を解放する。また変速を要する場合は、ダウンシフトさせる。これはモータ走行からエンジン走行への切り換え時には加速しているので、アップシフトよりもダウンシフトさせたほうがよいからである。この制御に対応させて変速制御手段としてのステップＳ２９−１では、元の変速段に戻す等の制御処理を行う。

【００７９】次にエンジン始動制御サブルーチンは、図１０に示すフローとなる。この場合のフローも前記第１実施形態と概ね共通となるので、異なる箇所のみ異なるステップ番号を付して説明する。このルーチンでは、ステップＳ３５−１で、モータトルク（Tm）をアクセル開度に応じたトルク（Ｔａｃｃ）とエンジン始動に必要なトルク（Ｔｃｒｕｎｋ）とを出力させる。そして、ステップ４１−１では、モータトルク（Tm）をアクセル開度に応じたトルク（Ｔａｃｃ）に戻す。これは、この時点でエンジンの始動によりクランキングトルク（Ｔｃｒｕｎｋ）は不要となるためである。

【００８０】なお、この形態におけるエンジン走行への切り換え終了後は、この制御開始前の変速段に戻すか、又はエンジンブレーキ用係合要素を係合に戻すことになる。この場合、他の変速制御方法として、通常の変速マップに従って変速段を設定することもできる。

【００８１】上記第２実施形態によれば、Ｃｉクラッチスタンバイ制御期間中もモータトルク（Tm）が出力されているので、エンジン再始動時の惰行期間を短くすることができる利点が得られる。

【００８２】以上、本発明を主として二つの実施形態に基づき変形形態をも含めて詳説したが、本発明は上記実施形態の開示内容のみに限定されることなく、特許請求の範囲に記載の事項の範囲内で種々に細部の具体的構成を変更して実施可能なものであることはいうまでもない。

【図面の簡単な説明】

【図１】本発明の第１実施形態に係る車両用ハイブリッド駆動装置のシステム構成図である。

【図２】上記駆動装置における制御装置内の走行モードマップである。

【図３】上記制御装置による走行中エンジン始動のタイムチャートである。

【図４】上記エンジン始動のメインフローチャートである。

【図５】上記メインフロー中のスタンバイ制御サブルーチンのフローチャートである。

【図６】上記メインフロー中のエンジン始動制御サブルーチンの一部を示すフローチャートである。

【図７】上記エンジン始動制御サブルーチンの他部を示すフローチャートである。

【図８】第２実施形態の制御装置によるエンジン始動のタイムチャートである。

【図９】上記エンジン始動におけるスタンバイ制御サブルーチンのフローチャートである。

【図１０】上記エンジン始動におけるエンジン始動制御サブルーチンを示すフローチャートである。

【図１１】一般的な６気筒エンジンのクランク回転に対するトルク変動を示す特性図である。

【図１２】一般的なエンジンのクランキングトルク特性を示す模式図である。

【図１３】上記クランキングトルクの立ち上がり特性を示す模式図である。

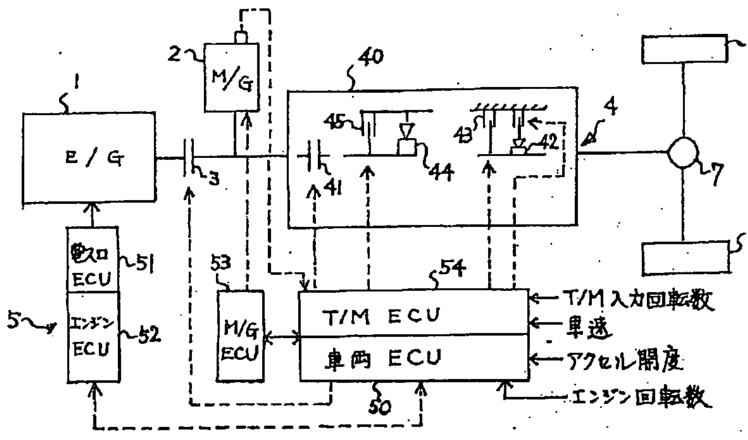
【符号の説明】

１	エンジン
２	モータジェネレータ
３	Ｃｉクラッチ（入力クラッチ）
４	伝動装置

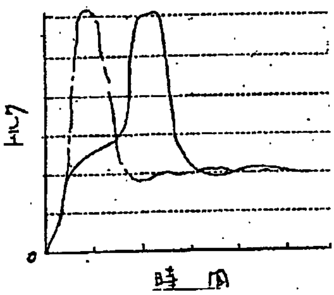
5　制御装置
40　自動変速機
41　C1クラッチ（第2のクラッチ）
42　ワンウェイクラッチ（第2のクラッチ）
43　エンジンブレーキ用係合要素
S5　スタンバイ制御手段

S6　始動制御手段
S21－1，S29－1　変速制御手段
S31～34　スイープアップ手段
S35　トルク増大手段
S36～S38　トルク制御手段
S44，S45　終了制御手段

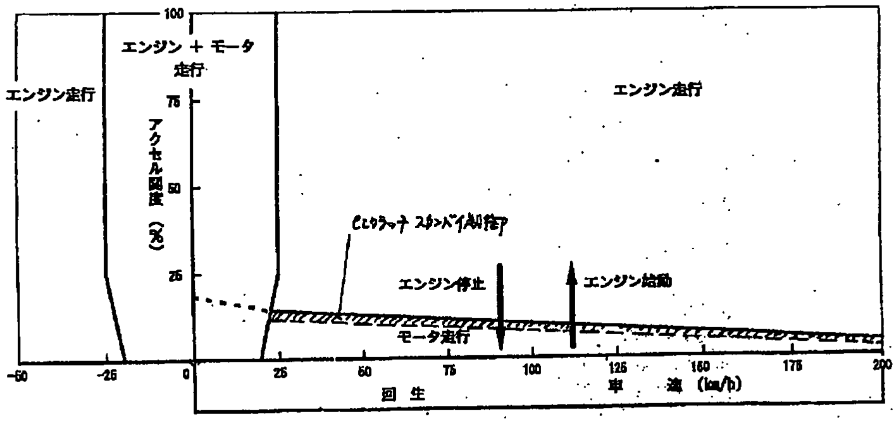
【図1】



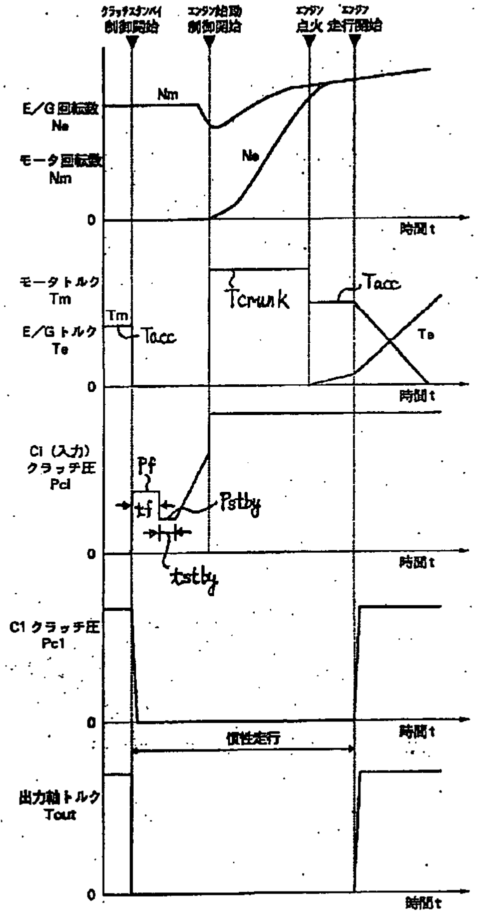
【図13】



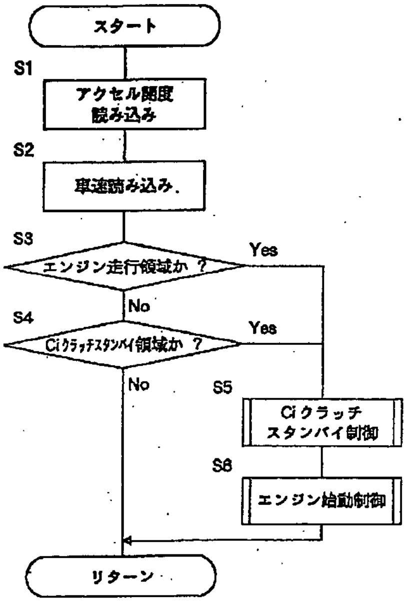
【図2】



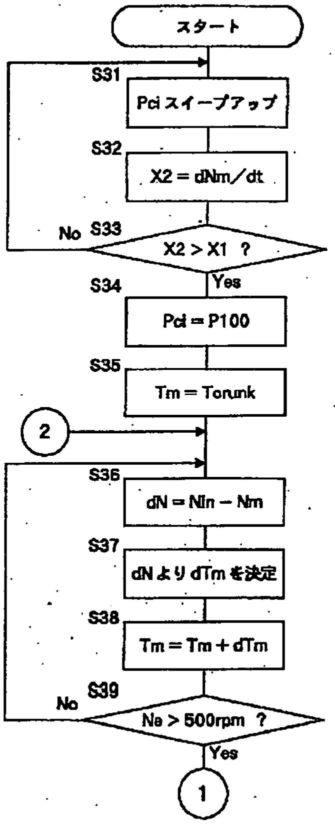
【図3】


クラッチスタンバイ制御開始
エンジン始動制御開始
エンジン点火
エンジン走行開始
E／G回転数 Ne
モータ回転数 Nm
Nm
Ne
0
時間t
モータトルク Tm
E／Gトルク Te
Tm
Tacc
Tcrunk
Tacc
Te
0
時間t
Ci（入力）クラッチ圧 Pci
Pf
tf
Pstby
tstby
0
時間t
C1クラッチ圧 Pc1
0
時間t
慣性走行
出力軸トルク Tout
0
時間t

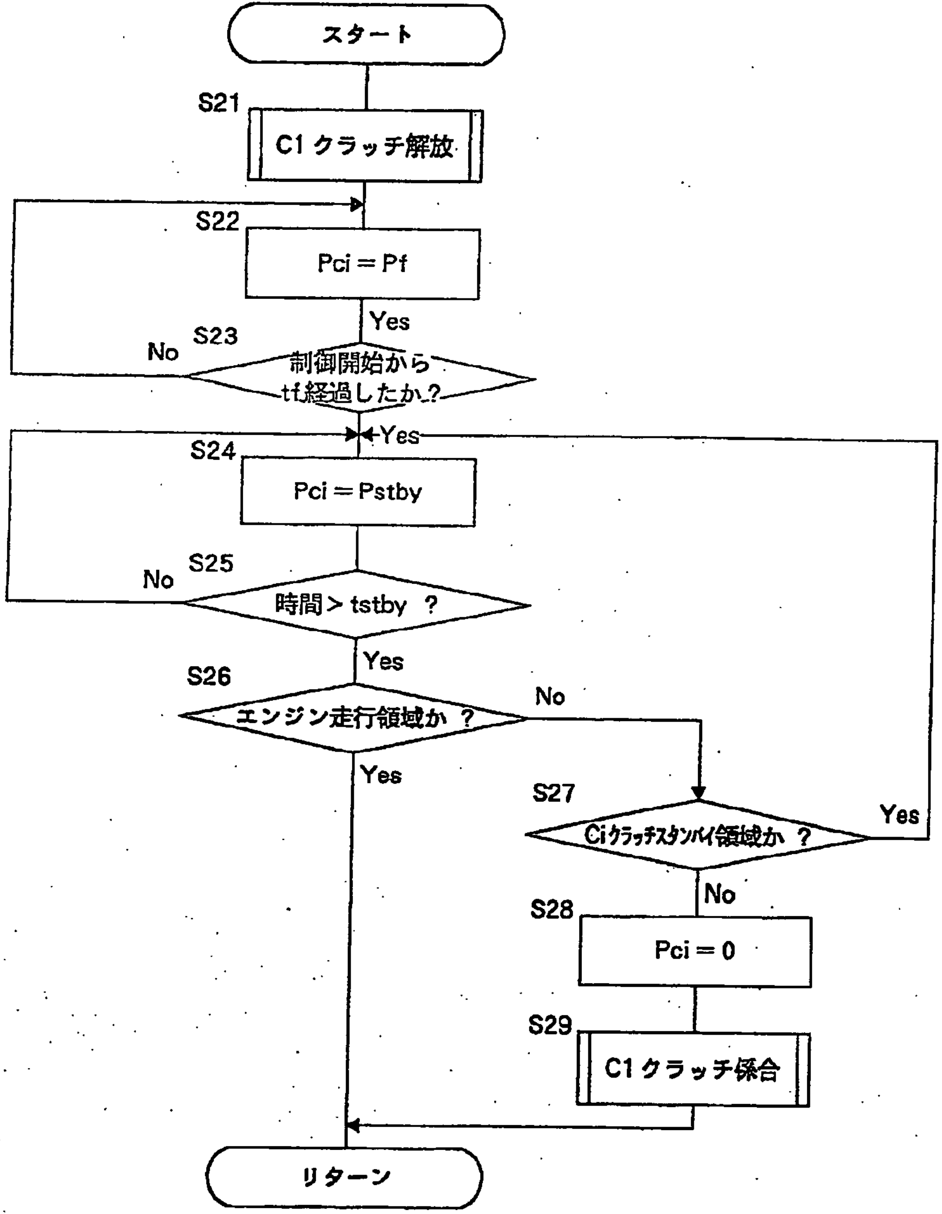
【図4】


スタート
S1
アクセル開度読み込み
S2
車速読み込み.
S3
エンジン走行領域か ？
Yes
No
S4
Ciクラッチスタンバイ領域か ？
Yes
No
S5
Ciクラッチスタンバイ制御
S6
エンジン始動制御
リターン

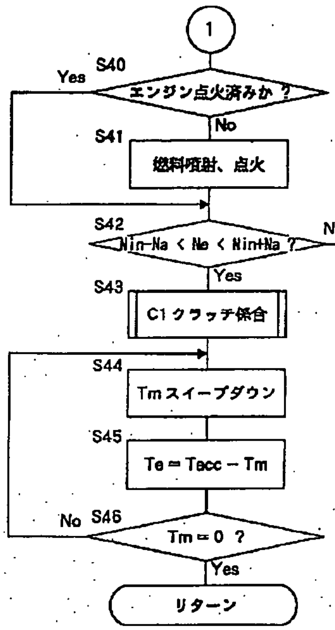
【図6】


スタート
S31
Pciスイープアップ
S32
X2 = dNm／dt
S33
X2 > X1 ？
No
Yes
S34
Pci = P100
S35
Tm = Tcrunk
2
S36
dN = Nin − Nm
S37
dNよりdTmを決定
S38
Tm = Tm + dTm
S39
Ne > 500rpm ？
No
Yes
1

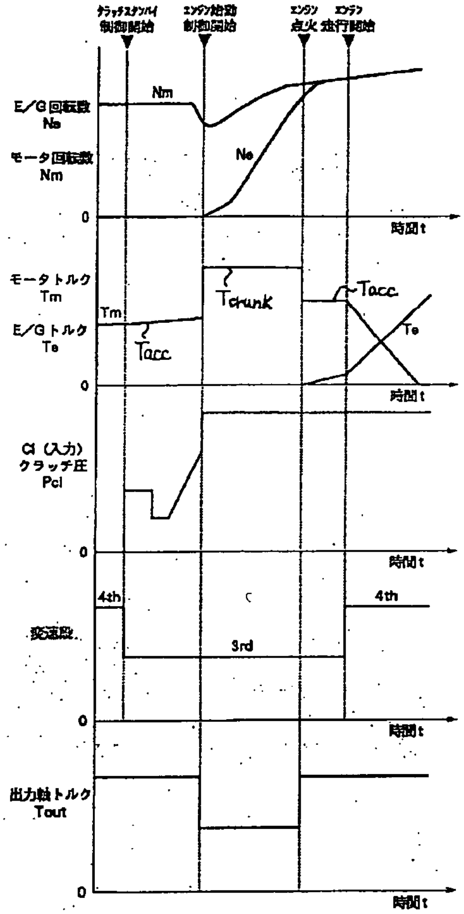
【図５】


スタート
S21
C1 クラッチ解放
S22
Pci＝Pf
Yes
S23
No
制御開始から tf経過したか？
Yes
S24
Pci＝Pstby
S25
No
時間＞tstby ？
Yes
S26
エンジン走行領域か ？
No
Yes
S27
Ciクラッチスタンバイ領域か ？
Yes
No
S28
Pci＝0
S29
C1 クラッチ係合
リターン

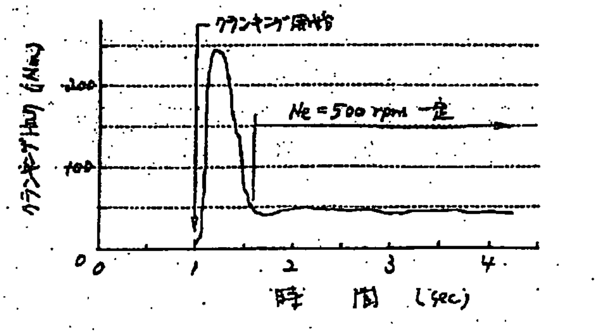
【図７】


1
S40
エンジン点火済みか？
Yes
No
S41
燃料噴射、点火
S42
Nin-Na ＜ Ne ＜ Nin+Na ？
No
2
Yes
S43
C1 クラッチ係合
S44
Tm スイープダウン
S45
Te = Tacc − Tm
S46
Tm = 0 ？
No
Yes
リターン

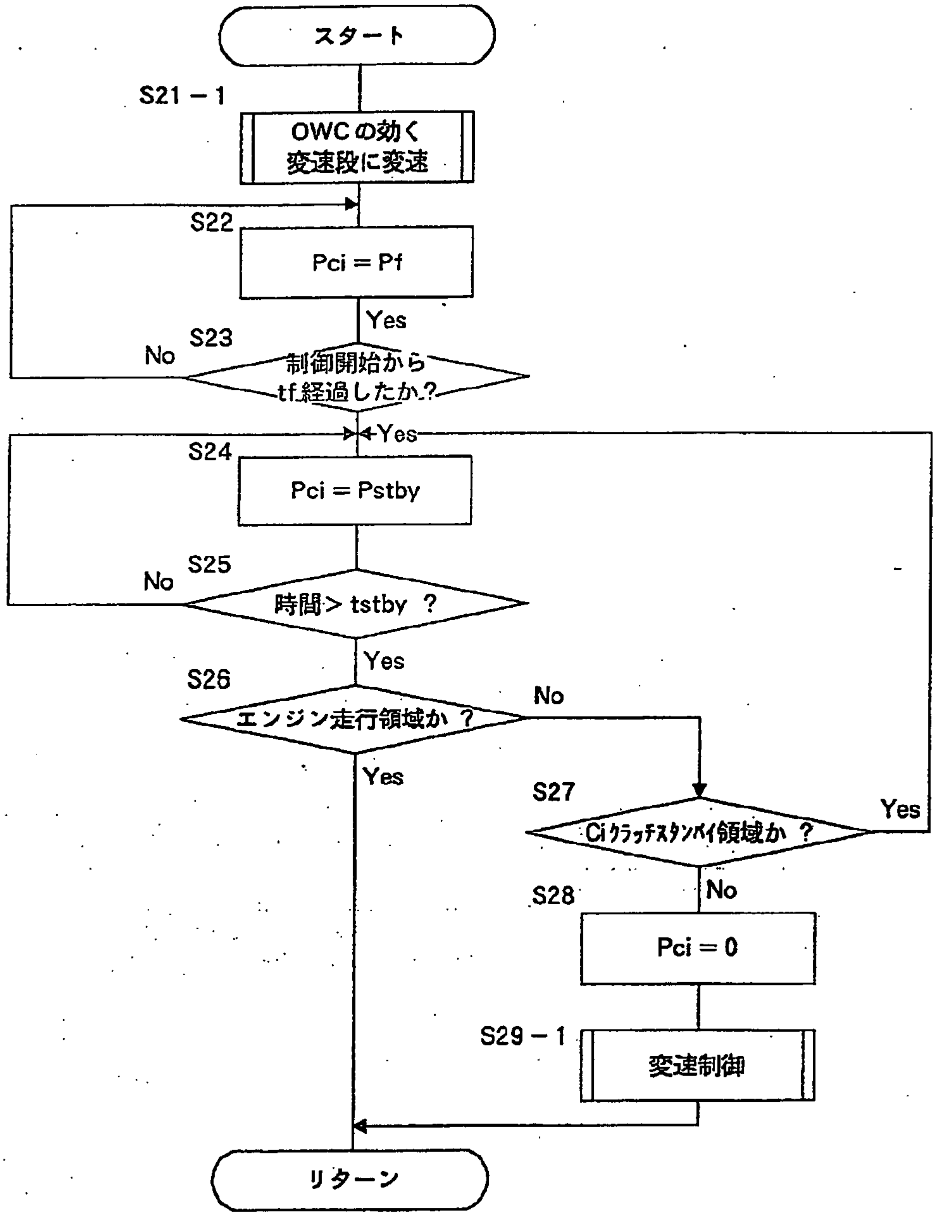
【図８】


クラッチスタンバイ制御開始
エンジン始動制御開始
エンジン点火
エンジン走行開始
E／G 回転数 Ne
モータ回転数 Nm
Nm
Ne
0
時間 t
モータトルク Tm
E／G トルク Te
Tm
Tacc
Tcrunk
Tacc
Te
0
時間 t
C1（入力）クラッチ圧 Pcl
0
時間 t
変速段
4th
3rd
4th
0
時間 t
出力軸トルク Tout
0
時間 t

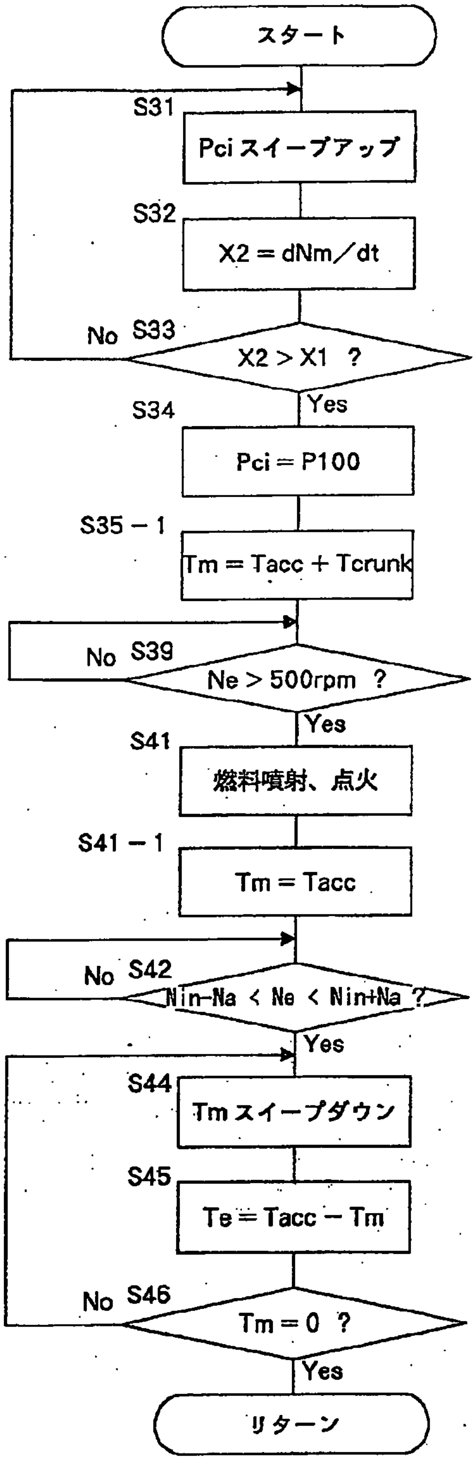
【図１２】


クランキング開始
Ne = 500 rpm 一定
クランキングトルク (Nm)
200
100
0
0
1
2
3
4
時間 (sec)

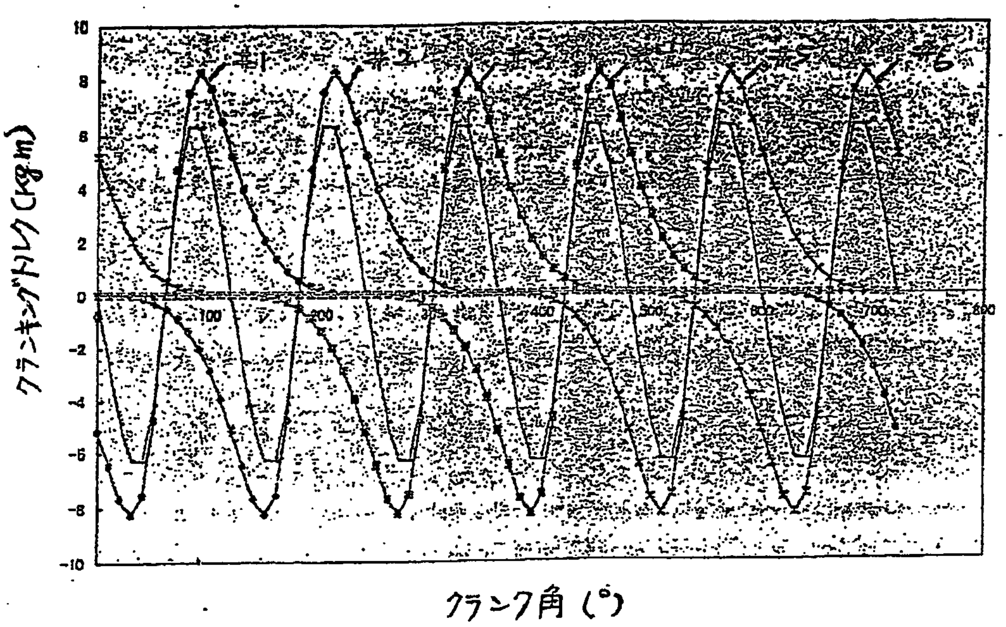
【図９】


スタート
S21－1
OWCの効く
変速段に変速
S22
Pci＝Pf
Yes
S23
No
制御開始から
tf経過したか？
Yes
S24
Pci＝Pstby
S25
No
時間＞tstby ？
Yes
S26
エンジン走行領域か ？
No
Yes
S27
Ciｸﾗｯﾁｽﾀﾝﾊﾞｲ領域か ？
Yes
S28
No
Pci＝0
S29－1
変速制御
リターン

【図１０】


スタート
S31
Pci スイープアップ
S32
X2＝dNm／dt
No
S33
X2＞X1 ？
Yes
S34
Pci＝P100
S35－1
Tm＝Tacc＋Tcrunk
No
S39
Ne＞500rpm ？
Yes
S41
燃料噴射、点火
S41－1
Tm＝Tacc
No
S42
Nin-Na ＜ Ne ＜ Nin+Na ？
Yes
S44
Tm スイープダウン
S45
Te＝Tacc－Tm
No
S46
Tm＝0 ？
Yes
リターン

【図１１】



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D2

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(22)Date of filing : 29.08.1997

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KURITA NORIYOSHI
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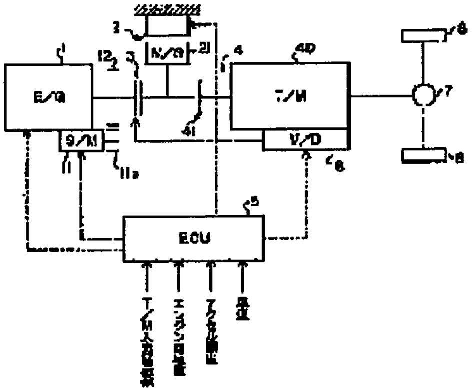
(54) ON-VEHICLE HYBRID DRIVE DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To improve response of restarting while running to reduce decelerating shock.

SOLUTION: This on-vehicle hybrid drive device is provided with an engine 1, a motor generator 2, a clutch 3, a transmission 4, and their controller 5. A control device 5 is provided with a stand-by control mean that controls to rotate the engine 1 to a cranking start position by previously transmitting a power of the motor generator 2 to the engine 1 by controlling an engaging pressure of the clutch 3 to fix cranking characteristics when starting an engine to improve starting response when shifting from motor generator running to engine running.



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[Date of registration]	
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特開平11－82261

(43)公開日　平成11年(1999)３月26日

(51)Int.Cl.^{6}	識別記号	ＦＩ	
F02N 11/04		F02N 11/04	D
B60K 41/02		B60K 41/02	
B60L 11/14		B60L 11/14	
F02B 61/00		F02B 61/00	D
F02D 29/02		F02D 29/02	D

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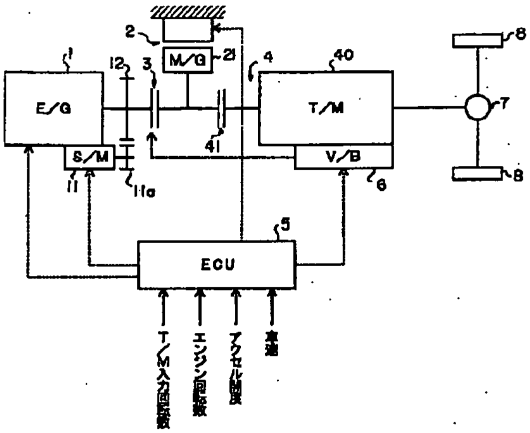
(54)【発明の名称】車両用ハイブリッド駆動装置

(57)【要約】

【課題】　走行中エンジン再始動のレスポンスを向上させ、減速ショックを低減する。

【解決手段】　車両用ハイブリッド駆動装置は、エンジン１、モータジェネレータ２、クラッチ３、伝動装置４及びそれらの制御装置５を備える。制御装置５は、モータジェネレータ走行からエンジン走行に移る際に、エンジン始動時のクランキング特性を一定にして始動レスポンスを向上させるべく、予めモータジェネレータ２の動力をクラッチ３の係合圧の制御によりエンジン１に伝達して、エンジン１をクランキング開始位置まで回転させる制御を行うスタンバイ制御手段を有する。



【特許請求の範囲】

【請求項１】　エンジンと、モータジェネレータと、前記エンジンとモータジェネレータの動力を車輪に伝達可能な伝動装置と、前記エンジン、モータジェネレータ及びそれらの動力の車輪への伝達を制御する制御装置と、を備える車両用ハイブリッド駆動装置において、
前記制御装置は、エンジンを停止させ、モータジェネレータの動力を車輪へ伝達している車両走行時に、アクセル操作を検出して、エンジンを始動させる始動制御手段と、該始動制御手段によるエンジンの始動に先行させて、エンジンをクランキング開始位置まで回転させる制御を行うスタンバイ制御手段とを有する、ことを特徴とする、車両用ハイブリッド駆動装置。

【請求項２】　前記エンジン及びモータジェネレータ相互間の動力伝達を制御可能なクラッチを有し、
前記スタンバイ制御手段は、前記クラッチのトルク伝達容量が、エンジンをクランキング開始位置まで回転させる容量となるように、クラッチ圧を制御するスタンバイ圧制御手段を含む、請求項１記載の車両用ハイブリッド駆動装置。

【請求項３】　前記始動制御手段は、スタンバイ制御後に、前記クラッチのトルク伝達容量がモータジェネレータの出力トルク以下となるように、クラッチの係合圧を制御するクランキング圧制御手段を含む、請求項２記載の車両用ハイブリッド駆動装置。

【請求項４】　前記エンジンを始動させるスタータモータを有し、
前記始動制御手段は、スタンバイ制御後に、スタータモータの起動と、前記クラッチの係合を同時に行わせる、請求項２記載の車両用ハイブリッド駆動装置。

【請求項５】　エンジンと、モータジェネレータと、前記エンジン及びモータジェネレータ相互間の動力伝達を制御可能なクラッチと、前記エンジンとモータジェネレータの動力を車輪に伝達可能な伝動装置と、前記エンジン、モータジェネレータ及びクラッチを制御する制御装置と、を備える車両用ハイブリッド駆動装置において、
前記制御装置は、エンジンを停止させ、クラッチを解放してモータジェネレータの動力を車輪へ伝達している車両走行時に、アクセル操作を検出して、クラッチの係合によりエンジンを始動させる始動制御手段と、該始動制御手段によるエンジンの始動に先行させて、クラッチの係合によりエンジンをクランキング開始位置まで回転させる制御を行うスタンバイ制御手段とを有し、
前記スタンバイ制御手段は、前記クラッチのトルク伝達容量が、エンジンをクランキング開始位置まで回転させる容量となるように、クラッチの係合圧を制御するスタンバイ圧制御手段を含み、前記始動制御手段は、スタンバイ制御後に、前記クラッチのトルク伝達容量がモータジェネレータの出力トルク以下となるように、クラッチの係合圧を制御するクランキング圧制御手段を含む、ことを特徴とする、車両用ハイブリッド駆動装置。

【請求項６】　エンジンと、モータジェネレータと、前記エンジンを始動させるスタータモータと、前記エンジン及びモータジェネレータ相互間の動力伝達を制御可能なクラッチと、前記エンジンとモータジェネレータの動力を車輪に伝達可能な伝動装置と、前記エンジン、モータジェネレータ、スタータモータ及びクラッチを制御する制御装置と、を備える車両用ハイブリッド駆動装置において、
前記制御装置は、エンジンを停止させ、クラッチを解放してモータジェネレータの動力を車輪へ伝達している車両走行時に、アクセル操作を検出して、エンジンを始動させる始動制御手段と、該始動制御手段によるエンジンの始動に先行させて、クラッチの係合によりエンジンをクランキング開始位置まで回転させる制御を行うスタンバイ制御手段とを有し、
前記スタンバイ制御手段は、前記クラッチのトルク伝達容量が、エンジンをクランキング開始位置まで回転させる容量となるように、クラッチの係合圧を制御するスタンバイ圧制御手段を含み、
前記始動制御手段は、スタンバイ制御後に、スタータモータの起動と、前記クラッチの係合を同時に行わせる、ことを特徴とする、車両用ハイブリッド駆動装置。

【請求項７】　前記クランキング圧制御手段は、エンジン回転の変化率が目標値になるように、クラッチの係合圧を制御する定加速制御手段を含む、請求項５記載の車両用ハイブリッド駆動装置。

【請求項８】　前記クランキング圧制御手段は、モータジェネレータ回転の減少度を所定値以内に抑えるようにクラッチの係合圧を制御する回転数維持制御手段を含む、請求項５記載の車両用ハイブリッド駆動装置。

【請求項９】　前記始動制御手段は、スタータモータをエンジンが微小回転する期間だけ作動させる立ち上げ制御手段を含む、請求項６記載の車両用ハイブリッド駆動装置。

【請求項１０】　前記始動制御手段は、クラッチの係合圧をクラッチがエンジンのクランキングトルクの平均値を伝達する値に設定するクランキング圧設定手段を含む、請求項６又は９記載の車両用ハイブリッド駆動装置。

【請求項１１】　前記始動制御手段は、モータジェネレータにエンジンのクランキングトルクの平均値と車両の駆動トルクを出力させるトルク制御手段を含む、請求項６、９又は１０記載の車両用ハイブリッド駆動装置。

【請求項１２】　前記始動制御手段は、モータジェネレータにスタータモータの起動電流に応じてトルクを出力させるトルク制御手段を含む、請求項６記載の車両用ハイブリッド駆動装置。

【請求項１３】　前記スタータモータの作動期間は、タイマ制御とされた、請求項６又は９記載の車両用ハイブ

リッド駆動装置。

【請求項１４】　前記始動制御手段は、モータジェネレータに最大トルクを出力させるトルク制御手段と、モータジェネレータの最大トルク出力時に、クラッチのトルク容量を大きくすべく係合圧を増大させる増圧手段を含む、請求項５又は７記載の車両用ハイブリッド駆動装置。

【請求項１５】　前記始動制御手段は、モータジェネレータにエンジンのクランキングトルクの平均値を出力させるトルク制御手段を含む、請求項５又は７記載の車両用ハイブリッド駆動装置。

【請求項１６】　前記始動制御手段は、クラッチの係合圧をスイープアップさせるスイープアップ手段を含む、請求項５又は８記載の車両用ハイブリッド駆動装置。

【請求項１７】　前記スタンバイ制御手段は、クラッチのピストンストロークを詰めるファーストフィル圧供給手段を含む、請求項５又は７記載の車両用ハイブリッド駆動装置。

【請求項１８】　前記制御装置は、モータ走行領域とエンジン走行領域との間にクラッチスタンバイ領域を設定された、請求項５又は７記載の車両用ハイブリッド駆動装置。

【請求項１９】　前記始動制御手段は、エンジン回転が所定回転になったとき、エンジンに燃料を供給し点火させる、請求項５、７、１４～１８のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項２０】　前記始動制御手段は、エンジン回転とモータジェネレータ回転の同期後にクラッチを完全係合させる、請求項５、７、１４～１９のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項２１】　前記制御装置は、エンジン始動後、モータジェネレータの出力トルクをスイープダウンさせ、エンジンのスロットル開度を開く、終了制御手段を有する、請求項５、７、１４～２０のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項２２】　前記スタンバイ制御手段は、クラッチのピストンストロークを詰めるファーストフィル圧供給手段を含む、請求項６、９～１３のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項２３】　前記制御装置は、モータ走行領域とエンジン走行領域との間にクラッチスタンバイ領域を設定された、請求項６、９～１３のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項２４】　前記始動制御手段は、エンジン回転が所定回転になったとき、燃料を供給し点火させる、請求項６、９～１３、２２、２３のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項２５】　前記始動制御手段は、エンジン回転とモータジェネレータ回転の同期後にクラッチを完全係合させる、請求項６、９～１３、２２～２４のいずれか１項記載の車両用ハイブリッド駆動装置。

【請求項２６】　前記制御装置は、エンジン始動後、モータジェネレータの出力トルクをスイープダウンさせ、エンジンのスロットル開度を開く、終了制御手段を有する、請求項６、９～１３、２２～２５のいずれか１項記載の車両用ハイブリッド駆動装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、エンジンとモータジェネレータを動力とする車両用ハイブリッド駆動装置に関し、特に、燃費節減のために車両走行中に停止させたエンジンをモータジェネレータ駆動による走行下で再始動させる技術に関する。

【０００２】

【従来の技術】車両用駆動装置として、燃焼機関（本明細書において、エンジンという）と電動発電機（同じく、モータジェネレータという）を動力源とするハイブリッド駆動装置がある。こうした装置における一方の動力源としてのエンジンは、その特性として、低負荷側で負荷の減少量に対して急激に効率の減少割合が大きくなる傾向がある。

【０００３】そこで、燃費性能を改善して省エネルギを図るため、低負荷すなわちアクセル操作量（同じく、アクセル開度という）が小さい状態での走行時に、エンジンを自動的に停止させ、モータジェネレータ駆動で走行する方式の駆動装置が提案されている。この方式では、アクセル開度が所定の低開度領域を出るとき、エンジンを自動的に再始動させなければならないが、その際に、走行のための駆動トルクを出力しているモータジェネレータの駆動力を一部エンジン始動に割くことになるため、エンジンのクランキング負荷による駆動力の低下で、大きな減速感が生じる。したがって、この方式では、エンジン再始動時の減速ショックを如何に軽減するかが解決しなければならない大きな問題点となる。

【０００４】こうした減速ショックの発生に対する対策として、従来、エンジン再始動時に、モータジェネレータの出力トルクをエンジンに伝達するクラッチの係合圧をスイープアップさせながら、クラッチの係合の進行に伴うトルク伝達力の増加につれて生じるモータジェネレータの微小回転変化率を認識し、その出力トルクを補足（ブースト）する制御を行う技術がある。

【０００５】ところで、エンジン始動時のクランキング負荷は、その停止状態からの加速に必要なイナーシャトルクの他に、各シリンダで吸入、圧縮、排気が生じることに伴う抵抗、機械的引きずり抵抗分のトルク、エアコン、オルタネータ、ウォータポンプ、オイルポンプ等の補機類の駆動トルク等の合成トルクとなる。これらのうち、特に吸排気動作による負荷は、例えば６気筒エンジンでは、図１２に各気筒ごとに異なる記号付の線で示すように周期的な変動トルクとなり、上記各トルクの合計

値は、実線で示すような特性となる。

【0006】しかしながら、実際のクランキングトルクは、一旦エンジンの回転が始まると、当初回転の抵抗となっていたイナーシャトルクが、フライホイールイナーシャの発生により、逆にトルク変動を抑制する要素として働くようになるため、図13に示すように、回転の立ち上がり時のみ極端に大きく、その後はほぼ一定の値となる特性を有する。したがって、トルク変動は残るものの、一定速度の回転を維持するために外部より平均的に与えなければならないクランキングトルクは、変動トルクの平均値でよいようになる。

【0007】そこで、こうしたクランキングトルクの特性に合わせて、再始動時にエンジンがある程度の回転数に達して、回転の立ち上げのための慣性力負荷が低減するまで吸排気動作に伴う負荷が生じないようにすることで、トルク負荷のピーク値を下げて、モータジェネレータにかかるクランキングトルクを軽減する技術が提案されている。

【0008】

【発明が解決しようとする課題】しかしながら、後者の技術は、エンジンの改変を要するばかりでなく、複雑な制御を必要とし、実用までには未だ多くの解決すべき問題点があると考えられる。他方、前者の技術にも、上記クランキングトルクの特性に伴う問題点がある。すなわち、クランキングトルクの立ち上がり特性は、前記の周期的な変動トルク成分があることで、エンジン停止時のクランクシャフトの位置により、図14に一点鎖線と実線で対比して示すようにピーク位置がずれて特性が異なってくる。このようにピークトルク発生タイミングがずれることで、クラッチの伝達トルク容量を異ならせるべく、クラッチ係合油圧もそれに合わせて変化させる必要が生じ、モータジェネレータ出力トルク増分をそれに応じて異ならせる極めてきめの細かな制御が必要となる。こうした精密な制御は、マップ制御のような簡易制御では困難である。また、この制御では、シリンダの圧縮、膨張で発生する変動トルク成分が正確に推定できないため、エンジン始動初期にショックが発生しやすい。更に、制御スピードが十分でない。

【0009】そこで本発明は、モータジェネレータによる走行中に、エンジンをレスポンスよく、しかも簡単な制御で再始動させるべく、エンジン再始動時のクランキング特性を一定化することができる車両用ハイブリッド駆動装置を提供することを第1の目的とする。

【0010】次に、本発明は、上記クランキング特性を一定化するためのスタンバイ状態を、油圧制御で実現することを第2の目的とする。

【0011】次に、本発明は、上記クランキング特性を一定化するためのスタンバイ状態と、その後の始動とを、限られたモータジェネレータ出力の範囲で可能とすることを第3の目的とする。

【0012】ところで、エンジン再始動の際の駆動力の低下によるショックを軽減するには、出力トルクに十分余裕のある大容量のモータジェネレータを用い、クランキング負荷に応じてその出力トルクを増大させる制御を行えばよいことになるが、エンジン始動のためだけに備えて、そうした大容量のモータジェネレータを搭載することは、自体の大型化を招くばかりでなく、それを制御するインバータの高容量化、更にはバッテリの高容量化を招き、有効な解決策とはなりえない。そこで、本発明は、エンジンに付設されたスタータモータを補助的に使用することで、クランキングのためにモータジェネレータの定格を大きくすることなく、しかも簡易なクラッチ係合圧の制御で、エンジンのクランキングをレスポンスよく可能とする車両用ハイブリッド駆動装置を提供することを第4の目的とする。

【0013】次に、本発明は、上記クランキング特性を一定化するためのスタンバイ状態と、その後の始動とを、格別の補助的駆動手段なしでモータジェネレータにより実現する車両用ハイブリッド駆動装置を提供することを第5の目的とする。

【0014】ところで、従来の一般的な技術として、スタータモータでエンジン始動する方法があるが、こうした方法を走行中のエンジン再始動に単に適用した場合、クランキングトルクの変動による駆動ノイズが際立つようになり、始動レスポンスも満足のいくものとはならない。そこで、本発明は、クランキングの際の、特に大きなトルクを要するエンジン回転立ち上げ時に、エンジンに付設されたスタータモータを補助的に使用することで、クランキングのためにモータジェネレータの定格を大きくすることなく、しかも簡易なクラッチ係合圧の制御で、エンジンのクランキングをレスポンスよく可能とする車両用ハイブリッド駆動装置を提供することを第6の目的とする。

【0015】次に、モータジェネレータのみでエンジン始動を行う場合、エンジンのクランキングのために、クラッチの係合圧を制御してエンジンの回転数を増加させて行くには種々の方法が考えられるが、係合圧の制御がそのために複雑なものとなるのでは実用性に乏しい。そこで本発明は、簡単なクラッチ係合圧の制御でエンジンを再始動させることを第7の目的とする。

【0016】また、同様にモータジェネレータのみでエンジン始動を行う場合、モータジェネレータの定格出力の制約下では、エンジンのクランキングのために生じる減速ショックの発生は避けられないが、減速感を所定の範囲に制限することで体感上のショックを軽減できる。そこで本発明は、クラッチ係合圧の制御でモータジェネレータの回転数の低下を所定の範囲内に抑えながらエンジンを再始動させることを第8の目的とする。

【0017】一方、スタータモータを使用する場合、従来からエンジンに付設されているスタータモータは、通

常、使用頻度が少ないため、かなりの大電流駆動の過負荷状態で作動させていることから、使用頻度の多い走行時のエンジン再始動に同様の負荷状態で使用すると、耐久性の低下が懸念される。そこで本発明は、スタータモータをモータジェネレータによるクランキングトルクを補う軽負荷状態で駆動し、しかも駆動時間を極限して使用することで、スタータモータの耐久性を確保することを第9の目的とする。

【0018】ところで、エンジン始動のためのクランキングトルクは、前述のように、当初のエンジン回転立ち上げ時には大きいが、その後はそれほど大きくなくなる。そこで、本発明は、上記の回転立ち上げ時に、スタータモータを補助的に利用することで、エンジン始動期間を通じてモータジェネレータのトルク出力の増大分を平均化することで、そのトルクを伝達するためのクラッチ係合圧の制御を単純化することを第１０の目的とする。

【００１９】また、上記のように回転立ち上げ時に、スタータモータを補助的に利用することで、エンジン始動期間を通じてモータジェネレータのトルク出力の増大分を軽減することができる。そこで、本発明は、エンジン始動のためのモータジェネレータのトルク負荷を軽減しながら、その出力トルク制御をも単純化することを第１１の目的とする。

【００２０】また、モータジェネレータトルクをエンジン始動のために割かない方法として、スタータモータのみで走行時のエンジン再始動を行わせることも考えられるが、そのようにすると、前記の理由から、スタータモータの耐久性の低下が懸念される。そこで、本発明は、前記とは逆に、スタータモータを主体としながらモータジェネレータトルクを補助的に利用することで、走行時エンジン再始動を行う場合でも、スタータモータの耐久性を確保することを第１２の目的とする。

【００２１】また、本発明は、始動制御時のスタータモータの制御を単純化することを第１３の目的とする。

【００２２】また、本発明は、モータジェネレータトルクのみで、減速ショックの発生を最小限に抑えながら、レスポンス良くエンジンを再始動させることを第１４の目的とする。

【００２３】また、本発明は、始動制御時のモータジェネレータのトルク制御をクラッチの係合圧制御に合わせて単純化することを第１５の目的とする。

【００２４】また、本発明は、スタンバイ制御から始動制御への移行の際のモータジェネレータのトルク制御を極めて単純な方法で行うことを第１６の目的とする。

【００２５】また、本発明は、モータジェネレータによる始動制御において、それに先行するスタンバイ制御のレスポンスを向上させることを第１７の目的とする。

【００２６】ところで、従来ハイブリッド駆動装置における走行モードの切り換えは、制御装置のマイクロコンピュータにメモリされ、アクセル開度と車速の関係から走行領域を定めた走行モードマップを参照しながら、各時点のアクセル開度と車速の関係に応じてなされる。そこで、本発明は、上記スタンバイ制御の開始時期をマップ上に設定することで、簡易なマップ制御で確実にエンジン再始動を行うことを第１８の目的とする。

【００２７】ところで、上記の制御において、エンジンの始動を確認することは、可能な限り短時間にエンジン始動制御を終了させる上で重要である。そこで、本発明は、的確なエンジン始動判断を可能とすることを第１９の目的とする。

【００２８】また、本発明は、モータジェネレータによるエンジン始動制御を円滑に終了させることを第２０の目的とする。

【００２９】また、本発明は、エンジン始動後のモータ走行からエンジン走行への移行を円滑に行うことを第２１の目的とする。

【００３０】また、本発明は、スタータモータを用いる始動制御において、それに先行するスタンバイ制御のレスポンスを向上させることを第２２の目的とする。

【００３１】また、本発明は、スタータモータを用いる始動制御において、それに先立つスタンバイ制御の開始時期をマップ上に設定することで、簡易なマップ制御で確実にエンジン再始動を行うことを第２３の目的とする。

【００３２】また、本発明は、適切な燃料供給の再開と点火により始動制御の最終段階でタイミング良くエンジンを自力回転させることを第２４の目的とする。

【００３３】また、本発明は、スタータモータを用いるエンジン始動制御を円滑に終了させることを第２５の目的とする。

【００３４】また、本発明は、スタータモータを用いるエンジン始動制御において、エンジン始動後のモータ走行からエンジン走行への移行を円滑に行うことを第２６の目的とする。

【００３５】

【課題を解決するための手段】上記第１の目的を達成するため、本発明は、エンジンと、モータジェネレータと、前記エンジンとモータジェネレータの動力を車輪に伝達可能な伝動装置と、前記エンジン、モータジェネレータ及びそれらの動力の車輪への伝達を制御する制御装置と、を備える車両用ハイブリッド駆動装置において、前記制御装置は、エンジンを停止させ、モータジェネレータの動力を車輪へ伝達している車両走行時に、アクセル操作を検出して、エンジンを始動させる始動制御手段と、該始動制御手段によるエンジンの始動に先行させて、エンジンをクランキング開始位置まで回転させる制御を行うスタンバイ制御手段とを有する、ことを特徴とする。

【００３６】次に、第２の目的を達成するため、前記駆

動装置は、前記エンジン及びモータジェネレータ相互間の動力伝達を制御可能なクラッチを有し、前記スタンバイ制御手段は、前記クラッチのトルク伝達容量が、エンジンをクランキング開始位置まで回転させる容量となるように、クラッチ圧を制御するスタンバイ圧制御手段を含む構成が採られる。

【００３７】更に、第３の目的を達成するため、前記始動制御手段は、スタンバイ制御後に、前記クラッチのトルク伝達容量がモータジェネレータの出力トルク以下となるように、クラッチの係合圧を制御するクランキング圧制御手段を含む構成とされる。

【００３８】また、第４の目的を達成するため、前記駆動装置は、前記エンジンを始動させるスタータモータを有し、前記始動制御手段は、スタンバイ制御後に、スタータモータの起動と、前記クラッチの係合を同時に行わせる構成とされる。

【００３９】次に、第５の目的を達成するため、本発明は、エンジンと、モータジェネレータと、前記エンジン及びモータジェネレータ相互間の動力伝達を制御可能なクラッチと、前記エンジンとモータジェネレータの動力を車輪に伝達可能な伝動装置と、前記エンジン、モータジェネレータ及びクラッチを制御する制御装置と、を備える車両用ハイブリッド駆動装置において、前記制御装置は、エンジンを停止させ、クラッチを解放してモータジェネレータの動力を車輪へ伝達している車両走行時に、アクセル操作を検出して、クラッチの係合によりエンジンを始動させる始動制御手段と、該始動制御手段によるエンジンの始動に先行させて、クラッチの係合によりエンジンをクランキング開始位置まで回転させる制御を行うスタンバイ制御手段とを有し、前記スタンバイ制御手段は、前記クラッチのトルク伝達容量が、エンジンをクランキング開始位置まで回転させる容量となるように、クラッチの係合圧を制御するスタンバイ圧制御手段を含み、前記始動制御手段は、スタンバイ制御後に、前記クラッチのトルク伝達容量がモータジェネレータの出力トルク以下となるように、クラッチの係合圧を制御するクランキング圧制御手段を含む、ことを特徴とする。

【００４０】また、第６の目的を達成するため、本発明は、エンジンと、モータジェネレータと、前記エンジンを始動させるスタータモータと、前記エンジン及びモータジェネレータ相互間の動力伝達を制御可能なクラッチと、前記エンジンとモータジェネレータの動力を車輪に伝達可能な伝動装置と、前記エンジン、モータジェネレータ、スタータモータ及びクラッチを制御する制御装置と、を備える車両用ハイブリッド駆動装置において、前記制御装置は、エンジンを停止させ、クラッチを解放してモータジェネレータの動力を車輪へ伝達している車両走行時に、アクセル操作を検出して、エンジンを始動させる始動制御手段と、該始動制御手段によるエンジンの始動に先行させて、クラッチの係合によりエンジンをクランキング開始位置まで回転させる制御を行うスタンバイ制御手段とを有し、前記スタンバイ制御手段は、前記クラッチのトルク伝達容量が、エンジンをクランキング開始位置まで回転させる容量となるように、クラッチの係合圧を制御するスタンバイ圧制御手段を含み、前記始動制御手段は、スタンバイ制御後に、スタータモータの起動と、前記クラッチの係合を同時に行わせる、ことを特徴とする。

【００４１】更に、第７の目的を達成するため、前記クランキング圧制御手段は、エンジン回転の変化率が目標値になるように、クラッチの係合圧を制御する定加速制御手段を含む構成とされる。

【００４２】次に、第８の目的を達成するため、前記クランキング圧制御手段は、モータジェネレータ回転の減少度を所定値以内に抑えるようにクラッチの係合圧を制御する回転数維持制御手段を含む構成とされる。

【００４３】次に、第９の目的を達成するため、前記始動制御手段は、スタータモータをエンジンが微小回転する期間だけ作動させる立ち上げ制御手段を含む構成とされる。

【００４４】更に、第１０の目的を達成するため、前記始動制御手段は、クラッチの係合圧をクラッチがエンジンのクランキングトルクの平均値を伝達する値に設定するクランキング圧設定手段を含む構成とされる。

【００４５】次に、第１１の目的を達成するため、前記始動制御手段は、モータジェネレータにエンジンのクランキングトルクの平均値と車両の駆動トルクを出力させるトルク制御手段を含む構成とされる。

【００４６】次に、第１２の目的を達成するため、前記始動制御手段は、モータジェネレータにスタータモータの起動電流に応じてトルクを出力させるトルク制御手段を含む構成とされる。

【００４７】次に、第１３の目的を達成するため、前記スタータモータの作動期間は、タイマ制御とされる。

【００４８】次に、第１４の目的を達成するため、前記始動制御手段は、モータジェネレータに最大トルクを出力させるトルク制御手段と、モータジェネレータの最大トルク出力時に、クラッチのトルク容量を大きくすべく係合圧を増大させる増圧手段を含む構成とされる。

【００４９】次に、第１５の目的を達成するため、前記始動制御手段は、モータジェネレータにエンジンのクランキングトルクの平均値を出力させるトルク制御手段を含む構成とされる。

【００５０】次に、第１６の目的を達成するため、前記始動制御手段は、クラッチの係合圧をスイープアップさせるスイープアップ手段を含む構成とされる。

【００５１】次に、第１７の目的を達成するため、前記スタンバイ制御手段は、クラッチのピストンストロークを詰めるファーストフィル圧供給手段を含む構成とされる。

【0052】次に、第18の目的を達成するため、前記制御装置は、モータ走行領域とエンジン走行領域との間にクラッチスタンバイ領域を設定された構成とされる。

【0053】次に、第19の目的を達成するため、前記始動制御手段は、エンジン回転が所定回転になったとき、エンジンに燃料を供給し点火させる構成とされる。

【0054】次に、第20の目的を達成するため、前記始動制御手段は、エンジン回転とモータジェネレータ回転の同期後にクラッチを完全係合させる構成とされる。

【0055】次に、第21の目的を達成するため、前記制御装置は、エンジン始動後、モータジェネレータの出力トルクをスイープダウンさせ、エンジンのスロットル開度を開く、終了制御手段を有する構成とされる。

【0056】次に、第22の目的を達成するため、前記スタンバイ制御手段は、クラッチのピストンストロークを詰めるファーストフィル圧供給手段を含む構成とされる。

【0057】次に、第23の目的を達成するため、前記制御装置は、モータ走行領域とエンジン走行領域との間にクラッチスタンバイ領域を設定された構成とされる。

【0058】次に、第24の目的を達成するため、前記始動制御手段は、エンジン回転が所定回転になったとき、燃料を供給し点火させる構成とされる。

【0059】次に、第25の目的を達成するため、前記始動制御手段は、エンジン回転とモータジェネレータ回転の同期後にクラッチを完全係合させる構成とされる。

【0060】次に、第26の目的を達成するため、前記制御装置は、エンジン始動後、モータジェネレータの出力トルクをスイープダウンさせ、エンジンのスロットル開度を開く、終了制御手段を有する構成とされる。

【0061】

【発明の作用及び効果】上記の構成を採る請求項1記載の車両用ハイブリッド駆動装置では、スタンバイ制御手段による制御下で、常にエンジンがクランキング開始位置まで回転させられた状態で、始動制御手段の制御によるエンジンのクランキングが開始されるので、不定位置からのクランキングと異なり、クランキングの制御が容易となり、実質上一定の短い時間内で安定してエンジンを始動させることができる。したがって、この構成によれば、モータジェネレータによる走行中に、エンジンをレスポンスよく再始動させることができ、結果的に、エンジン再始動の際の駆動トルクの大きな落ち込みを、簡単な始動制御で防ぐことができるようになる。

【0062】次に、請求項2記載の構成では、上記のスタンバイ制御を行なう際に、スタンバイ圧制御手段によるクラッチの係合圧の制御でトルク容量を制限することで、モータジェネレータのトルクを利用して、確実にエンジンをクランキング開始位置まで回転させることができる。

【0063】更に、請求項3記載の構成では、エンジンのクランキング時に、クランキング圧制御手段によるクラッチの係合圧の制御で、トルク伝達容量をモータジェネレータの出力トルク以下に制限することで、出力可能トルク内でエンジンをクランキングすることができる。

【0064】一方、請求項4記載の構成では、スタンバイ制御後に、始動制御手段によりクラッチの係合と同時にスタータモータが起動されるので、特にクランキング当初のエンジン回転の立ち上げ時の大きなトルクを必要とする時期に合わせて、スタータモータのトルクを有効に利用することができる。

【0065】次に、請求項5記載の構成では、上記クランキング特性を一定化するためのスタンバイ状態を得た上で、その後の始動をモータジェネレータの出力トルク以下で行うことができる。したがって、この構成によれば、エンジンのクランキングのためのスタンバイ状態と、その後のクランキングによる始動とを、格別の補助的駆動手段なしでモータジェネレータにより行うことができる。

【0066】また、請求項6に記載の構成では、上記クランキング特性を一定化するためのスタンバイ状態を得た上で、その後のクランキングの際の、特に大きなトルクを要するエンジン回転立ち上げ時に、エンジンに付設されたスタータモータを補助的に使用することで、モータジェネレータとスタータモータ両方の負荷を軽減しながらエンジンをクランキングすることができる。したがって、この構成によれば、クランキングのためにモータジェネレータの定格を大きくすることなく、しかもエンジンの再始動をレスポンスよく行うことができる。

【0067】更に、請求項7に記載の構成では、エンジンのクランキングのために、クラッチの係合圧を、エンジン回転の変化率が一定となるように制御しているので、簡単なクラッチ係合圧の制御でエンジンを再始動させることができる。

【0068】更に、請求項8に記載の構成では、エンジンのクランキングのために、クラッチの係合圧を、モータジェネレータの回転数の低下が所定の範囲内に抑えられるように制御しているので、本来検出精度の高いモータジェネレータ回転数を基とする体感上の減速感に沿った始動制御が可能となる。

【0069】更に、請求項9に記載の構成では、スタータモータをモータジェネレータによるクランキングトルクを補う軽負荷状態で駆動し、しかも駆動時間を極限して使用した始動制御が行われるので、クランキングの際のモータジェネレータとスタータモータの負荷を共に軽減しながら、スタータモータの耐久性を確保することができる。

【0070】次に、請求項10に記載の構成では、クランキング当初の回転立ち上げ時に、スタータモータを補助的に利用し、エンジン始動期間を通じてモータジェネレータのトルク出力の増大分を平均化することで、その

トルクを伝達するためのクラッチ係合圧の制御を単純化することができる。

【００７１】更に、請求項１１に記載の構成では、上記のように回転立ち上げ時に、スタータモータを補助的に利用し、エンジン始動期間を通じてモータジェネレータのトルク出力の増大分を軽減することで、エンジン始動のためのモータジェネレータのトルク負荷を軽減しながら出力トルク制御を単純化することができる。

【００７２】更に、請求項１２に記載の構成では、スタータモータを主体としながらモータジェネレータトルクを補助的に利用したエンジン始動が行われるので、モータジェネレータのクランキングのためのトルクを軽減して駆動トルクへの影響を最小限に抑える制御が可能となり、しかもスタータモータの耐久性を確保することができる。

【００７３】更に、請求項１３に記載の構成では、始動制御時のスタータモータの制御を単純化することができる。

【００７４】更に、請求項１４に記載の構成では、クランキング時にモータジェネレータの出力可能な最大のトルクでエンジンのクランキングが行われるので、減速ショックの発生を最小限に抑えながら、モータジェネレータのみでレスポンス良くエンジンを再始動させることができる。

【００７５】更に、請求項１５に記載の構成では、始動制御時にモータジェネレータに一定のトルクを出力させながら、エンジンを定加速でクランキングすることができるので、モータジェネレータの制御を単純化することができる。

【００７６】更に、請求項１６に記載の構成では、スタンバイ制御から始動制御への移行の際のクラッチの係合圧の制御を単純化することができる。

【００７７】更に、請求項１７に記載の構成では、モータジェネレータによる始動制御において、それに先行するスタンバイ制御のためのクラッチのピストンストロークを迅速に行わせることができるので、スタンバイ制御のレスポンスを向上させることができる。

【００７８】更に、請求項１８に記載の構成では、スタンバイ制御の開始時期を領域判断で簡単に行うことができるので、スタンバイ制御のロジックを単純化しながら、迅速にスタンバイ制御を実行することができる。

【００７９】更に、請求項１９に記載の構成では、エンジン回転が所定の回転数になったところで始動のためにエンジンに燃料を供給し、点火する制御が行われるので、的確なエンジン始動が可能となる。

【００８０】更に、請求項２０に記載の構成では、モータジェネレータによるエンジン始動制御を円滑に終了させることができる。

【００８１】更に、請求項２１に記載の構成では、エンジン始動後のモータ走行からエンジン走行への移行を円滑に行うことができる。

【００８２】更に、請求項２２に記載の構成では、スタータモータを用いる始動制御において、それに先行するスタンバイ制御のためのクラッチのピストンストロークを迅速に行わせることができるので、スタンバイ制御のレスポンスを向上させることができる。

【００８３】更に、請求項２３に記載の構成では、スタータモータを用いる再始動におけるスタンバイ制御の開始時期を領域判断で簡単に行うことができるので、スタンバイ制御のロジックを単純化しながら、迅速にスタンバイ制御を実行することができる。

【００８４】更に、請求項２４に記載の構成では、スタータモータを用いる再始動において、エンジン回転が所定の回転数になったところで始動のためにエンジンに燃料を供給し、点火する制御が行われるので、的確なエンジン始動が可能となる。

【００８５】更に、請求項２５に記載の構成では、モータジェネレータとスタータモータによるエンジン始動制御を円滑に終了させることができる。

【００８６】更に、請求項２６に記載の構成では、モータジェネレータとスタータモータによるエンジン始動後のモータ走行からエンジン走行への移行を円滑に行うことができる。

【００８７】

【発明の実施の形態】以下、図面に沿い、本発明の実施形態について説明する。図１は第１実施形態に係る車両用ハイブリッド駆動装置のシステム構成を示すもので、この装置は、エンジン（E／G）１と、モータジェネレータ（M／G）２と、エンジン１及びモータジェネレータ２相互間の動力伝達を制御可能なクラッチ３と、エンジン１とモータジェネレータ２の動力を車輪に伝達可能な伝動装置４と、エンジン１、モータジェネレータ２、スタータモータ（S／M）１１及びクラッチ３を制御する制御装置５（ECU）とを備えている。

【００８８】エンジン１は、本形態において、その補機として補機用１２Ｖ低電圧バッテリを電源として作動するスタータモータ１１を備えており、その起動により通常のスタータと同様に、回転する出力歯車１１ａがエンジン１のクランク軸に固定された大歯車１２に噛合し、停止により噛合から外れる構成とされている。

【００８９】モータジェネレータ２は、そのロータ２１がクラッチ（以下、実施形態の説明において、他のクラッチと区別する意味でＣｉクラッチという）３を介してエンジン１に連結され、更に、入力クラッチ（同じく、実施形態の説明においてＣ１クラッチという）４１を介して主たる伝動装置４を構成する自動変速機（T／M）４０に連結されている。

【００９０】伝動装置４を構成する自動変速機４０は、本形態において油圧コントロールユニット（V／B）６により制御される所定のギヤトレインを備えるものとさ

れ、その出力軸は、ディファレンシャル装置７を介して左右の駆動輪８に連結されている。この装置では、油圧コントロールユニット６は、Ｃｉクラッチ３の油圧サーボを制御するコントロールユニットを兼ねている。

【００９１】制御装置５は、モータジェネレータ２を図示しないインバータを介して、また、油圧コントロールユニット６を図示しないソレノイドを介して、更に、スタータモータ１１をリレー等を介して制御するマイクロコンピュータを主体とする電子制御装置を構成している。そして、制御装置５へは、車両の各部に通常配置される各図示しないセンサからのアクセル開度信号、車速信号、トランスミッション入力回転数信号及びエンジン回転数信号が取込み可能とされている。

【００９２】本発明に従い、制御装置５は、エンジン１を停止させ、Ｃｉクラッチ３を解放させてモータジェネレータ２の動力を車輪８へ伝達している車両走行時に、アクセル開度を検出して、エンジン１を始動させる制御装置内の処理プロセスとしての始動制御手段を有している。更に、制御装置５は、始動制御手段によるエンジン１の始動に先行させて、エンジン１をクランキング開始位置まで回転させる制御を行う同じく処理プロセスとしてのスタンバイ制御手段を有する。具体的には、本形態におけるスタンバイ制御手段は、Ｃｉクラッチ３の係合圧を制御して動力伝達を調整するスタンバイ圧制御手段を主な処理プロセスとして包含している。

【００９３】更に、制御装置５は、そのマイクロコンピュータのメモリ上に走行モードマップを備えている。図２はこのマップデータを図式化して示すもので、車速と、アクセル開度との関係から、アクセルオン時の負（後進）高車速側にエンジン走行領域、車速０を挟む正負（前進及び後進）両低車速側にエンジン及びモータ走行領域、低アクセル開度を除く正（前進）高車速側にエンジン走行領域、そして低アクセル開度側にモータ走行領域、更に、アクセルオフの正（ホイール駆動の前進）車速側に回生領域を設定されている。そして、本形態では、特に、エンジン走行領域に隣接するモータ走行領域に、後に詳記するＣｉクラッチスタンバイ制御領域が設定されている。

【００９４】次に、上記走行モードマップを参照して行われる本発明の主題に係る制御内容を具体的に説明する。まず、エンジン停止判断は、本発明の主題とは直接関係ないが、例えば、図２に示す走行モードマップに従い、アクセル開度が所定時間以上モータ走行領域にあるとき、制御装置５のエンジン停止可の判断により行われる。そしてこうしたエンジン停止下での走行状態において、上記エンジン停止判断と逆に、アクセル開度が所定時間以上エンジン走行領域にあるとき、制御装置５によりエンジン始動必要と判断することで、エンジン再始動判断がなされる。そして、このエンジン再始動判断により、Ｃｉクラッチ３のスタンバイ制御と、エンジン始動制御と、完爆判断と、終了制御が実行される。更に、エンジン始動制御は、クランキングの前半部分のエンジン回転の立ち上げ制御と、後半部分の加速制御と、燃料供給及び点火で構成されている。

【００９５】まず、Ｃｉクラッチのスタンバイ制御は、次の三つのタイミングで実行可能である。第１は、上記再始動判断が成立したときであり、第２は、アクセル開度が図２に示す走行モードマップのＣｉクラッチスタンバイ制御領域に入ったときであり、第３は、エンジン停止制御が終了した後の所定時間の間である。これらのうち、第２の判断方法が最も効果的である。なお、本形態では、これらを併用している。

【００９６】以下、図３に示すタイムチャートに基づき、図１を併せて参照しながら、順次制御内容を説明する。当初、エンジン回転数（Ｎｅ）は停止状態の０、モータ回転数（Nm）は車速の増加に連れて漸増、エンジントルク（Ｔｅ）は停止状態の０、モータトルク（Ｔm）は、アクセル開度に応じてあらかじめ設定された出力制御マップに基づき出力されるトルクで加速状態の漸増、Ｃｉクラッチ圧（Ｐｃｉ）は解放状態の０、出力軸トルク（Ｔｏｕｔ）はモータトルク駆動力に見合ったトルク漸増状態となっている。

【００９７】ここで、モータ走行領域から、アクセル開度がＣｉクラッチスタンバイ制御領域に入ると、制御装置５から油圧コントロールユニット６へのソレノイド信号出力（図１に破線で示す）で、Ｃｉクラッチ圧（Ｐｃｉ）をファーストフィル圧（Ｐｆ）としてファーストフィル時間（ｔｆ）だけＣｉクラッチ３の油圧サーボへ供給する（図１に一点鎖線で示す）制御が行われる。このファーストフィル圧（Ｐｆ）とファーストフィル時間（ｔｆ）は、素早くクラッチピストンをストロークさせ、Ｃｉクラッチ油圧サーボのシリンダ内がオイルで充満できる程度の値に設定される。

【００９８】次に、同様の手順で、スタンバイ圧（Ｐｓｔｂｙ）の供給がスタンバイ時間（ｔｓｔｂｙ）だけ行われる。スタンバイ圧（Ｐｓｔｂｙ）は、Ｃｉクラッチ３が少しトルクを伝え、エンジン１のクランクシャフトが少し回転し、圧縮トルクを必要とする直前の角度位置で停止する程度の圧力（例えば１００～２００ｋＰａ程度）とする。スタンバイ時間（ｔｓｔｂｙ）は、第１又は第３の判断方法によるときは、例えば数１００ｍｓｅｃ程度必要であり、第１の判断方法の場合は、その後直ちにスイープアップ制御に移り、第３の判断方法の場合は、その後Ｃｉクラッチオフでモータ走行に移る。また、第２の判断方法の場合は、スタンバイ時間（ｔｓｔｂｙ）は、Ｃｉクラッチ圧の次の制御（スイープアップ制御）が始まるまで続けられる。

【００９９】このように、Ｃｉクラッチスタンバイ制御を実行することで、Ｃｉクラッチ３を介してモータジェネレータ２のトルクがエンジン１に伝達され、エンジン

１は回転するが、最初のシリンダの圧縮行程に入るところで、所要トルクが大きくなることでＣｉクラッチ３はスリップし、エンジン１はそのクランク角位置で停止してクランキング前のスタンバイ状態となる。この回転角は、６気筒エンジンで最大でも１００°程度である。この間、モータトルク（Tm）の一部はエンジン１のクランキング開始位置までの回転のために使われるが、回転抵抗が小さいため、出力軸トルク（Ｔｏｕｔ）への影響はごく僅かである。かくして、クランク角位置を常にクランキングのピークトルクが発生する手前に置くことで、制御開始時のクランキングトルクの立ち上がり特性を同じにすることができる。その結果、エンジン始動制御時のＣｉクラッチ圧のスイープアップレスポンスを高めることができる。

【０１００】このようにしてスタンバイ状態が達成されるスタンバイ時間（ｔｓｔｂｙ）が経過すると、今度は、始動制御手段によるエンジン始動が行われる。この場合、モータトルク（Tm）の増大と、Ｃｉクラッチ圧（Ｐｃｉ）の上昇と、スタータモータ１１の始動が同時に行われる。これにより、モータトルク（Tm）は、車両の駆動に必要なアクセル開度に応じたそれまでのトルク（Ｔａｃｃ）にトルク増大分（Ｔｃｒｕｎｋ）とスタータトルクを加えたトルクが付加され、Ｃｉクラッチ圧（Ｐｃｉ）の上昇によりトルク伝達容量を増したクラッチを介するトルク伝達でエンジンのクランキングが行われる。これにより、エンジンはその回転の立ち上がり時のイナーシャトルクによるピークトルクを乗り越えて回転を始める。回転の立ち上がりの判断は、エンジン回転数（Ｎｅ）の検出により行うこともできないではないが、こうした低回転数の高精度の検出は困難なので、本形態では、スタータモータのオフ時間（ｔｏｆｆ）の経過でなされ、その時間経過でスタータはオフ（ＯＦＦ）とされる。その後もモータトルクの増大状態は継続され、この場合は、エンジン回転が所定回転数になることで点火タイミングが図られる。そして点火と同時にモータトルク（Tm）は、車両走行駆動に必要なトルクに戻される。

【０１０１】エンジンの始動（エンジンが自力で回転を持続できる状態）を確認する完爆判断は、下記の方法により行うことができる。その第１は、通常の空燃比制御に使用するエグゾースト側に設けたO_2（酸素）センサの出力を用いる方法である。この方法では、シリンダ内での燃焼が全シリンダで連続して生じるようになると、排ガス中の酸素濃度が極めて少なくなるので、エンジン完爆判定が可能となる。また、第２は、排ガス温度又は排ガス処理用触媒コンバータの温度をみる方法である。そして、第３は、シリンダ内の燃焼圧力をみる方法である。上記方法のうち、第１の方法が最も効果的であり、特に排ガス温度が低い状態のときでもセンサ性能（感度）が安定するようにしたヒータ付O_2センサを用いると更に有効である。これに対して、第３の方法は、リーンバーンエンジンでしか使用しないセンサを用いることになるため、通常のエンジンに適用した場合、センサは完爆判定以外には使用しないものとなってしまう点でコスト上は不利となる。

【０１０２】こうしてエンジン完爆を判断した時点で、エンジン１の電磁制御スロットルバルブを、その時々のアクセル開度に応じた開度に開き、同じくアクセル開度に応じた出力トルクによりモータ駆動されているトランスミッションの入力回転数にエンジン１の回転数を近付けていく。そして、Ｃｉクラッチ３が係合完了（エンジン回転数とトランスミッション入力回転数すなわちモータ回転数が等しくなったとき）すると、モータ出力トルク（Tm）をアクセル開度に応じた所定勾配でスイープダウンさせる。

【０１０３】次に、上記制御を実行する具体的な手順をフローで説明する。図４は、走行中エンジン始動制御メインフローを示す。まず、ステップＳ１のアクセル開度読み込みと、ステップＳ２の車速読み込みにより、ステップＳ３で、走行マップ（図２参照）から現在の走行状態がエンジン走行領域にあるか否かを判断する。また、ステップＳ４では、同じく走行マップからＣｉクラッチスタンバイ領域にあるか否かを判断する。これらステップＳ３とステップＳ４の何れかの判断が成立（Ｙｅｓ）する場合に、ステップＳ５で、Ｃｉクラッチスタンバイ制御を実行し、次いで、ステップＳ６によるエンジン始動制御を実行することになる。

【０１０４】図５は、図４に示すステップＳ５のＣｉクラッチスタンバイ制御のサブルーチンを示す。このルーチンでは、当初のステップＳ２１で、Ｃｉクラッチ圧（Ｐｃｉ）を初期値（Ｐｆ）にして出力し、クラッチのピストンストロークを詰める処理を行う。この処理によるＣｉクラッチの作動は、ステップＳ２２によるタイマ判断で、油圧出力から時間（ｔｆ）が経過したことにより確認される。

【０１０５】この時間経過を待って、ステップＳ２３で、Ｃｉクラッチ圧（Ｐｃｉ）をエンジンのクランキング開始位置になるように、所定のスタンバイ圧（Ｐｓｔｂｙ）に設定し、出力する。これにより、エンジンのクランク軸が微小回転し、クランキング開始位置（圧縮行程手前）になる。このクランキング開始位置の確認は、ステップＳ２４で、スタンバイ圧（Ｐｓｔｂｙ）を出力してからの時間が所定のスタンバイ時間（ｔｓｔｂｙ）経過したかの判断で行われる。次に、ステップＳ２５で、エンジン走行領域になったかを判断する。そして、この判断が成立（Ｙｅｓ）の場合には、エンジン始動制御サブルーチンに入る。一方、ステップＳ２５で、エンジン走行領域判断が不成立（Ｎｏ）の場合には、更に、ステップＳ２６で、Ｃｉクラッチスタンバイ領域にあるかを判断し、これが成立（Ｙｅｓ）の場合は、ステップ

Ｓ２３に戻って、Ｃｉクラッチ圧（Ｐｃｉ）をスタンバイ圧（Ｐｓｔｂｙ）状態に保持する。また、ステップＳ２６のＣｉクラッチスタンバイ領域判断が不成立（Ｎｏ）の場合は、モータ走行領域に戻ったとして本制御を中止すべく、ステップＳ２７で、Ｃｉクラッチ圧（Ｐｃｉ）を０にする処理を行う。

【０１０６】このようにしてスタンバイ状態になった後のエンジン始動制御は、大別して２つの形態を採ることができる。まず第１実施形態として、スタータモータを用いる制御について説明する。

【０１０７】この場合、図６に示すエンジン始動制御サブルーチンに入ると、ステップＳ３１からステップ３３を同時に実行することになるが、チャート表現の便宜上、順次並べて表記されている。ステップＳ３１では、スタータモータを始動する。ステップＳ３２では、Ｃｉクラッチ圧（Ｐｃｉ）をＰｃｉ＝（Ｔｃｒｕｎｋ／μ－ｃ）／ａのように設定する。ここに、Ｔｃｒｕｎｋは、エンジンのクランキングトルクの平均値で、エンジンによって予め決まった値である。μは、クラッチの摩擦材の摩擦係数である。ａとｃはクラッチによって決まる定数である。また、ステップＳ３３では、モータトルク（Tm）を出力する。このモータトルクは、Tm＝Ｔｃｒｕｎｋ＋Ｔａｃｃとする。ここに、Ｔｃｒｕｎｋは、エンジン始動に必要なトルクであり、Ｔａｃｃは、アクセル開度に応じたトルクで、車両の駆動に必要となるトルクである。このように、各ステップを同時に実行したのち、ステップＳ３４で、制御開始からの時間がオフ時間（ｔｏｆｆ）を過ぎたかをみる。この時間は、エンジンが微小回転（１回転）すればよい時間なので、非常に微小な時間である。そして、オフ時間（ｔｏｆｆ）経過が確認されたら、ステップＳ３５で、スタータモータをオフ（ＯＦＦ）する。この場合、非常に微小なオフ時間（ｔｏｆｆ）のみスタータを作動させるので、スタータの耐久性、スタータ始動による異音などは問題ない。以上のステップＳ３１～ステップＳ３５は、エンジン回転の立ち上げ制御を構成する。

【０１０８】更に、ステップＳ３６で、エンジン回転が所定回転数（例えば、５００ｒｐｍ、すなわち燃料供給と点火によりエンジンが自力回転可能な完爆状態となる回転数）になったかを判断する。そして、ステップＳ３６の判断が成立（Ｙｅｓ）の場合は、ステップＳ３７で、実際にエンジンに燃料を噴射し、点火させ、エンジンを始動させる。上記ステップＳ３２～ステップＳ３６は、エンジン回転の加速制御を構成する。

【０１０９】かくして、エンジンが始動したら、ステップＳ３８で、モータのトルク（Tm）をアクセル開度に応じたトルク（Ｔａｃｃ）に戻す。この処理は、エンジンの始動によりクランキングトルク（Ｔｃｒｕｎｋ）は不要となったためである。そして、次に、ステップＳ３９で、エンジン回転数（Ｎｅ）が変速機の入力回転数（Ｎｉｎ）と同期したかを、±Ｎａの幅の範囲で判断する。これによる同期の判断が成立（Ｙｅｓ）したところで、ステップＳ４０により、Ｃｉクラッチ圧（Ｐｃｉ）を１００％の圧、すなわちＰ１００にする。かくして、Ｃｉクラッチの完全係合により、エンジンのトルクが車輪に伝達可能となるので、ステップＳ４１で、モータトルク（Tm）を減少させていく処理を行う。併せて、ステップＳ４２で、モータトルク（Tm）のスイープダウンにより減少した分をエンジンに出力させる（Ｔｅ＝Ｔａｃｃ－Tm）処理を行う。具体的には、電子スロットルへの信号出力でスロットルを開いて行く。最後に、ステップＳ４３でモータトルク（Tm）が０になったかを判断する。この判断が成立（Ｙｅｓ）することで、モータ走行からエンジン走行の切換えが終了する。以上のステップＳ３８～ステップＳ４３は、終了制御を構成する。

【０１１０】上記実施形態によれば、モータジェネレータが車両駆動性能に加えてクランキングトルク分を出力できるように性能を見積もる必要がないので、モータジェネレータの大型化が防げる。また、スタータモータの方は、通常エンジン駆動車用の量産品と共用できるので、コストアップが最小限に抑えられる。更に、付随的な利点として、高圧系（モータジェネレータ駆動用電源）ＳＯＣが長期不使用による自己放電等で０％になっても、通常のエンジン駆動車のように１２Ｖ補機バッテリでエンジン始動が可能な利点が得られる。また、ブースタケーブルによるジャンピングスタートも可能である。また、極低温（－３０～－４０°Ｃ）のエンジン始動も、電動オイルポンプの低温時性能によらず、現行車両と同様のレスポンスで可能である。

【０１１１】ところで、上記第１実施形態ではモータジェネレータ２を主とし、スタータモータ１１を補助として使用する形態を採ったが、逆にスタータモータ１１を主としてモータジェネレータ２を補助的に使用する形態を採ることもできる。この場合、スタータモータ駆動回路にスタータモータに突入する電流値を計測する電流センサを設け、この出力値を始動制御時のモータジェネレータ出力トルク制御のフィードバック制御に用いる。図７はこうした制御形態を採る場合のタイムチャートを示す。この制御では、スタータモータ駆動電流（Ｉｓｔ）が所定値を超えないようにモータジェネレータ出力トルクを調整する。この場合のクラッチ係合圧（Ｐｃｉ）は、スタータモータの起動と同時にライン圧（P_L）までスイープアップし、以後一定に保つ制御で足りる。そして、スタータモータの停止は、エンジン回転が所定の回転数になったときとする。

【０１１２】こうした制御を行った場合、スタータモータ１１の駆動負荷を図に実線で示すように所定のしきい値以下に抑えることができる。そして、図に点線で示すピーク分のクランキング負荷をモータジェネレータ２が

負担することになる。

【０１１３】次に、前記第１実施形態では、エンジン１のクランキングを主としてモータジェネレータ２で行い、エンジン回転の立ち上げにスタータモータ１１を補助的に使用する構成を採っているが、エンジン１のクランキングは、立ち上げ時も含めて、スタータモータ１１を用いずにモータジェネレータ２のみで行うこともできる。次に、こうした形態を採る第２実施形態について図８に示すタイムチャートを参照しながら説明する。

【０１１４】この形態でも、当初の状態からスタンバイ制御までの期間は、前記第１実施形態と同様であるので、その参照をもって説明に代える。そして、同様にしてスタンバイ状態が達成されるスタンバイ時間（ｔｓｔｂｙ）が経過すると、始動制御手段によるエンジン始動が行われる。この場合、前形態と異なり、モータトルク（Tm）の最大値（Tmmａｘ）までの増大と、Ｃｉクラッチ圧（Ｐｃｉ）の上昇とが同時に行われる。これにより、モータトルク（Tm）は、車両の駆動に必要なアクセル開度に応じたそれまでのトルク（Ｔａｃｃ）にトルク増大分を加えたトルクが付加され、Ｃｉクラッチ圧（Ｐｃｉ）の上昇によりトルク伝達容量を増したＣｉクラッチ３を介するトルク伝達でエンジン１のクランキングが行われる。これにより、エンジン１はその回転の立ち上がり時のイナーシャトルクによるピークトルクを乗り越えて回転を始める。回転の立ち上がり（微小回転）の判断はタイマ又はエンジン回転数（Ｎｅ）でなされる。その後モータトルク（Tm）はエンジン回転数を所定変化率で上昇できるトルク（Ｔｍｔ）まで下げられて増大状態は継続され、この場合も、エンジン回転が所定回転数になることで点火タイミングが図られる。点火と同時にモータトルク（Tm）は駆動に必要なトルク（Ｔａｃｃ）に戻される。これ以後の制御は、前記第１実施形態の場合と同様である。

【０１１５】このようにモータジェネレータ２のみでエンジン始動を行う場合、エンジン始動に伴う車両駆動トルク（Ｔｏｕｔ）の変化（落ち込み）は、Ｃｉクラッチ３の伝達トルク容量の大きさそのものとなる。したがって、Ｃｉクラッチ３の伝達トルク容量を係合圧力で制御し、駆動トルクの落ち込みとその継続時間との兼ね合いから、モータジェネレータ２のトルク出力能力の範囲内で、ショックを体感上許容できるレベル以下に抑えることで、不快な減速感が生じるのを防ぐことになる。

【０１１６】この場合、最も大きな始動トルクを必要とする領域は、エンジン始動初期制御（立ち上げ制御）領域（Ｎｅ＝０～Ｎｅ１）となるので、この期間モータ出力トルクを出力可能な最大値（Tmmａｘ）とする。この値は、車速、バッテリ温度、ＳＯＣなどの諸条件によって異なる。そして、このトルク制御と同時に、Ｃｉクラッチ圧（Ｐｃｉ）を下記要領で出力させる。すなわち、エンジン始動（最初に回転させるため）に使われるトルクをＴｍｅｓとして、

Ｔｍｅｓ＝Ｔｃｉ（Ｃｉクラッチ伝達トルク容量）＝（ａＰｃｉ＋ｃ）μ

ここに、ａ，ｃはクラッチ諸元により決まる定数、μはクラッチ摩擦材の摩擦係数、ＰｃｉはＣｉクラッチ係合圧を表す。なお、μは摩擦材のスリップ速度、押し付け面圧、オイル温度により、マップからの読み取りで決定される。

【０１１７】なお、エンジン始動に使われるトルク（Ｔｍｅｓ）と車両駆動に使われるトルク（Tmk）の割合は、実車による感応評価で決定する。この場合、限られた出力可能なトルク最大値（Tmmａｘ）の範囲内でエンジン始動に使われるトルク（Ｔｍｅｓ）を小さく設定すると、エンジン始動初期制御（立ち上げ制御）領域（Ｎｅ＝０～Ｎｅ１）の時間が長くなり、エンジン始動レスポンスが悪くなる。逆に、トルク（Ｔｍｅｓ）を大きく設定すると、駆動トルクの不足で始動ショックが大きくなる。上記制御をエンジン回転数が所定の微小回転数（Ｎｅ１）に達するまで継続する。

【０１１８】このエンジン回転数が微小回転数（Ｎｅ１）に達するまでのように、回転数が低い領域では、電磁ピックアップセンサのような安価なセンサでは、正確にエンジン回転数（Ｎｅ）を検知できない場合があるので、前述の制御をエンジン回転数（Ｎｅ）ではなく、エンジンの吸入空気量センサの出力により行うようにしてもよい。

【０１１９】上記の制御の後に定加速制御を行う。この制御では、あらかじめ設定された加速度でエンジン回転数が上昇するようＣｉクラッチ係合圧をフィードバック制御する。この場合、エンジン回転数（Ｎｅ）が微小回転数（Ｎｅ１）に達したら、モータ出力をエンジンを定常的に加速するトルク（Ｔｍｔ）まで下げる。このトルクは、エンジン油温（Ｔｅｏｉｌ）とエンジン回転数（Ｎｅ）で決定できる。この関係は、実験値として入手できる。そして、上記モータ出力の条件で、エンジン回転数（Ｎｅ）の上昇率（ｄＮｅ／ｄｔ）が所定値となるように、Ｃｉクラッチ係合圧（Ｐｉｃ）出力をフィードバック制御する。

【０１２０】こうしてエンジン回転数（Ｎｅ）が同期回転数（Ｎｉｎ、約５００～７００ｒpm程度が適当）に達したら、前形態と同様の方法で燃料噴射と点火のためのエンジン制御を開始する。そして、最後に終了制御に入る。この制御では、モータ走行からエンジン走行へ駆動源を切り換える。その際、同期確認後適当なタイマを設定し、同期を確実にするため、連続同期状態を保持した後、Ｃｉクラッチ係合圧をデューティ比１００％に対応する圧力まで上げる。

【０１２１】この第２実施形態のエンジン始動制御サブルーチンは、図９及び図１０に示すフローとなる。この場合、ステップＳ５１で、モータトルク（Tm）をモー

タジェネレータがそのときの条件下で出力可能な最大トルク（Ｔｍｍａｘ）にする。ここに、最大トルク（Ｔｍａｘ）は、エンジンの始動トルク（Ｔｍｅｓ）と車両駆動トルク（Ｔｍｋ）の両方を出力できる値である。これは、車速、バッテリ容量ＳＯＣ、バッテリ温度に応じて変更してもよい。同時に、ステップＳ５２で、Ｃｉクラッチ圧（Ｐｃｉ）をＰｃｉ＝（Ｔｍｅｓ／μ－ｃ）／ａのように設定する。すなわち、Ｃｉクラッチ圧（Ｐｃｉ）を始動トルク（Ｔｍｅｓ）だけ伝達可能な値に設定する。

【０１２２】ステップＳ５３で、エンジン回転数（Ｎｅ）が所定微小回転数（Ｎｅ１）を上回ったかを判断する。この判定は回転数でなく、タイマで設定してもよい。そして、ステップＳ５４で、モータトルク（Ｔｍ）をエンジン回転数を所定変化率で上昇できるトルク（Ｔｍｔ）に減少させる。次に、ステップＳ５５で、Ｃｉクラッチ圧（Ｐｃｉ）をフィードバック初期値（Ｐａ）にする。そして、ステップＳ５６で、エンジン回転数の現在の変化率（ｄＸ２）を求める。更に、ステップＳ５７で、目標変化率（ｄＸ１）との偏差（ｄＸ）を求める。ステップＳ５８では、求めた偏差（ｄＸ）からＣｉクラッチ圧（Ｐｃｉ）の変更圧（ｄＰｃｉ）を求める。この値は、偏差（ｄＸ）が正側に大きいときにはＣｉクラッチ圧（Ｐｃｉ）を減少させ、偏差（ｄＸ）が負側に大きいときにはＣｉクラッチ圧（Ｐｃｉ）を増大させるように設定される。かくしてステップＳ５９で、フィードバック制御を実行する。

【０１２３】次に、ステップＳ６０で、エンジン回転数（Ｎｅ）が所定回転数（例えば、５００ｒｐｍ）を上回ったかをみる。この判断が成立するまで、ステップＳ５６に戻って、フィードバック制御を実行する。やがてステップＳ６０のエンジン回転数判断が成立すると、ステップＳ６１で、エンジンがすでに点火されている完爆状態か否かを判断する。この判断は、前記のように空燃比制御のためにエンジンのエグゾースト側に設けたO_2（酸素）センサの出力に基づいて、シリンダ内での燃焼が全シリンダで連続して生じることで、排ガス中の酸素濃度が極めて少なくなることで判定が可能となる。初回のループではこの判断は不成立（Ｎｏ）となるので、ステップＳ６２で、エンジンへの燃料の噴射を行い、点火する。

【０１２４】以後のステップＳ６３～ステップＳ６７のプロセスは、前記第１実施形態のステップＳ３９～ステップＳ４３のものと実質上同様であるので、説明を省略する。

【０１２５】上記第２実施形態によれば、スタータモータ１１を使用せずに、簡単な制御でレスポンスよくエンジン再始動を実現できる。従って、この制御は、スタータモータ１１を備えないハイブリッド駆動装置にも適用可能な利点を有する。

【０１２６】ところで、上記第２実施形態の始動制御は、モータ回転数が推定値をトレースするように制御する変形形態を採ることもできる。この場合、始動制御でのモータ出力トルクの制御は、第２実施形態と同様とする。そして、Ｃｉクラッチ圧（Ｐｉｃ）の制御を図１１のタイムチャートに示すように行う。すなわち、クランキング開始の所定時間前におけるモータ回転数（Ｎｍ）の変化率からクランキング以降のモータ回転数（Ｎｍ）の経過を推定する。この推定値による目標値と実際のモータ回転数（Ｎｍ）の値との偏差（ｅ）を取り、モータ回転数（Ｎｍ）が目標値をトレースするよう、Ｃｉクラッチ圧（Ｐｃｉ）の出力をフィードバック制御する。なお、この制御では、モータ磁極位置センサ（レゾルバ）の出力（速度検出値）をベースに制御を行うのが好適である。その後の制御は、第２実施形態と同様である。

【０１２７】なお、この形態において、モータ回転数（Ｎｍ）の目標値を車速から演算する方法も考えられるが、当制御での偏差量ｅは、極小値であるので、十分な精度が得られない。これに対してモータジェネレータの磁極センサの場合、精度は極めて高く（角度にして数十秒～数分程度）、駆動系の捩じれ量を検出するにも十分な精度である。

【０１２８】以上、本発明を、その制御形態を中心として、図１に示す特定のシステム構成の駆動装置に適用して例示したが、次に、伝動装置４のシステム構成の変形形態について説明する。図１５に示す第３実施形態は、伝動装置４中の自動変速機４０とＣ１クラッチ４１との間に、第２のモータジェネレータ（Ｍ／Ｇ）２Ａを付設したものである。また、この形態では、走行時エンジン停止中も補機９を稼働すべく、モータジェネレータ２Ａに補機９をＶベルト掛け等で駆動連結する構成を採っている。こうした形態の駆動装置においても、前記のスタンバイ制御と始動制御は、同様の手法で行なうことができる。なお、この形態の場合、エンジンの始動制御時に、第２のモータジェネレータ２Ａでトルクの落ち込み分を補う制御を行なうことで、エンジン始動時のショックを一層小さくすることも可能となる。その余の構成については、前記第１実施形態のものと同様であるので、相当する要素に同じ参照符号を付して説明に代える。

【０１２９】次に、図１６に示す第４実施形態は、伝動装置４内に、モータジェネレータ２をエンジン（Ｅ／Ｇ）１と自動変速機（Ｔ／Ｍ）４０とに連結する直結クラッチ４２付きプラネタリギヤ４０Ａを配置して、エンジン１とモータジェネレータ２とによるパラレル駆動とスプリット駆動とを可能としたものである。そして、プラネタリギヤ４０Ａのサンギヤ４３がモータジェネレータ２に連結され、リングギヤ４５がエンジン１に連結され、キャリア４４が出力要素として自動変速機４０に連結されている。その余の構成については、前記第１実施形態のものと同様であるので、この場合も相当する要素

に同じ参照符号を付して説明に代える。この形態では、モータ走行によるエンジン始動時は、直結クラッチ４２を係合状態として、先に述べたスタンバイ制御と始動制御に従って、Ｃｉクラッチ３の制御とモータジェネレータ２の制御を行なうことになる。

【０１３０】最後に、図１７に示す第５実施形態は、伝動装置４内に、モータジェネレータ２をエンジン（Ｅ／Ｇ）１と自動変速機に置き代わる第２のモータジェネレータ（Ｍ／Ｇ）２Ｂに連結するプラネタリギヤ４０Ｂを配置したものである。そして、上記第４実施形態とは逆に、プラネタリギヤ４０Ｂのサンギヤ４３をモータジェネレータ２に、キャリア４４をエンジン１に連結し、リングギヤ４５を出力要素として第２のモータジェネレータ（Ｍ／Ｇ）２Ｂに連結に連結している。この形態の場合、前記各形態において必ず設けられているＣｉクラッチ３を廃止した構成が採られている。この伝動装置の構成では、モータ走行時は、第２のモータジェネレータ２Ｂの正転で車両を駆動させ、エンジン１の停止のために、第１のモータジェネレータ２による反力支持を逃がすべく、モータジェネレータ２を空転状態とすることになる。そしてエンジン始動時のスタンバイ制御では、第１のモータジェネレータ２を小さなトルク出力で正転方向へ微小回転させることでスタンバイ状態とし、その後、始動制御では、第１のモータジェネレータ２と第２のモータジェネレータ２Ｂを同時にトルク増大制御することになる。この形態においても前記第３実施形態のものと同様に、エンジン始動時のショックを一層小さくすることができる。

【０１３１】以上、本発明を５つの実施形態に基づき変形形態をも含めて詳説したが、本発明は上記実施形態の開示内容のみに限定されることなく、特許請求の範囲に記載の事項の範囲内で種々に細部の具体的構成を変更して実施可能なものであることはいうまでもない。

【図面の簡単な説明】

【図１】本発明の第１実施形態に係る車両用ハイブリッド駆動装置のシステム構成図である。

【図２】上記駆動装置における制御装置内の走行モードマップである。

【図３】上記制御装置による走行中エンジン始動のタイムチャートである。

【図４】上記エンジン始動のメインフローチャートである。

【図５】上記メインフロー中のスタンバイ制御サブルーチンのフローチャートである。

【図６】上記メインフロー中のエンジン始動制御サブルーチンのフローチャートである。

【図７】上記第１実施形態の始動制御の変形形態を示すタイムチャートである。

【図８】第２実施形態の制御装置によるエンジン始動のタイムチャートである。

【図９】上記エンジン始動におけるエンジン始動制御サブルーチンの一部を示すフローチャートである。

【図１０】上記エンジン始動制御サブルーチンの他部を示すフローチャートである。

【図１１】上記第２実施形態の始動制御の変形形態を示すタイムチャートである。

【図１２】一般的な６気筒エンジンのクランク回転に対するトルク変動を示す特性図である。

【図１３】一般的なエンジンのクランキングトルク特性を示す模式図である。

【図１４】上記クランキングトルクの立ち上がり特性を示す模式図である。

【図１５】本発明の第３実施形態に係る車両用ハイブリッド駆動装置のシステム構成図である。

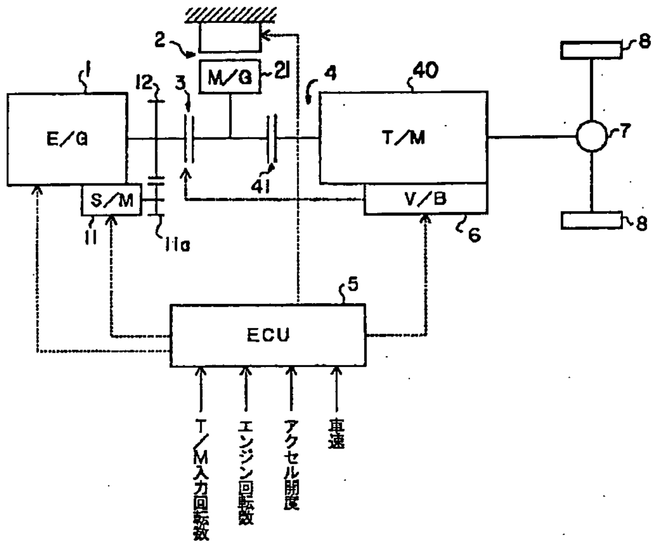
【図１６】本発明の第４実施形態に係る車両用ハイブリッド駆動装置のシステム構成図である。

【図１７】本発明の第５実施形態に係る車両用ハイブリッド駆動装置のシステム構成図である。

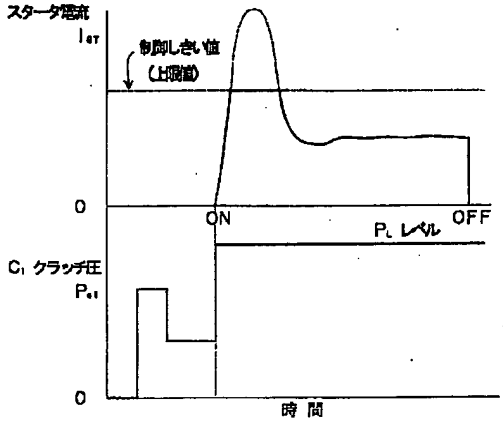
【符号の説明】

１	エンジン
２	モータジェネレータ
３	Ｃｉクラッチ（クラッチ）
４	伝動装置
５	制御装置
１１	スタータモータ
Ｓ５	スタンバイ制御手段
Ｓ６	始動制御手段
Ｓ２１	ファーストフィル圧供給手段
Ｓ２３	スタンバイ圧制御手段
Ｓ３１，Ｓ３４	立ち上げ制御手段
Ｓ３２	クランキング圧設定手段
Ｓ３３	トルク制御手段
Ｓ４１，Ｓ４２	終了制御手段
Ｓ５１	トルク制御手段
Ｓ５２	クランキング圧制御手段，増圧手段
Ｓ５８	定加速制御手段

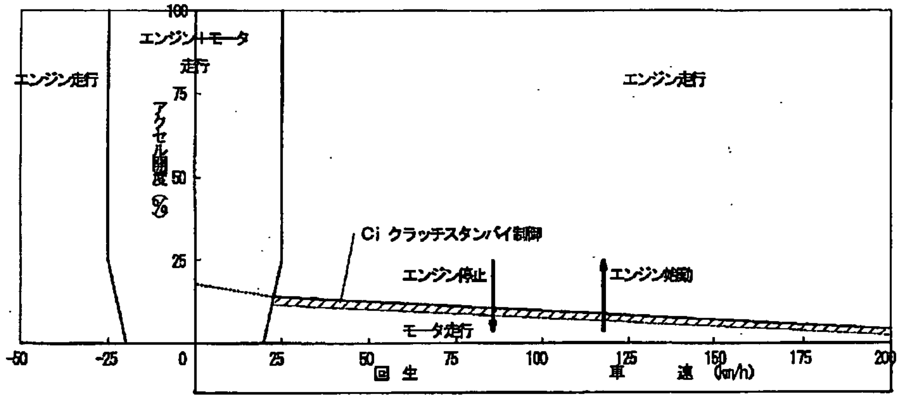
【図１】



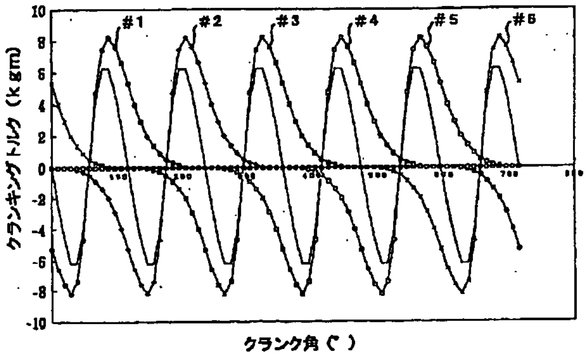
【図７】



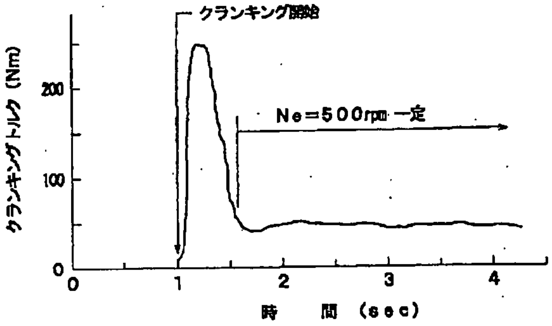
【図２】



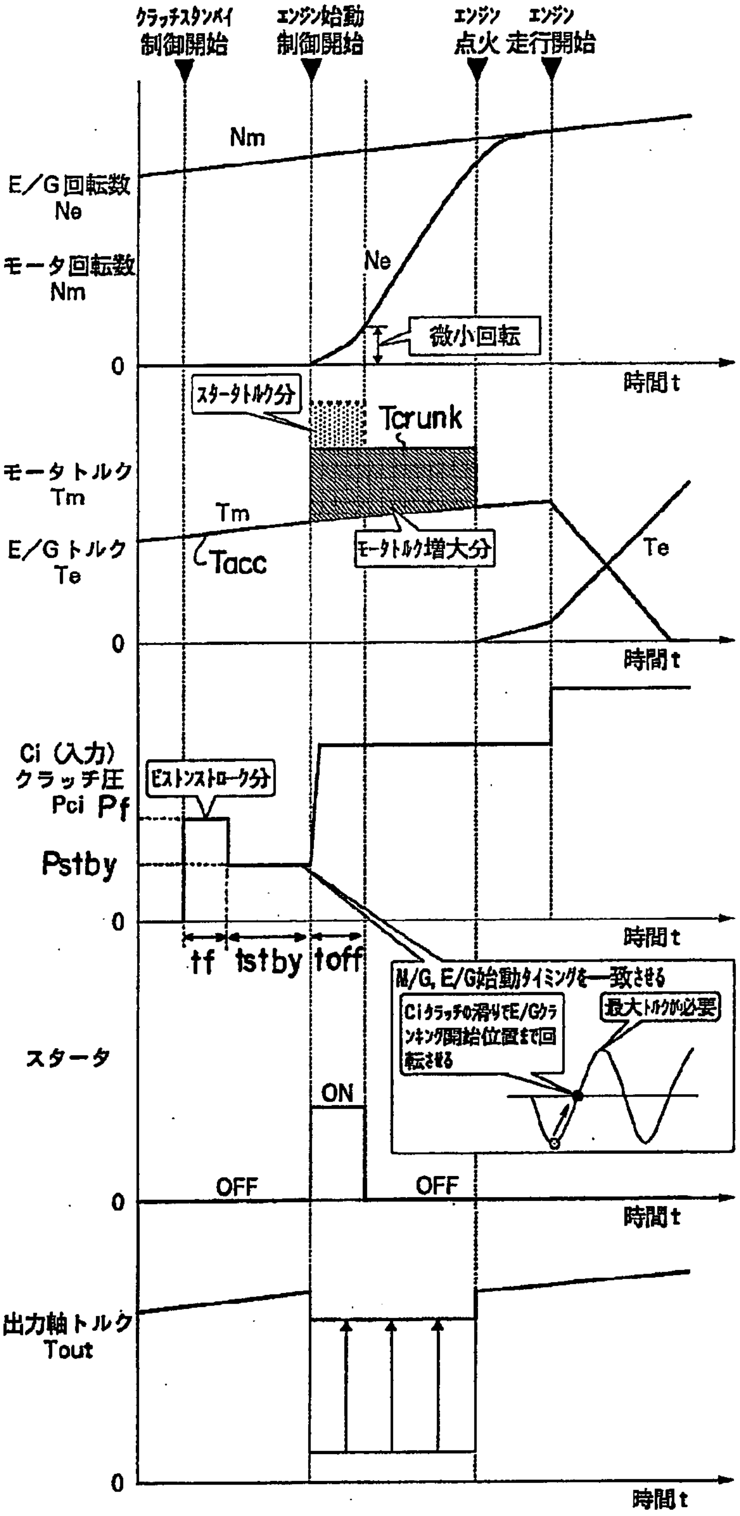
【図１２】



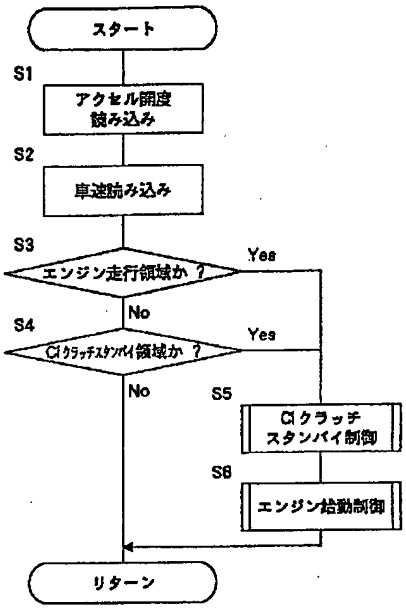
【図１３】



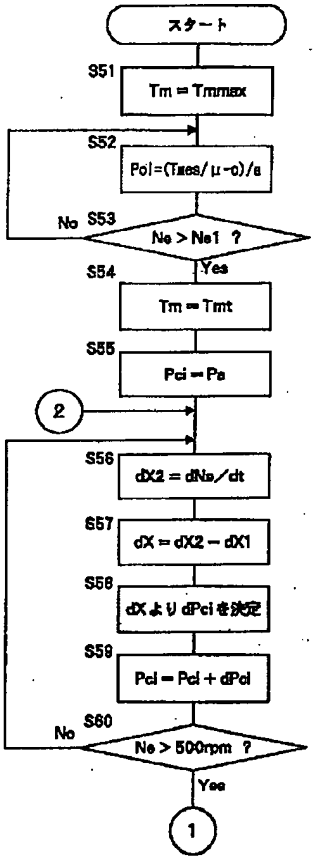
【図３】


クラッチスタンバイ
制御開始
エンジン始動
制御開始
エンジン
点火
エンジン
走行開始
Nm
E／G回転数
Ne
モータ回転数
Nm
Ne
微小回転
0
時間t
スタータトルク分
Tcrunk
モータトルク
Tm
Tm
E／G トルク
Te
Tacc
モータトルク増大分
Te
0
時間t
Ci (入力)
クラッチ圧
Pci
Pf
ピストンストローク分
Pstby
0
時間t
tf
tstby
toff
M/G, E/G始動タイミングを一致させる
Ciクラッチの滑りでE/Gクランキング開始位置まで回転させる
最大トルクが必要
スタータ
ON
OFF
OFF
0
時間t
出力軸トルク
Tout
0
時間t

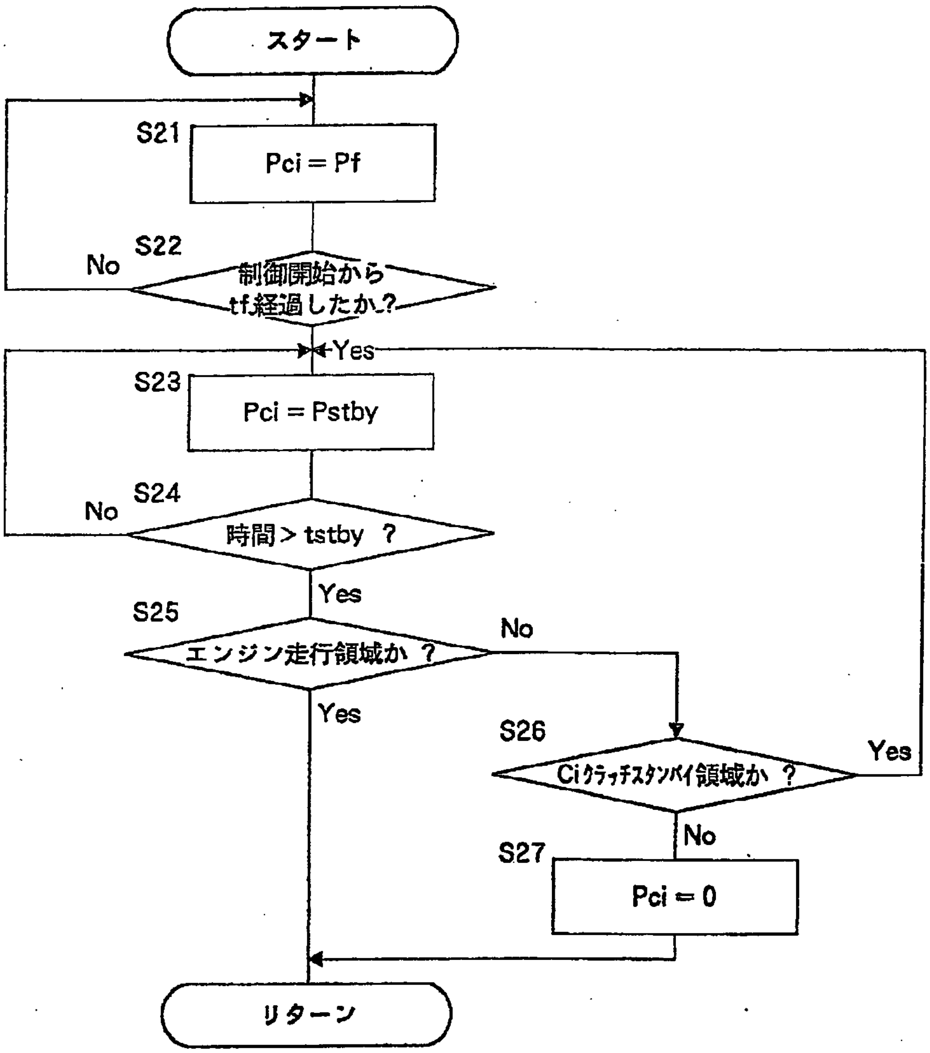
【図４】


スタート
S1
アクセル開度
読み込み
S2
車速読み込み
S3
エンジン走行領域か ？
Yes
No
S4
Ciクラッチスタンバイ領域か ？
Yes
No
S5
Ciクラッチ
スタンバイ制御
S6
エンジン始動制御
リターン

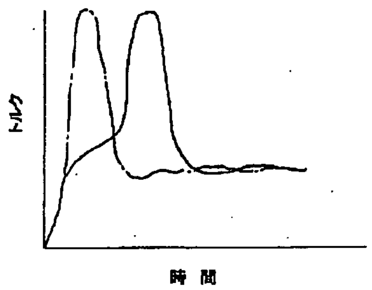
【図９】


スタート
S51
Tm＝Tmmax
S52
Pci＝(Tses/μ−c)/a
No
S53
Ne＞Ne1 ？
Yes
S54
Tm＝Tmt
S55
Pci＝Pa
2
S56
dX2＝dNe／dt
S57
dX＝dX2－dX1
S58
dXよりdPciを決定
S59
Pci＝Pci＋dPci
No
S60
Ne＞500rpm ？
Yes
1

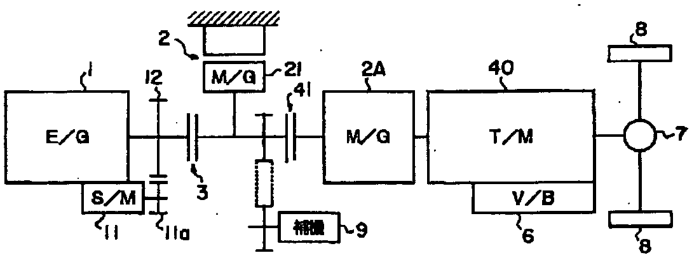
【図５】


スタート
S21
Pci＝Pf
S22
No
制御開始から
tf経過したか？
Yes
S23
Pci＝Pstby
S24
No
時間＞tstby ？
Yes
S25
エンジン走行領域か ？
No
Yes
S26
Ciクラッチスタンバイ領域か ？
Yes
No
S27
Pci＝0
リターン

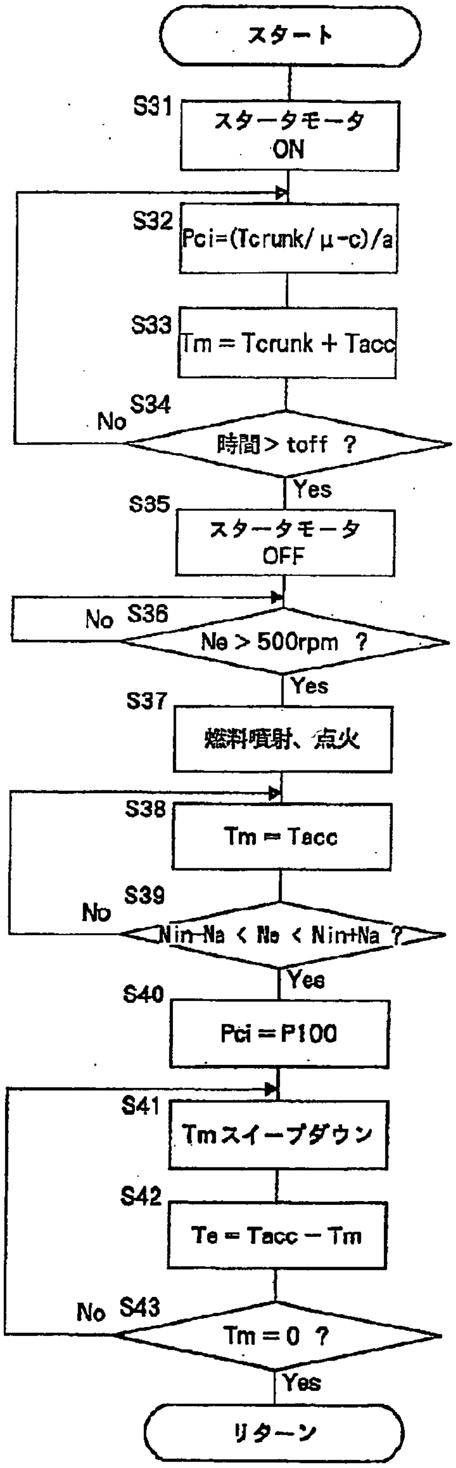
【図１４】


トルク
時間

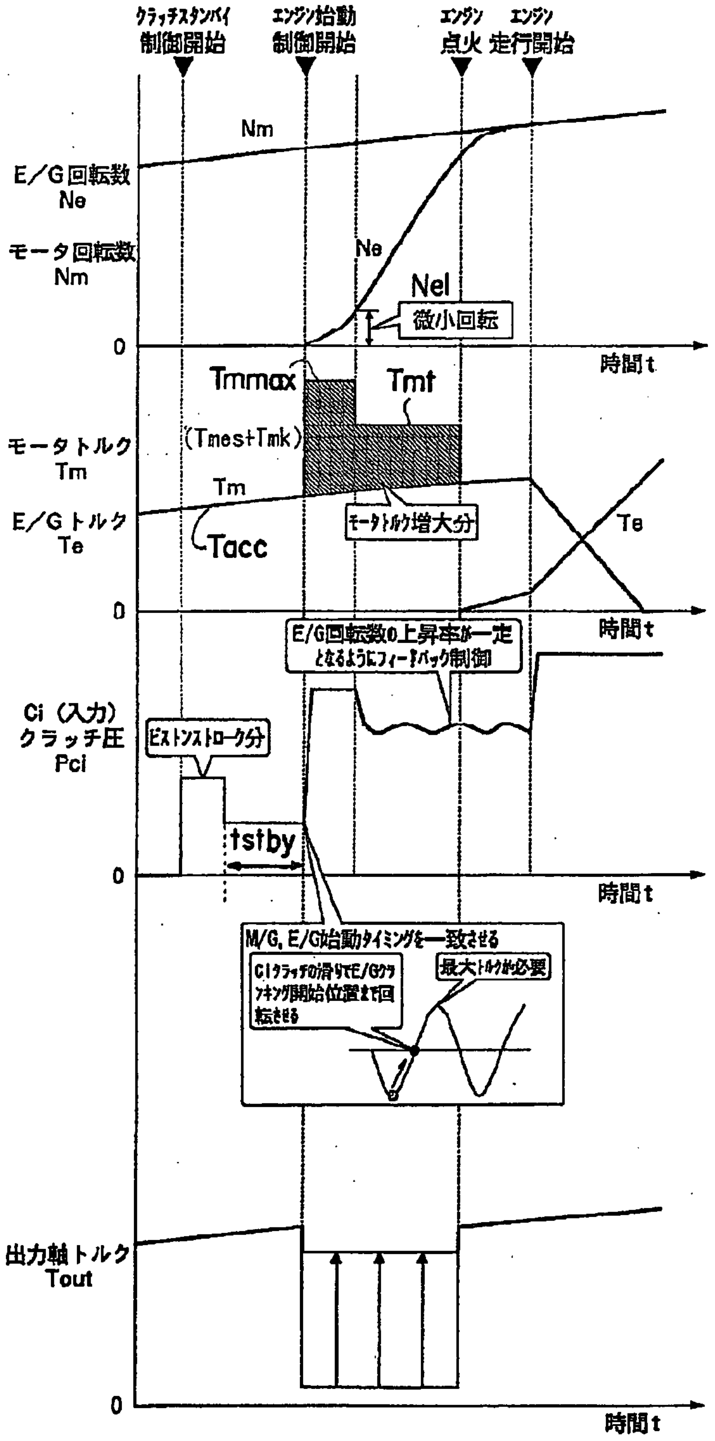
【図１５】


2
M/G
21
1
12
2A
40
8
41
E/G
M/G
T/M
7
S/M
3
V/B
11
11a
補機
9
6
8

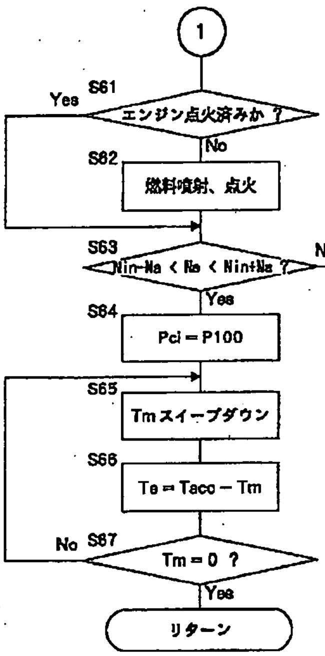
【図6】


スタート
S31
スタータモータ ON
S32
Pci=(Tcrunk/μ-c)/a
S33
Tm＝Tcrunk＋Tacc
S34
No
時間＞toff ？
Yes
S35
スタータモータ OFF
No
S36
Ne＞500rpm ？
Yes
S37
燃料噴射、点火
S38
Tm＝Tacc
S39
No
Nin-Na ＜ Ne ＜ Nin+Na ？
Yes
S40
Pci＝P100
S41
Tmスイープダウン
S42
Te＝Tacc－Tm
No
S43
Tm＝0 ？
Yes
リターン

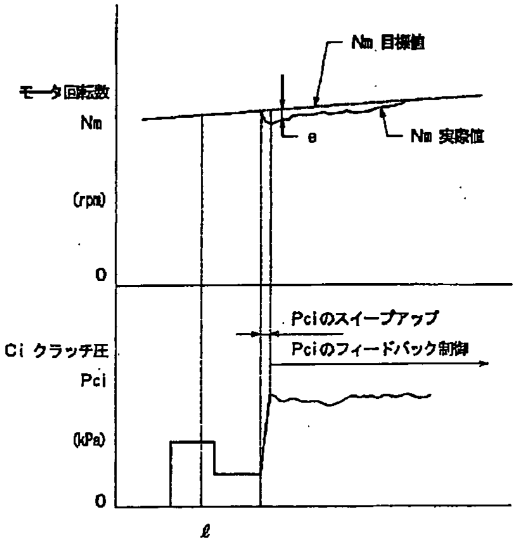
【図8】


クラッチスタンバイ 制御開始
エンジン始動 制御開始
エンジン 点火
エンジン 走行開始
Nm
E／G回転数 Ne
モータ回転数 Nm
Ne
Nel
微小回転
0
時間t
Tmmax
Tmt
(Tmes+Tmk)
モータトルク Tm
Tm
E／Gトルク Te
Tacc
モータトルク増大分
Te
0
時間t
E/G回転数の上昇率が一定となるようにフィードバック制御
Ci（入力）クラッチ圧 Pci
ピストンストローク分
tstby
0
時間t
M/G, E/G始動タイミングを一致させる
C1クラッチの滑りでE/Gクランキング開始位置まで回転させる
最大トルクが必要
出力軸トルク Tout
0
時間t

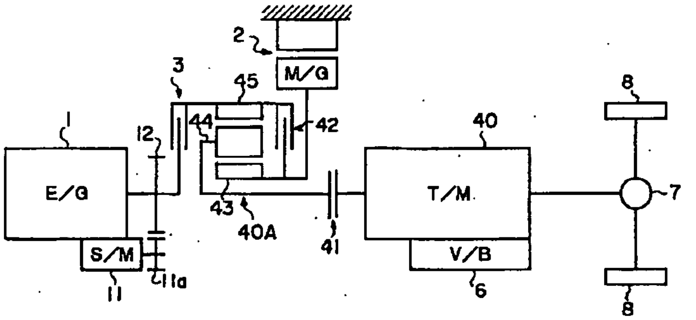
【図１０】



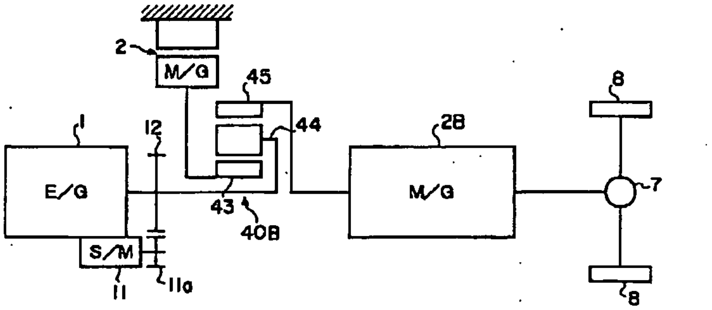
【図１１】



【図１６】



【図１７】



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Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Hybridantriebsvorrichtung für ein Fahrzeug

(57) Eine Hybridantriebsvorrichtung für ein Fahrzeug, die in der Lage ist, das Ansprechen beim Wiederanlassen einer Maschine während der Fahrt eines Fahrzeuges zu verbessern. Im Ergebnis kann ein Stoß infolge einer Verzögerung vermindert werden. Die Hybridantriebsvorrichtung für ein Fahrzeug hat eine Maschine, einen Elektromotor, eine Kupplung, eine Getriebeeinheit und eine Steuereinheit zur Steuerung der anderen Elemente. Die Steuereinheit hat eine Wartezustandssteuereinrichtung zur Realisierung einer konstanten Anlaßkennlinie, um das Anlaßansprechen beim Anlassen der Maschinen durch Übertragung der Kraft des Elektromotors auf die Maschine und Steuern des Eingriffsdrucks der Kupplung zu verbessern, um somit die Maschine in eine Anlaßstartposition zu drehen.

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Beschreibung

Die Erfindung bezieht sich auf eine Hybridantriebsvorrichtung für ein Fahrzeug mit einem Verbrennungsmotor und einem Elektromotor Generator als Antriebsquellen und bezieht sich insbesondere auf eine Lehre zum Anlassen des Verbrennungsmotors der in einem Zustand angehalten wurde, in welchem das Fahrzeug durch den Elektromotor Generator zur Verminderung des Kraftstoffkonsums angetrieben wird.

Eine Hybridantriebsvorrichtung ist als eine Antriebsvorrichtung für ein Fahrzeug bekannt, welches eine Brennkraftmaschine (nachfolgend als Maschine bezeichnet) und einen Elektromotor-Generator (nachfolgend als Elektromotor bezeichnet) aufweist, die jeweils als eine Antriebsquelle dienen. Die Maschine, eine der Antriebsquellen, ist dadurch gekennzeichnet, daß die Wirkungsgradabnahme rasch ansteigt, um die Lastabnahmerate im Bereich leichterer Lasten zu schneiden.

Um den Kraftstoffverbrauch zur Energieeinsparung zu reduzieren, wurde eine Antriebsvorrichtung vorgeschlagen, die an ein Verfahren angepaßt ist, eine Maschine automatisch anzuhalten und das Fahrzeug mit einem Elektromotor bei leichter Last anzutreiben, d. h. der Zustand, in welchem der Betrag des Niederdrückens eines Gaspedals (nachfolgend als Gaspedalstellung bezeichnet) einen geringen Wert annimmt. Bei dem vorgenannten Verfahren muß die Maschine automatisch angelassen werden, wenn die Gaspedalstellung auf einen Wert größer als der kleine Wert gesetzt wird. Zu dieser Zeit wird, weil ein Teil der Antriebskraft des Elektromotors zur Bewegung des Fahrzeugs verwendet wird, ein anderer Teil zum Anlassen des Motors verwendet. Folglich liegt infolge der Anlaßlast für die Maschine eine Verminderung in der Antriebskraft vor, die den Fahrer des Fahrzeugs das Gefühl einer übermäßigen Verzögerung gibt. Folglich ist ein Verfahren erforderlich, um die vorgenannte Schwierigkeit zu überwinden, in dem der aus der Verzögerung beim Wiederanlassen der Maschine erzeugte Stoß vermindert wird.

Als eine Maßnahme zur Verhinderung eines Stoßes infolge einer Verzögerung ist eine Technologie bekannt, mit der der Eingriffsdruck der Kupplung zwischen dem Elektromotor und der Maschine abgetastet wird, um eine leichte Änderung der Drehzahl des Elektromotors zu erfassen, die durch den Anstieg der Übertragungskraft des Drehmoments bei dem Kupplungseingriff hervorgerufen ist. Daraufhin wird das Ausgangsdrehmoment des Elektromotors angehoben.

Die beim Wiederanlassen der Maschine erzeugte Anlaßlast ist ein künstliches Drehmoment, das aus dem Widerstandsdrehmoment, das durch Ansaug-, Verdichtungs- und Ausstoßhub in jedem Zylinder hervorgerufen ist, dem dem mechanischen Schleppwiderstand entsprechenden Drehmoment, dem Drehmoment zur Betätigung von Hilfseinrichtungen, wie eine Klimaanlage, eine Lichtmaschine, eine Wasserpumpe und eine Ölpumpe und dem Trägheitsdrehmoment besteht, das erforderlich ist, um die angehaltene Maschine zu beschleunigen. Darüber hinaus ist die durch die Ansaug/Ausstoßvorgänge erzeugte Last ein periodisch oszillierendes Drehmoment, wie durch Linien mit entsprechend den Zylindern jeweils unterschiedlichen Symbolen in **Fig.** 12 gezeigt ist. Der Gesamtwert des vorgenannten Drehmoments hat eine Kennlinie, die mit einer durchgezogenen Linie angedeutet ist.

Das tatsächliche Anlaßdrehmoment ist dadurch gekennzeichnet, daß es sehr steil ansteigt, um lediglich beim Beginn der Umdrehung einen übermäßig hohen Drehmomentwert anzunehmen und dann einen im wesentlichen gleichmäßigen Wert annimmt, wie in **Fig.** 13 gezeigt ist. Dies liegt am Trägheitsdrehmoment als ein Widerstand gegen die Umdrehungen, das wiederum dazu dient, die Schwankungen des Drehmoments durch die Schwungradträgheit zu begrenzen, nach dem die Maschine gestartet wurde. Folglich kann das Anlaßdrehmoment, welches erforderlich ist, Umdrehungen mit einer vorbestimmten Geschwindigkeit aufrechtzuerhalten, einen Durchschnittswert annehmen.

Entsprechend wurde eine Technologie vorgeschlagen, um die Erzeugung jedweder Last während der Ansaug- und Ausstoßvorgänge zu verhindern, bis der Motor wieder angelassen wurde, um eine bestimmte Drehzahl in Übereinstimmung mit der Kennlinie des Anlaßdrehmoments zu haben. Folglich ist der Spitzenwert der Drehmomentlast vermindert, um das auf den Elektromotor aufgebrachte Anlaßdrehmoment zu vermindern.

Jedoch erfordert die letztgenannte Technik Veränderungen der Maschine sowie eine komplizierte Steuerung. Folglich muß für eine praktische Anwendung eine Vielzahl von Schwierigkeiten gelöst werden. Währenddessen hat die erstgenannte Technik eine durch die Kennlinie des Anlaßdrehmoments hervorgerufene Schwierigkeit. Die Anlaufkennlinie des Anlaßdrehmoments mit der vorgenannten periodisch oszillierenden Drehmomentkomponente wird verändert, weil die Position der Spitze von der Kurbelwellenposition im Anhaltezustand der Maschine, die mit einer unterbrochenen Linie gezeigt ist, in die durch die durchgezogene Linie von **Fig.** 14 gezeigte Position verschoben sein kann. Weil der Zeitpunkt der Erzeugung des Spitzendrehmoments wie oben beschrieben verschoben ist, muß der hydraulische Druck für den Eingriff der Kupplung verändert werden, um mit dem vorgenannten Effekt übereinzustimmen. Folglich muß eine sehr genaue Steuerung ausgeführt werden, dahingehend daß der Anstiegsbetrag des Ausgangsdrehmoments von dem Elektromotor verändert wird, um mit dem vorgenannten Hydraulikdruck übereinzustimmen. Diese genaue Steuerung kann nicht durch eine einfache Steuerung bewältigt werden, die beispielsweise eine Steuerung unter Verwendung eines Kennfelds ist. Weil die Steuerung die durch die Verdichtungs- und Expansionshübe in den Zylindern hervorgerufene oszillierende Drehmomentkomponente nicht genau abschätzen kann, kann leicht zu Beginn des Anlassens der Maschine ein Stoß hervorgerufen werden. Erschwerend kommt hinzu, daß eine zufriedenstellend hohe Steuergeschwindigkeit nicht realisiert werden kann.

Entsprechend ist es eine erste Aufgabe der Erfindung, eine Hybridantriebsvorrichtung für ein Fahrzeug zu schaffen, die ausgelegt ist, eine Anlaßkennlinie beim Wiederanlassen der Maschine konstant zu machen, so daß die Maschine mit guten Ansprechen unter einfacher Steuerung in einem Zustand wieder angelassen werden kann, in welchem das Fahrzeug durch den Elektromotor angetrieben ist.

Ein zweites Ziel der Erfindung ist es einen Wartezustand durch hydraulische Steuerung zu realisieren, um die Anlaßkennlinie konstant zu machen.

Ein drittes Ziel der Erfindung ist es, den Wartezustand zur Vergleichmäßigung der Einlaßkennlinie anzupassen und das nachfolgende Anlassen innerhalb eines begrenzten Ausgangsleistungsbereich vor dem Elektromotor zu realisieren.

Um einen Stoß infolge der Abnahme der Antriebskraft beim Wiederanlassen der Maschine zu vermeiden, muß ein Elektromotor mit einer großen Kapazität verwendet werden, um ein ausreichend großes Drehmoment abzugeben. Zudem muß eine Steuerung für die Steigerung des Ausgangsdrehmoments in Übereinstimmung mit der Anlaßlast ausgeführt werden. Wenn der Elektromotor mit der großen Kapazität lediglich zum Anlassen der Maschine vorgesehen werden muß, wird die Größe des Elektromotors unnötig groß. Die

Kapazität eines Wandlers zur Steuerung des Elektromotors wird entsprechend größer, was zu einer vergrößerten Batteriekapazität führt. Somit kann das vorgenannte Verfahren die Schwierigkeiten nicht effizient lösen.

Entsprechend ist es ein viertes Ziel der Erfindung, eine Hybridantriebsvorrichtung für ein Fahrzeug zu schaffen, welches einen Anlassermotor für eine Maschine verwendet, der zusätzlich betätigt wird, um die Maschine mit einem zufriedenstellenden Ansprechen anzuwerfen, ohne den Elektromotor zu vergrößern, und um das Anlassen unter einfacher Steuerung des Eingriffsdrucks der Kupplung auszuführen.

Ein fünftes Ziel der Erfindung ist es, eine Hybridantriebsvorrichtung für ein Fahrzeug zu schaffen, die ausgelegt ist, einen Wartezustand zu realisieren, um die Anlaßkennlinie konstant zu machen und den Motor durch einen Elektromotor nachfolgend anzulassen, ohne spezielle Hilfsantriebsmittel zu verwenden.

Es ist ein allgemeines Verfahren bekannt, bei dem eine Maschine durch einen Anlassermotor angelassen wird. Wenn das vorgenannte Verfahren lediglich angewandt wird, um die Maschine während der Fahrt des Fahrzeugs anzuwerfen, wird ein störendes Geräusch infolge von Veränderungen des Anlaßdrehmoments erzeugt und das Start verhalten kann die Anforderungen nicht erfüllen. Entsprechend ist es ein sechstes Ziel der Erfindung, eine Hybridantriebsvorrichtung für ein Fahrzeug zu schaffen, welche einen Anlassermotor für eine Maschine verwendet, um zusätzlich beim Beginn der Maschinendrehung, die ein im wesentlichen hohes Drehmoment beim Anlassen erfordert, betrieben zu werden, um ein Anwerfen der Maschine mit guten Ansprechen zu ermöglichen, ohne den Elektromotor zu vergrößern, und um das Anlassen unter einer einfachen Steuerung des Eingriffsdrucks der Kupplung zu ermöglichen.

Wenn die Maschine lediglich durch den Elektromotor angelassen wird, können verschiedene Verfahren verwendet werden, um den Eingriffsdruck der Kupplung zu steuern, um die Anzahl-Umdrehungen der Maschine zum Anlassen der Maschine anzuheben. Wenn die Steuerung des Eingriffsdrucks kompliziert wird, kann ein Verfahren nach dem vorhergehenden Typ praktisch nicht verwendet werden. Entsprechend ist es ein siebtes Ziel der Erfindung, eine Maschine wieder anzulassen, in dem der Eingriffsdruck der Kupplung auf einfache Weise gesteuert wird.

Wenn die Maschine lediglich durch den Elektromotor angelassen wird, kann die Erzeugung eines Verzögerungsstoßes infolge des Anlassens der Maschine nicht bei dem begrenzten Ausgang des Elektromotors verhindert werden. Wenn das Verzögerungsgefühl auf einen vorbestimmten Bereich begrenzt wird, kann ein fühlbarer Stoß verhindert werden. Entsprechend ist es ein achtes Ziel der Erfindung, die Maschine anzulassen, während eine Verminderung der Drehzahl eines Elektromotors verhindert ist, um einen vorbestimmten Drehzahlbereich durch Steuerung des Eingriffsdrucks einer Kupplung einzuhalten.

Weil ein Anlassermotor für die Maschine nicht häufig betrieben wird, wird er in einem Überlastzustand betrieben, der einen hohen elektrischen Strom erfordert. Wenn jedoch der Anlassermotor häufig zum Wiederanlassen der Maschine in diesem Überlastzustand verwendet wird, kann die Haltbarkeit des Anlassermotors vermindert sein. Entsprechend ist ein neuntes Ziel der Erfindung, die Lebensdauer des Anlassermotors aufrechtzuerhalten, indem der Anlassermotor in einem Leichtlastzustand betrieben wird, wobei das Anlaßdrehmoment durch einen Elektromotor vervollständigt ist, so daß die Betriebszeit stark begrenzt ist.

Wie oben beschrieben ist, wird das Anlaßdrehmoment zum Anlassen der Maschine zu Beginn der Umdrehung der Maschine hoch und das nachfolgende Drehmoment nimmt ab. Folglich ist es ein zehntes Ziel der Erfindung, die Steuerung des Eingriffsdrucks der Kupplung zur Drehmomentübertragung zu vereinfachen, indem zusätzlich ein Anlassermotor betrieben wird, um das erhöhte Ausgangsdrehmoment des Elektromotors während des gesamten Maschinenanlaßvorgangs auszumitteln.

Wenn der Anlassermotor zusätzlich während der Umdrehungsanfangszeitspanne betrieben wird, kann der Anstieg des Ausgangsdrehmoments von dem Elektromotor über die gesamte Maschinenanlaßzeitspanne vermindert werden. Entsprechend ist es ein elftes Ziel der Erfindung, die Drehmomentbelastung des Elektromotors zum Anlassen der Maschine zu vermindern und die Ausgangsdrehmomentsteuerung zu vereinfachen.

Als ein Verfahren zur Verhinderung, daß das Drehmoment des Elektromotors zum Anlassen der Maschine verwendet wird, könnte es machbar sein, ein Verfahren zum Wiederanlassen der Maschine während der Fahrt nur durch den Anlassermotor zu verwenden. Wenn dieses Verfahren verwendet wird, kann die Lebensdauer des Anlassermotors aus den vorgenannten Gründen beeinträchtigt sein. Entsprechend ist es ein zwölftes Ziel der Erfindung, die Lebensdauer des Anlassermotors aufrechtzuerhalten, sogar wenn der Anlassermotor hauptsächlich verwendet wird und das Drehmoment des Elektromotors zusätzlich verwendet wird, um die Maschine während der Fahrt anzulassen.

Ein dreizehntes Ziel der Erfindung ist es die Steuerung des Anlassermotors bei der Anlaßsteuerung zu vereinfachen.

Ein vierzehntes Ziel der Erfindung ist es, die Maschine mit gutem Ansprechen lediglich durch das Elektromotordrehmoment anzulassen, während die Erzeugung eines Verzögerungsstoßes auf ein Minimum unterdrückt wird.

Ein fünfzehntes Ziel der Erfindung ist es, die Drehmomentsteuerung des Elektromotordrehmoments bei der Anlaßsteuerung in Übereinstimmung mit der Steuerung des Eingriffsdrucks der Kupplung zu vereinfachen.

Ein sechzehntes Ziel der Erfindung ist es, die Drehmomentsteuerung des Elektromotordrehmoments auszuführen, wenn die Wartezustandssteuerung mit einem sehr einfachen Verfahren auf die Anlaßsteuerung übergehen wird.

Ein siebzehntes Ziel der Erfindung ist es, das Ansprechen einer Wartezustandssteuerung vor der Anlaßsteuerung durch den Elektromotor zu verbessern.

Der Antriebsmodus in der herkömmlichen Hybridantriebsvorrichtung ist derart geschaltet, daß auf ein Antriebsmoduskennfeld, das in einem Mikrocomputer einer Steuereinheit gespeichert ist, Bezug genommen wird, welches Antriebsbereiche hat, die in Übereinstimmung mit der Beziehung zwischen dem Grad der Gaspedalstellung und der Fahrzeuggeschwindigkeit vorbestimmt sind. Zudem wird der vorgenannte Umschaltvorgang in Übereinstimmung mit der Beziehung zwischen dem Grad der Gaspedalstellung zu jedem Zeitpunkt und der Fahrzeuggeschwindigkeit ausgeführt. Ein achtzehntes Ziel der Erfindung es ist, die Maschine wieder anzulassen, indem eine einfache Steuerung unter Verwendung eines Kennfelds ausgeführt wird, in welchem die Zeit zum Beginn der Wartezustandssteuerung eingestellt ist.

Es ist wichtig, das Anlaufen der Maschine zu bestätigen, um die Maschinenanlaßsteuerung in einer möglichst kurzen Zeitspanne zu vollenden. Entsprechend ist es ein neunzehntes Ziel der Erfindung, das Anlaufen der Maschine genau zu bestimmen.

Ein zwanzigstes Ziel der Erfindung ist es, die Maschinenanlaßsteuerung mit dem Elektromotor sanft zu beenden.

Ein einundzwanzigstes Ziel der Erfindung ist es, den

Elektromotorantrieb auf den Maschinenantrieb umzuschalten, nachdem die Maschine angelassen wurde.

Ein zweiundzwanzigstes Ziel der Erfindung ist es, das Ansprechen einer Wartezustandssteuerung zu verbessern, die vor der Anlaßsteuerung mit dem Anlassermotor ausgeführt wird.

Ein dreiundzwanzigstes Ziel der Erfindung ist es, den Motor durch Ausführen einer simplen Steuerung unter Verwendung eines Kennfelds wieder anzulassen, in welchem die Start zeit der Wartezustandssteuerung vor die Anlaßsteuerung unter Verwendung des Anlassermotors gesetzt ist.

Ein vierundzwanzigstes Ziel der Erfindung ist es, die Maschine zum spontanen Drehen mit einer guten Zeitsteuerung in einer Endstufe der Anlaßsteuerung zu bewegen, indem die Kraftstoffversorgung angemessen fortgesetzt und die Zündung ausgeführt wird.

Ein fünfundzwanzigstes Ziel der Erfindung ist es, die Maschinenanlaßsteuerung unter Verwendung eines Anlassermotors sanft zu beenden.

Ein sechsundzwanzigstes Ziel der Erfindung ist es, sanft von dem Elektromotorantrieb auf den Maschinenantrieb nach dem Anlassen der Maschine unter der Maschinenanlaßsteuerung unter Verwendung eines Anlassermotors umzuschalten.

Um die erste Aufgabe zu lösen hat gemäß einem Aspekt der Erfindung eine Hybridantriebsvorrichtung für ein Fahrzeug eine Maschine, einen Elektromotor, eine Getriebeeinheit, die geeignet ist die Kraft der Maschine und des Elektromotors auf die Räder zu übertragen, und eine Steuereinheit zur Steuerung der Maschine, des Elektromotors sowie der Kraftübertragung der Maschine und des Elektromotors auf die Räder. Die Steuereinheit hat Anlaßsteuerungseinrichtungen zum Anlassen der Maschine wenn ein Fahrzeug in einem Zustand gefahren wird, in welchem die Maschine angehalten ist und Leistung von dem Elektromotor auf die Räder übertragen wird, und hat Wartezustandssteuereinrichtungen um eine Steuerung auszuführen, um die Maschine in eine Anlaßstartposition zu drehen, bevor das Anlassen der Maschine durch die Anlaßsteuereinrichtungen ausgeführt wird.

Um das zweite Ziel zu erreichen, hat eine Hybridantriebsvorrichtung für ein Fahrzeug ferner eine Kupplung, die ausgelegt ist, die Kraftübertragung zwischen der Maschine und dem Elektromotor zu steuern. Die Wartezustandssteuereinrichtung hat eine Wartezustandsdrucksteuereinrichtung zur Steuerung eines Kupplungsdrucks derart, daß das durch die Kupplung übertragene Drehmoment eine Größe annimmt, die es gestattet, die Maschine in die Anlaßstartposition zu drehen.

Um das dritte Ziel zu erreichen hat die Anlaßsteuereinrichtung eine Anlaßdrucksteuereinrichtung zur Steuerung des Eingriffsdrucks der Kupplung derart, daß die Größe des durch die Kupplung übertragenen Drehmoments kleiner oder gleich einem Ausgangsdrehmoment von dem Elektromotor nach der Wartezustandssteuerung ist.

Um das vierte Ziel zu erreichen, hat die Hybridantriebsvorrichtung für ein Fahrzeug ferner einen Anlassermotor zum Anlassen der Maschine. Die Anlaßsteuereinrichtung veranlaßt, daß der Anlassermotor startet und die Kupplung in Eingriff gebracht wird, gleichzeitig nach der Wartezustandssteuerung.

Um das fünfte Ziel zu erreichen, hat eine Hybridantriebsvorrichtung für ein Fahrzeug eine Maschine, eine Elektromotor, eine Kupplung, die geeignet ist, eine Kraftübertragung zwischen der Maschine und dem Elektromotor zu steuern, eine Getriebeeinheit, die ausgelegt ist, die Kraft der Maschine und des Elektromotors auf die Räder zu übertragen und eine Steuereinheit zur Steuerung der Maschine, des Elektromotors und der Kupplung. Die Anlaßsteuereinrichtung bringt die Kupplung in Eingriff, um die Maschine anzulassen, wenn ein Fahrzeug in einem Zustand gefahren wird, in welchem die Maschine angehalten ist, und die Kupplung wird außer Eingriff gebracht, um es dem Elektromotor zu gestatten, seine Leistung auf die Räder zu übertragen, und es ist eine Wartezustandssteuereinrichtung vorgesehen, um eine Steuerung auszuführen, mit der die Kupplung in Eingriff gebracht wird, um die Maschine in eine Anlaßstartposition zu bringen, bevor das Anlassen der Maschine durch die Anlaßsteuereinrichtung ausgeführt wird. Die Wartezustandssteuereinrichtung hat eine Wartezustandsdrucksteuereinrichtung zur Steuerung des Eingriffsdrucks der Kupplung derart, daß die Größe des durch die Kupplung übertragenen Drehmoments eine Größe annimmt, die es gestattet, die Maschine in die Anlaßstartposition zu drehen. Die Anlaßsteuereinrichtung hat eine Anlaßdrucksteuereinrichtung zur Steuerung des Eingriffsdrucks der Kupplung derart, daß die Größe des durch die Kupplung übertragenen Drehmoments nach der Wartezustandssteuerung gleich oder kleiner wird als ein Ausgangsdrehmoment von dem Elektromotor.

Um das sechste Ziel zu erreichen, ist eine Hybridantriebsvorrichtung für ein Fahrzeug mit einer Maschine, einem Elektromotor, einem Anlassermotor zum Anlassen der Maschine, einer Kupplung, die ausgelegt ist, eine Leistungsübertragung zwischen der Maschine und dem Elektromotor zu steuern, einer Getriebeeinheit, die ausgelegt ist, die Leistung der Maschine und des Elektromotors auf die Räder zu übertragen, und eine Steuereinheit zum Steuern der Maschine, des Elektromotors, des Anlassermotors und der Kupplung vorgesehen. Die Steuereinheit hat eine Anlaßsteuereinrichtung zum Anlassen der Maschine, wenn ein Fahrzeug in einem Zustand gefahren wird, in welchem die Maschine angehalten ist, die Kupplung außer Eingriff ist und die Leistung des Elektromotors auf die Räder übertragen wird, und hat eine Wartezustandssteuereinrichtung zum Ausführen einer Steuerung, um die Kupplung in Eingriff zu bringen, um die Maschine in eine Anlaßstartposition zu drehen, bevor die Maschine durch die Anlaßsteuereinrichtung angelassen wird. Die Wartezustandssteuereinrichtung hat eine Wartezustandsdrucksteuereinrichtung zum Steuern des Eingriffsdrucks der Kupplung derart, daß die Größe des durch die Kupplung übertragenen Drehmoments eine Größe annimmt, die es gestattet, die Maschine in die Anlaßstartposition zu drehen, und die Anlaßsteuereinrichtung startet nach der Wartezustandssteuerung den Anlassermotor und bringt die Kupplung gleichzeitig in Eingriff.

Um das siebte Ziel zu erreichen, hat die Anlaßdrucksteuereinrichtung eine Konstantbeschleunigungssteuereinrichtung zur Steuerung des Eingriffsdrucks der Kupplung derart, daß eine Änderungsrate der Umdrehungen der Maschine auf einen gewünschten Wert gesetzt ist.

Um das achte Ziel zu erreichen, hat die Anlaßdrucksteuereinrichtung eine Drehzahlaufrechterhaltungs- und Steuereinrichtung zum Steuern des Eingriffsdrucks der Kupplung derart, daß die Abnahmerate der Umdrehungen des Elektromotors gleich oder kleiner einem vorbestimmten Wert wird.

Um das neunte Ziel zu erreichen, hat die Anlaßsteuereinrichtung eine Anfangssteuereinrichtung zum Betreiben des Anlassermotors lediglich während einer Zeitspanne, in welcher die Maschine nur langsam dreht.

Um das zehnte Ziel zu lösen, hat die Anlaßsteuereinrichtung eine Anlaßdruckeinstelleinrichtung zum Einstellen des Eingriffsdrucks der Kupplung auf einen Wert, bei dem die Kupplung einen Mittelwert des Anlaßdrehmoments der Maschine überträgt.

Um das elfte Ziel zu erreichen, hat die Anlaßsteuereinrichtung eine Drehmomentsteuereinrichtung, um zu bewirken, daß der Elektromotor einen Ausgang mit dem Mittelwert des Anlaßdrehmoments der Maschine erzeugt und ein Ausgangsdrehmoment zum Antrieb des Fahrzeugs erzeugt.

Um das zwölfte Ziel zu erreichen, hat die Anlaßsteuereinrichtung eine Drehmomentsteuereinrichtung, um zu bewirken, daß der Elektromotor ein Ausgangsdrehmoment entsprechend einem Anlaßstrom des Anlassermotors erzeugt.

Um das dreizehnte Ziel zu erreichen, ist eine Zeit zum Betrieb des Anlassermotors durch einen Zeitgeber gesteuert.

Um das vierzehnte Ziel zu erreichen, hat die Anlaßsteuereinrichtung eine Drehmomentsteuereinrichtung, um zu bewirken, daß der Elektromotor ein maximales Drehmoment herausgibt, und hat Druckerhöhungseinrichtungen zur Erhöhung des Eingriffsdrucks um die Drehmomentkapazität der Kupplung zu erhöhen, wenn der Elektromotor ein maximales Ausgangsdrehmoment erzeugt.

Um das fünfzehnte Ziel zu erreichen, hat die Anlaßsteuereinrichtung eine Drehmomentsteuereinrichtung, um zu bewirken, daß der Elektromotor eigen Mittelwert eines Anlaßdrehmoments der Maschine erzeugt.

Um das sechzehnte Ziel zu erreichen, hat die Anlaßsteuereinrichtung Abtasteinrichtungen zum Abtasten des Eingangsdrucks der Kupplung.

Um das siebzehnte Ziel zu erreichen, hat die Wartezustandssteuereinrichtung eine Schnellfülldruckversorgungseinrichtung zur Verkürzung eines Kolbenhubs der Kupplung.

Um das achtzehnte Ziel zu erreichen, hat die Steuereinheit einen Kupplungswartezustandsbereich, der zwischen einem Elektromotorantriebsbereich und einem Maschinenantriebsbereich bestimmt ist.

Um das neunzehnte Ziel zu erreichen, führt die Anlaßsteuereinrichtung Kraftstoff zum Entzünden der Maschine zu, wenn die Umdrehungen der Maschine eine vorbestimmte Drehzahl erreicht haben.

Um das zwanzigste Ziel zu erreichen, bringt die Anlaßsteuereinrichtung die Kupplung nach der Synchronisation der Umdrehungen der Maschine und des Elektromotors in vollständigen Eingriff.

Um das einundzwanzigste Ziel zu erreichen, hat die Steuereinheit eine Vollendungssteuereinrichtung, um das Ausgangsdrehmoment von dem Elektromotor herunterzufahren und eine Drosselöffnung der Maschine zu vergrößern.

Um das zweiundzwanzigste Ziel zu erreichen, hat die Wartezustandssteuereinrichtung eine Schnellfülldruckversorgungseinrichtung zur Verkürzung des Kolbenhubs der Kupplung.

Um das dreiundzwanzigste Ziel zu erreichen, hat die Steuereinheit einen Kupplungswartezustandsbereich, der zwischen einem Elektromotorantriebsbereich und einem Maschinenantriebsbereich bestimmt ist.

Um das vierundzwanzigste Ziel zu erreichen, führt die Anlaßsteuereinrichtung Brennstoff zur Zündung zu, wenn die Umdrehungen der Maschine eine vorbestimmte Anzahl von Umdrehungen erreicht haben.

Um das fünfundzwanzigste Ziel zu erreichen, bringt die Anlaßsteuereinrichtung die Kupplung nach der Synchronisation der Umdrehungen der Maschine und des Elektromotors in vollständigen Eingriff.

Um das sechsundzwanzigste Ziel zu erreichen, hat die Steuereinheit eine Vollendungssteuereinrichtung zum Herunterfahren des Ausgangsdrehmoments von dem Elektromotor und zur Vergrößerung einer Drosselöffnung der Maschine.

Erfindungsgemäß ist die Hybridantriebsvorrichtung für ein Fahrzeug derart aufgebaut, daß das Anlassen der Maschine stets in einem Zustand begonnen wird, in welchem die Maschine durch die Wartezustandssteuereinrichtung gesteuert ist, um sich in die Anlaßstartposition zu drehen. Im Unterschied zu einem Anlassen, das an einer unbestimmten Position ausgeführt wird, kann das vorgenannte Anlassen auf leichte Weise gesteuert werden. Folglich kann die Maschine innerhalb einer vorbestimmten Zeitspanne von relativ kurzer Dauer stabil angelassen werden. Folglich gestattet der vorgenannte Aufbau das Wiederanlassen der Maschine mit zufriedenstellendem Ansprechen, während mit dem Elektromotor gefahren wird. Im Ergebnis kann eine bei dem Wiederanlassen der Maschine erzeugte große Abnahme des Antriebsdrehmoments mit einer einfachen Anlaßsteuerung verhindert werden.

Weil die Wartezustandssteuerung derart ausgeführt wird, daß der Eingriffsdruck der Kupplung durch die Wartezustandsdrucksteuereinrichtung gesteuert ist, um die Drehmomenthöhe zu begrenzen, kann die Maschine zuverlässig in die Anlaßstartposition unter Verwendung des Elektromotordrehmoments gedreht werden.

Weil die Maschine so angelassen wird, daß der Eingriffsdruck der Kupplung durch die Anlaßdrucksteuereinrichtung gesteuert ist, um die Höhe des übertragenen Drehmoments auf einen Wert gleich oder kleiner als das Ausgangsdrehmoment des Elektromotors zu begrenzen, kann die Maschine innerhalb des erzeugbaren Drehmoments angelassen werden.

Weil der Anlassermotor durch die Anlaßsteuereinrichtung gleichzeitig mit dem Eingriff der Kupplung gestartet wird, kann das Drehmoment effizient verwendet werden, wenn ein großes Drehmoment zu Beginn der Maschinendrehung in einer Anfangsstufe des Anlaßvorgangs erforderlich ist.

In einem Wartezustand, in welchem die Anlaßkennlinie konstant gehalten ist, ist ein Anlassen der Maschine mit einem Drehmoment möglich, daß kleiner oder gleich dem Ausgangsdrehmoment des Elektromotors ist. Folglich kann der Elektromotor den Wartezustand für das Anlassen der Maschine erzeugen und danach den Anlaßvorgang ohne spezielle Hilfsantriebseinrichtungen ausführen.

Wenn das ein großes Drehmoment erfordernde Anlassen der Maschine ausgeführt wird, nachdem der Wartezustand zur Konstantmachung der Anlaßkennlinie realisiert wurde, wird der für die Maschine vorgesehene Anlassermotor zusätzlich verwendet. Somit kann die Maschine angelassen werden, während sowohl die Belastung des Elektromotors und die des Anlassermotors vermindert sind. Folglich kann mit dem vorgenannten Aufbau die Maschine mit zufriedenstellendem Ansprechverhalten ohne Vergrößerung des Elektromotors für das Anlassen wieder angelassen werden.

Weil der Eingriffsdruck der Kupplung derart gesteuert ist, daß die Änderungsrate der Drehzahlen der Maschine beim Anlassen der Maschine konstant gehalten ist, kann die Maschine durch einfache Steuerung des Eingriffsdrucks der Kupplung wieder angelassen werden.

Der Eingriffsdruck der Kupplung wird derart gesteuert, daß eine Abnahme in der Anzahl der Umdrehungen des Elektromotors in einen vorbestimmten Bereich beim Anlassen der Maschine fällt. Folglich kann eine Anlaßsteuerung in Übereinstimmung mit einem Verzögerungsgefühl auf der Basis der Anzahl von Umdrehungen des Elektromotors ausgeführt werden.

Weil die Anlaßsteuerung derart ausgeführt wird, daß der Anlassermotor bei einer leichten Last betrieben wird, um das durch den Elektromotor für eine begrenzte Zeitspanne erzeugte Anlaßdrehmoment auszugleichen, ist die Lebensdauer des Anlassermotors gewahrt, während sowohl die Last des Elektromotors als auch die Last des Anlassermotors beim Anlassen vermindert sind.

Weil der Anlassermotor zusätzlich verwendet wird, wenn die Umdrehung in einer Anfangsstufe des Anlassens beginnt und das Ausgangsdrehmoment von dem Elektromotor erhöht wird, um einen Mittelwert während der Maschinenanlaßperiode anzunehmen, kann die Steuerung des Eingriffsdrucks der Kupplung zur Übertragung des Drehmoments vereinfacht werden.

Wenn die Umdrehung beginnt, wird der Anlassermotor zusätzlich verwendet und das Ausgangsdrehmoment von dem Elektromotor wird angehoben, um einen Mittelwert während der Maschinenanlaßperiode anzunehmen, wobei die Steuerung des Ausgangsdrehmoments vereinfacht werden kann, während die Drehmomentbelastung des Elektromotors zum Anlassen der Maschine reduziert ist.

Die Maschine wird derart angelassen, daß der Anlassermotor hauptsächlich verwendet und das Elektromotordrehmoment zusätzlich verwendet wird. Folglich kann eine solche Steuerung ausgeführt werden, daß das Anlaßdrehmoment von dem Elektromotor vermindert wird, um somit den Einfluß auf das Antriebsdrehmoment zu minimieren. Zudem ist die Lebensdauer des Anlassermotors gewahrt. Die Anlaßsteuerung des Anlassermotors ist vereinfacht.

Weil die Maschine mit einem Maximaldrehmoment angelassen wird, daß von dem Elektromotor erzeugt werden kann, kann die Maschine mit einem zufriedenstellenden Ansprechen durch den Elektromotor gestartet werden, während die Erzeugung eines Verzögerungsstoßes verhindert ist.

Weil die Maschine mit einer vorbestimmten Beschleunigung angelassen werden kann, während der Elektromotor einen Ausgang mit einem vorbestimmten Drehmoment bei der Anlaßsteuerung erzeugt, kann die Steuerung des Elektromotors vereinfacht werden.

Erfindungsgemäß kann die Steuerung des Eingriffsdrucks der Kupplung, die bei einem Übergang von der Wartezustandssteuerung zu der Anlaßsteuerung ausgeführt wird, vereinfacht werden.

Weil die Anlaßsteuerung durch den Elektromotor ausgeführt werden kann, um den Kolbenhub der Kupplung zur Ausführung der Wartezustandssteuerung schnell zu vollenden, ist das Ansprechen der Wartezustandssteuerung verbessert.

Weil die Anlaßzeitsteuerung der Wartezustandssteuerung auf einfache Weise mit einer Bestimmung eines Bereichs bestimmt werden kann, kann die Logik für die Wartezustandssteuerung vereinfacht werden und die Wartezustandssteuerung kann schnell ausgeführt werden.

Weil Kraftstoff der Maschine zur Zündung zu einem Zeitpunkt zugeführt wird, in welchem die Anzahl Umdrehungen der Maschine einen vorbestimmten Wert erreicht haben, kann die Maschine angemessen angelassen werden.

Erfindungsgemäß kann die Maschinenanlaßsteuerung durch den Elektromotor sanft vollendet werden.

Erfindungsgemäß kann der Übergang von dem Elektromotorantrieb auf den Maschinenantrieb nach dem Anlassen der Maschine sanft ausgeführt werden.

Erfindungsgemäß kann die Anlaßsteuerung unter Verwendung des Anlassermotors derart ausgeführt werden, daß der Kolbenhub der Kupplung für die Wartezustandssteuerung schnell ausgeführt werden kann, wodurch das Ansprechen der Wartezustandssteuerung verbessert ist.

Weil die Zeitsteuerung des Beginns der Wartezeitsteuerung auf einfache Weise durch Bestimmen des Bereichs beim Wiederstarten durch den Anlassermotor bestimmt werden kann, kann die Wartezustandssteuerung schnell ausgeführt werden, während deren Logik vereinfacht ist.

Weil die Steuerung derart ausgeführt wird, daß die Kraftstoffzuführung und Zündung zu einem Zeitpunkt ausgeführt wird, wenn die Anzahl von Umdrehungen einen vorbestimmten Wert beim Wiederstart unter Verwendung des Anlassermotors erreicht haben, kann die Maschine angemessen angelassen werden.

Erfindungsgemäß kann die Maschinenanlaßsteuerung unter Verwendung des Elektromotors und des Anlassermotors sanft ausgeführt werden.

Erfindungsgemäß kann der Übergang von dem Elektromotorantrieb auf den Maschinenantrieb nach dem Maschinenanlassen durch den Elektromotor und den Anlassermotor jeweils sanft ausgeführt werden.

Andere Ziele, Merkmale und Vorteile der Erfindung werden aus der nachfolgenden genauen Beschreibung der bevorzugten Ausführungsbeispiele, die anhand der beigefügten Zeichnungen erläutert sind, deutlich.

Die Erfindung wird anhand der nachfolgenden Zeichnungen erläutert, in welchen gleiche Elemente mit gleichen Bezugszeichen bezeichnet sind. Es zeigen:

Fig. 1 ein Diagramm, das das System einer Hybridantriebsvorrichtung für ein Fahrzeug gemäß einem ersten Ausführungsbeispiel der Erfindung zeigt:

Fig. 2 ein Antriebsmoduskennfeld in einer Steuereinheit der Hybridantriebsvorrichtung für ein Fahrzeug;

Fig. 3 eine Zeittafel für einen Prozeß zum Anlassen der Maschine, der durch die Steuereinheit ausgeführt wird;

Fig. 4 ein Hauptflußdiagramm des Prozesses zum Anlassen der Maschine;

Fig. 5 ein Flußdiagramm einer Subroutine in dem Hauptflußdiagramm für die Wartezustandssteuerung;

Fig. 6 ein Flußdiagramm einer Subroutine in dem Hauptflußdiagramm zur Steuerung des Anlassens der Maschine;

Fig. 7 eine Zeittafel, die eine Modifikation der Anlaßsteuerung gemäß dem ersten Ausführungsbeispiel zeigt;

Fig. 8 eine Zeittafel für einen Prozeß zum Anlassen der Maschine der Hybridantriebsvorrichtung für ein Fahrzeug gemäß dem zweiten Ausführungsbeispiel;

Fig. 9 ein Flußdiagramm eines Teils der Subroutine zur Maschinenanlaßsteuerung zum Anlassen der Maschine;

Fig. 10 ein Flußdiagramm, daß den anderen Teil der Subroutine für die Maschinenanlaßsteuerung zeigt;

Fig. 11 eine Zeittafel, die eine Modifikation der Anlaßsteuerung gemäß einem zweiten Ausführungsbeispiel der Erfindung zeigt;

Fig. 12 eine charakteristische Darstellung, die Drehmomentveränderungen bezüglich Umdrehungen einer Kurbelwelle einer üblichen Sechszylindermaschine zeigt;

Fig. 13 einen Graph, der eine Anlaßdrehmomentkennlinie der allgemein verwendeten Maschine zeigt;

Fig. 14 einen Graph, der eine Anfangscharakteristik des vorgenannten Anlaßdrehmoments zeigt;

Fig. 15 ein Diagramm, das das System einer Hybridantriebsvorrichtung für ein Fahrzeug gemäß einem dritten Ausführungsbeispiel der Erfindung zeigt;

Fig. 16 ein Diagramm, das das System einer Hybridantriebsvorrichtung für ein Fahrzeug gemäß einem vierten Ausführungsbeispiel der Erfindung zeigt; und

Fig. 17 ein Diagramm, das eine Hybridantriebsvorrichtung für ein Fahrzeug gemäß einem fünften Ausführungsbeispiel der Erfindung zeigt.

Ausführungsbeispiele der Erfindung werden nun unter Bezugnahme auf die Zeichnungen beschrieben. **Fig.** 1 ist ein Diagramm, das den Aufbau des Systems einer Hybridantriebsvorrichtung für ein Fahrzeug gemäß einem ersten Ausführungsbeispiel der Erfindung zeigt. Die Hybridantriebsvorrichtung für ein Fahrzeug gemäß dem ersten Ausführungsbeispiel hat eine Maschine (E/G) **1**, einen Elektromotor (M/G) **2**, eine Kupplung **3**, welche geeignet ist die Kraftübertragung zwischen der Maschine **1** und dem Elektromotor **2** zu steuern, eine Getriebeeinheit **4**, welche geeignet ist, Leistung der Maschine **1** und des Elektromotors **2** auf die Fahrzeugräder zu übertragen, und eine elektrische Steuereinheit (ECU) **5** zur Steuerung der Maschine **1**, des Elektromotors **2**, eines Anlassermotors (S/M) **11** und der Kupplung **3**.

Die Maschine **1** hat einen Hilfsmotor als den Anlassermotor **11**, der ausgelegt ist, von einer 12 V Niedrigspannungsbatterie für Hilfseinrichtungen betrieben zu werden. Wie ein üblicherweise verwendeter Anlasser, wird ein Ausgangszahnrad **11**a gedreht und während der Drehung des Anlassermotors **11** mit einem Zahnrad **12**, das an der Kurbelwelle der Maschine **1** befestigt ist, in Eingriff gebracht. Wenn die Drehung des Anlassermotors **11** unterbrochen wird, gelangt das Ausgangszahnrad **11**a außer Eingriff von dem Zahnrad **12**.

Der Elektromotor **2** hat einen Rotor **21** der mit der Maschine **1** über eine Kupplung **3** (nachfolgend als "Ci-Kupplung" bezeichnet, um von anderen Kupplungen unterschieden zu werden) verbunden ist. Ferner ist der Elektromotor **2** mit einer automatischen Getriebeeinheit (T/M) **40**, die hauptsächlich die Getriebeeinheit **4** bildet, über eine Eingangskupplung **41** (nachfolgend als "Cl-Kupplung" bezeichnet) verbunden.

Die die Getriebeeinheit **4** bildende automatische Getriebeeinheit **40** hat einen vorbestimmten Zahnradsatz, der durch eine hydraulische Steuereinrichtung (V/B) **6** gesteuert ist. Eine Ausgangswelle der automatischen Getriebeeinheit **40** ist über eine Differentialeinheit **7** mit linken und rechten Antriebsrädern **8** verbunden. Bei der Vorrichtung gemäß diesem Ausführungsbeispiel dient die hydraulische Steuereinheit **6** als eine Steuereinheit zur Steuerung des hydraulischen Servos (Antriebseinheit) der Ci-Kupplung **3**.

Die Steuereinheit **5** hat eine elektronische Steuereinheit mit einem Mikrocomputer zur Steuerung des Elektromotors **2** über einen Inverter (nicht gezeigt), der hydraulischen Steuereinheit **6** über ein Solenoid (nicht gezeigt) und des Anlassermotors **11** über ein Relais. Die Steuereinheit kann ein den Grad der Gaspedalstellung wiedergebendes Signal, ein Fahrzeuggeschwindigkeitssignal, ein die Anzahl von in das Getriebe eingegebenen Umdrehungen anzeigendes Signal und ein die Anzahl von Umdrehungen der Maschine **1** anzeigendes Signal von zugehörigen Sensoren (nicht gezeigt) empfangen.

Die Steuereinheit **5** hat eine Anlaßsteuereinrichtung. Die Anlaßsteuereinrichtung erfaßt den Grad der Gaspedalstellung, um die Maschine **1** während der Fahrt des Fahrzeugs in einem Zustand anzulassen, in welchem die Maschine **1** angehalten und die Ci-Kupplung **3** außer Eingriff ist, um die Kraft des Elektromotors **2** auf die Antriebsräder **8** zu übertragen. Die Steuereinheit **5** hat eine Wartezustandssteuereinrichtung zum Drehen der Maschine **1** in eine Position in der das Anlassen beginnt, bevor der Vorgang von der Anlaßsteuereinrichtung ausgeführt wird.

Insbesondere hat die Anlaßsteuereinrichtung die Wartezustandsdrucksteuereinrichtung zum Steuern des Eingriffsdrucks der Ci-Kupplung **3**, um die Kraftübertragung einzustellen.

Ferner hat die Steuereinheit **5** ein in dem Speicher ihres Mikrocomputers gespeichertes Antriebsmoduskennfeld. **Fig.** 2 zeigt grafisch die Kennfelddaten. In Übereinstimmung mit der Beziehung zwischen der Fahrzeuggeschwindigkeit und dem Grad der Gaspedalstellung sind die folgenden Bereiche vorgesehen: ein Maschinenantriebsbereich, der in einem Bereich hoher negativer Geschwindigkeiten (Rückwärtsantrieb) ausgebildet ist, wenn das Gaspedal eingeschaltet ist, Maschinen- und Elektromotorantriebsbereiche, die in einem niedrigen Positivgeschwindigkeitsbereich und einem niedrigen Negativgeschwindigkeits- (vorwärts/rückwärts) Bereich auf beiden Seiten einer Position, die die Fahrzeuggeschwindigkeit Null enthält, ausgebildet sind, ein Maschinenbetriebsbereich, der in einem Bereich hoher positiver Geschwindigkeiten (Vorwärtsfahrt) ausgebildet ist, mit Ausnahme eines Bereichs eines niedrigen Grads der Gaspedalstellung, ein Elektromotorantriebsbereich, der in dem Bereich niedrigen Grads der Gaspedalstellung ausgebildet ist, und ein Regenerativbereich, der in einem positiven Fahrzeuggeschwindigkeitsbereich (Vorwärtsbewegung zum Antrieb des Rads) ausgebildet ist, wenn das Gaspedal ausgeschaltet ist. Ein Ci-Kupplungs-Wartezustandssteuerbereich, der später zu beschreiben ist, ist in dem Elektromotorantriebsbereich neben dem Maschinenantriebsbereich ausgebildet.

Ein Ablauf zur Bestimmung, ob die Maschine angehalten ist, wird ausgeführt, wenn die Steuereinheit **5** bestimmt, daß die Maschine **1** in Übereinstimmung mit dem in **Fig.** 2 gezeigten Antriebsmoduskennfeld angehalten sein könnte in einem Fall, in welchem der Grad der Gaspedalstellung in dem Elektromotorantriebsbereich für eine Zeit ist, die nicht kürzer ist, als eine vorbestimmte Zeit.

Wenn die Steuereinheit **5** bestimmt, daß das Anlassen der Maschine **1** in einem Fall erforderlich ist, in welchem der Grad der Gaspedalstellung, entgegengesetzt zu der vorgenannten Bestimmung zum Anhalten der Maschine **1**, in dem Maschinenantriebsbereich für eine Zeit ist, die nicht kürzer ist als eine bestimmte Zeitspanne, wird bestimmt, daß die Maschine **1** wieder angelassen wurde. Wenn bestimmt wird, daß die Maschine **1** angelassen werden sollte, werden die Wartezustandssteuerung der Ci-Kupplung **3** und die Anlaßsteuerung der Maschine **1** ausgeführt. Dann wird bestimmt, daß die Verbrennung vollendet wurde und die Vollendungssteuerung wird ausgeführt. Die Anlaßsteuerung der Maschine **1** besteht aus der Steuerung des Beginns der Drehungen der Maschine, die in der ersten Hälfte eines Anlaßvorgangs ausgeführt wird, der Steuerung der Beschleunigung, die in der zweiten Hälfte des Anlaßvorgangs ausgeführt wird, der Kraftstoffzufuhr und der Zündung. Die Wartezustandssteuerung der Ci-Kupplung **3** kann zu den folgenden drei Zeitpunkten erfolgen. Ein erster Zeitpunkt ist ein Zeitpunkt, wenn die Bestimmung zum Wiederanlassen gemacht wurde. Ein zweiter Zeitpunkt ist ein Zeitpunkt, wenn der Ci-Kupplungs-Wartezustandssteuerbereich in dem in **Fig.** 2 gezeigten Antriebsmoduskennfeld gestartet wurde. Ein dritter Zeitpunkt ist ein Zeitpunkt innerhalb einer vorbestimmten Zeitspanne nachdem die Maschinenabschaltsteuerung vollendet wurde. Ein Verfahren, das den vorgenannten zweiten Zeitpunkt verwendet, ist das effizientes Verfahren. In diesem Ausführungsbeispiel werden die vorgenannten Verfahren alle verwendet.

Bezug nehmend auf die Zeittafel in **Fig.** 3 und ebenfalls Bezug nehmend auf **Fig.** 1 wird der Inhalt der Steuerung sequentiell beschrieben. Zunächst nimmt die Maschinendrehzahl (Ne) einen Wert Null an, der den Haltezustand angibt, die Elektromotorumdrehung (Nm) wird allmählich angehoben wenn die Fahrzeuggeschwindigkeit zunimmt, das Maschinendrehmoment (Te) nimmt einen Wert Null an, der den Haltezustand angibt, das Motordrehmoment (Tm) wird allmählich in einem beschleunigten Zustand angehoben, wobei das Ausgangsdrehmoment in Übereinstimmung mit einem Ausgangssteuerkennfeld ist, welches zuvor in Übereinstimmung mit dem Grad der Gaspedalstellung bestimmt wurde, der Ci-Kupplungsdruck (Pci) nimmt einen Wert von Null an, der den Nichteingriffszustand wiedergibt, und das Ausgangswellendrehmoment (Tout) ist in einem Zustand, in dem es allmählich angehoben ist, um mit den Antriebskräften übereinzustimmen, die durch das Elektromotordrehmoment verwirklicht sind.

Wenn der Grad der Gaspedalstellung im Elektromotorantriebsbereich angehoben wird, um in den Ci-Kupplungswartezustandssteuerbereich überzugehen, wird ein Solenoidsignal (wie mit einer unterbrochenen Linie in **Fig.** 1 gezeigt ist) von der Steuereinheit **5** zu der hydraulischen Steuereinheit **6** übertragen. Folglich wird eine solche Steuerung ausgeführt, daß der Ci-Kupplungsdruck, wie der Schnellfülldruck (Pf), dem hydraulischen Servo der Ci-Kupplung **3** für eine Schnellfüllzeitspanne (tf) (wie durch eine unterbrochene Linie in **Fig.** 1 gezeigt ist) zugeführt wird. Der Schnellfülldruck (Pf) und die Schnellfüllzeitspanne (tf) sind auf einen Wert bestimmt, durch den der Kupplungskolben schnell bewegt werden kann und der Zylinder des hydraulischen Servos der Ci-Kupplung **3** mit Öl gefüllt werden kann.

Dann wird ein ähnlicher Vorgang verwendet, so daß der Wartezustandsdruck (Pstby) für eine Wartezustandszeitspanne (tstby) aufgebracht wird. Der Wartezustandsdruck (Pstby) hat ein Druckniveau (beispielsweise etwa 100 kPa bis etwa 200 kPa) bei dem die Ci-Kupplung **3** in der Lage ist, kleine Drehmomente zu übertragen, um die Kurbelwelle der Maschine **1** leicht zu drehen und bei dem die Kurbelwelle in einer Winkelposition angehalten wird, die mit dem Verdichtungsdrehmoment übereinstimmt, unmittelbar vor der Position, die dem erforderlichen Kompressionsdrehmoment entspricht. Die Wartezustandszeitspanne (tstby) muß beispielsweise etwa mehrere hundert Millisekunden betragen, wenn das erste oder das dritte Bestimmungsverfahren verwendet werden. Wenn das erste Bestimmungsverfahren verwendet wird, wird die Abtaststeuerung sofort begonnen. Wenn das dritte Bestimmungsverfahren verwendet wird, wird die Ci-Kupplung **3** abgeschaltet. Dann wird ein Elektromotorantriebsmodus gestartet. Wenn das zweite Bestimmungsverfahren verwendet wird, wird die Wartezustandszeitspanne (tstby) fortgesetzt, bis die nächste Steuerung (Abtaststeuerung) des Drucks der Ci-Kupplung **3** ausgeführt wird.

Wenn die Ci-Kupplungswartezustandssteuerung wie oben beschrieben ausgeführt wurde, wird das Drehmoment des Elektromotors **2** auf die Maschine **1** über die Ci-Kupplung **3** übertragen. Somit wird die Maschine **1** gedreht. Weil das erforderliche Drehmoment zu Beginn des Kompressionshubs des ersten Zylinders erhöht ist, rutscht die Ci-Kupplung **3** durch. Somit wird die Maschine **1** an einer Position angehalten, die dem gegenwärtigen Kurbelwinkel entspricht, so daß die Maschine **1** vor dem Anlaßbetrieb in den Wartezustand gebracht ist. Der Drehwinkel für die Maschine **1** ist nicht größer als etwa 100° im Fall einer Sechszylindermaschine. Während der vorgenannten Zeitspanne wird ein Teil des Elektromotordrehmoments (Tm) verwendet, um die Maschine **1** in die Anlaßstartstellung zu drehen. Weil nur ein geringer Drehwiderstand vorliegt, wird kein großer Einfluß auf das Ausgangswellendrehmoment (Tout) ausgeübt. Weil die Kurbelwinkelposition stets vor der Stellung positioniert wird, in der das Anlaßdrehmoment wie oben beschrieben erzeugt wird, wird stets dasselbe Anstiegsverhalten des Anlaßdrehmoments realisiert, wenn die Steuerung beginnt. Im Ergebnis kann die Abtastantwort des Ci-Kupplungsdrucks während der Maschinenanlaßsteuerung verbessert werden.

Nach dem Verstreichen der Wartezustandszeitspanne (tstby) in der der Wartezustand realisiert ist, wird das Maschinenanlassen durch die Anlaßsteuereinrichtung ausgeführt. In diesem Fall werden das Elektromotordrehmoment (Tm) und der Ci-Kupplungsdruck (Pci) angehoben und der Anlassermotor **11** wird gleichzeitig gestartet. Im Ergebnis wird das Elektromotordrehmoment (Tm) derart angehoben, daß das angehobene Drehmoment (Tcrunk) und das Anlaßdrehmoment zu dem vorhergehenden Drehmoment (Tacc) addiert werden, das erforderlich ist, daß Fahrzeug anzutreiben und dem Grad der Gaspedalstellung entspricht. Das Drehmoment wird über die Kupplung übertragen, deren Drehmomentübertragungsleistung im Zusammenhang mit dem Anheben des Ci-Kupplungsdrucks (Pci) angehoben wurde, um somit die Maschine **1** anzuwerfen. Im Ergebnis beginnt die Maschine **1** zu drehen, während sie das Spitzendrehmoment übersteigt, daß aus Trägheitsdrehmomenten resultiert, die bei der Erhöhung der Umdrehungen der Maschine **1** erzeugt sind. Obwohl der Anstieg der Umdrehungen durch Erfassen der Maschinendrehzahl (Ne) bestimmt werden kann, wird bestimmt ob die Ausschaltzeit (toff) des Anlassermotors vergangen ist, weil die kleine Anzahl von Umdrehungen nicht genau erfaßt werden kann. Wenn die Ausschaltzeit (toff) verstrichen ist, wird der Anlasser ausgeschaltet. Der Zustand, in welchem das Elektromotordrehmoment angehoben ist, wird aufrechterhalten. Wenn die Anzahl von Umdrehungen der Maschine **1** auf eine vorbestimmte Anzahl von Umdrehungen in diesem Fall angehoben wurde, wird der Zündzeitpunkt eingestellt. Gleichzeitig mit der Zündung wird das Elektromotordrehmoment (Tm) auf den Drehmomentwert zurückgeführt, der erforderlich ist, um das Fahrzeug anzutreiben.

Die Bestimmung hinsichtlich der Beendigung der Verbrennung zur Bestätigung des Anspringens der Maschine (in einem Zustand in dem die Maschine kontinuierlich drehen kann), kann durch die nachfolgend beschriebenen Verfahren ausgeführt werden. Ein erstes Verfahren nutzt den Ausgang eines O_2 Sensors, der in dem Abgasabschnitt angeordnet ist, um zur allgemeinen Steuerung des Luft Brennstoffverhältnisses verwendet zu werden. Bei diesem Verfahren wird die Konzentration von Sauerstoff im Abgas deutlich vermindert, wenn der Verbrennungshub in dem Zylinder kontinuierlich ausgeführt wird. Folglich kann bestimmt werden, daß die Verbrennung vervollständigt wurde. Ein zweites Verfahren ist die Erfassung der Temperatur des Abgases oder der Temperatur eines katalytischen Wandlers (Katalysator) zur Verarbeitung des Abgases. Ein drittes Verfahren ist die Erfassung des Verbrennungsdrucks in dem Zylinder. Das erste Verfahren ist das effizienteste unter den vorgenannten Verfahren. Wenn ein O_2 Sensor mit einem Heizer verwendet wird, um die Leistung (Empfindlichkeit) des Sensors zu stabilisieren, sogar wenn die Temperatur des Abgases niedrig ist, kann ein noch besseres Ergebnis erhalten werden. Weil das dritte Verfahren einen Sensor enthält, der ausschließlich bei Magermotoren verwendet wird, würde ein solcher Sensor andernfalls lediglich zur Bestimmung der Vollendung der Verbrennung verwendet. Folglich ist das dritte Verfahren hinsichtlich der Kostenverminderung nachteilig.

Wenn die Vollendung der Verbrennung in der Maschine **1** bestimmt wurde, wird ein elektrisches Drosselventil zu einem Grad geöffnet, der der Gaspedalstellung bei den verschiedenen Gelegenheiten entspricht. Folglich wird die Anzahl Umdrehungen der Maschine **1** der Eingangsanzahl von Umdrehungen in das Getriebe angenähert, das durch den Elektromotor mit dem dem Grad der Gaspedalstellung entsprechenden Drehmoment betrieben wird. Wenn der Eingriff der Ci-Kupplung **3** vervollständigt ist (wenn die Anzahl von Umdrehungen der Maschine **1** und die Eingangsanzahl von Umdrehungen in das Getriebe identisch sind) wird das Elektromotorausgangsdrehmoment (Tm) mit einem vorbestimmten Gradienten in Übereinstimmung mit dem Grad der Gaspedalstellung heruntergefahren.

Ein spezieller Ablauf zur Durchführung der vorgenannten Steuerung wird nun unter Bezugnahme auf ein Flußdiagramm beschrieben. **Fig.** 4 zeigt ein Hauptflußdiagramm zur Steuerung des Anlassens der Maschine während der Fahrt des Fahrzeugs. Der Grad der Gaspedalstellung wird im Schritt S1 eingelesen und die Fahrzeuggeschwindigkeit wird im Schritt S2 eingelesen. Somit wird im Schritt S3 auf der Basis des Antriebskennfelds (siehe **Fig.** 2) bestimmt, ob der gegenwärtige Fahrzustand im Maschinenantriebsbereich ist. Im Schritt S4 wird auf der Basis des Antriebskennfelds bestimmt, ob der gegenwärtige Fahrzustand im Wartezustandsbereich der Ci-Kupplung **3** ist. Wenn die Bestimmung in einem der Schritte S3 oder S4 JA ist, wird die Ci-Kupplungswartezustandssteuerung im Schritt S5 ausgeführt. Im Schritt S6 wird die Maschinenanlaßsteuerung ausgeführt.

Fig. 5 zeigt eine Subroutine für die Wartezustandssteuerung der Ci-Kupplung, die im Schritt S5 gemäß **Fig.** 4 ausgeführt wird. In der vorgenannten Routine wird zur Ausgabe im Schritt S21 der Ci-Kupplungsdruck (Pci) auf einen Anfangswert (Pf) gesetzt. Somit wird ein Vorgang zur Verkürzung des Kolbenhubs der Kupplung ausgeführt. Der Betrieb der Ci-Kupplung durch den vorgenannten Vorgang kann bestätigt werden, wenn die Zeit (tf) seit der Ausgabe des hydraulischen Drucks in Übereinstimmung mit einem Zeitgeber im Schritt S22 verstrichen ist.

Nachdem die vorgenannte Zeit verstrichen ist, wird der Ci-Kupplungsdruck (Pci) auf den vorbestimmten Wartezustandsdruck (Pstby) gesetzt, um die Maschine in die Anlaßstartposition im Schritt S23 zu bringen. Dann wird der Wartezustandsdruck (Pstby) ausgegeben. Als ein Ergebnis wird die Kurbelwelle der Maschine leicht gedreht, so daß die Maschine in die Anlaßstartposition gebracht wird (vor den Verdichtungshub). Die Anlaßstartposition wird im Schritt **27** bestätigt, indem bestimmt wird ob die vorbestimmte Wartezustandszeitspanne (tstby) seit dem Ausgang des Wartezustandsdrucks (Pstby) verstrichen ist. Im Schritt S25 wird bestimmt, ob der Maschinenantriebsbereich gestartet wurde. Wenn die vorgenannte Bestimmung JA ist, wird die Maschinenanlaßsteuersubroutine gestartet. Wenn die Bestimmung des Maschinenantriebsbereichs im Schritt S25 NEIN ist, wird im Schritt S26 bestimmt, ob der Zustand in dem Wartezustandsbereich der Ci-Kupplung ist. Wenn die vorgenannte Bestimmung JA ist, kehrt der Betrieb zum Schritt S23 zurück, so daß der Ci-Kupplungsdruck (Pci) auf dem Wartezustandsdruck (Pstby) gehalten wird. Wenn die Bestimmung des Wartezustandsbereichs der Ci-Kupplung im Schritt S26 NEIN ist, wird bestimmt, daß der Zustand in den Elektromotorantriebsbereich zurückgekehrt ist. Somit wird die vorgenannte Steuerung unterbrochen, indem ein Ablauf zum Zurücksetzen des Ci-Kupplungsdrucks (Pci) auf Null in Schritt S27 ausgeführt wird.

Das Anlassen der Maschine wird durch zwei Verfahren gesteuert, nachdem der vorgenannte Wartezustand realisiert wurde. Ein erstes Ausführungsbeispiel, eine den Anlassermotor verwendende Steuerung, wird nun beschrieben.

In dem ersten Ausführungsbeispiel werden die Schritte S31 bis S33 zu Beginn der Maschinenanlaßsteuerungssubroutine gemäß **Fig.** 6 gleichzeitig ausgeführt. Um das Diagramm verständlicher beschreiben zu können, werden die Schritte sequentiell dargestellt. Im Schritt S31 wird der Anlassermotor gestartet. Im Schritt S32 wird der Ci-Kupplungsdruck (Pci) so gesetzt, daß er die Bedingung Pci = (Tcrunk/m – c)/a erfüllt, wobei Tcrunk ein Mittelwert des Anlassens ist, d. h. erforderliches Anlaßdrehmoment der Maschine, das zuvor für die Maschine bestimmt wurde, m ein Reibungskoeffizient eines Reibelements der Kupplung ist und a und c auf der Basis der Kupplung bestimmte Konstanten sind.

Im Schritt S23 wird ein Ausgang des Elektromotordrehmoments (Tm) erzeugt. Das Motordrehmoment ist so gewählt, daß es die Bedingung Tm = Tcrunk + Tacc erfüllt, wobei Tcrunk das zum Anlassen der Maschine erforderliche Drehmoment ist und Tacc das Drehmoment ist, das dem Grad der Gaspedalstellung entspricht und erforderlich ist, um das Fahrzeug anzutreiben. Nachdem die vorhergehenden Schritte wie oben beschrieben ausgeführt wurden, wird im Schritt S34 bestimmt, ob die Ausschaltzeit (toff) vom Beginn der Steuerung verstrichen ist. Die vorgenannte Zeit ist eine sehr kurze Zeitspanne, die es der Maschine gestattet sich langsam zu drehen (eine Umdrehung). Wenn das Verstreichen der Ausschaltzeit (toff) bestätigt ist, wird der Anlassermotor im Schritt S35 abgeschaltet (AUS). Weil der Anlasser für eine sehr kurze Zeitspanne im vorgenannten Fall betätigt wird, entstehen keine Schwierigkeiten hinsichtlich der Lebensdauer des Anlassers und hinsichtlich der durch den Start des Anlassers erzeugten Geräusche. Die oben beschriebenen Schritte S31 bis S35 bilden die Steuerung des Beginns der Maschinenumdrehung. In Schritt S36 wird bestimmt, ob die Umdrehung der Maschine eine vorbestimmte Anzahl von Umdrehungen (beispielsweise 500 U/min hat, d. h. die Anzahl Umdrehungen, bei der der vollständige Verbrennungszustand erreicht wird, und die Maschine in der Lage ist, durch Kraftstoffversorgung und Zündung zu drehen). Wenn die Bestimmung im Schritt S36 JA ist, wird im Schritt S37 der Kraftstoff in die Maschine eingespritzt, so daß die Zündung ausgeführt wird, und somit ist die Maschine angelassen. Die obigen Schritte S32 bis S36 bilden die Steuerung der Beschleunigung der Maschinenumdrehung.

Nachdem die Maschine angelassen wurde, wird das Elektromotordrehmoment (Tm) auf das dem Grad der Gaspedalstellung entsprechende Drehmoment (Tacc) im Schritt S38 zurückgeführt. Der vorgenannte Vorgang wird ausgeführt, weil das Anlaßdrehmoment (Tcrunk) nach dem Anlassen der Maschine nicht erforderlich ist. Im Schritt S39 wird bestimmt, ob die Maschinendrehzahl (Ne) mit der Eingangsanzahl von Umdrehungen (Nin) des Getriebes innerhalb eines Bereichs von ± Na synchronisiert ist. Wenn die Synchronisierung bestätigt wird (JA) wird der Ci-Kupplungsdruck (Pci) im Schritt S40 auf 100% gesetzt, d. h. P100. Somit ist die Ci-Kupplung vollständig in Eingriff und das Drehmoment der Maschine kann auf die Räder übertragen werden. Folglich wird ein Vorgang zur Verminderung des Elektromotordrehmoments (Tm) im Schritt S41 ausgeführt. Gleichzeitig nimmt ein Drehmomentausgang (Te = Tacc – Tm) infolge des Herunterfahrens des Elektromotordrehmoments (Tm) ab. Insbesondere wird ein Signal zu der elektrischen Drossel übertragen, um die Drossel zu öffnen. Im Schritt S43 wird bestimmt, ob das Elektromotordrehmoment (Tm) auf Null gesetzt wurde. Wenn die vorgenannte Bestimmung JA ist, ist das Umschalten vom Elektromotorantrieb auf den Maschinenantrieb vollendet. Die vorgenannten Schritte S38 bis S43 bilden den die Steuerung abschließenden Teil.

Das erste Ausführungsbeispiel beseitigt die Notwendigkeit des Elektromotors die Leistung zur Herausgabe des Anlaßdrehmoments zusätzlich zu der Leistung zum Antrieb des Fahrzeugs anzupassen. Folglich kann die Größe des Elektromotors vermindert werden. Weil der übliche massenproduzierte Anlassermotor zum Drehen der Maschine allgemein verwendet werden kann, kann ein Kostenanstieg minimiert werden. Wenn ferner der Ladezustand (SOC) eines Hochspannungssystems (einer Stromquelle zum Betrieb des Elektromotors) auf Null gesetzt wurde, infolge von Selbstentladung oder dergleichen, die durch unsachgemäßem Gebrauch über eine größere Zeitspanne hervorgerufen wurde, ist ein Vorteil darin zu sehen, daß die Maschine mit der 12 V Batterie für die Hilfseinrichtungen angelassen werden kann, wie die üblichen maschinenbetriebenen Fahrzeuge.

Zudem kann Starthilfe mit einem Starthilfekabel gegeben werden. Ferner kann ein Anlassen der Maschine bei sehr niedrigen Temperaturen (–30°C bis –40°C) mit einem gleichen Ansprechverhalten wie bei einem herkömmlichen

Fahrzeug ausgeführt werden unabhängig von der Leistung der elektrischen Ölpumpe bei niedrigen Temperaturen.

Das erste Ausführungsbeispiel ist derart aufgebaut, daß der Elektromotor **2** hauptsächlich betrieben wird und der Anlassermotor **11** zusätzlich betrieben wird. Ein anderer, gegensätzlicher Aufbau kann verwendet werden, bei dem der Anlassermotor **11** hauptsächlich und der Elektromotor **2** zusätzlich betrieben wird. In diesem Fall ist ein Stromsensor zur Messung eines Stromwerts in dem Schaltkreis zum Betrieb des Anlassermotors vorgesehen, um einen Stromwert zu messen, der in den Anlassermotor fließt. Ein Ausgangswert vom Stromsensor wird verwendet, um eine Regelung des Ausgangsdrehmoments des Elektromotors auszuführen, wenn die Anlaßsteuerung ausgeführt wird. **Fig.** 7 zeigt eine Zeittafel der vorgenannten Steuerung. Bei der Steuerung wird das Ausgangsdrehmoment vom Elektromotor derart eingestellt, daß der Strom (Ist) zum Betrieb des Anlassermotors einen vorbestimmten Wert nicht übersteigt. Der Kupplungsdruck (Pci) soll einfach so gesteuert werden, daß der Druck simultan mit dem Start des Anlassermotors auf den Leitungsdruck hochgefahren wird, wonach er konstant gehalten wird. Der Betrieb des Anlassermotors wird unterbrochen, wenn die Maschinendrehzahl auf eine vorbestimmte Umdrehungszahl angestiegen ist.

Wenn die vorgenannte Steuerung ausgeführt wird, kann die Betriebslast des Anlassermotors **11** auf einen Wert gleich oder kleiner als ein vorbestimmter Grenzwert vermindert werden, wie mit einer durchgezogenen Linie in **Fig.** 7 gezeigt ist. Die Anlaßlast entsprechend der durch eine unterbrochene Linie in **Fig.** 7 gezeigten Spitze wird durch den Elektromotor **2** zur Verfügung gestellt.

Das erste Ausführungsbeispiel hat den Aufbau, bei dem das Anlassen der Maschine **1** hauptsächlich durch den Elektromotor **2** erfolgt. Ferner wird der Anlassermotor **11** zusätzlich betätigt, wenn die Umdrehung der Maschine **1** beginnt. Jedoch kann das Anlassen der Maschine **1** inklusive deren Beginn lediglich durch den Elektromotor **2** ausgeführt werden, ohne den Anlassermotor **11** zu betätigen. Ein zweites Ausführungsbeispiel mit dem vorgenannten Aufbau wird nun unter Bezugnahme auf eine Zeittafel gemäß **Fig.** 8 beschrieben.

Auch in dem zweiten Ausführungsbeispiel ist der Vorgang vom Ausgangszustand in die Wartezustandssteuerung auf eine gleiche Weise ausgeführt wie bei dem ersten Ausführungsbeispiel. Folglich ist dort wo der Vorgang der gleiche ist, dieser aus der Beschreibung weggelassen.

Nachdem die Wartezustandszeitspanne (tstby) in der der Wartezustand realisiert wird, verstrichen ist, läßt die Anlaßsteuereinrichtung die Maschine an. Im Unterschied zum ersten Ausführungsbeispiel werden der Anstieg des Elektromotordrehmoments (Tm) auf einen maximalen Wert (Tmmax) und das Anheben des Ci-Kupplungsdrucks (Pci) gleichzeitig ausgeführt. Im Ergebnis wird das Elektromotordrehmoment (Tm) durch Addieren des erhöhten Drehmoments zu dem vorhergehenden Drehmoment (Tacc) entsprechend dem Grad der Gaspedalstellung und erforderlich zum Antrieb des Fahrzeugs erhalten. Weil das Drehmoment über die Ci-Kupplung **3** übertragen wird, deren Drehmomentübertragungsleistung infolge des Anstiegs des Ci-Kupplungsdrucks (Pci) angehoben wurde, wird das Anlassen der Maschine **1** ausgeführt. Im Ergebnis beginnt die Maschine **1** zu drehen, während sie das Spitzendrehmoment übersteigt, das durch das Trägheitsdrehmoment zur Zeit des Anstiegs der Drehzahl der Maschine **1** erzeugt ist. Der Beginn der Drehung (leichte Drehung) wird durch einen Zeitgeber oder die Maschinendrehzahl (Ne) bestimmt. Dann wird das Elektromotordrehmoment (Tm) auf das Drehmoment (Tmt) reduziert, welches ausreicht die Anzahl der Umdrehungen der Maschine mit einem vorbestimmten Änderungsgrad zu erhöhen, während es den Anstiegszustand aufrechterhält. Auch in diesem Fall wird der Zündzeitpunkt bestimmt, wenn die Anzahl von Umdrehungen der Maschine **1** auf eine vorbestimmte Anzahl von Umdrehungen angehoben wurde. Gleichzeitig mit der Zündung wird das Elektromotordrehmoment (Tm) auf das Drehmoment (Tacc) zurückgeführt, das erforderlich ist, das Fahrzeug anzutreiben. Die nachfolgende Steuerung wird auf eine gleiche Weise ausgeführt, wie bei dem ersten Ausführungsbeispiel.

Wenn die Maschine lediglich durch den Elektromotor **2** angelassen wird, entspricht die Änderung (Abnahme) des Drehmoments (Tout) zum Antrieb des Fahrzeugs beim Anlassen der Maschine der Höhe des Drehmoments, das durch die Ci-Kupplung **3** übertragen werden kann. Folglich ist die Höhe des Drehmoments, das durch die Ci-Kupplung **3** übertragen werden kann, durch den Eingriffsdruck gesteuert. Unter Berücksichtigung der Kombination der Verminderung des Antriebsdrehmoments und der Zeit während der die Verminderung anhält, wird ein Stoß auf einen erlaubten Pegel, der durch den Körper eines mitfahrenden Passagiers erfaßt wird, innerhalb des Bereichs des Ausgangsdrehmoments des Elektromotors **2** reduziert. Folglich kann die Erzeugung eines unangenehmen Verzögerungsgefühls verhindert werden.

Weil ein Ausgangsbereich (eine Anlaßsteuerung) (Ne = 0 bis Ne1, eine vorbestimmte geringe Anzahl von Umdrehung) für die Steuerung des Anlassens der Maschine in diesem Fall das größte Anlaßdrehmoment erfordert, ist das Ausgangsdrehmoment von dem Elektromotor auf den maximalen Wert (Tmmax) für die vorgenannte Zeitspanne gesetzt. Der vorhergehende Wert variiert in Abhängigkeit von verschiedenen Bedingungen, inklusive der Fahrzeuggeschwindigkeit, der Temperatur der Batterie, dem Ladezustand (SOC) und dergleichen. Gleichzeitig mit der Drehmomentsteuerung wird eine auf die nachfolgende Weise beschriebene Steuerung des Ausgangs eines Ci-Kupplungsdrucks (Pci) erzeugt. Es wird angenommen, daß das zum Anlassen der Maschine (um die Drehungen zu beginnen) erforderliche Drehmoment Tmes wie folgt ist:

Tmes = Tci (von der Ci-Kupplung übertragenes Drehmoment) = (aPci + c) m,

wobei a und c Konstanten sind, die durch die Eigenschaften der Kupplung bestimmt sind, m ein Reibkoeffizient des Reibglieds der Kupplung und Pci ein Eingriffsdruck der Ci-Kupplung ist. Es ist anzumerken, daß m in Übereinstimmung mit der Durchrutschgeschwindigkeit des Reibglieds berechnet ist, wobei der auf die Druckfläche aufgebrachte Druck und die Öltemperatur so sind, wie sie dem Fachmann bekannt sind. Das Verhältnis des Drehmoments (Tmes) zum Anlassen der Maschine bezüglich des Drehmoments (Tmk) zum Antreiben des Fahrzeugs ist in Übereinstimmung mit einem Ergebnis einer Auswertung eines Gefühls in einem tatsächlichen Fahrzeug ermittelt. Wenn das Drehmoment (Tmes) zum Anlassen der Maschine in einem Bereich des maximalen Drehmoments (Tmmax), das erzeugt werden kann, abnimmt, ist die Zeit für die anfängliche Steuerung des Anlassens der Maschine (die Anlaßsteuerung) im Bereich (Ne = 0 bis Ne 1) verlängert. In diesem Fall ist das Anlaßansprechen gestört. Wenn im Gegensatz dazu das Drehmoment (Tmes) angehoben wird, bewirkt ein nichtausreichendes Drehmoment, daß der Passagier im Fahrzeug einen großen Stoß beim Anlassen fühlt. Die vorgenannte Steuerung wird ausgeführt, bis die Anzahl Umdrehungen der Maschine eine vorbestimmte geringe Anzahl von Umdrehungen (Ne1) erreicht.

In einem Bereich, in welchem die Anzahl von Umdrehungen klein ist, bis sie die kleine Anzahl von Umdrehungen

(Ne1) erreicht, kann ein preiswerter Sensor, wie ein elektromagnetischer Aufnehmer die Maschinenumdrehungen (Ne) nicht genau erfassen. Folglich kann die vorgenannte Steuerung in Übereinstimmung mit einem Ausgang von einem Sensor zur Erfassung der Luftansaugmenge der Maschine anstelle der Maschinenumdrehungen (Ne) erfolgen.

Nachdem die vorgenannte Steuerung ausgeführt wurde, wird die Konstantbeschleunigungssteuerung ausgeführt. Die vorgenannte Steuerung erfolgt derart, daß der Eingriffsdruck der Ci-Kupplung geregelt wird, so daß die Anzahl von Umdrehungen der Maschine mit einer vorbestimmten Beschleunigung erhöht wird. Wenn die Maschinenumdrehungen (Ne) auf die kleine Anzahlumdrehungen (Nel) angehoben ist, wird der Ausgang des Elektromotors auf das Drehmoment (Tmt) zur konstanten Beschleunigung der Maschine reduziert. Das vorgenannte Drehmoment kann in Übereinstimmung mit einer Maschinenöltemperatur (Teoil) und der .Maschinendrehzahl (Ne) bestimmt werden. Die vorgenannte Beziehung kann als ein Wert von experimentellen Ergebnissen erhalten werden. Bei der vorgenannten Bedingung des Ausgangs von dem Elektromotor ist der Ausgang des Ci-Kupplungseingriffsdrucks (Pci) geregelt, so daß die Anstiegsrate (dNe/dt) auf einen vorbestimmten Wert gesetzt ist.

Nachdem die Maschinendrehzahl (Ne) die Synchronisierungsanzahl von Umdrehungen (Nin, ein zwischen 500 U/min bis etwa 700 U/min reichender angemessener Wert) erreicht hat, wird die Steuerung der Maschine zum Einspritzen von Kraftstoff auf die gleiche Weise wie bei dem vorhergehenden Verfahren gestartet. Dann wird schließlich die Vollendungssteuerung begonnen. Bei der vorgenannten Steuerung wird die Antriebsquelle vom Elektromotorantrieb auf den Maschinenantrieb umgeschaltet. Zu dieser Zeit ist ein Zeitgeber auf eine angemessene Zeit nach der Bestätigung der Synchronisierung gesetzt. Um eine zuverlässige Synchronisierung auszuführen, wird der kontinuierlich synchronisierte Zustand aufrechterhalten und dann wird der Eingriffsdruck der Ci-Kupplung auf einen Druck angehoben, der einem Leistungsverhältnis von 100% entspricht.

Eine Subroutine zur Steuerung des Anlassens der Maschine gemäß dem zweiten Ausführungsbeispiel wird in Übereinstimmung mit einem in **Fig.** 9 und 10 gezeigten Flußdiagramm ausgeführt. Im Schritt S51 wird das Elektromotordrehmoment (Tm) auf das maximale Drehmoment (Tmmax) gesetzt, das von dem Elektromotor bei den vorliegenden Bedingungen abgegeben werden kann. Das Maximaldrehmoment (Tmmax) ist das Drehmoment, mit dem sowohl das Drehmoment (Tmes) zum Anlassen der Maschine als auch das Drehmoment (Tmk) zum Antreiben des Fahrzeugs erzeugt werden. Des maximale Drehmoment (Tmmax) kann in Übereinstimmung mit der Fahrzeuggeschwindigkeit, dem Ladezustand der Batterie oder der Temperatur der Batterie verändert werden. Gleichzeitig wird im Schritt S52 der Ci-Kupplungsdruck (Pci) derart bestimmt, daß er $Pci - ((Tmes/m) - c)/a$ erfüllt. Dies bedeutet, daß der Ci-Kupplungsdruck (Pci) auf einen Wert bestimmt ist, der es gestattet, daß die Ci-Kupplung das Anlaßdrehmoment (Tmes) übertragen kann.

Im Schritt S53 wird bestimmt, ob die Maschinendrehzahl (Ne) größer ist als die vorbestimmte geringe Anzahl von Umdrehungen (Nel). Die vorgenannte Bestimmung kann in Übereinstimmung mit der durch den Zeitgeber gemessenen Zeit erfolgen anstelle der Anzahl von Umdrehungen. Im Schritt S54 wird das Elektromotordrehmoment (Tm) auf das Drehmoment (Tmt) abgesenkt, mit dem die Anzahl von Umdrehungen der Maschine mit einer vorbestimmten Änderungsrate erhöht werden kann. Im Schritt S55 wird der Ci-Kupplungsdruck (Pci) auf einen Regelungsausgangswert (Pa) gesetzt. Im Schritt S56 wird die gegenwärtige Änderungsrate (dX2) der Anzahl der Umdrehungen der Maschine erhalten. Im Schritt S57 wird eine Abweichung (dX) von einer erforderlichen Änderungsrate (dX1) erhalten. Im Schritt S58 wird eine Druckänderung (dPci) in Übereinstimmung mit der erhaltenen Abweichung (dX) erhalten. Der vorgenannte Wert ist derart bestimmt, daß wenn die Abweichung (dX) in Richtung positiver Werte groß ist, der Ci-Kupplungsdruck (Pci) reduziert wird. Wenn die Abweichung (dX) in Richtung negativer Werte groß ist, wird der Ci-Kupplungsdruck (Pci) erhöht. Somit wird die tatsächliche Regelung im Schritt S59 ausgeführt.

Im Schritt S60 wird bestimmt, ob die Maschinendrehzahl (Ne) eine vorbestimmte Anzahl von Umdrehungen überschritten hat (beispielsweise 500 U/min). Der Ablauf kehrt zum Schritt S56 zur Ausführung der Regelung zurück, bis die vorgenannte Bestimmung gemacht wird. Wenn im Schritt S60 bestimmt wird, daß die Anzahl von Maschinenumdrehungen die vorbestimmte Anzahl von Umdrehungen erreicht hat, schreitet der Ablauf zum Schritt S61 fort. Im Schritt S61 wird bestimmt, ob der Zustand einen vollständigen Verbrennungszustand erreicht hat, bei dem die Zündung in der Maschine aufgetreten ist. Die vorgenannte Bestimmung kann in Übereinstimmung mit einem Ausgang vom O_2 (Sauerstoffsensor) ausgeführt werden, der im Abgasabschnitt der Maschine vorgesehen ist, um das Luft Brennstoffverhältnis wie oben beschrieben zu steuern. Wenn die Verbrennung in dem Zylinder aufeinander folgend in allen Zylindern ausgeführt wird und somit die Sauerstoffkonzentration im Abgas deutlich verringert ist, kann die vorgenannte Bestimmung ausgeführt werden. Weil die vorgenannte Bestimmung in einem ersten Umlauf NEIN ist, geht das Programm zum Schritt S62 über, in dem Kraftstoff zur Zündung in die Maschine eingespritzt wird.

Die nachfolgenden Abläufe in den Schritten S63 bis S67 sind im wesentlichen gleich jenen in den Schritten S39 bis S43 des ersten Ausführungsbeispiels. Folglich werden die gleichen Abläufe nicht erneut beschrieben.

Bei dem zweiten Ausführungsbeispiel kann die Maschine mit einem schnellen Ansprechen unter einfacher Steuerung wieder angelassen werden, ohne den Anlassermotor **11** zu verwenden. Folglich kann mit der vorgenannten Steuerung ein dahingehender Vorteil realisiert werden, daß die vorgenannte Steuerung auf eine Hybridantriebsvorrichtung angewandt werden kann, die keinen Anlassermotor **11** hat.

Die Anlaßsteuerung gemäß dem zweiten Ausführungsbeispiel kann derart modifiziert werden, daß die Anzahl von Umdrehungen des Elektromotors geschätzten Werten folgt. In diesem Fall wird die Steuerung des Ausgangsdrehmoments von dem Elektromotor in der Anlaßsteuerung auf eine gleiche Weise ausgeführt, wie bei dem zweiten Ausführungsbeispiel. Die Steuerung des Ci-Kupplungsdrucks (Pci) wird in Übereinstimmung mit einer Zeittafel gemäß **Fig.** 11 ausgeführt. Dies bedeutet, daß der Übergang der Elektromotorumdrehung (Nm) vom Anlassen in Übereinstimmung mit einer Änderungsrate in der Elektromotordrehzahl (Nm) um eine vorbestimmte Zeitspanne vor dem Beginn des Anlassens geschätzt wird. Dann wird eine Abweichung (e) zwischen einem in Übereinstimmung mit dem geschätzten Wert bestimmten Sollwert und der tatsächlichen Elektromotordrehzahl (Nm) erhalten. Um zu bewirken, daß die Elektromotordrehzahl (Nm) den Sollwerten folgt, wird der Ausgang des Ci-Kupplungsdrucks (Pci) geregelt. Vorzugsweise wird die vorgenannte Steuerung auf der Basis eines Ausgangs (erfaßte Geschwindigkeit) von einem Sensor (einem Drehgeber) zur Erfassung der Position eines magnetischen Pols eines Elektromotors ausgeführt. Die nachfolgende Steuerung wird auf die gleiche Weise wie bei dem zweiten

Ausführungsbeispiel ausgeführt.

Obwohl ein Verfahren verwendet werden kann, in welchem der Sollwert der Elektromotordrehzahl (Nm) in Übereinstimmung mit der Fahrzeuggeschwindigkeit berechnet ist, kann eine zufriedenstellende Genauigkeit nicht erreicht werden, weil die Abweichung e bei dieser Modifikation sehr klein ist. Wenn der Magnetpolsensor des Elektromotors verwendet wird, kann eine zufriedenstellende Genauigkeit (ein Drehwinkel im Bereich von 10 Winkelsekunden bis zu einigen Minuten) erfaßt werden, um die Verwindung des Antriebssystems ebenfalls zu erfassen.

Die Beschreibung wurde dahingehend gemacht, daß das erfindungsgemäße Steuersystem auf die Antriebsvorrichtung mit dem in **Fig.** 1 gezeigten spezifischen Systemaufbau angewandt wurde. Eine Modifikation des Systemaufbaus der Getriebeeinheit **4** wird nun beschrieben. Ein drittes Ausführungsbeispiel gemäß **Fig.** 15 hat einen Aufbau, in welchem ein zweiter Elektromotor (M/G) **2A** zwischen der automatischen Getriebeeinheit **40** und der Ci-Kupplung **41** in der Getriebeeinheit **4** angeordnet ist. Bei diesem Ausführungsbeispiel wird eine Hilfseinheit **9** sogar betrieben, wenn die Maschine während der Fahrt abgestellt ist, indem ein Aufbau verwendet wird, bei dem die Hilfseinheit **9** über einen Keilriemen mit dem Elektromotor **2A** verbunden ist, um synchron betrieben zu werden. Auch die Antriebsvorrichtung mit dem vorgenannten Aufbau kann die Wartezustandssteuerung und die Anlaßsteuerung durch Verfahren gleich denen der vorgenannten Ausführungsbeispiele ausführen. Im vorgenannten Fall wird bei der Steuerung des Maschinenanlassens, der zweite Elektromotor **2A** gesteuert, um die Abnahme beim Drehmoment zu kompensieren. Folglich kann der durch das Anlassen der Maschine hervorgerufene Stoß daran gehindert werden, auf die mitfahrenden Passagiere aufgebracht zu werden. Weil die anderen Elemente gleich denen des ersten Ausführungsbeispiels sind, sind übereinstimmende Elemente mit den gleichen Bezugszeichen bezeichnet. Folglich sind die übereinstimmenden Elemente nicht beschrieben.

Ein in **Fig.** 16 gezeigtes viertes Ausführungsbeispiel hat einen Aufbau, in welchem ein Planetenzahnrad **40A** mit einer Verriegelungskupplung **42** zur Verbindung des Elektromotors **2** mit der Maschine (E/G) **1** und der automatischen Getriebeeinheit (T/M) **40** in der Getriebeeinheit **4** angeordnet ist. Folglich kann ein paralleler Antrieb und ein geteilter Antrieb der Maschine **1** und des Elektromotors **2** ausgeführt werden. Ein Sonnenrad **43** des Planetenzahnrads **40A** ist mit dem Elektromotor **2** verbunden, während ein Ringzahnrad **45** mit der Maschine **1** verbindbar ist. Ferner ist der als ein Ausgangselement dienende Träger **44** mit der automatischen Getriebeeinheit **40** verbunden. Andere diesen Aufbau bildende Elemente sind gleich jenen des ersten Ausführungsbeispiels. Folglich sind die gleichen Bezugszeichen an die gleichen Elemente vergeben und eine Beschreibung der gleichen Elemente unterbleibt. Wenn in diesem Ausführungsbeispiel die Maschine durch das Elektromotorantriebsverfahren angelassen wird, wird die Verriegelungskupplung **42** in den Eingriffszustand gebracht. Ferner werden die vorgenannte Wartezustandssteuerung und die Anlaßsteuerung ausgeführt, um die Steuerung der Ci-Kupplung **3** und des Elektromotors **2** auszuführen.

Ein in **Fig.** 17 gezeigtes fünftes Ausführungsbeispiel hat einen Aufbau, in welchem ein Planetenzahnrad **40B** zur Verbindung des Elektromotors **2** mit der Maschine (E/G) **1** und einem zweiten Elektromotor (M/G) **2B**, die anstelle der automatischen Getriebeeinheit verwendet werden, in der Getriebeeinheit **4** angeordnet ist. Im Gegensatz zu dem vierten Ausführungsbeispiel ist das Sonnenrad **43** des Planetenzahnrads **40B** mit den Elektromotor **2** verbunden, während der Träger **44** mit der Maschine **1** verbunden ist. Ferner ist das als ein Ausgabeelement dienende Ringzahnrad **45** mit dem zweiten Elektromotor (M/G) **2B** verbunden. Dieses Ausführungsbeispiel ist so aufgebaut, das die Ci-Kupplung, die in jedem der vorhergehenden Ausführungsbeispiele vorhanden war, entfernt ist. Mit dem vorgenannten Aufbau der Getriebeeinheit wird der Elektromotorantriebsbetrieb derart ausgeführt, daß der Elektromotor **2B** vorwärts dreht, um das Fahrzeug anzutreiben. Wenn die Maschine **1** angehalten wird, wird die Reaktion des Elektromotors **2** unterdrückt, indem der Elektromotor **2** durchgedreht wird. Wenn die Wartezustandssteuerung ausgeführt wird, um die Maschine anzulassen, wird der erste Elektromotor **2** mit einem kleinen Ausgangsdrehmoment langsam vorwärts gedreht. Somit wird der Wartezustand realisiert. Dann wird die Anlaßsteuerung ausgeführt, so daß das Drehmoment des ersten Elektromotors **2** und das des zweiten Elektromotors **2B** gleichzeitig erhöht werden. Auch bei diesem Ausführungsbeispiel kann der Stoß infolge des Anlassens der Maschine auf eine Weise gleich dem dritten Ausführungsbeispiel weiter minimiert werden.

Obwohl die Erfindung in fünf bevorzugten Formen mit einem gewissen Genauigkeitsgrad beschrieben wurde, ist anzumerken, daß die vorliegende Darstellung der bevorzugten Ausführungsform der Erfindung in Einzelheiten des Aufbaus und in der Kombination und Anordnung von Teilen variiert werden kann.

Es ist eine Hybridantriebsvorrichtung für ein Fahrzeug beschrieben, die in der Lage ist das Ansprechen beim Wiederanlassen einer Maschine während der Fahrt eines Fahrzeugs zu verbessern. Im Ergebnis kann ein Stoß infolge einer Verzögerung vermindert werden. Die Hybridantriebsvorrichtung für ein Fahrzeug hat eine Maschine, einen Elektromotor, eine Kupplung, eine Getriebeeinheit und eine Steuereinheit zur Steuerung der anderen Elemente. Die Steuereinheit hat eine Wartezustandssteuereinrichtung zur Realisierung einer konstanten Anlaßkennlinie, um das Anlaßansprechen beim Anlassen der Maschine durch Übertragung der Kraft des Elektromotors auf die Maschine und Steuern des Eingriffsdrucks der Kupplung zu verbessern, um somit die Maschine in eine Anlaßstartposition zu drehen.

Patentansprüche

1. Hybridantriebsvorrichtung für ein Fahrzeug, mit
einer Maschine (1),
einem Elektromotor (2),
einer Getriebeeinheit (4) zur Übertragung der Leistung der Maschine (1) und des Elektromotors (2) auf Räder (8), und einer Steuereinrichtung (5) zur Steuerung der Maschine (1), des Elektromotors (2) und der Übertragung der Leistung der Maschine (1) und des Elektromotors (2) auf die Räder (8), **dadurch gekennzeichnet**, daß die Steuereinrichtung (5)
eine Anlaßsteuerungseinrichtung (56) zum Anlassen der Maschine (1), wenn das Fahrzeug in einem Zustand fährt, in welchem die Maschine (1) angehalten ist und Leistung von dem Elektromotor (2) auf die Räder übertragen wird, und
eine Wartezustandssteuereinrichtung (S5) enthält, um eine Steuerung zur Drehung der Maschine (1) in eine Anlaßstartposition auszuführen, bevor das Anlassen der Maschine (1) von der Anlaßsteuerungseinrichtung (S6) ausgeführt wird.

2. Hybridantriebsvorrichtung nach Anspruch 1, ferner mit einer Kupplung (3) zwischen der Maschine (1) und dem Elektromotor (2), wobei die Wartezustandssteuer-

einrichtung (S5) eine Wartezustandsdrucksteuereinrichtung (S23) zur Steuerung eines Kupplungsdruck aufweist, so daß das von der Kupplung (3) übertragene Drehmoment eine Größe annimmt, die eine Drehung der Maschine (1) in die Anlaßstartposition zuläßt.

3. Hybridantriebsvorrichtung nach Anspruch 2, wobei die Anlaßsteuerungseinrichtung (S6) eine Anlaßdrucksteuerungseinrichtung (S52) aufweist, um den Eingriffsdruck der Kupplung (3) so zu steuern, daß die Größe des von der Kupplung (3) übertragenen Drehmoments kleiner oder gleich einem Ausgangsdrehmoment von dem Elektromotor (2) nach der Wartezustandssteuerung wird.

4. Hybridantriebsvorrichtung nach Anspruch 2, ferner mit einem Anlassermotor (11) zum Anlassen der Maschine (1), wobei die Anlaßsteuerungseinrichtung (S6) veranlaßt, daß nach der Wartezustandssteuerung gleichzeitig der Anlassermotor (11) gestartet und die Kupplung (3) eingerückt werden.

5. Hybridantriebsvorrichtung für ein Fahrzeug, mit
einer Maschine (1),
einem Elektromotor (2),
einer Kupplung (3) zur Steuerung der Leistungsübertragung zwischen der Maschine (1) und dem Elektromotor (2),
einer Getriebeeinheit (4) zur Übertragung der Leistung der Maschine (1) und des Elektromotors (2) auf Räder (8), und
einer Steuereinrichtung (5) zur Steuerung der Maschine (1), des Elektromotors (2) und der Kupplung (3), dadurch gekennzeichnet, daß die Steuereinrichtung (5)
eine Anlaßsteuerungseinrichtung (S6) zum Einrücken der Kupplung (3) zum Anlassen der Maschine (1), wenn das Fahrzeug in einem Zustand fährt, in welchem die Maschine (1) angehalten ist, die Kupplung (3) ausgerückt ist und Leistung von dem Elektromotor (2) auf die Räder übertragen wird, und
eine Wartezustandssteuereinrichtung (S5) enthält, um die Kupplung (3) einzurücken, um eine Drehung der Maschine (1) in eine Anlaßstartposition auszuführen, bevor das Anlassen der Maschine (1) von der Anlaßsteuerungseinrichtung (S6) ausgeführt wird, wobei die Wartezustandssteuereinrichtung (S5) eine Wartezustandsdrucksteuereinrichtung (S23) zur Steuerung eines Kupplungsdrucks aufweist, so daß das von der Kupplung (3) übertragene Drehmoment eine Größe annimmt, die eine Drehung der Maschine (1) in die Anlaßstartposition zuläßt, und wobei die Anlaßsteuerungseinrichtung (56) eine Anlaßdrucksteuerungseinrichtung (S52) aufweist, um den Eingriffsdruck der Kupplung (3) so zu steuern, daß die Größe des von der Kupplung (3) übertragenen Drehmoments kleiner oder gleich einem Ausgangsdrehmoment von dem Elektromotor (2) nach der Wartezustandssteuerung wird.

6. Hybridantriebsvorrichtung für ein Fahrzeug, mit
einer Maschine (1),
einem Elektromotor (2),
einem Anlassermotor (11) zum Anlassen der Maschine (1),
einer Kupplung (3) zur Steuerung der Leistungsübertragung zwischen der Maschine (1) und dem Elektromotor (2),
einer Getriebeeinheit (4) zur Übertragung der Leistung der Maschine (1) und des Elektromotors (2) auf Räder (8), und
einer Steuereinrichtung (5) zur Steuerung der Maschine (1), des Elektromotors (2), des Anlassermotors (11) und der Kupplung (3), dadurch gekennzeichnet, daß die Steuereinrichtung (5)
eine Anlaßsteuerungseinrichtung (S6) zum Anlassen der Maschine (1), wenn das Fahrzeug in einem Zustand fährt, in welchem die Maschine (1) angehalten ist, die Kupplung (3) ausgerückt ist und Leistung von dem Elektromotor (2) auf die Räder übertragen wird, und
eine Wartezustandssteuereinrichtung (S5) enthält, um die Kupplung (3) einzurücken, um eine Drehung der Maschine (1) in eine Anlaßstartposition auszuführen, bevor das Anlassen der Maschine (1) von der Anlaßsteuerungseinrichtung (S6) ausgeführt wird, wobei die Wartezustandssteuereinrichtung (S5) eine Wartezustandsdrucksteuereinrichtung (S23) zur Steuerung eines Einrückdrucks der Kupplung aufweist, so daß das von der Kupplung (3) übertragene Drehmoment eine Größe annimmt, die eine Drehung der Maschine (1) in die Anlaßstartposition zuläßt, und wobei die Anlaßsteuerungseinrichtung (S6), nach Beendigung der Wartezustandssteuerung gleichzeitig den Anlassermotor (11) startet und die Kupplung (3) einrückt.

7. Hybridantriebsvorrichtung nach Anspruch 5, wobei die Anlaßdrucksteuerungseinrichtung (S52) eine Konstantbeschleunigungssteuereinrichtung (S58) zur Steuerung des Eingriffsdrucks der Kupplung (3) hat, derart, daß eine Änderungsrate der Drehzahl der Maschine (1) einen Sollwert annimmt.

8. Hybridantriebsvorrichtung nach Anspruch 5, wobei die Anlaßdrucksteuerungseinrichtung (S52) eine Drehzahlhalte- und steuereinrichtung zur Steuerung des Eingriffsdrucks der Kupplung (3) hat, derart, daß eine Abnahmerate der Drehzahl des Elektromotors (2) kleiner oder gleich einem vorbestimmten Wert ist.

9. Hybridantriebsvorrichtung nach Anspruch 6, wobei die Anlaßsteuerungseinrichtung (S6) eine Anfangssteuerungseinrichtung (S31, S34) zum Betreiben des Anlassermotors (11) lediglich für eine Zeitspanne aufweist, in der die Maschine (1) leicht dreht.

10. Hybridantriebsvorrichtung nach Anspruch 6, wobei die Anlaßsteuerungseinrichtung (S6) eine Anlaßdruckeinstelleinrichtung (S32) zum Einstellen des Einrückdrucks der Kupplung (3) auf einen Wert aufweist, bei dem die Kupplung (3) einen Mittelwert des Anlaßdrehmoments der Maschine (1) überträgt.

11. Hybridantriebsvorrichtung nach Anspruch 6, wobei die Anlaßsteuerungseinrichtung (S6) eine Drehmomentsteuerungseinrichtung (S33) aufweist, um den Elektromotor (2) zu veranlassen, ein Ausgangsdrehmoment mit dem Mittelwert des Anlaßdrehmoments der Maschine (1) sowie dem Drehmoment zum Antrieb des Fahrzeugs zu erzeugen.

12. Hybridantriebsvorrichtung nach Anspruch 6, wobei die Anlaßsteuerungseinrichtung (S6) eine Drehmomentsteuerungseinrichtung aufweist um den Elektromotor (2) zu veranlassen, ein Ausgangsdrehmoment entsprechend dem Anlaufstrom für den Anlassermotor (11) zu erzeugen.

13. Hybridantriebsvorrichtung nach Anspruch 6, wobei eine Betriebszeit des Anlassermotors (11) durch einen Zeitgeber gesteuert ist.

14. Hybridantriebsvorrichtung nach Anspruch 5, wobei die Anlaßsteuerungseinrichtung (S6) eine Drehmomentsteuerungseinrichtung (S51) aufweist, um den Elektromotor (2) zu veranlassen, ein maximales Drehmoment abzugeben, und eine Druckerhöhungseinrichtung (S52) hat, um den Einrückdruck zur Erhöhung des von der Kupplung (3) übertragbaren Drehmoments zu erhöhen, wenn der Elektromotor (2) ein maximales

Ausgangsdrehmoment erzeugt.

15. Hybridantriebsvorrichtung nach Anspruch 5, wobei die Anlaßsteuerungseinrichtung (S6) eine Drehmomentsteuerungseinrichtung aufweist, um den Elektromotor (2) zu veranlassen, ein Ausgangsdrehmoment mit dem Mittelwert des Anlaßdrehmoments der Maschine (1) zu erzeugen.

16. Hybridantriebsvorrichtung nach Anspruch 5, wobei die Anlaßsteuerungseinrichtung (S6) eine Hochfahreinrichtung aufweist, um den Einrückdruck der Kupplung (3) hochzufahren.

17. Hybridantriebsvorrichtung nach Anspruch 5, wobei die Wartezustandssteuereinrichtung (S5) eine Schnellfüll-Druckversorgungseinrichtung (S21) zur Verkürzung eines Kolbenhubs der Kupplung (3) hat.

18. Hybridantriebsvorrichtung nach Anspruch 5, wobei die Steuereinheit (5) einen Kupplungswartezustandsbereich hat, der zwischen einem Elektromotorantriebsbereich und einem Maschinenantriebsbereich bestimmt ist.

19. Hybridantriebsvorrichtung nach Anspruch 5, wobei die Anlaßsteuerungseinrichtung (S6) der Maschine (1) Kraftstoff zur Zündung zuführt, wenn die Umdrehungen der Maschine (1) eine vorbestimmte Anzahl von Umdrehungen pro Zeiteinheit erreicht haben.

20. Hybridantriebsvorrichtung nach Anspruch 5, wobei die Anlaßsteuerungseinrichtung (S6) nach der Synchronisation der Umdrehungen der Maschine (1) und des Elektromotors (2) die Kupplung (3) vollständig einrückt.

21. Hybridantriebsvorrichtung nach Anspruch 5, wobei die Steuereinheit (5) eine Vollendungssteuerungseinrichtung (S41) aufweist, um das Ausgangsdrehmoment des Elektromotors (2) herunterzufahren und eine Drosselöffnung der Maschine (1) zu vergrößern.

22. Hybridantriebsvorrichtung nach Anspruch 6, wobei die Wartezustandssteuereinrichtung (S5) eine Schnellfüll-Druckversorgungseinrichtung (S21) zur Verkürzung eines Kolbenhubs der Kupplung (3) hat.

23. Hybridantriebsvorrichtung nach Anspruch 6, wobei die Steuereinheit (5) einen Kupplungswartezustandsbereich hat, der zwischen einem Elektromotorantriebsbereich und einem Maschinenantriebsbereich bestimmt ist.

24. Hybridantriebsvorrichtung nach Anspruch 6, wobei die Anlaßsteuerungseinrichtung (S6) Kraftstoff zur Zündung zuführt, wenn die Umdrehungen der Maschine (1) eine vorbestimmte Anzahl von Umdrehungen pro Zeiteinheit erreicht haben.

25. Hybridantriebsvorrichtung nach Anspruch 6, wobei die Anlaßsteuerungseinrichtung (S6) nach der Synchronisation der Umdrehungen der Maschine (1) und des Elektromotors (2) die Kupplung (3) vollständig einrückt.

26. Hybridantriebsvorrichtung nach Anspruch 6, wobei die Steuereinheit (5) eine Vollendungssteuerungseinrichtung (S65) aufweist, um das Ausgangsdrehmoment des Elektromotors (2) herunterzufahren und eine Drosselöffnung der Maschine (1) zu vergrößern.

Hierzu 16 Seite(n) Zeichnungen

FIG. 1

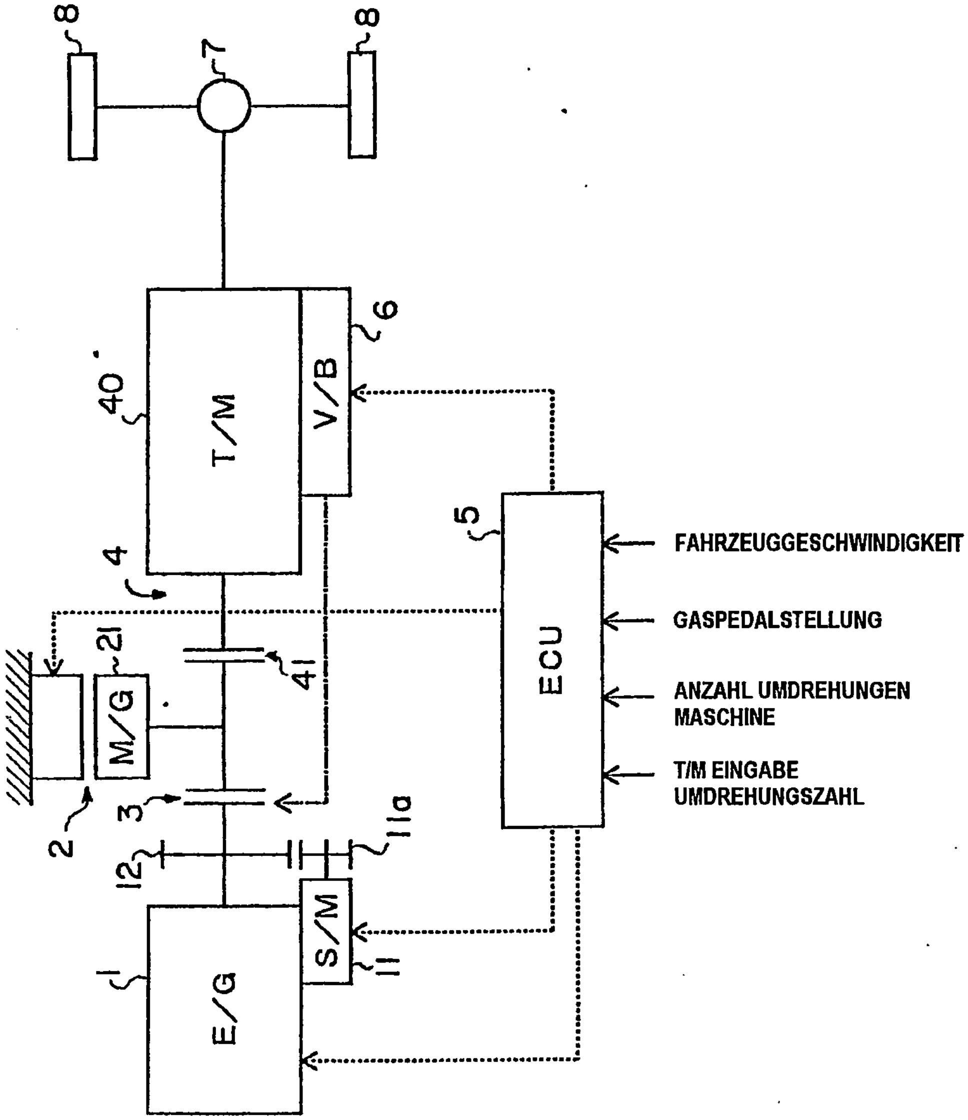
8
7
8
T/M
40
V/B
6
ECU
5
4
21
M/G
41
2
3
12
11a
S/M
11
E/G
1
FAHRZEUGGESCHWINDIGKEIT
GASPEDALSTELLUNG
ANZAHL UMDREHUNGEN MASCHINE
T/M EINGABE UMDREHUNGSZAHL

FIG. 2

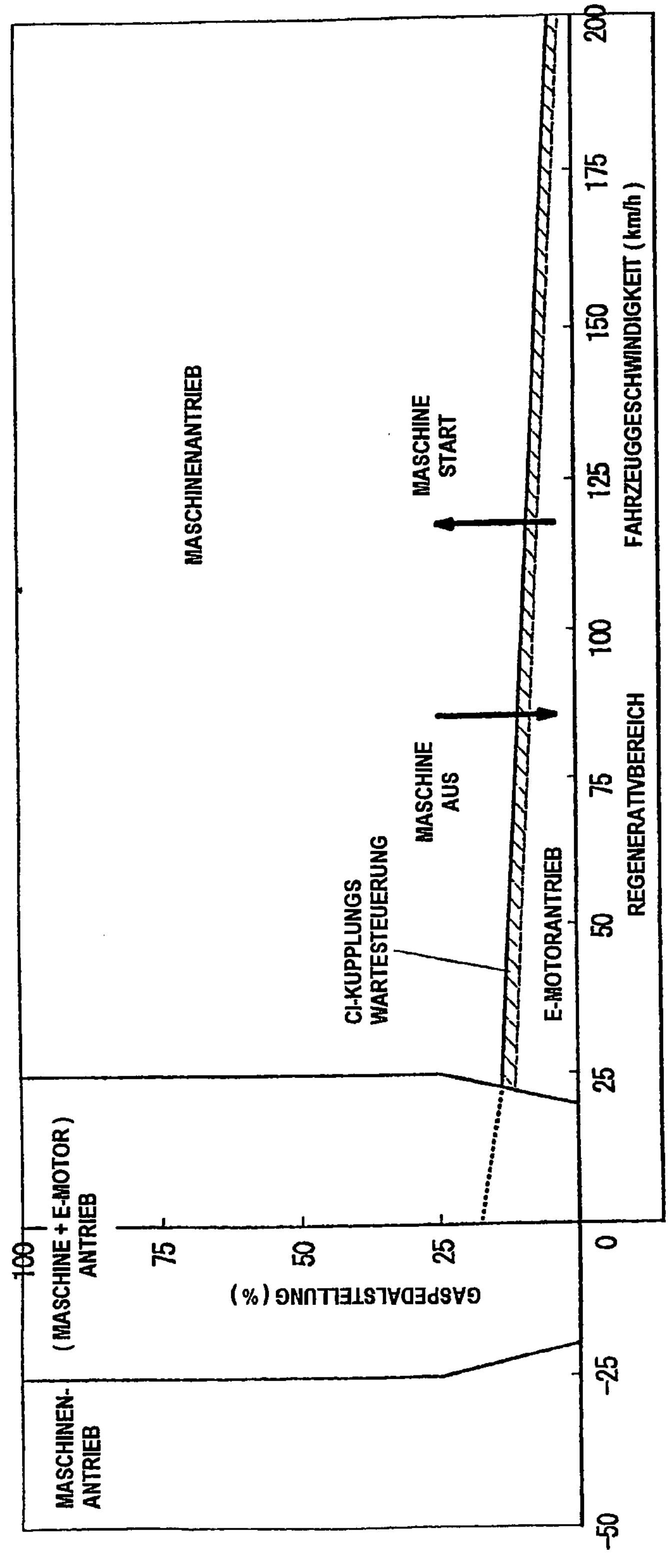
MASCHINENANTRIEB
MASCHINE START
MASCHINE AUS
CI-KUPPLUNGS WARTESTEUERUNG
E-MOTORANTRIEB
REGENERATIVBEREICH
(MASCHINE + E-MOTOR) ANTRIEB
MASCHINEN- ANTRIEB
GASPEDALSTELLUNG (%)
100
75
50
25
FAHRZEUGGESCHWINDIGKEIT (km/h)
-50
-25
0
25
50
75
100
125
150
175
200

FIG. 3

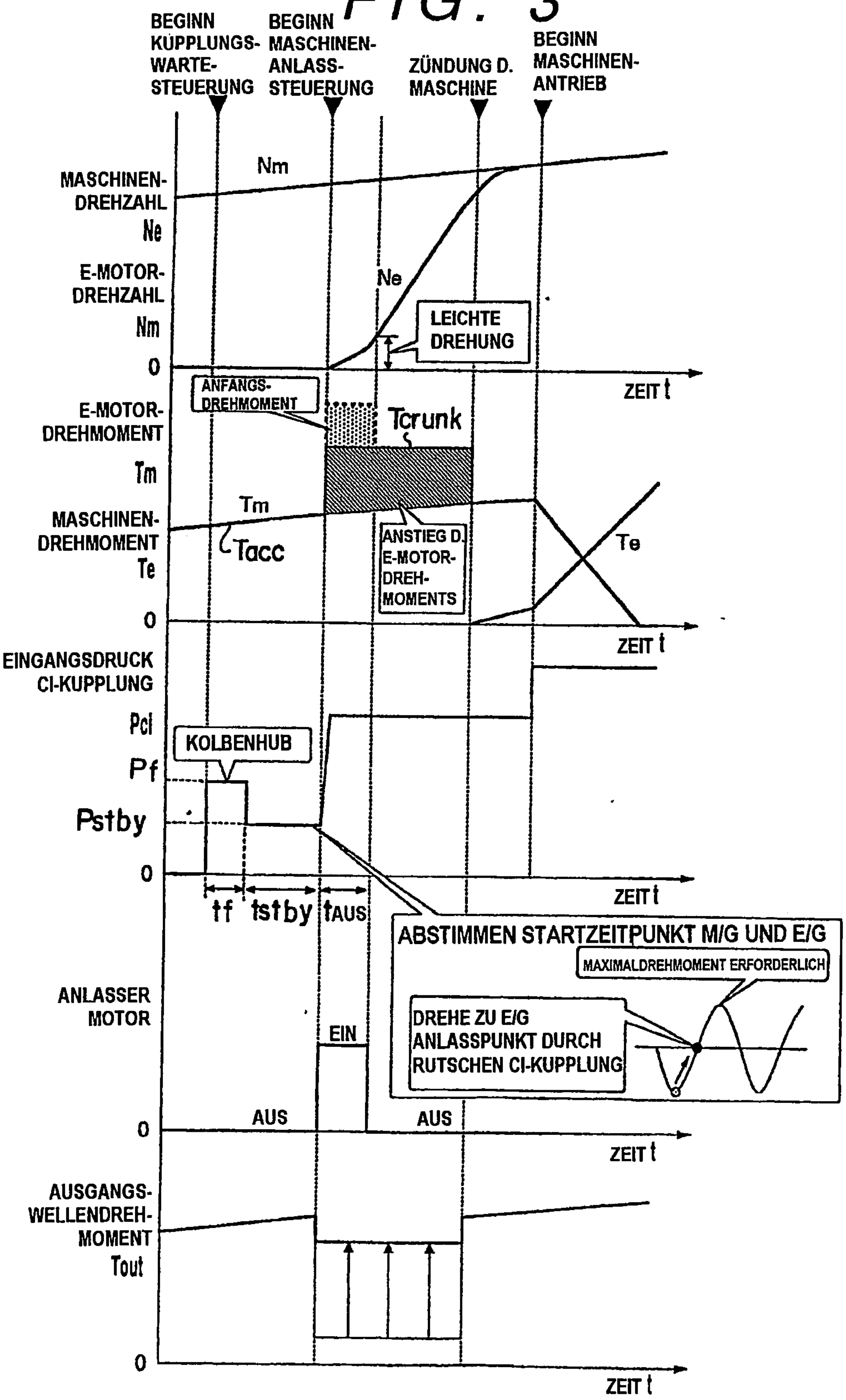
BEGINN KUPPLUNGS-WARTE-STEUERUNG
BEGINN MASCHINEN-ANLASS-STEUERUNG
ZÜNDUNG D. MASCHINE
BEGINN MASCHINEN-ANTRIEB
MASCHINEN-DREHZAHL Ne
E-MOTOR-DREHZAHL Nm
Nm
Ne
LEICHTE DREHUNG
0
ZEIT t
E-MOTOR-DREHMOMENT Tm
ANFANGS-DREHMOMENT
Tcrunk
MASCHINEN-DREHMOMENT Te
Tm
Tacc
ANSTIEG D. E-MOTOR-DREH-MOMENTS
Te
0
ZEIT t
EINGANGSDRUCK CI-KUPPLUNG
Pcl
KOLBENHUB
Pf
Pstby
0
ZEIT t
tf
tstby
tAUS
ABSTIMMEN STARTZEITPUNKT M/G UND E/G
MAXIMALDREHMOMENT ERFORDERLICH
DREHE ZU E/G ANLASSPUNKT DURCH RUTSCHEN CI-KUPPLUNG
ANLASSER MOTOR
EIN
AUS
AUS
0
ZEIT t
AUSGANGS-WELLENDREH-MOMENT Tout
0
ZEIT t

FIG. 4

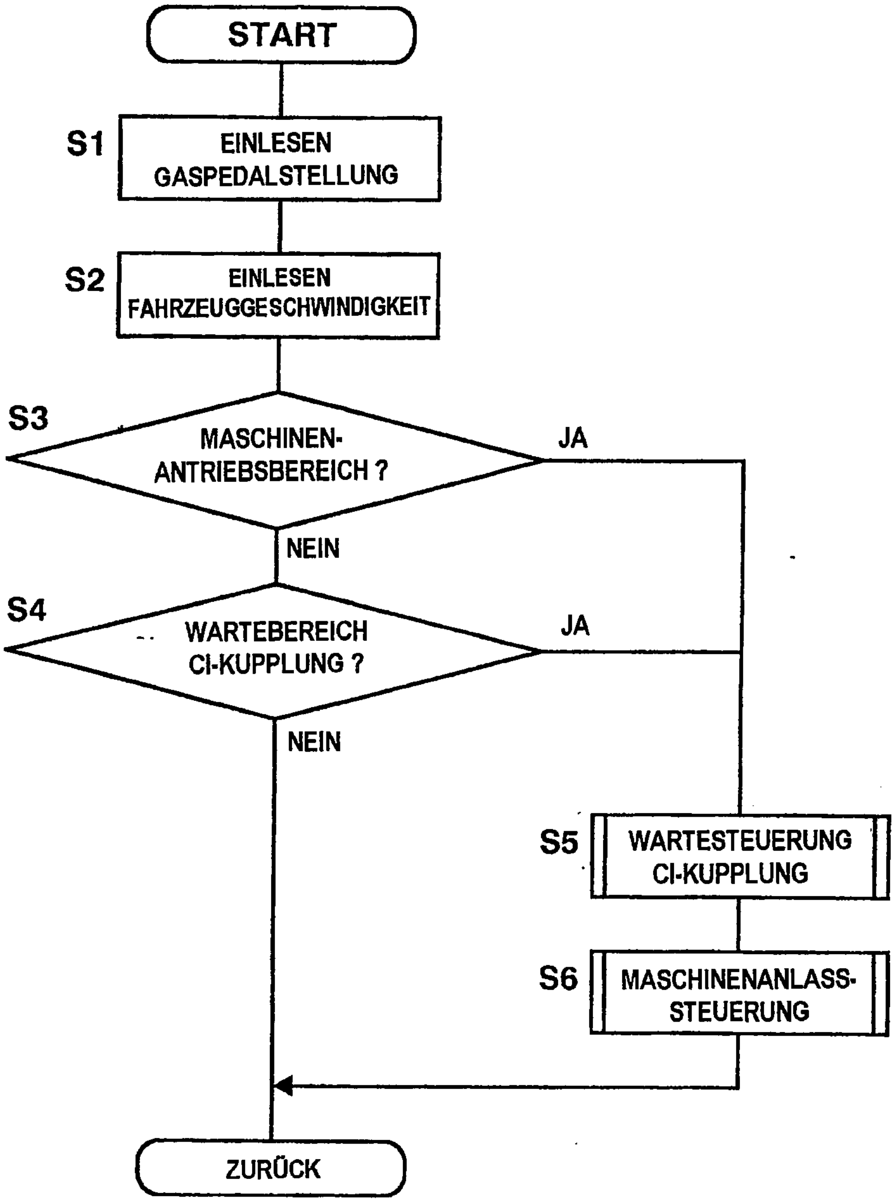
START
S1
EINLESEN GASPEDALSTELLUNG
S2
EINLESEN FAHRZEUGGESCHWINDIGKEIT
S3
MASCHINEN-ANTRIEBSBEREICH ?
JA
NEIN
S4
WARTEBEREICH CI-KUPPLUNG ?
JA
NEIN
S5
WARTESTEUERUNG CI-KUPPLUNG
S6
MASCHINENANLASS-STEUERUNG
ZURÜCK

FIG. 5

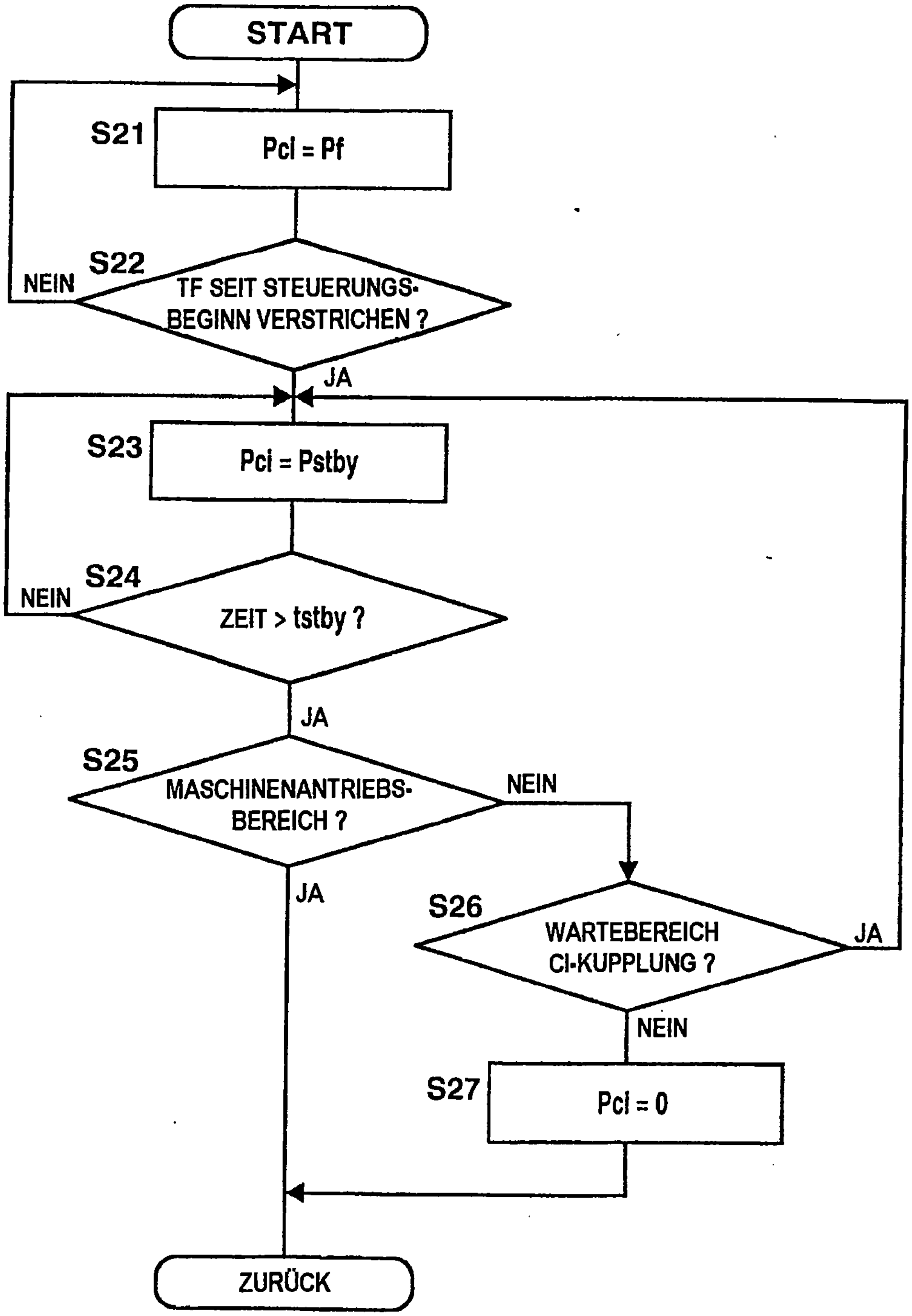

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FIG. 6

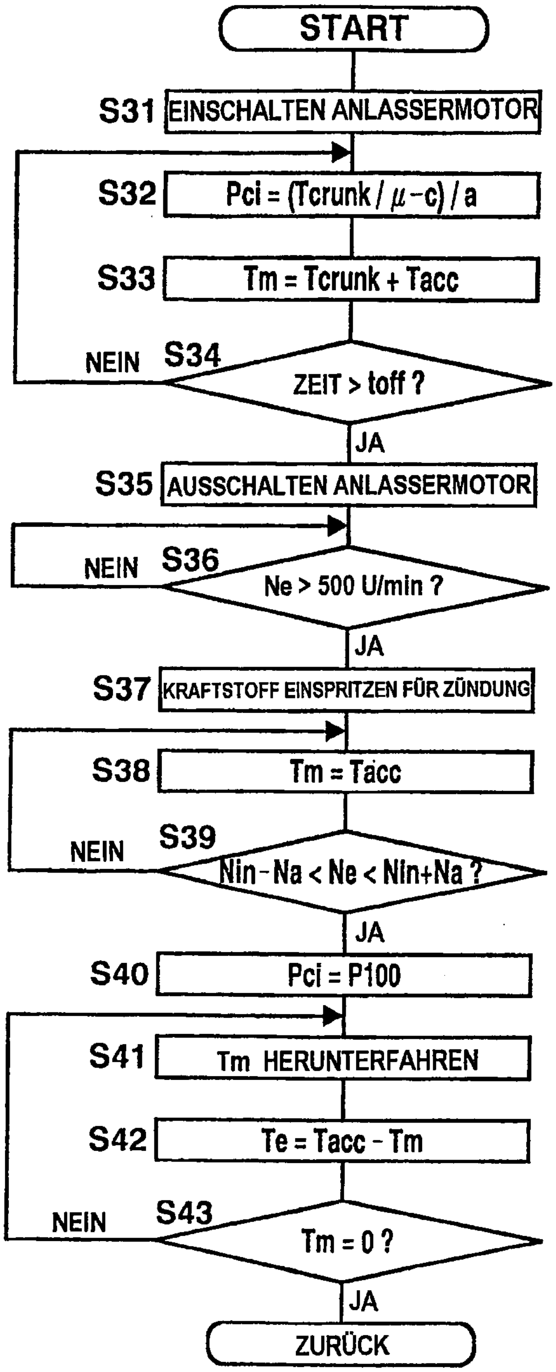
START
S31 EINSCHALTEN ANLASSERMOTOR
S32 Pci = (Tcrunk / μ-c) / a
S33 Tm = Tcrunk + Tacc
NEIN
S34 ZEIT > toff ?
JA
S35 AUSSCHALTEN ANLASSERMOTOR
NEIN
S36 Ne > 500 U/min ?
JA
S37 KRAFTSTOFF EINSPRITZEN FÜR ZÜNDUNG
S38 Tm = Tacc
NEIN
S39 Nin-Na < Ne < Nin+Na ?
JA
S40 Pci = P100
S41 Tm HERUNTERFAHREN
S42 Te = Tacc - Tm
NEIN
S43 Tm = 0 ?
JA
ZURÜCK

FIG. 7

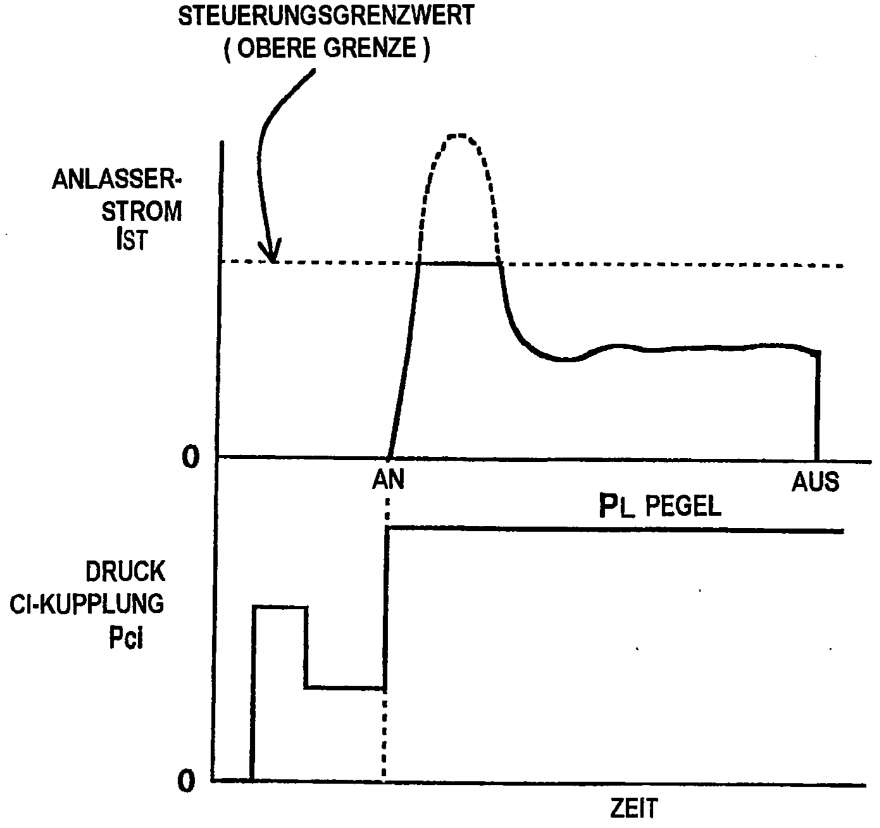

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FIG. 8

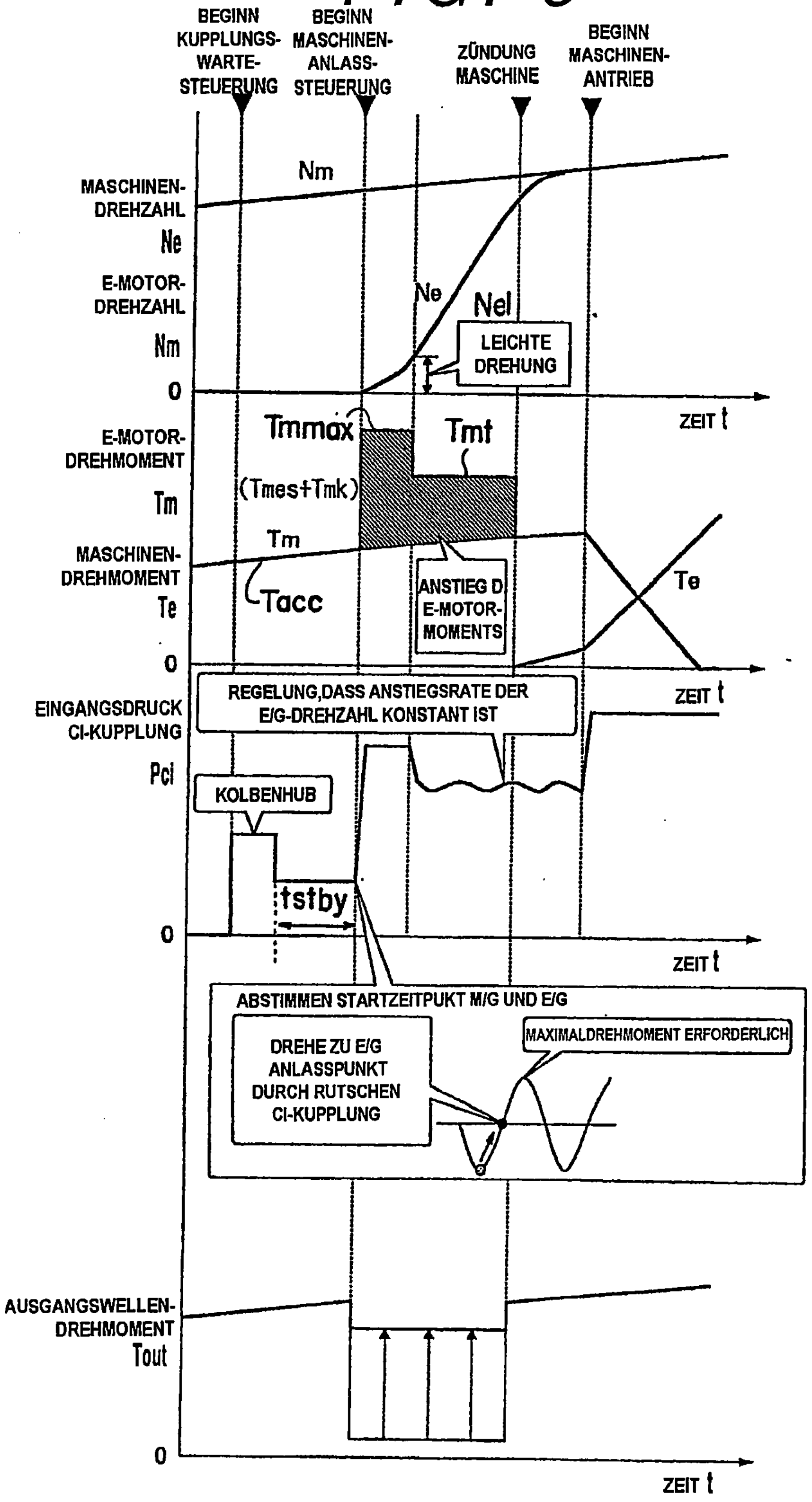
BEGINN KUPPLUNGS-WARTE-STEUERUNG
BEGINN MASCHINEN-ANLASS-STEUERUNG
ZÜNDUNG MASCHINE
BEGINN MASCHINEN-ANTRIEB
MASCHINEN-DREHZAHL
Ne
E-MOTOR-DREHZAHL
Nm
Nm
Ne
Nel
LEICHTE DREHUNG
0
ZEIT t
E-MOTOR-DREHMOMENT
Tm
Tmmax
Tmt
(Tmes+Tmk)
Tm
MASCHINEN-DREHMOMENT
Te
Tacc
ANSTIEG D E-MOTOR-MOMENTS
Te
0
ZEIT t
EINGANGSDRUCK CI-KUPPLUNG
Pci
REGELUNG,DASS ANSTIEGSRATE DER E/G-DREHZAHL KONSTANT IST
KOLBENHUB
tstby
0
ZEIT t
ABSTIMMEN STARTZEITPUKT M/G UND E/G
DREHE ZU E/G ANLASSPUNKT DURCH RUTSCHEN CI-KUPPLUNG
MAXIMALDREHMOMENT ERFORDERLICH
AUSGANGSWELLEN-DREHMOMENT
Tout
0
ZEIT t

FIG. 9

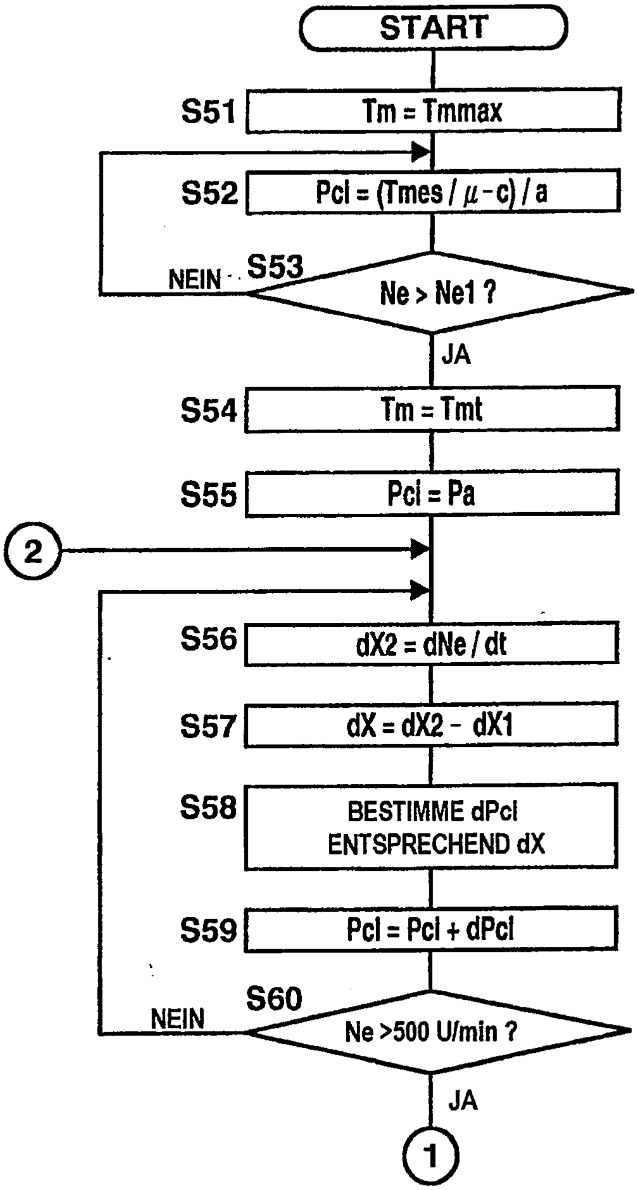
START
S51
Tm = Tmmax
S52
Pcl = (Tmes / μ - c) / a
S53
Ne > Ne1 ?
NEIN
JA
S54
Tm = Tmt
S55
Pcl = Pa
2
S56
dX2 = dNe / dt
S57
dX = dX2 - dX1
S58
BESTIMME dPcl
ENTSPRECHEND dX
S59
Pcl = Pcl + dPcl
S60
Ne >500 U/min ?
NEIN
JA
1

FIG. 10

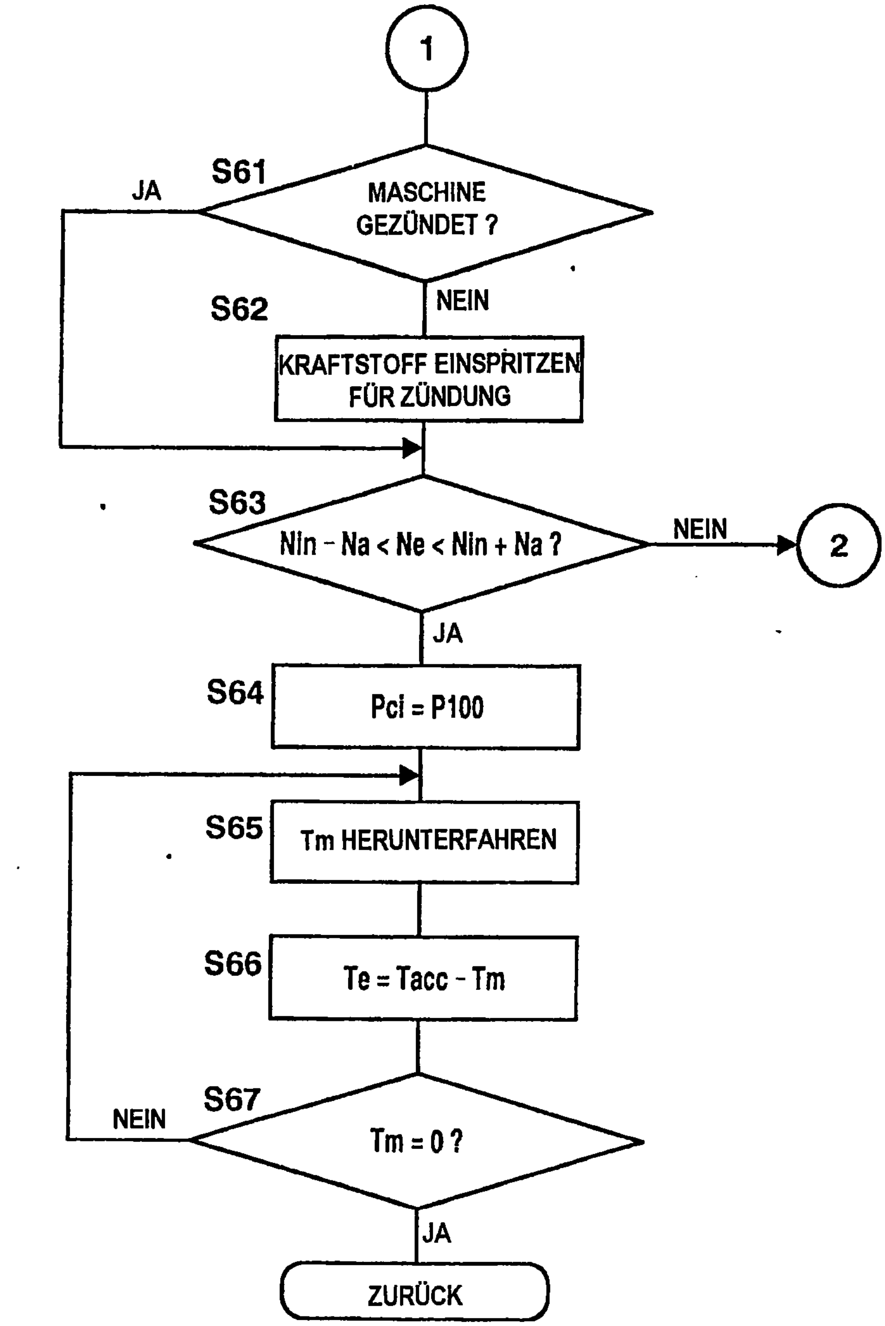

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FIG. 11

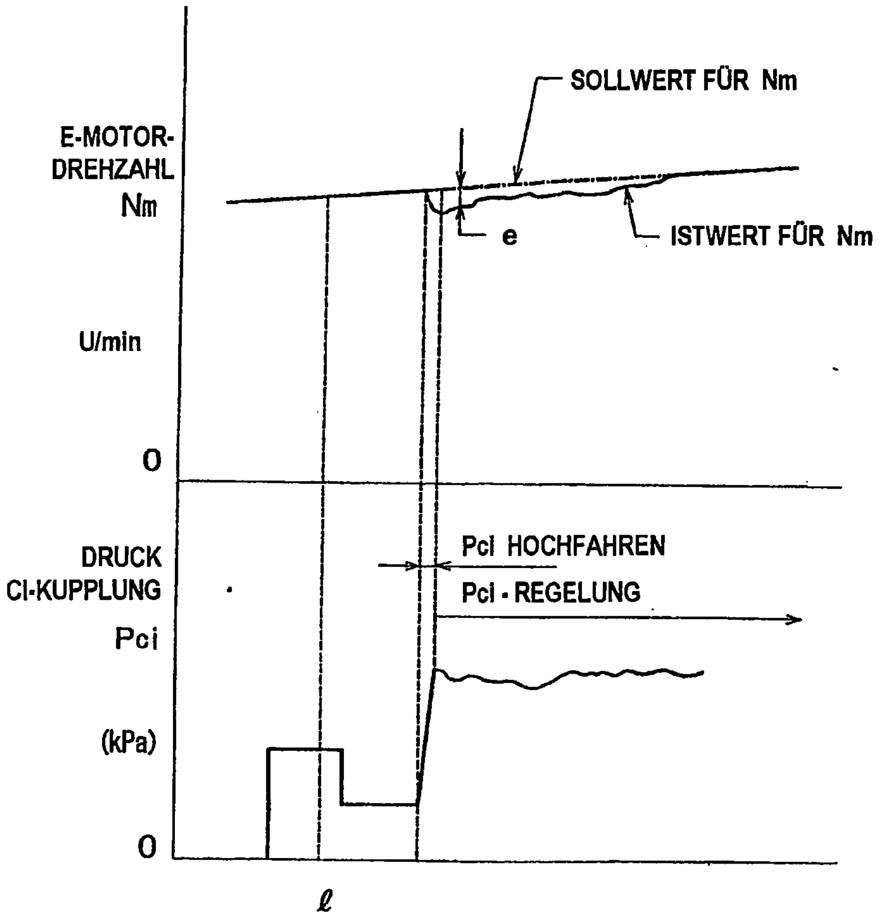

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FIG. 12

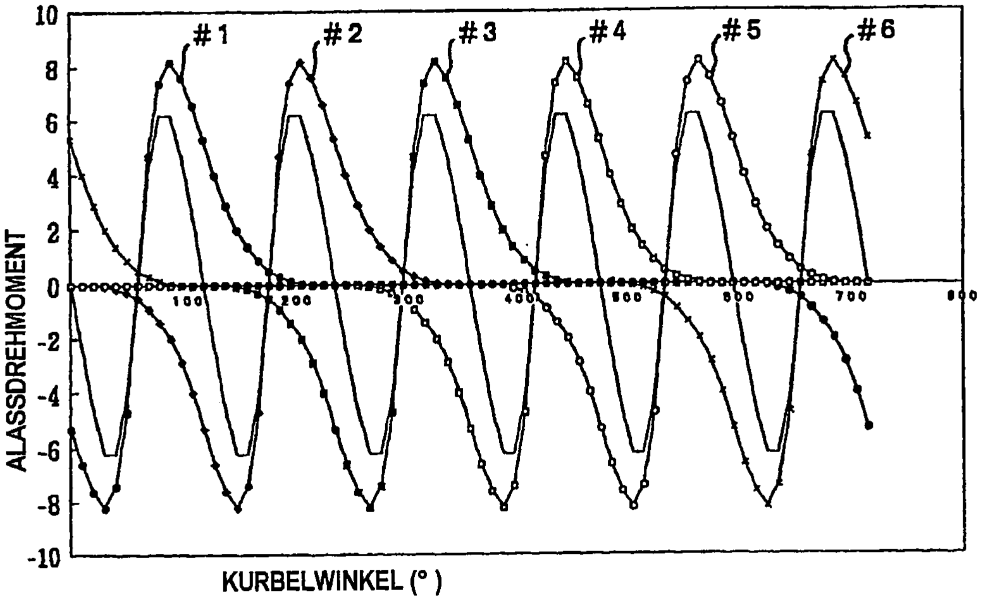

FIG. 13

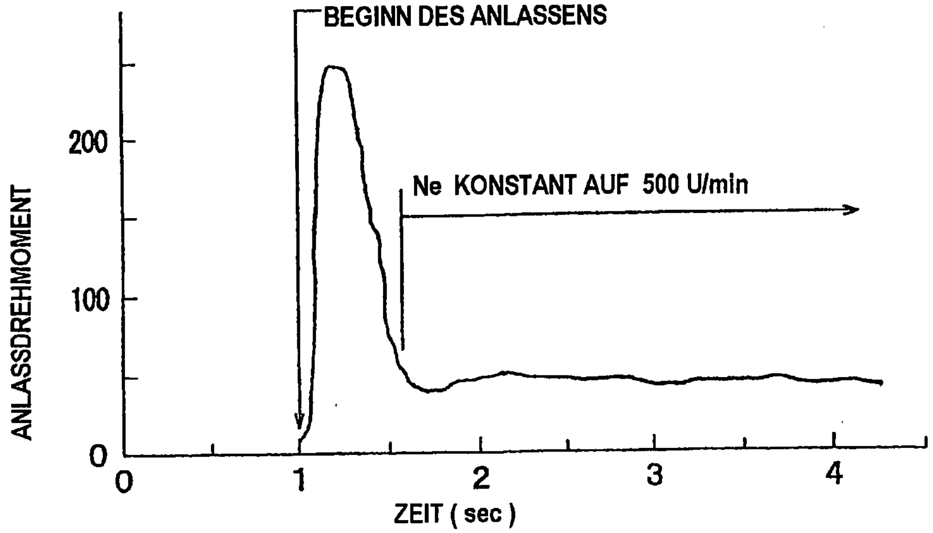

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FIG. 14

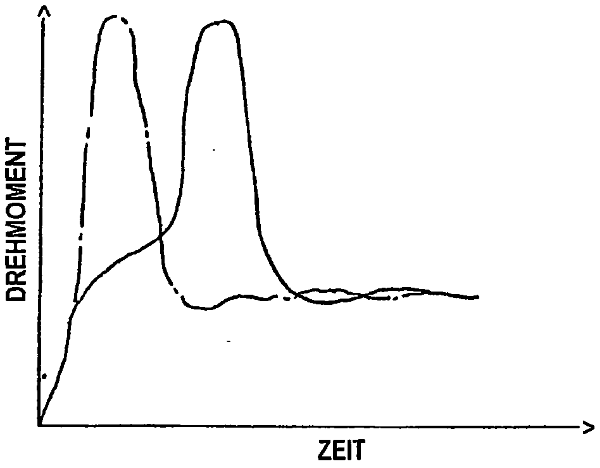

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FIG. 15

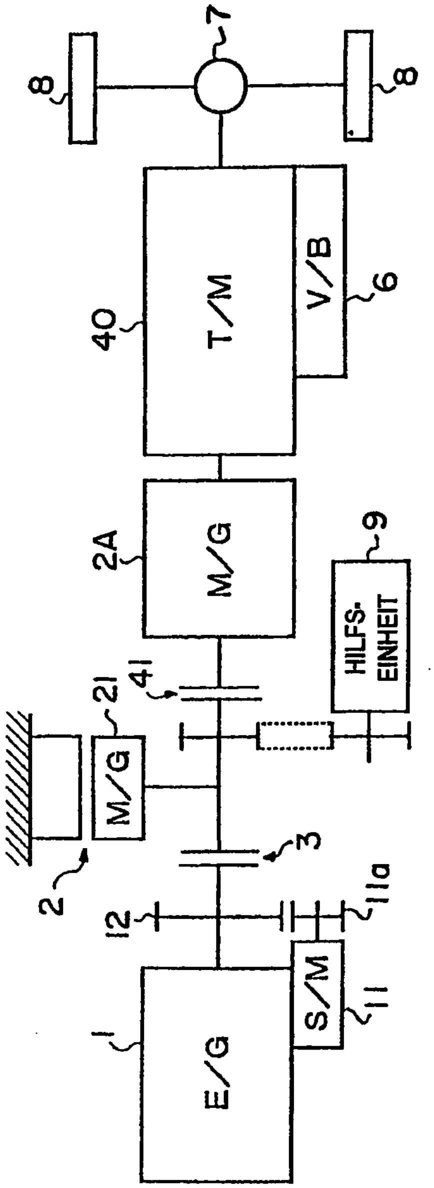


FIG. 16

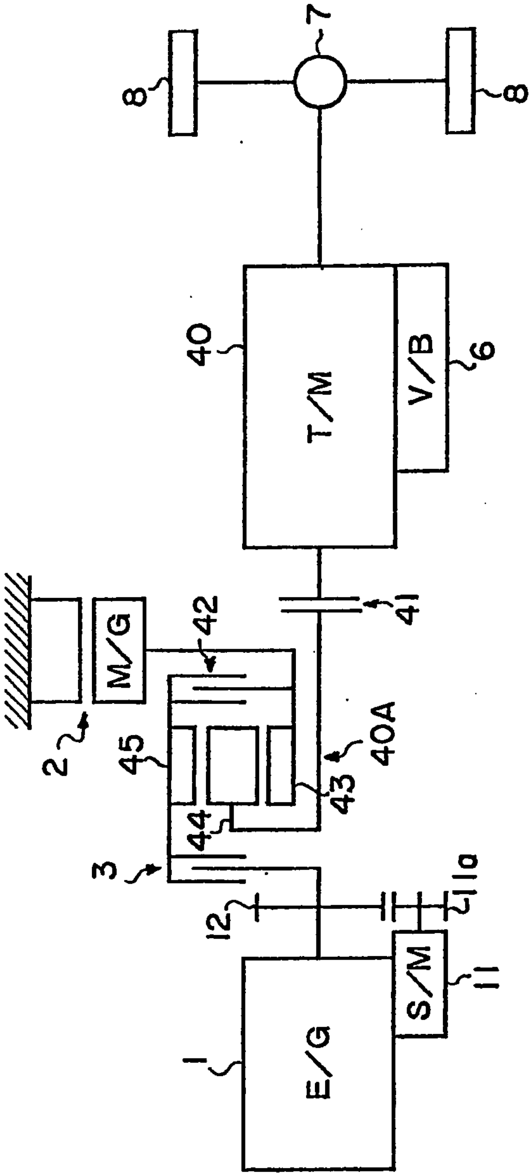
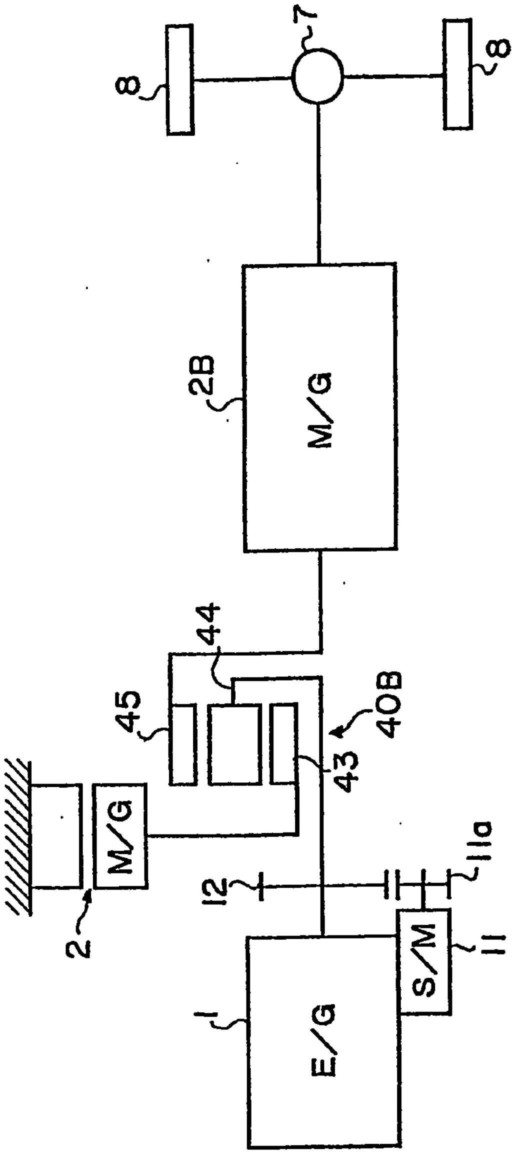


FIG. 17



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(56) Entgegenhaltungen:

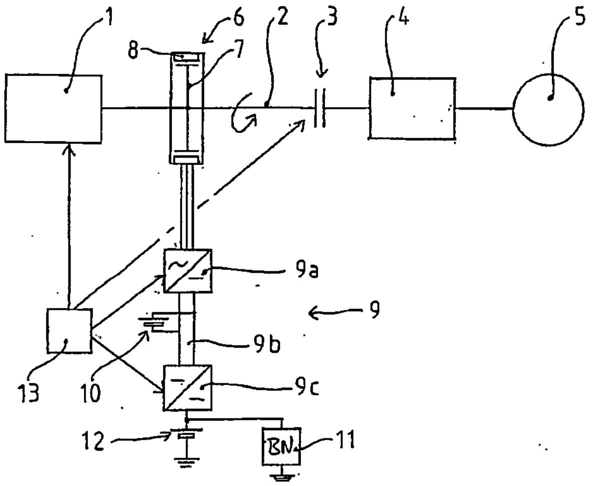
DE	1 95 39 571 A1
DE	1 95 30 231 A1

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

Prüfungsantrag gem. § 44 PatG ist gestellt

(54) Antriebssystem für ein Kraftfahrzeug sowie Verfahren zum Betreiben desselben

(57) Die Erfindung betrifft ein Antriebssystem für ein Kraftfahrzeug, mit einem Verbrennungsmotor (1) und wenigstens einer elektrischen Maschine (6, 6'), die jeweils für sich als Antriebsmotor des Fahrzeugs dienen können, wobei das Antriebssystem so ausgebildet ist, daß die Anfahrphase des Fahrzeugs folgendermaßen abläuft:
i) das Fahrzeug wird anfangs allein durch die elektrische Maschine (6, 6') beschleunigt,
ii) der Verbrennungsmotor (1) wird währenddessen gestartet,
iii) der Verbrennungsmotor (1) übernimmt darauffolgend den Antrieb des Fahrzeugs,
wobei ein ruckartiges Ankuppeln des Verbrennungsmotors (1) Verlauf der Schritte i) bis iii) vermieden wird, indem entweder
a) der Verbrennungsmotor (1), während die elektrische Maschine (6, 6') das Fahrzeug beschleunigt, mitgeschleppt wird, oder
b) der Verbrennungsmotor (1) in vom Antrieb entkoppeltem Zustand zwecks Starten hochgedreht wird und bei Synchrondrehzahl mit dem Antrieb gekoppelt wird.
Die Erfindung ist auch auf ein entsprechendes Verfahren zum Betreiben eines Antriebssystems gerichtet.



DE 198 14 402 A 1

Beschreibung

Die Erfindung betrifft ein Antriebssystem für ein Kraftfahrzeug mit einem Verbrennungsmotor und wenigstens einer elektrischen Maschine, die jeweils für sich als Antriebsmotor des Fahrzeugs dienen können. Die Erfindung betrifft ferner ein Verfahren zum Betreiben eines solchen Antriebssystems. Solche Antriebssysteme, bei denen Verbrennungsmotor und elektrische Maschine jeweils für sich den Fahrzeugantrieb übernehmen können, sind auch unter der Bezeichnung "Parallelhybridantrieb" bekannt.

Ein wesentliches Ziel bei der Entwicklung von Kraftfahrzeugantrieben ist die Reduzierung der von den Verbrennungsmotoren verursachten Schadstoff- und Lärmemissionen. Ein kritischer Bereich ist hierbei die Anfahrphase der Fahrzeuge: hier kommt es zu einem erhöhten spezifischen Kraftstoffverbrauch und zu relativ hohen Schadstoffemissionen. Letzteres stört insbesondere im Stadtbereich aufgrund der dort gehäuften Anfahrvorgänge. Hinzu kommt eine erhöhte Lärmbelästigung aufgrund des Hochdrehens der Motoren vor dem Einkuppeln.

Parallelhybridantriebe bieten in diesem Zusammenhang die Möglichkeit, das Fahrzeug in der Anfahrphase ausschließlich mit Hilfe eines elektrischen Antriebes zu beschleunigen und den Verbrennungsmotor erst zuzuschalten, wenn der Betriebspunkt in einem hinsichtlich Wirkungsgrad und Schadstoffemissionen günstigeren Bereich liegt. Eine solche Lösung ist beispielsweise aus der DE 33 35 923 A1 bekannt. Hier wird nach dem elektrischen Anfahren der Verbrennungsmotor mit Hilfe einer Kupplung über die elektrische Maschine mit der Antriebsachse verbunden. Dieser wird dabei durch das Ankuppeln angeworfen. Eine entsprechende Lösung ist aus der EP 0 743 216 A2 bekannt. Das Ankuppeln des Verbrennungsmotors an den Antriebsstrang erfolgt dort nicht mechanisch, sondern mit Hilfe einer elektromagnetischen Kupplung. Das Ankuppeln des stillstehenden Verbrennungsmotors an den rotierenden Antriebsstrang hat den Nachteil, daß schlagartig ein relativ großes Drehmoment aufgebracht werden muß. Dies kann zu einem ruckartigen Abfall des Antriebsmoments führen. Um diesen unerwünschten Effekt zu mindern, ist in der erstgenannten DE 33 35 923 A1 der Verbrennungsmotor mit einem abschaltbaren Schwungrad ausgebildet. Dadurch kann sein Trägheitsmoment verkleinert werden, so daß er beim Ankuppeln leichter "mitgerissen" werden kann. In der zweitgenannten EP 0 743 216 A2 wird dem ruckartigen Momentenabfall mit einer entsprechenden Erhöhung des elektrischen Antriebsmoments entgegengewirkt.

Der vorliegenden Erfindung liegt die Aufgabe zugrunde, ein weiteres Antriebssystem anzugeben, welches einen elektrischen Anfahrvorgang und ein späteres Zuschalten des Verbrennungsmotors ermöglicht. Dazu gehört auch die Bereitstellung eines entsprechenden Verfahrens.

Die Erfinder der vorliegenden Erfindung haben erkannt, daß es wünschenswert wäre, zur Beseitigung des o.g. Problems den Kupplungsruck im Ansatz zu beseitigen, und nicht nur seine Auswirkungen zu mindern. Sie haben erkannt, daß dies durch eine Synchronisation von Verbrennungsmotor und Antrieb erzielbar ist. Dies kann erfindungsgemäß auf zwei Arten geschehen: einerseits, indem der Verbrennungsmotor vom elektrischen Antrieb schon am Anfang der Anfahrphase mitgeschleppt wird. Er wird dann zum gewünschten Zeitpunkt einfach gestartet, z. B. durch Aktivierung von Kraftstoffzufuhr und/oder Zündung. Die andere Art ist diejenige, den Verbrennungsmotor im entkoppelten Zustand zu starten und auf Synchrondrehzahl mit der zu koppelnden Antriebswelle zu bringen, bevor er an den Antrieb gekoppelt wird. Beide Lösungen vermeiden einen ruckartigen Kuppelvorgang.

Im einzelnen stellt die Erfindung gemäß Anspruch 1 ein Antriebssystem gemäß der eingangs genannten Art bereit, welches so ausgebildet ist, daß die Anfahrphase des Fahrzeugs folgendermaßen abläuft:

i) das Fahrzeug wird anfangs allein durch die elektrische Maschine beschleunigt,
ii) der Verbrennungsmotor wird währenddessen gestartet,
iii) der Verbrennungsmotor übernimmt darauffolgend den Antrieb des Fahrzeugs,

wobei ein ruckartiges Ankuppeln des Verbrennungsmotors im verlauf der Schritte i) bis iii) vermieden wird, indem entweder

a) der Verbrennungsmotor, während die elektrische Maschine das Fahrzeug beschleunigt, mitgeschleppt wird, oder+z b) der Verbrennungsmotor in vom Antrieb entkoppeltem Zustand zwecks Starten hochgedreht wird und bei Synchrondrehzahl mit dem Antrieb gekoppelt wird.

Eine entsprechende verfahrensmäßige Lösung ist in Anspruch 16 angegeben.

Wie oben bereits ausgeführt wurde, vermeidet die Erfindung das Auftreten eines Startrucks bereits im Ansatz und macht daher aufwendige und nicht optimale Lösungen, etwa nach Art eines verstellbaren Trägheitsmoments hinfällig.

In den Unteransprüchen sind vorteilhafte Ausgestaltungen angegeben. Die Ansprüche 2 bis 7 beziehen sich auf die erste Alternative, bei welcher die elektrische Maschine den Verbrennungsmotor im Rahmen der Fahrzeugbeschleunigung mitschleppt. Die Ansprüche 8 bis 13 beziehen sich auf die zweite Alternative. Die Ansprüche 14 und 15 betreffen Ausgestaltungen zu beiden Alternativen.

Beim Mitschleppen des Verbrennungsmotors entstehen störende Drehmomentschwankungen durch die alleinige Wirkung von Massenkräften des Kurbeltriebs. Gemäß Anspruch 2 wirkt eine mit dem Verbrennungsmotor gekoppelte elektrische Maschine diesen Drehmomentschwankungen aktiv entgegen, indem sie entgegengerichtete (gegenphasige) Drehmomente aufbringt. Gemäß Anspruch 3 handelt es sich bei dieser elektrischen Maschine um diejenige, welche auch als Antriebsmotor für das Fahrzeug fungiert. Zu diesem Zweck wird die Maschine so gesteuert, daß sie die entgegengerichteten, im allgemeinen zeitlich schnell variierenden Drehmomente dem (relativ dazu nur langsam variierenden) Antriebsmoment überlagert.

Zur Verminderung der vom Komprimieren herrührenden Drehmomentschwankungen erfolgt gemäß Anspruch 4 das Mitschleppen des Verbrennungsmotors zunächst im dekomprimierten Zustand. Um einen etwaigen Ruck beim Übergang vom Betrieb unter Dekompression zu demjenigen unter Kompression zu vermeiden, setzt gemäß Anspruch 5 die Kompression nach dem anfänglichen dekomprimierten Mitschleppen weich ein. Um eine besonders wirksame Dämpfung der Ungleichförmigkeiten zu erzielen, kann vorteilhaft die Dekompression kombiniert mit der obigen Aktivdämpfung durch die elektrische Maschine zur Anwendung kommen. Gemäß Anspruch 6 ist der Verbrennungsmotor zur Erzielung der Dekompressionsfunktion vorteilhaft mit einem elektromagnetischen oder elektrodynamischen Ventiltrieb ausgestattet (ein elektromagnetischer Ventiltrieb ist beispielsweise aus der DE 30 24 109 A1 bekannt). Die Dekompression und ggf. der weiche Übergang von Dekompression zu Kompression werden durch entsprechende Ansteuerung des Ventiltriebs bewirkt. Der hohe Bedarf an elektrischer Energie, den ein solcher Ventiltrieb hat, kann vorteilhaft gedeckt werden, indem die dem Antrieb dienenende elektrische Maschine nach Beendigung der Anfahrphase als Generator fungiert.

Das eigentliche Starten des mitgeschleppten Verbrennungsmotors kann dadurch herbeigeführt werden, daß bei Erreichen einer ausreichenden Drehzahl die Zündung und/oder die Kraftstoffeinspritzung aktiviert werden (Anspruch 7).

Die folgenden Ausgestaltungen beziehen sich auf die zweite Alternative des Hauptanspruchs, wonach der Verbrennungsmotor in vom Antrieb entkoppeltem Zustand zwecks Starten hochgedreht wird. Gemäß Anspruch 8 erfolgt hierbei das Hochdrehen und Starten des Verbrennungsmotors durch eine elektrische Maschine. Grundsätzlich kann nach dem Start ein ggf. erforderliches weiteres Hochdrehen des Verbrennungsmotors bis zur Erreichung der Synchrondrehzahl aus eigener Kraft erfolgen. Dies erfolgt jedoch nur relativ träge; zudem ist eine genaue Synchronisation auf diesem Wege steuerungstechnisch nur schwierig zu beherrschen. Um diese Nachteile zu vermeiden, übernimmt gemäß Anspruch 9 die für das Starten sorgende elektrische Maschine auch die Aufgabe, den Verbrennungsmotor aktiv auf die Synchrondrehzahl zu bringen.

Für das Starten des Verbrennungsmotors im vom Antrieb abgekoppelten Zustand schlägt die vorliegende Erfindung zwei verschiedene Ausgestaltungen vor:

Nach einer ersten Ausgestaltung gemäß Anspruch 10 ist die für das Starten sorgende elektrische Maschine mit der für die Fahrzeugbeschleunigung sorgenden identisch. Sie wird nach Beschleunigung des Fahrzeugs vom Antrieb abgekoppelt, dann an den Verbrennungsmotor angekoppelt, und dreht diesen dann hoch, so daß er startet. Anschließend wird der Verbrennungsmotor bei Synchrondrehzahl mit dem Antrieb gekoppelt; er übernimmt dann den Fahrzeugantrieb. Bei einer Variante gemäß Anspruch 11 ist die elektrische Maschine als eine elektrische Doppelmaschine ausgebildet, welche zwei Läufer und einen umschaltbaren Ständer aufweist. Die Umschaltung kann beispielsweise durch mechanische Verschiebung des Ständers oder durch elektrische Umschaltung einer Art Doppelständer erfolgen.

Nach einer zweiten Ausgestaltung gemäß Anspruch 12 sind die für das Starten und für den Fahrzeugantrieb sorgenden elektrischen Maschinen zwei gesonderte elektrische Maschinen. Diese arbeiten simultan: eine von ihnen startet den vom Antrieb entkoppelten Verbrennungsmotor, während die andere das Fahrzeug beschleunigt. Bei Erreichen der Synchrondrehzahl wird der Verbrennungsmotor dann mit dem Antrieb gekoppelt.

Gemäß Anspruch 13 ist zwischen den beiden elektrischen Maschinen eine Kupplung angeordnet. Das Koppeln des Verbrennungsmotors mit dem Antrieb erfolgt dann durch Schließen dieser Kupplung.

Für alle genannten Ausgestaltungen der Erfindung ist es vorteilhaft, wenn die zum Starten und/oder Fahrzeugbeschleunigen dienende/n Maschine/n auf der Kurbelwelle des Verbrennungsmotors oder einer Antriebswelle sitzt und während des Antriebs durch den Verbrennungsmotor mitdreht (Anspruch 14).

Besonders vorteilhaft ist die Erfindung im Rahmen einer automatischen Start-Stop-Steuerung des Verbrennungsmotors einsetzbar (Anspruch 14). Bei einer solchen Start-Stop-Steuerung muß ein Fahrzeug nämlich sehr häufig aus einem Zustand mit abgestelltem Verbrennungsmotor beschleunigen. Die Charakteristika des erfindungsgemäßen Antriebssystems – absolut verzögerungsfreies Losfahren sowie geringe Lärm- und Schadstoffemissionen in der Anfahrphase – schlagen hierbei besonders vorteilhaft zu Buche.

Die obigen Ausführungen zum Antriebssystem haben vollinhaltlich auch Gültigkeit für das erfindungsgemäße Verfahren (Anspruch 16) und dessen vorteilhafte Ausgestaltungen (Anspruch 17).

Die Erfindung wird nun anhand von Ausführungsbeispielen und der angefügten beispielhaften Zeichnung näher erläutert.

In der Zeichnung zeigen:

Fig. 1 eine Schemadarstellung der wichtigsten Funktionseinheiten eines ersten Ausführungsbeispiels;

Fig. 2a, 2b ein zum ersten Ausführungsbeispiel gehöriges Diagramm der Drehzahl des Antriebs als Funktion der Zeit und ein zugehöriges Diagramm des Moments der elektrischen Maschine;

Fig. 3 eine vereinfachte Schemadarstellung eines zweiten Ausführungsbeispiels;

Fig. 4a, 4b ein zum zweiten Ausführungsbeispiel gehöriges Diagramm entsprechend **Fig.** 2a sowie ein zugehöriges Diagramm der Drehzahl der elektrischen Maschine als Funktion der Zeit (**Fig.** 4b);

Fig. 5 eine Darstellung entsprechend **Fig.** 3 eines dritten Ausführungsbeispiels mit zwei elektrischen Maschinen;

Fig. 6a–6c zum dritten Ausführungsbeispiel gehörige Diagramme entsprechend **Fig.** 4a und 4b, mit einem zusätzlichen Drehzahl-Zeit-Diagramm der zweiten elektrischen Maschine.

In den Figuren sind funktionsgleiche oder -ähnliche Teile mit gleichen Bezugsziffern gekennzeichnet.

Ein Antriebssystem für ein Kraftfahrzeug, z. B. einen Personenkraftwagen, weist gemäß **Fig.** 1 einen Verbrennungsmotor **1** auf, der Drehmoment über eine Antriebswelle **2** (z. B. die Kurbelwelle des Verbrennungsmotors **1** und eine damit verbundene Wellenfortsetzung), eine Kupplung **3** und ein Getriebe **4** auf Antriebsräder **5** des Fahrzeugs abgibt. Auf der Antriebswelle **2** sitzt eine ebenfalls als Antriebsquelle dienende elektrische Maschine **6**, hier eine Asynchron-Drehstrommaschine. Sie weist einen direkt auf der Antriebswelle **2** sitzenden und drehfest mit ihr verbundenen Läufer **7** sowie einen z. B. am Gehäuse des Verbrennungsmotors **1** gegen Drehung abgestützten Ständer **8** auf. Die elektrische Maschine **6** (sowie die unten näher beschriebenen Einrichtungen zu ihrer Speisung und zur Energiespeicherung) sind so dimensioniert, daß sie das Fahrzeug aus dem Stand beschleunigen kann und dabei den Verbrennungsmotor **1** mitschleppen kann, und zwar ohne Über- oder Untersetzung zwischen der elektrischen Maschine **6** und dem Verbrennungsmotor **1**, so daß beide permanent mit gleicher Drehzahl zusammenlaufen können. Bei (nicht dargestellten) Ausführungsformen ist zwischen der Antriebswelle **5** und der elektrischen Maschine **6** ein Untersetzungsgetriebe angeordnet, z. B. in Form eines Planetengetriebes, so daß die elektrische Maschine **6** beispielsweise mit der doppelten Drehzahl des Verbrennungsmotors **1** dreht. Die (nicht dargestellte) Wicklung des Ständers **8** wird durch einen Wechselrichter **9** mit elektrischen Strömen und Spannungen praktisch frei einstellbarer Amplitude, Phase und Frequenz gespeist. Es handelt sich z. B. um einen Gleichspannungs-Zwischenkreis-Wechselrichter, welcher aus einer im wesentlichen konstanten Zwischenkreis-Gleichspannung mit Hilfe von elektronischen Schaltern z. B. sinusbewertete breitenmodulierte Pulse herausschneidet, die – gemittelt durch die Induktivität der elektrischen Maschine **6** – zu nahezu sinusförmigen Strömen der gewünschten Frequenz, Amplitude und Phase führen. Der Wechselrichter **9** besteht im wesentlichen aus einem Gleichstrom-Wechselstrom-Umrichter **9a**, einem Zwischenkreis **9b** und einem Gleichspannungs-Wandler **9c**. Ein Hochleistungsenergiespeicher

10 liegt – elektrisch gesehen – im Zwischenkreis 9b. Es handelt sich bei ihm z. B. um eine Kurzzeitbatterie oder einen Kondensatorspeicher mit hoher Kapazität. Der Wandler 9c ist mit einem Niederspannungs-Fahrzeugbordnetz 11 und einem Langzeitspeicher, hier einer herkömmlichen Niederspannungs-Bordnetzbatterie 12, gekoppelt. Das Bordnetz 11 und die Batterie 12 liegen auf einem niedrigen Spannungsniveau, z. B. 12 oder 24 Volt. Der Zwischenkreis 9b liegt demgegenüber auf einer erhöhten Spannung, z. B. an der oberen Grenze des Niederspannungsbereichs (z. B. 42 Volt) oder auch weit darüber, z. B. 200 bis 300 Volt. Die elektrische Maschine 6 kann nach dem (unten noch näher beschriebenen) Anfahrvorgang, bei dem sie elektrische Energie aus dem Hochleistungsspeicher 10 entnimmt, als Generator fungieren, d. h. elektrische Energie liefern. Diese dient der Aufladung des Hochleistungsspeichers 10, der Niederspannungsbatterie 12 sowie der Versorgung von Verbrauchern, beispielsweise Hochleistungsverbrauchern (z. B. elektromagnetischer Ventiltrieb) auf einem erhöhten Spannungsniveau (z. B. dem Zwischenkreisniveau) und normalen Verbrauchern im Niederspannungsnetz 11, und zwar nach Gleichrichtung durch den Umrichter 9a und ggf. Spannungsherabsetzung durch den Wandler 9c. Im Motorbetrieb wandelt der Umrichter 9a die von der Hochleistungsbatterie 10 in den Zwischenkreis 9b abgegebene Gleichspannung in Wechselspannung um. Ein übergeordnetes Steuergerät 13 steuert den Wechselrichter 9, und zwar den Umrichter 9a und den Wandler 9c. Es steuert ferner den Verbrennungsmotor 1 und die (automatisch betätigbare) Kupplung 3. Bei weiteren (nicht gezeigten) Ausführungsformen liegen Zwischenkreis und Fahrzeugbordnetz auf dem gleichen Spannungsniveau, z. B. an der oberen Grenze des Niederspannungsbereichs (z. B. 42 Volt).

Anhand **Fig.** 2 wird nun die Funktionsweise des Antriebssystems von **Fig.** 1 erläutert: Der Fahrer des Fahrzeugs gibt bei abgestelltem Verbrennungsmotor **1** ein Anfahrsignal, z. B. durch Betätigen des Fahrpedals. Das Fahrzeug fährt daraufhin praktisch verzögerungsfrei an und beschleunigt stetig. Der erste Teil des Anfahrvorgangs erfolgt durch den Antrieb der elektrischen Maschine **6** bis, für den Fahrer praktisch unmerklich, der Verbrennungsmotor **1** den weiteren Antrieb übernimmt. Dies ist im Drehzahldiagramm der Antriebswelle **2** gemäß **Fig.** 2a dargestellt.

Die elektrische Maschine **6** hat in der ersten Phase des Anfahrvorgangs eine Doppelfunktion. Und zwar dient sie einerseits der Fahrzeugbeschleunigung, andererseits dreht sie gleichzeitig den drehfest mit ihr verbundenen Verbrennungsmotor mit hoch, so daß dieser im Verlauf der Anfahrbeschleunigung gestartet werden kann. Im ersten Teil dieser Phase wird der Verbrennungsmotor **1** im dekomprimierten Zustand hochgedreht, wobei die Dekompression beispielsweise durch ein offenhalten des Auslaßventils erfolgen kann. Ein derartiges Ventilverhalten kann einfach mit Hilfe einer elektromagnetischen Ventilsteuerung realisiert werden. Bei Erreichen einer ausreichenden Drehzahl wird die Dekompression beendet (gekennzeichnet mit "K" in **Fig.** 2a), wobei der Übergang von Dekompression zu Kompression vorzugsweise weich erfolgt. Kurz danach beginnt die Einspritzung des Kraftstoffes und die Aktivierung der Zündung (gekennzeichnet mit "F, Z" in **Fig.** 2a). Sodann startet der Verbrennungsmotor **1** und übernimmt die weitere Fahrzeugbeschleunigung (gekennzeichnet durch "Start"). Um diesen Losfahrvorgang zu ermöglichen, erzeugt die elektrische Maschine **6** ab dem Zeitpunkt des Anfahrsignals ein hohes Antriebs-Drehmoment, welches bei Übernahme des Fahrzeugantriebs durch den Verbrennungsmotor **1** wieder zurückgenommen wird. Diesem, im wesentlichen konstanten Drehmoment ist ein Wechseldrehmoment überlagert, das betragsgleich gegenphasig zu den Drehmomentschwankungen ist, welche der Verbrennungsmotor **1** beim Mitschleppen erzeugt. Wie in **Fig.** 2b dargestellt ist, nimmt dieses über lagerte Wechseldrehmoment nach Beendigung der Dekompression stark zu. Dann nehmen nämlich die Gaskräfte des mitgeschleppten Verbrennungsmotors **1** zu, so daß zu deren Kompensation ein entsprechend größeres Wechseldrehmoment erforderlich ist.

Bei dem Ausführungsbeispiel gemäß **Fig.** 3 ist im Antriebsstrang zwischen dem Verbrennungsmotor **1** und der elektrischen Maschine **6** eine weitere Kupplung **3'** angeordnet. Abgesehen von – unten näher erläuterten – steuerungstechnischen Unterschieden (also einer unterschiedlichen Programmierung des Steuergeräts **13**) gleicht dieses Ausführungsbeispiel ansonsten dem vorbeschriebenen Ausführungsbeispiel der **Fig.** 1. Die diesbezüglichen obigen Ausführungen haben daher auch für das vorliegende Ausführungsbeispiel Gültigkeit.

In den **Fig.** 4a und 4b ist die Funktionsweise des Ausführungsbeispiels gemäß **Fig.** 3 dargestellt. Der Anfahr- und Startvorgang weist vier verschiedene Phasen I bis IV auf. (Anmerkung: Die Einteilung dieser Phasen ist nicht mit der Einteilung i-iii der Schritte in Anspruch 1 identisch.) **Fig.** 4a zeigt ein Drehzahldiagramm der Antriebswelle **2**. In der ersten Phase I sorgt die elektrische Maschine für den Antrieb des Fahrzeugs. In den anschließenden Phasen II und III rollt das Fahrzeug vorübergehend antriebslos weiter. In der letzten Phase IV erfolgt der Antrieb durch den Verbrennungsmotor **1** (wobei es möglich ist, daß auch in Phase IV die elektrische Maschine **6** antriebsunterstützend wirkt).

Das Drehzahldiagramm der **Fig.** 4b zeigt im einzelnen, wie dieses Wechselspiel von elektrischer Maschine **6** und Verbrennungsmotor **1** abläuft. Dabei ist die Drehzahl der elektrischen Maschine **6** mit durchgezogener und diejenige des Verbrennungsmotors **1** mit strichpunktierter Linie dargestellt. In der Phase I ist die Kupplung **3** geschlossen und die Kupplung **3'** offen. In diesem Zustand beschleunigt die elektrische Maschine **6** das Fahrzeug aus dem Stand auf die Endgeschwindigkeit der Phase I. Zu Beginn der Phase II wird die Kupplung **3** geöffnet. Die elektrische Maschine **6** wird dann auf generatorischen Betrieb umgeschaltet und durch die Generatorbremswirkung schnell zum Stillstand gebracht. Zu Beginn der anschließenden Phase III wird die Kupplung **3'** geschlossen. Die elektrische Maschine **6** dreht dann – wieder motorisch betrieben – den Verbrennungsmotor **1** auf eine Drehzahl, bei der zunächst dessen Start erfolgt, und anschließend noch höher auf eine Drehzahl, welche der momentanen Drehzahl des Antriebs entspricht ("Synchrondrehzahl"). Hierbei handelt es sich im wesentlichen um die am Ende der Phase I erzielte Drehzahl, ggf. vermindert um eine geringfügige Abnahme aufgrund der antriebslosen Phasen II und III. Zu Beginn der Phase IV wird die Kupplung **3** geschlossen, und zwar ruckfrei aufgrund der Synchronisierung. Die weitere Beschleunigung des Fahrzeugs im Verlauf der Phase IV übernimmt der Verbrennungsmotor **1**. Die elektrische Maschine **6** läuft dann mit, was durch das Wort "passiv" gekennzeichnet ist; sie kann beispielsweise leicht bremsend wirken (für eine Funktion als Fahrzeuggenerator) oder die zeitweise Fahrzeugbeschleunigung durch motorische Wirkung unterstützen.

Das dritte Ausführungsbeispiel gemäß **Fig.** 5 entspricht wiederum demjenigen der **Fig.** 1, wobei hier aber zwischen der Kupplung **3** und dem Getriebe **4** eine weitere elektrische Maschine **6'** angeordnet ist. Abgesehen von diesem Unterschied und einer hieraus resultierenden anderen Funktionsweise haben die obigen Ausführungen zu **Fig.** 1 auch für dieses Ausführungsbeispiel Gültigkeit.

Die Drehzahldiagramme gemäß **Fig.** 6a bis 6c veranschaulichen dessen Funktionsweise. Gemäß **Fig.** 6a erfolgt der Antrieb der Fahrzeugs in einer ersten Phase α zunächst durch die elektrische Maschine **6**. In einer anschließenden zweiten Phase β übernimmt der Verbrennungsmotor **1** den Fahrzeugantrieb, ohne daß dazwischen eine antriebslose Phase läge. Vorzugsweise ist der Übergang so gestaltet, daß die Drehzahl des Antriebs als Funktion der Zeit sowie deren zeitliche Ableitung an der Übergangsstelle stetig sind, mit anderen Worten also an der Übergangsstelle kein Sprung in der Drehzahl oder der Drehzahländerung als Funktion der Zeit auftritt. In Phase α ist die Kupplung **3** offen, in Phase β ist sie geschlossen.

Die **Fig.** 6b und 6c verdeutlichen, wie diese Funktion erzielt wird. Und zwar beschleunigt die elektrische Maschine **6'** bei offener Kupplung **3** das Fahrzeug aus dem Stand bis zum Ende der Phase α (**Fig.** 6b). Simultan dazu dreht die elektrische Maschine **6** den Verbrennungsmotor **1** hoch, so daß dieser startet. Die elektrische Maschine dreht ihn darüberhinaus noch weiter, bis am Ende der Phase α die gleiche Drehzahl wie diejenige der elektrischen Maschine **6'** erreicht ist ("Synchrondrehzahl"). Zu diesem Zeitpunkt wird die Kupplung **3** geschlossen. Der Verbrennungsmotor **1** übernimmt dann den Antrieb, so daß beide elektrischen Maschinen **6, 6'** mitlaufen, was durch die Wörter "passiv" gekennzeichnet ist. Sie können dabei generatorisch bremsend wirken oder zeitweise die weitere Fahrzeugbeschleunigung unterstützen.

Patentansprüche

1. Antriebssystem für ein Kraftfahrzeug, mit einem Verbrennungsmotor (1) und wenigstens einer elektrischen Maschine (6, 6'), die jeweils für sich als Antriebsmotor des Fahrzeugs dienen können, wobei das Antriebssystem so ausgebildet ist, daß die Anfahrphase des Fahrzeugs folgendermaßen abläuft:
   i) das Fahrzeug wird anfangs allein durch die elektrische Maschine (6, 6') beschleunigt,
   ii) der Verbrennungsmotor (1) wird währenddessen gestartet,
   iii) der Verbrennungsmotor (1) übernimmt daraufolgend den Antrieb des Fahrzeugs,

   wobei ein ruckartiges Ankuppeln des Verbrennungsmotors (1) im Verlauf der Schritte i) bis iii) vermieden wird, indem entweder
   a) der Verbrennungsmotor (1), während die elektrische Maschine (6, 6') das Fahrzeug beschleunigt, mitgeschleppt wird, oder
   b) der Verbrennungsmotor (1) in vom Antrieb entkoppeltem Zustand zwecks Starten hochgedreht wird und bei Synchrondrehzahl mit dem Antrieb gekoppelt wird.

2. Antriebssystem nach Anspruch 1, bei welchem beim Mitschleppen des Verbrennungsmotors (1) auftretende Drehmomentschwankungen aktiv durch entgegengerichtete Drehmomente verringert werden, welche von einer elektrischen Maschine (6) aufgebracht werden.

3. Antriebssystem nach Anspruch 2, bei welchem die entgegengerichteten Drehmomente von der das Fahrzeug antreibenden elektrischen Maschine (6) aufgebracht und dabei dem antreibenden Moment überlagert werden.

4. Antriebssystem nach einem der Ansprüche 1 bis 3, bei welchem der Verbrennungsmotor (1) am Anfang des Mitschleppens dekomprimiert mitgedreht wird.

5. Antriebssystem nach Anspruch 4, bei welchem die Kompression nach dem anfänglichen, dekomprimierten Mitschleppen weich einsetzt.

6. Antriebssystem nach Anspruch 4 oder 5, bei welchem der Verbrennungsmotor (1) mit einem elektromagnetischen oder elektrodynamischen Ventiltrieb ausgerüstet ist und die Dekompression durch geeignete Ansteuerung dieses Ventiltriebs erreicht wird.

7. Antriebssystem nach einem der Ansprüche 1 bis 4, bei welchem beim Mitschleppen des Verbrennungsmotors (1) die Kraftstoffzufuhr und/oder die Zündung wenigstens so lange verzögert wird, bis eine zum Starten des Verbrennungsmotors (1) ausreichende Drehzahl erreicht wird.

8. Antriebssystem nach Anspruch 1, bei welchem das Hochdrehen und Starten des Verbrennungsmotors (1) in vom Antrieb entkoppeltem Zustand gemäß Schritt ii) durch eine elektrische Maschine (6) erfolgt.

9. Antriebssystem nach Anspruch 7, bei welchem die im entkoppelten Zustand für das Starten sorgende elektrische Maschine (6) den Verbrennungsmotor (1) auf Synchrondrehzahl bringt, bevor er im darauffolgenden Schritt iii) den Fahrzeugantrieb übernimmt.

10. Antriebssystem nach Anspruch 8 oder 9, bei welchem die für das Starten im abgekoppelten Zustand sorgende elektrische Maschine (6) mit der für die Fahrzeugbeschleunigung sorgenden identisch ist, und diese elektrische Maschine (6) nach Beschleunigung des Fahrzeugs gemäß Schritt i) vom Antrieb abgekoppelt wird, dann an den Verbrennungsmotor (1) angekoppelt wird und diesen gemäß Schritt ii) hochdreht und startet, wobei der Verbrennungsmotor (1) anschließend bei Synchrondrehzahl mit dem Antrieb gekoppelt wird und gemäß Schritt iii) den Fahrzeugantrieb übernimmt.

11. Antriebssystem nach Anspruch 8 oder 9, bei welchem die für das Starten sorgende elektrische Maschine (6) und die für die Fahrzeugbeschleunigung sorgende als eine elektrische Doppelmaschine ausgebildet sind, welche zwei Läufer und einen umschaltbaren Ständer aufweist, wobei die Umschaltung durch mechanische Verschiebung des Ständers oder durch elektrisches Umschalten eines Doppelständers erfolgt.

12. Antriebssystem nach Anspruch 8 oder 9, bei welchem die für das Starten und die für den Fahrzeugantrieb sorgenden elektrischen Maschinen zwei gesonderte elektrische Maschinen (6 und 6') sind, von denen simultan eine (6) den vom Antrieb entkoppelten Verbrennungsmotor (1) startet und die andere (6') das Fahrzeug beschleunigt, wobei der Verbrennungsmotor (1) nach Erreichen der Synchrondrehzahl mit dem Antrieb gekoppelt wird.

13. Antriebssystem nach Anspruch 12, welches eine Kupplung (3) zwischen den beiden elektrischen Maschinen (6, 6') aufweist, und bei welchem das Koppeln des Verbrennungsmotors (1) mit dem Antrieb durch Schließen der Kupplung (3) erfolgt.

14. Antriebssystem nach einem der Ansprüche 1 bis 13, bei welchem die für das Starten und/oder das Fahrzeugbeschleunigen sorgende elektrische Maschine (6, 6') auf der Kurbelwelle des Verbrennungsmotors (1) oder einer Antriebswelle (2) sitzt und beim Antrieb durch den Verbrennungsmotor (1) mitgedreht wird.

15. Antriebssystem nach einem der Ansprüche 1 bis 14, welches mit einer automatischen Start-Stop-Steuerung des Verbrennungsmotors (1) ausgerüstet ist.

16. Verfahren zum Betreiben eines – Antriebssystems für ein Kraftfahrzeug, welches mit einem Verbrennungsmotor (1) und wenigstens einer elektrischen Maschine (6, 6') ausgerüstet ist, die jeweils für sich als Antriebsmotor des Fahrzeugs dienen können, mit folgen-

den Schritten:

i) das Fahrzeug wird anfangs allein durch die elektrische Maschine (**6, 6'**) beschleunigt,

ii) der Verbrennungsmotor (**1**) wird währenddessen gestartet,

iii) der Verbrennungsmotor (**1**) übernimmt darauffolgend den Antrieb des Fahrzeugs,

wobei ein ruckartiges Ankuppeln des Verbrennungsmotors (**1**) im Verlauf der Schritte i) bis iii) vermieden wird, indem entweder

a) der Verbrennungsmotor (**1**), während die elektrische Maschine das Fahrzeug beschleunigt, mitgeschleppt wird, oder

b) der Verbrennungsmotor (**1**) in vom Antrieb entkoppeltem Zustand zwecks Starten hochgedreht wird und bei Synchrondrehzahl mit dem Antrieb gekoppelt wird.

17. Verfahren nach Anspruch 16, welches eines oder mehrere der Merkmale der Ansprüche 2 bis 14 aufweist.

Hierzu 3 Seite(n) Zeichnungen

- Leerseite -

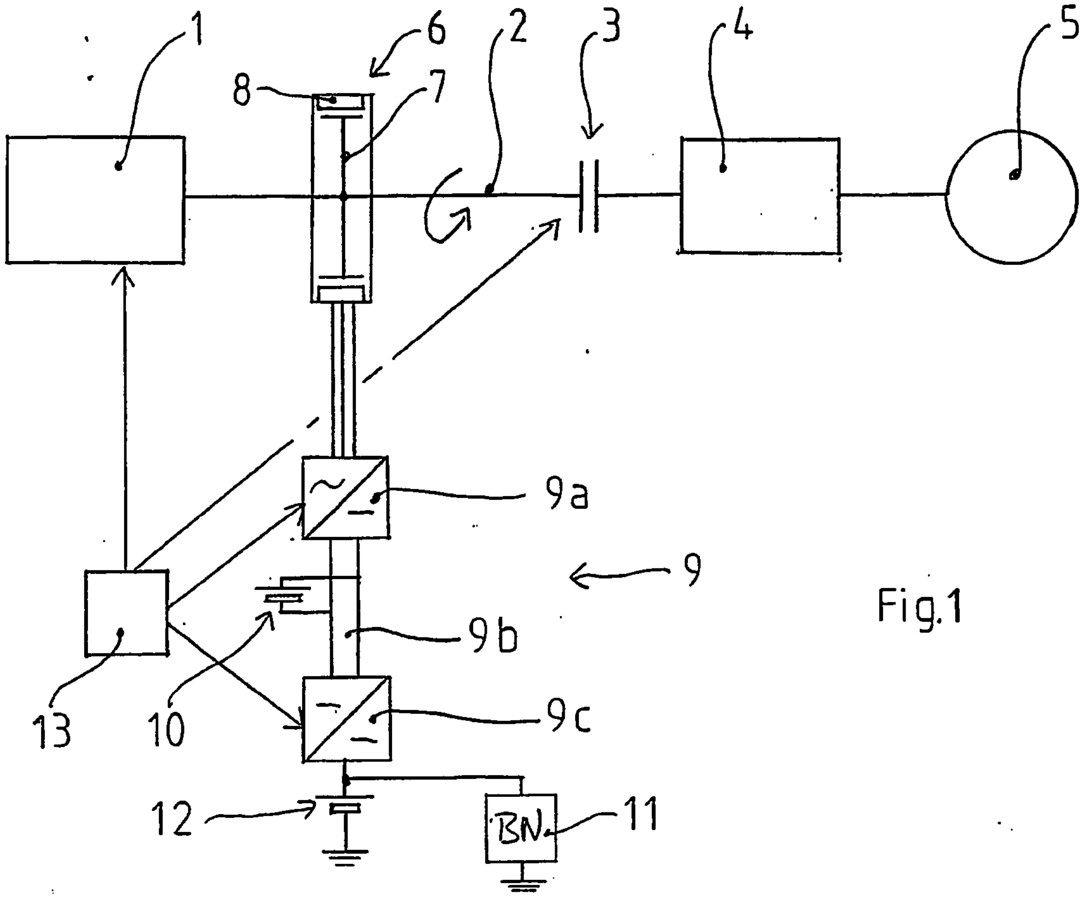


Fig.1

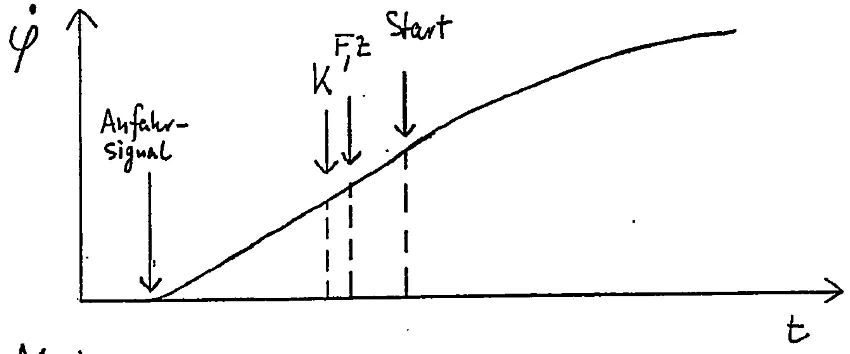


Fig. 2a

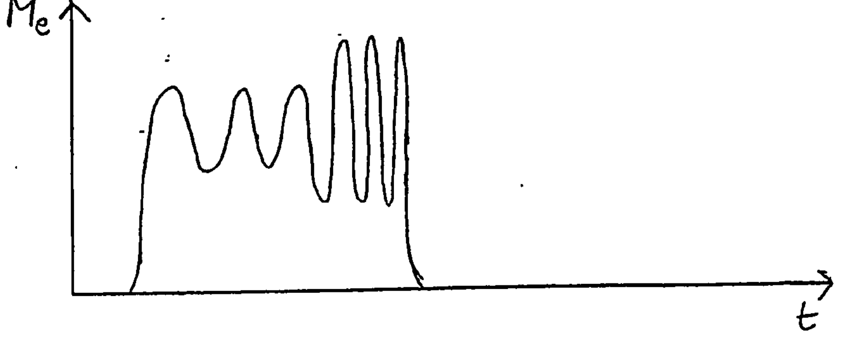


Fig. 2b

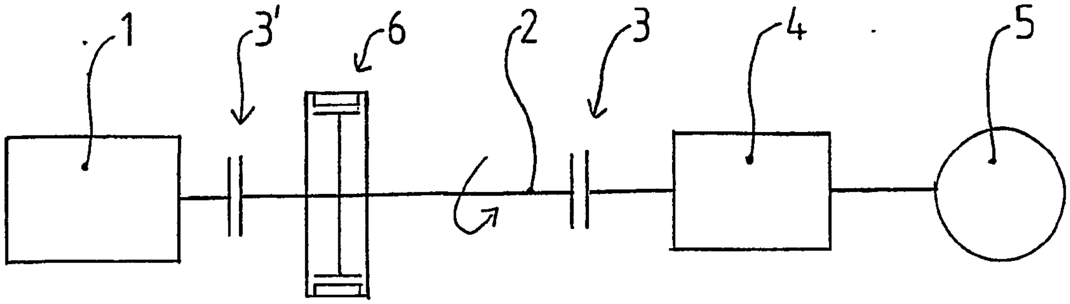


Fig. 3

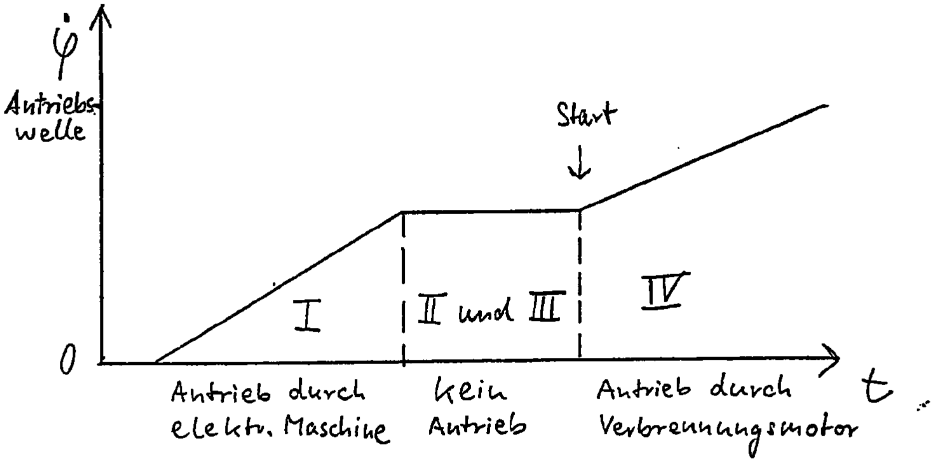


Fig.4a

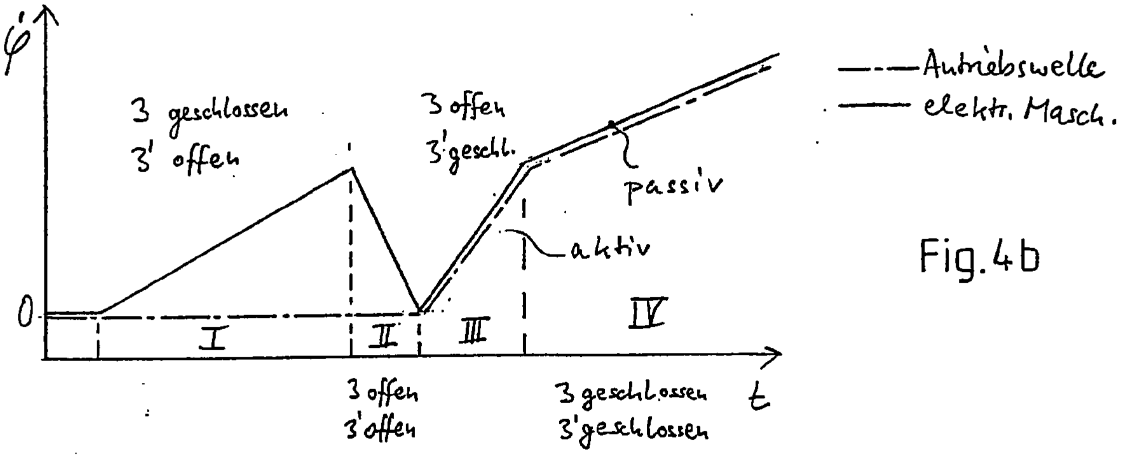


Fig.4b

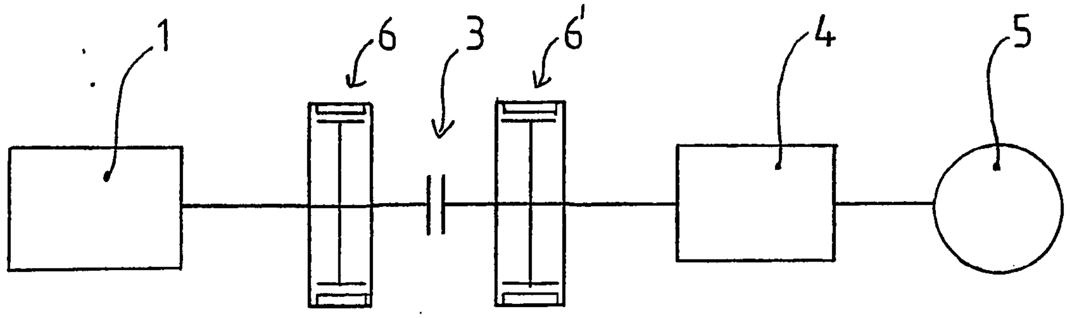


Fig. 5

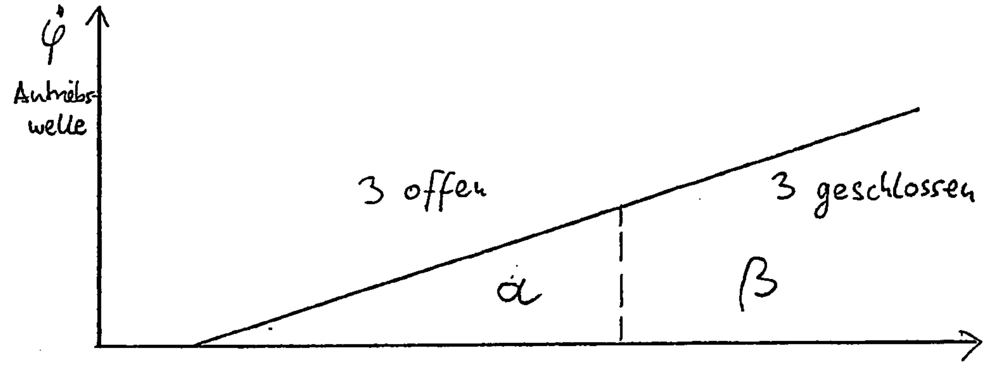


Fig.6a

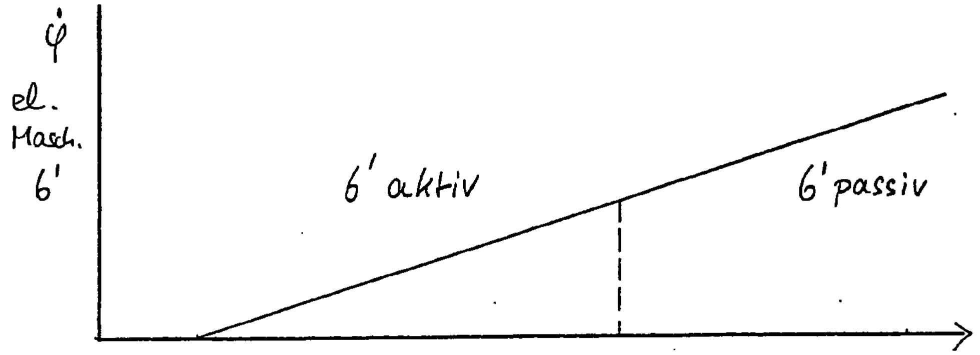


Fig. 6b

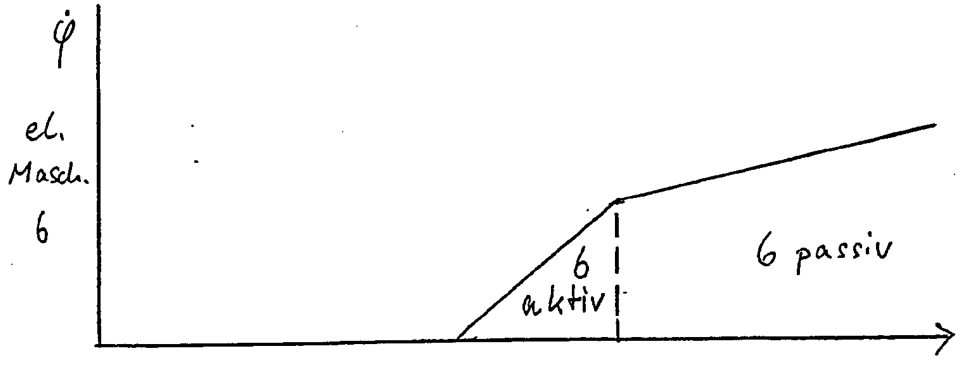


Fig. 6c

PTO/SB/06 (08-03)
Approved for use through 7/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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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

	(Column 1)		(Column 2)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED		NUMBER EXTRA	RATE	FEE		RATE	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	+ $____ =	
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL		OR	TOTAL	750

CLAIMS AS AMENDED – PART II

2-22-05

AMENDMENT A	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE	ADDI-TIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDI-TIONAL FEE
Total (37 CFR 1.16(c))	* 41	Minus	** 124	=	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	

AMENDMENT B	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE	ADDI-TIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDI-TIONAL 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	

AMENDMENT C	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE	ADDI-TIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDI-TIONAL 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 [illegible] 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.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

7590 04/21/2005

Michael de Angeli
60 Intrepid Lane
Jamestown, RI 02835

EXAMINER	
DUNN, DAVID R	
ART UNIT	**PAPER NUMBER**
3616	

DATE MAILED: 04/21/2005

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	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$300	$1700	07/21/2005

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 REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

f the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:	If the SMALL ENTITY is shown as NO:
A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.	A. Pay TOTAL FEE(S) DUE shown above, or
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	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 should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. 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.

I. 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 (703) 746-4000

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 04/21/2005

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 (703) 746-4000, 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	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$300	$1700	07/21/2005

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 enclosed:

☐ Issue Fee

☐ Publication Fee (No small entity discount permitted)

☐ Advance Order - # of Copies ____________

4b. Payment of Fee(s):

☐ A check in the amount of the fee(s) is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director is hereby authorized by charge the required fee(s), 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).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
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. ____________________

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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PTOL-85 (Rev. 12/04) Approved for use through 04/30/2007. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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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 04/21/2005

Michael de Angeli
60 Intrepid Lane
Jamestown, RI 02835

EXAMINER	
DUNN, DAVID R	
ART UNIT	PAPER NUMBER
3616	

DATE MAILED: 04/21/2005

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 210 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 210 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 (703) 305-8283.

PTOL-85 (Rev. 12/04) Approved for use through 04/30/2007.

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*.
2. ☒ The allowed claim(s) is/are *82-122*.
3. ☒ The drawings filed on *07 March 2003* are accepted by the Examiner.
4. ☐ 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.

5. ☐ 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.
6. ☐ 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).
7. ☐ 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 2/22/05
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

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	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	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

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

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	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	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.

Issue Classification	Application No.	Applicant(s)
	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)						
180	65.2	180	65.4						
INTERNATIONAL CLASSIFICATION		701	54						
B 6 0 K	6/02								
	/								
	/								
	/								
	/								

(Assistant Examiner) (Date)

M. E. 3-16-05
(Legal Instruments Examiner) (Date)

3/16/05
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
	11		41		71		101		131		161		191
	12		42		72		102		132		162		192
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	16		46		76		106		136		166		196
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	18		48		78		108		138		168		198
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	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.** 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	"	"

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner
180	65.2	3/16/05	DD
	65.4		

SEARCH NOTES (INCLUDING SEARCH STRATEGY)

	DATE	EXMR
EAST text search	11/29/2004	DD

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Part of Paper No. 20041130

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BIBDATASHEET

Bib Data Sheet

CONFIRMATION NO. 9389

SERIAL NUMBER 10/382,577	FILING DATE 03/07/2003 RULE	CLASS 180	GROUP ART UNIT 3616	ATTORNEY DOCKET NO. PAICE201.DIV

APPLICANTS

Alex J. Severinsky, Washington, DC;

Theodore Louckes, Holly, MI;

** CONTINUING DATA *************************

This application is a DIV of 09/822,866 04/02/2001 PAT 6,554,088
which is a CIP of 09/264,817 03/09/1999 PAT 6,209,672
which claims benefit of 60/100,095 09/14/1998
This application 10/382,577
is a CIP of 09/392,743 09/09/1999 PAT 6,338,391
which claims benefit of 60/122,296 03/01/1999

D.D.

** FOREIGN APPLICATIONS ********************

NONE DD

IF REQUIRED, FOREIGN FILING LICENSE GRANTED
** 04/25/2003

Foreign Priority claimed ☐ yes ☑ no 35 USC 119 (a-d) conditions met ☐ yes ☐ no ☐ Met after Allowance Verified and Acknowledged ______ Examiner's Signature ______ Initials	STATE OR COUNTRY DC	SHEETS DRAWING 17	TOTAL CLAIMS 7	INDEPENDENT CLAIMS 3

ADDRESS
Michael de Angeli
60 Intrepid Lane
Jamestown , RI
02835

TITLE
Hybrid vehicles

FILING FEE RECEIVED 3466	FEES: Authority has been given in Paper No. ________ to charge/credit DEPOSIT ACCOUNT No. ________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue)

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7590 04/21/2005

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OIPE JC133
JUL 0 1 2005
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07/05/2005 MBEYENE2 00000022 10382577

01 FC:1501 1400.00 OP
02 FC:1504 300.00 OP
03 FC:8001 30.00 OP

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(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	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$300	$1700	07/21/2005

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: PAICELLC

(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

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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).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.

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 6/30/05

Typed or printed name Michael de Angeli Registration No. 27,869

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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PATENT & TRADEMARK OFFICE

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

Examiner: David Dunn
Group Art Unit: 3616
Att. Dkt.: PAICE201.DIV
Confirmation No. 5936

For: Hybrid Vehicles

Mail Stop ISSUE FEE
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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 JC139
JUL 01 2005
PATENT & TRADEMARK OFFICE

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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

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

07/05/2005 MBEYENE1 00000029 10382577
01 FC:1806 180.00 OP

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,

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

Dated: 6/30/05

OIPE JC135
JUL 0 1 2005
PATENT & TRADEMARK OFFICE

1/5

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
	5844342	12/1998	Miyatani et al			
	5804947	9/1998	Nii et al			
	5457363	10/1995	Yoshii et al			
	5907191	5/1999	Sasaki et al			
	5914575	6/1999	Sasaki			
	6005297	12/1999	Sasaki et al			
	6166499	12/2000	Kanamori et al			
	5801497	9/1998	Shamoto et al			
	5909720	6/1999	Yamaoka			
	5698955	12/1997	Nii			
	5428274	6/1995	Furutani et al			
	6077186	6/2000	Kojima et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
	2419832	3/1978	France			X	
	3124201	10/1989	Japan			X	
	51 103220	2/1975	Japan			X	
	H5 64531	9/1984	Japan			X	
	S 48 49115	10/1971	Japan			X	

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

- Winkelman et al, SAE paper 730511, "Computer Simulation...." (1973)
- Berman et al, IEEE VT-23, NO. 3, pp. 61-72 "Propulsion Systems...."(1974)
- Berman SPC-TUE-2 "Battery Powered Regenerative SCR Drive"(1970)
- Gelb et al "Performance Analyses..." ACS pub (1972), pp 977-988
- Berman SPC-TUE-1 "Design Considerations...." (1971)
- Berman SPC-TUE-2" All Solid State Method....." (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
	5991683	11/1999	Takaoka et al			
	5473228	12/1995	Nii			
	5927415	7/1999	Ibaraki et al			
	5928301	7/1999	Soga et al			
	6176807	1/2001	Oba et al			
	5904631	5/1999	Morisawa et al			
	5789877	8/1998	Yamada et al			
	6087734	7/2000	Maeda et al			
	5973460	10/1999	Taga et al			
	5988307	11/1999	Yamada et al			
	5991683	11/1999	Takaoka et al			
	5818116	10/1998	Nakae			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO
	S50302223	7/1973	Japan			X	
	WO 8201170	4/1982	PCT				
	0510582	12/1995	EPO				
	4297330	3/1991	Japan				✓

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

		Minorikawa et al, "Current Status and Future Trends...." (Undated)
		Baum et al "Semiconductor Technologies..." (Undated)
		Chen "Automotive Electronics in the Year 2000..." (Apparently 1992)
		Brusaglino, SAE paper 910244 "Electric Vehicle Development..." (1991)
		Anderson et al, SAE paper 910246 "Integrated Electric..." (1991)
		Burke, SAE paper 911914 "Battery Availability for Near-Term..." (1991)

EXAMINER	DATE CONSIDERED

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201.DIV	APPLICATION NUMBER 10/382,577	
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FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

Chang, IEEE AES Magazine (1993) "Recent Developments of Electric ..."

Kamiyama et al, IEEE 0-7803-0582-5 (1992) "Application Trends...."

Sen, IEEE Trans. Ind. Elec. (1990) "Electric Motor Drives..."

Wang et al, PCSC '71 Record, "Analysis of SCR Chopper Drive" (1971)

EPRI Report TR-101264 "Assessment of Electric Motor Technology (1992)

Berman et al, SAE paper 720111 "Electric Car Drives...." (1972)

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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	NO
	WO 9924280	11/1997	PCT			X	
	EP 0743211	5/1996	EP				
	EP 0839683	10/1997	EP				

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

		Gelb et al, "The Application of Solid Electrolyte Batteries..." (Undated)
		Miller, "Integrated Power Module Requirements for Automotive..." (Undated)
		Vukosavic et al, IEEE Trans. Ind. App. "SRM Inverter Topologies..." (1991)

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(51) Classification internationale des brevets 6 :
B60K 6/04

A1

(11) Numéro de publication internationale: **WO 99/24280**

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(21) Numéro de la demande internationale: PCT/FR98/02403

(22) Date de dépôt international: 10 novembre 1998 (10.11.98)

(30) Données relatives à la priorité:
97/14174 12 novembre 1997 (12.11.97) FR

(71) Déposant *(pour tous les Etats désignés sauf US)*: RENAULT [FR/FR]; 34, quai du Point du Jour, F-92109 Boulogne Billancourt Cedex (FR).

(72) Inventeurs; et
(75) Inventeurs/Déposants *(US seulement)*: BORGEAUD, Yves [FR/FR]; 24, rue de Mussel Burgh, F-95500 Champigny sur Marne (FR). CAILLARD, Benoît [FR/FR]; 69, boulevard Desgranges, F-92330 Sceaux (FR). HEMEDINGER, Stéphane [FR/FR]; 32, rue Juliette Savar, F-94000 Créteil (FR). PANNEQUIN, William [FR/FR]; 46, avenue de Buzenval, F-92500 Rueil Malmaison (FR).

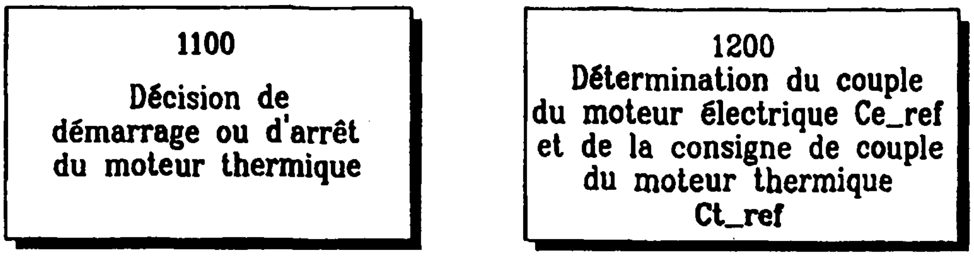
(74) Mandataire: ROUGEMONT, Bernard; Renault, Service 0267 - TPZ 0J2 110, 860, quai de Stalingrad, F-92109 Boulogne Billancourt Cedex (FR).

(81) Etats désignés: BR, CN, JP, US, brevet européen (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Publiée
Avec rapport de recherche internationale.

(54) Title: MOTOR VEHICLE WITH DUAL ENGINE SYSTEM

(54) Titre: VEHICULE AUTOMOBILE A MOTORISATION HYBRIDE



1100...DECISION TO START OR TO STOP HEAT ENGINE
1200...DETERMINATION OF THE ELECTRIC ENGINE TORQUE Ce-ref AND SET POINT OF HEAT ENGINE TORQUE Ct-ref

(57) Abstract

The invention concerns a motor vehicle with dual engine system comprising an electric engine and a heat engine, wherein a central management unit executes a first task (1200) including the determination of a torque which each engine must provide to supply an engine torque in conformity with the torque requested by the driver, and wherein the heat engine can be stopped. The invention is characterised, at least for some operating modes, the central unit executes a second task (1100) during which the decision to stop or to start the heat engine is taken, and the first and second tasks are executed in parallel, the execution frequency of the second task being less frequently operated than the first.

(57) Abrégé

L'invention propose un véhicule automobile à motorisation hybride comportant un moteur électrique et un moteur thermique, du type dans lequel une unité centrale de gestion exécute une première tâche (1200) comportant la détermination du couple que doit fournir chaque moteur pour fournir un couple moteur conforme à un couple demandé par le conducteur, et du type dans lequel le moteur thermique est susceptible d'être arrêté, caractérisé en ce que, au moins pour certains modes de fonctionnement, l'unité centrale exécute une deuxième tâche (1100) au cours de laquelle est décidé l'arrêt ou le démarrage du moteur thermique, et en ce que la première et la deuxième tâche sont exécutées en parallèle, la fréquence d'exécution de la deuxième tâche étant inférieure à celle de la première tâche.

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Véhicule automobile à motorisation hybride

L'invention concerne un véhicule automobile à motorisation hybride comportant des moyens perfectionnés de gestion de l'énergie.

L'invention concerne plus particulièrement un véhicule automobile à motorisation hybride, du type dans lequel un ensemble motopropulseur comporte un moteur électrique et un moteur thermique qui sont susceptibles de contribuer à l'entraînement du véhicule, et du type dans lequel une unité centrale de gestion exécute une première tâche comportant la détermination du couple que doit fournir chaque moteur pour que l'ensemble motopropulseur fournisse au véhicule un couple moteur conforme à un couple demandé par le conducteur du véhicule, et du type dans lequel le moteur thermique est susceptible d'être arrêté, le véhicule étant alors entraîné par le seul moteur électrique alimenté en courant électrique par une batterie d'accumulateurs.

Dans la recherche de véhicules moins polluants que les véhicules automobiles ne comportant qu'un unique moteur thermique, les véhicules à motorisation hybride se présentent comme une alternative particulièrement intéressante aux véhicules strictement électrique.

En effet, ces derniers présentent l'avantage de n'émettre par eux-mêmes aucune substance toxique tout en étant à la fois particulièrement silencieux et économiques à l'usage. Cependant, les véhicules électriques ne tirent leur énergie que des seules batteries d'accumulateurs qu'ils embarquent avec eux. Or, étant données les faibles performances des batteries d'accumulateurs actuellement connues, du moins celles susceptibles d'être utilisées à un coût raisonnable dans un véhicule automobile, les véhicules électriques ne peuvent emmagasiner qu'une quantité d'énergie relativement faible, en dépit d'une masse conséquente, ce qui leur confère à la fois une faible autonomie et de faibles performances.

Aussi, la solution d'une motorisation hybride comportant un moteur thermique susceptible de participer à l'entraînement du véhicule permet de réaliser des véhicules présentant des performances et une autonomie bien plus élevée, satisfaisante pour un usage normal du véhicule.

Il existe deux types principaux de véhicules hybrides.

Dans les véhicules hybrides série, seul le moteur électrique est susceptible d'entraîner directement les roues motrices du véhicule, éventuellement au travers d'une boîte de vitesses, d'un différentiel et/ou d'un embrayage. Le moteur électrique tire son énergie d'une batterie d'accumulateurs rechargée d'une génératrice électrique qui est entraînée par le moteur thermique.

Dans un tel type de véhicule hybride, le moteur électrique est donc toujours en fonctionnement et le moteur thermique peut soit être arrêté, le véhicule fonctionnant alors en mode électrique pur, soit être mis en marche de manière que la génératrice produise de l'électricité en vue d'alimenter le moteur électrique et/ou de recharger les batteries.

Dans un véhicule hybride parallèle, le moteur thermique et le moteur électrique sont tous les deux reliés, généralement par un système de boîte de vitesses à deux entrées, aux roues motrices du véhicule. Généralement, un embrayage est interposé entre chaque moteur et les roues motrices pour permettre le désaccouplement du moteur lorsque celui-ci n'est pas utilisé pour l'entraînement. Les véhicules automobiles de type hybride parallèle peuvent donc être entraînés soit à l'aide du seul moteur électrique, soit à l'aide du seul moteur thermique, ou encore à l'aide des deux moteurs simultanément. Par ailleurs, dans certaines configurations, il est possible d'utiliser le moteur électrique pour assurer le démarrage du moteur thermique et le moteur électrique peut aussi être « inversé » de telle sorte que, le moteur thermique entraînant en rotation le moteur électrique, éventuellement en même temps qu'il entraîne en rotation les roues motrices du véhicule, assure le rechargement des batteries.

Il est à noter qu'il existe une variante de réalisation des véhicules hybrides en parallèle dans lesquels chacun des deux moteurs thermique et électrique est accouplé non pas à un même essieu, mais à des essieux différents.

Quel que soit le type de véhicule hybride envisagé, il est donc nécessaire de gérer le plus efficacement possible la commande de chacun des moteurs thermique et électrique pour assurer l'entraînement du véhicule selon les desiderata du conducteur qui détermine à chaque instant le couple moteur nécessaire à l'avancement du véhicule pour assurer l'accélération ou la décélération du véhicule, ou le maintien du véhicule à une vitesse stabilisée.

Notamment, le choix de l'utilisation ou non du moteur thermique est particulièrement crucial car il permet de déterminer l'autonomie du véhicule, ses performances, tout cela dans la mesure où la mise en route du moteur thermique est effectivement possible, ce qui peut par exemple être interdit dans certaines zones au trafic particulièrement dense ou à certaines périodes pour limiter la pollution.

Par ailleurs, il est nécessaire que les transferts de répartition de la puissance fournie par chacun des moteurs se fassent de manière « transparente » pour le conducteur, c'est-à-dire en ne produisant qu'un minimum de perturbations et d'à-coups.

Aussi, l'invention propose un véhicule automobile du type décrit précédemment, caractérisé en ce que, au moins pour certains modes de fonctionnement de l'ensemble motopropulseur, l'unité centrale exécute une deuxième tâche au cours de laquelle est décidé l'arrêt ou le démarrage du moteur thermique, en ce que la première tâche et la deuxième tâche sont exécutées en parallèle, et en ce que la fréquence d'exécution de la deuxième tâche est inférieure à celle de la première tâche.

Selon d'autres caractéristiques de l'invention :

- le conducteur peut imposer à l'ensemble motopropulseur un mode de fonctionnement électrique dans lequel le moteur thermique est arrêté ;
- le conducteur peut imposer à l'ensemble motopropulseur un mode de fonctionnement de régénération dans lequel le moteur thermique est utilisé notamment pour assurer le rechargement de la batterie ;
- le conducteur peut imposer à l'ensemble motopropulseur un mode de fonctionnement hybride dans lequel l'unité centrale exécute la deuxième tâche au cours de laquelle est décidé l'arrêt ou le démarrage du moteur thermique ;
- la décision d'arrêt ou de démarrage du moteur thermique est prise notamment en fonction d'un niveau de charge de la batterie ;
- le démarrage du moteur thermique est décidé ou confirmé lorsque le niveau de charge de la batterie est inférieur à un niveau de seuil bas, et en ce que l'arrêt du moteur thermique est susceptible d'être décidé ou d'être confirmé lorsque le niveau de charge de la batterie est supérieur à un niveau de seuil haut ;
- la décision d'arrêt ou de démarrage du moteur thermique est prise notamment en fonction du couple instantanée demandé par le conducteur ;

- la décision d'arrêt ou de démarrage du moteur thermique est prise notamment en fonction du couple moyen demandé par le conducteur pendant un intervalle de temps prédéterminé précédant de la décision ;
- le démarrage du moteur thermique est décidé ou confirmé lorsque le couple instantané demandé par le conducteur est supérieur à un niveau de seuil haut, et en ce que l'arrêt du moteur thermique est susceptible d'être décidé ou d'être confirmé lorsque le couple instantané et le couple moyen demandés par le conducteur sont inférieurs à un niveau de seuil bas ;
- l'arrêt du moteur thermique est décidé ou confirmé lorsque, à la fois, le niveau de charge de la batterie est supérieur à un niveau de seuil haut et le couple instantané et le couple moyen demandés par le conducteur sont inférieurs à un niveau de seuil bas ;
- la décision d'arrêt ou de démarrage du moteur thermique est prise notamment en fonction d'un écart entre le couple demandé par le conducteur et le couple effectivement fourni par l'ensemble motopropulseur ;
- en fonctionnement du mode de fonctionnement sélectionné par le conducteur, il est fixé un niveau de consigne de charge de la batterie ;
- l'ensemble motopropulseur est un ensemble hybride en série dans lequel les roues motrices du véhicule sont entraînées exclusivement par le moteur électrique qui est alimentée par du courant électrique provenant soit de la batterie soit d'une génératrice entraînée par le moteur thermique ;
- il est déterminé la puissance électrique à fournir à la batterie en fonction d'un écart entre les niveaux réel et de référence de la batterie, en tenant compte de valeurs limites

de puissance de charge et de décharge de la batterie ;

- le démarrage du moteur thermique est déterminé en fonction de la puissance électrique à fournir à la batterie, de la puissance électrique absorbée par le moteur électrique et en fonction d'un écart entre la valeur du couple demandé par le conducteur et la valeur du couple fourni par le moteur électrique ;

- il est déterminé un niveau de consigne de la puissance fournie par la génératrice en fonction de la puissance réelle fournie par la génératrice, de la puissance réelle fournie par la batterie, et de la puissance à fournir à la batterie, en tenant compte la puissance maximale susceptible d'être fournie par la génératrice ;

- il est déterminé une puissance électrique nécessaire en fonction du couple moteur demandé par le conducteur, en tenant compte, au moins lorsque ce couple est supérieur en valeur absolue à une valeur minimale, d'un rendement du moteur électrique ;

- il est déterminé une valeur de consigne du couple fourni par le moteur électrique en fonction du couple moteur demandé par le conducteur multiplié par, au moins lorsque la puissance électrique nécessaire est supérieure en valeur absolue à une valeur de seuil, du rapport de la puissance électrique susceptible d'être fournie au moteur électrique divisée par la puissance électrique nécessaire, la puissance électrique susceptible d'être fournie au moteur électrique tenant compte de la puissance électrique nécessaire, de la puissance réelle fournie par la génératrice, de la puissance susceptible d'être fournie par la batterie, et de la puissance maximale susceptible d'être absorbée par le moteur ;

- l'ensemble motopropulseur est un ensemble hybride en parallèle dans lequel le moteur électrique et le moteur thermique entraînent chacun soit au moins une même roue motrice soit des roues motrices différentes ;

- l'ensemble motopropulseur fonctionne en mode de régénération, le moteur électrique ne délivre un couple moteur que si le conducteur provoque une hausse brutale du couple demandé ;

- lorsque l'ensemble motopropulseur fonctionne en mode de régénération, le moteur thermique est commandé pour fournir un couple maximal ;

- lorsque l'ensemble motopropulseur fonctionne en mode hybride et que le niveau de charge de la batterie est précédemment devenu inférieur à un niveau de seuil bas et n'a pas encore dépassé un niveau de seuil haut, le moteur thermique est commandé pour fournir un couple de consigne au moins égal à un couple optimal correspondant à des conditions de rendement optimales du moteur thermique ;

- lorsque l'ensemble motopropulseur fonctionne en mode hybride et que le couple instantané demandé par le conducteur est précédemment devenu supérieur à un niveau de seuil haut sans être redevenu inférieur à un niveau de seuil bas en même temps que le niveau moyen est inférieur au niveau de seuil bas, le moteur thermique est commandé pour fournir un couple de consigne au moins égal à une valeur filtrée du couple demandé par le conducteur ; et

- si une valeur filtrée du couple demandé par le conducteur est supérieure au couple maximal du moteur thermique, le moteur électrique est sollicité pour fournir, dans la mesure du possible, la quantité de couple manquante.

D'autres caractéristiques et avantages de l'invention apparaîtront à la lecture de la description détaillée qui suit pour la compréhension de laquelle on se reportera aux dessins annexés dans lesquels :

- la figure 1 est une vue schématique illustrant l'architecture d'un véhicule automobile à motorisation hybride, de type parallèle ;
- la figure 2 est une vue similaire à celle de la figure 1 illustrant un véhicule hybride de type série ;
- les figures 3A à 3K sont des organigrammes illustrant une première stratégie de gestion d'un véhicule hybride conforme aux enseignements de l'invention, plus particulièrement destinée à un véhicule hybride de type parallèle ; et
- les figures 4A à 4H illustrent un organigramme d'une stratégie de gestion selon l'invention, plus particulièrement destinée à un véhicule de type hybride en série.

Dans un véhicule à motorisation hybride en parallèle, du type de celle illustrée à la figure 1, un moteur thermique 10 et un moteur électrique 12 sont tous les deux susceptibles d'entraîner directement les roues motrices du véhicule.

Le moteur thermique 10 est généralement un moteur à combustion interne du type à pistons alternatifs ou à piston rotatif ou encore de type turbine. Il est alimenté en énergie sous forme chimique par un carburant liquide ou gazeux de type hydrocarbure.

Le moteur électrique 12 est relié électriquement à une batterie d'accumulateurs 16 porté par le véhicule, éventuellement par le biais d'un convertisseur onduleur 17. Les deux moteurs 10, 12 entraînent chacun en rotation un arbre d'entrée 18, 20 d'un organe de répartition de puissance 22 dont le ou les arbres de sortie 24 entraînent en rotation les roues motrices. L'organe de distribution de puissance 22 peut comporter par exemple une boîte de vitesses, un différentiel et on peut choisir d'interposer entre l'un au moins des moteurs et l'arbre d'entrée 18, 20 correspondant, un dispositif d'embrayage 25 qui permet d'accoupler ou de désaccoupler à volonté le moteur par rapport à l'organe de distribution de puissance 22.

Le véhicule ainsi équipé peut donc être entraîné soit à l'aide du seul moteur thermique 10, soit à l'aide du seul moteur électrique 12, soit à l'aide des deux moteurs simultanément. Éventuellement, le moteur thermique peut voir sa puissance répartie entre d'une part l'entraînement des roues motrices 14, et d'autre part l'entraînement en rotation du moteur électrique « inversé » qui se transforme alors en une génératrice électrique susceptible de recharger la batterie d'accumulateurs 16.

De même, le moteur électrique 12 peut éventuellement être utilisé pour démarrer le moteur thermique 10.

Dans le véhicule hybride de type série qui est illustré à la figure 2, seul le moteur électrique 12 est relié directement aux roues motrices, éventuellement par le biais d'un organe de distribution de puissance (non représenté). Le moteur électrique 12 peut être alimenté en énergie électrique par la batterie d'accumulateurs 16 ou par une génératrice électrique 26 qui est entraînée par le moteur électrique 12.

Dans tous les cas, il peut être prévu des convertisseurs onduleur 17 et redresseur 19 si le moteur électrique doit être alimenté en courant alternatif.

De préférence, pour assurer la gestion de l'entraînement du véhicule, chacun des éléments principaux du véhicule est pourvu d'une unité locale de commande, chacune de ces unités locales étant à son tour commandée par une unité centrale de gestion qui permet de centraliser à la fois les informations concernant l'état de chacun des organes, des informations quant à l'état du véhicule et aussi des informations quant aux souhaits du conducteur.

L'unité centrale de gestion a notamment pour but de commander les deux moteurs 10, 12 de manière à utiliser au mieux l'énergie du véhicule qui est stockée soit sous la forme électrique dans les batteries, soit sous la forme de carburant de type hydrocarbure. Cette gestion a aussi pour but de répondre à tout moment de la manière la plus satisfaisante possible aux souhaits du conducteur quant à l'accélération et à la décélération du véhicule, ce souhait étant de préférence représenté par un couple moteur Cdemandé au niveau des roues motrices.

Deux tâches principales sont exécutées cycliquement par l'unité centrale de gestion, à savoir d'une part la décision du démarrage ou de l'arrêt du moteur thermique 10 et, d'autre part, la détermination des consignes du couple ou de la puissance que doivent fournir le moteur électrique et le moteur thermique pour assurer l'entraînement du véhicule conformément aux souhaits du conducteur.

Selon l'invention, ces deux tâches sont effectuées en parallèle et elles sont exécutées à des fréquences différentes.

Ainsi, la tâche consistant à déterminer les consignes de couple à fournir par le moteur électrique et le moteur thermique sera par exemple exécutée toutes les quarante millisecondes tandis que la tâche de décision du démarrage ou de l'arrêt du moteur thermique sera par exemple effectué toutes les secondes.

En découplant de la sorte ces deux tâches, on parvient à obtenir une gestion de la puissance fournie par l'ensemble motopropulseur constitué par les deux moteurs 10, 12 qui permet de répondre de manière quasi instantanée aux sollicitations du conducteur. De plus, en rendant la décision de démarrage et d'arrêt du moteur thermique indépendante de la gestion instantanée de la puissance, on évite de multiplier ces phases d'arrêt et de démarrage qui sont à la fois des sources de pollution accentuées et des sources d'instabilité quant à la puissance totale fournie par les moteurs qui peut se traduire par des à-coups ressentis par le conducteur et les passagers du véhicule.

La stratégie de gestion du véhicule hybride selon l'invention sera plus particulièrement décrite ci-après selon deux modes de réalisation dont l'un est plus particulièrement adapté à un véhicule hybride de type parallèle illustré à la figure 1, et dont l'autre est plus particulièrement adapté à un véhicule hybride de type série illustré à la figure 2.

La première de ces deux stratégies fait appel à une série de variables qui sont regroupées et explicitées dans le tableau ci-dessous.

Notation	Signification	Unités
C1 à C4	Constantes permettant de calculer Cbas et Chaut en fonction de jauge_batterie	Nm
Cbas	Seuil de couple inférieur pour la détermination de th_roulage	Nm
Cdemandé	Couple demandé par le conducteur (positif pour l'accélération, négatif pour la décélération)	Nm
Cdemandé_filtre1	Valeur filtrée à temps de réponse rapide de Cdemandé	Nm
Cdemandé_filtre2	Valeur filtrée à temps de réponse lent de Cdemandé	Nm
Ce_ref	Consigne de couple du moteur électrique (Positif pour la traction. négatif pour le freinage récupératif)	Nm
Cel_freinage_max	Couple de freinage récupératif maximum admissible par le moteur électrique (négatif)	Nm
Cel_traction_max	Couple de traction maximum admissible par le moteur électrique (positif)	Nm
Cemax	Couple électrique maximum compte tenu de l'état de la batterie et de mode_selectionne (positif)	Nm
Cemin	Couple électrique minimum compte tenu de l'état de la batterie et de mode_selectionne (négatif)	Nm
Chaut	Seuil de couple supérieur pour la détermination de th_roulage	Nm
Ct_maximum	Couple maximum du moteur thermique. utilisé en mode Régénération	Nm
Ct_optimal	Couple du moteur thermique correspondant à sa consommation spécifique minimale	Nm
Ct_ref	Consigne de couple du moteur thermique (Positif pour la traction. négatif pour le frein moteur)	Nm
Ct_ref_int	Estimation intermédiaire de la valeur de Ct_ref	Nm
Ct_refl	Estimation intermédiaire de la valeur de Ct_ref	Nm
Cth_freinage_max	Couple de frein moteur maximum admissible par le moteur thermique (négatif)	Nm
Cth_traction_max	Couple de traction maximum admissible par le moteur thermique (positif)	Nm
Ctmax	Couple électrique maximum compte tenu de mode_selectionne (positif)	Nm
Ctmin	Couple électrique minimum compte tenu de mode_selectionne (négatif)	Nm
D_inf	Valeur intermédiaire dans le calcul de Ct_ref	Nm
D_sup	Valeur intermédiaire dans le calcul de Ct_ref	Nm
Demande_électrique	Demande de démarrage du moteur électrique	Booléen
Demande_thermique	Demande de démarrage du moteur thermique	Booléen
Hyst_mode_batterie	Grandeur intermédiaire pour la détermination de th_récupération	-

	(Electrique. Hybride)	
Hyst_mode_couple	Grandeur intermédiaire pour la détermination de th_roulage (Electrique. Hybride)	-
jauge_batterie	Etat de charge de la batterie de traction	%
Kickdown demandé	Demande de complément d'accélération électrique (mode Régénération)	Booléen
mode_selectionne	mode de fonctionnement sélectionné par le conducteur (Electrique. Hybride ou Régénération)	-
N	Vitesse de rotation du moteur électrique	rad/s
PbatMaxD	Puissance maximale de décharge de la batterie de traction (positive)	W
PbatmaxR	Puissance maximale de recharge de la batterie de traction (négative)	W
Re_inf	Valeur intermédiaire dans le calcul de Ct_ref (Cf. schéma ci-dessous)	Nm
Re_sup	Valeur intermédiaire dans le calcul de Ct_ref (Cf. schéma ci-dessous)	Nm
Rt_inf	Valeur intermédiaire dans le calcul de Ct_ref (Cf. schéma ci-dessous)	Nm
Rt_sup	Valeur intermédiaire dans le calcul de Ct_ref (Cf. schéma ci-dessous)	Nm
seuil_jauge_bas	Seuil bas de jauge batterie pour la détermination de th_récupération	%
seuil_jauge_haut	Seuil Faut de jauge batterie pour la détermination de th_récupération	%
th_récupération	Détermine si le moteur thermique contribue à recharger la batterie	Booléen
th_régénération	Détermine si le moteur thermique contribue à recharger fortement la batterie	Booléen
th_roulage	Détermine si le moteur thermique contribue à assurer le roulage	Booléen

Sur la figure 3A, on a illustré les deux tâches principales qui sont exécutées en parallèle l'une par rapport à l'autre, à des fréquences différentes. Bien entendu, les fréquences de 1 hertz et de 25 hertz données ici pour d'une part la tâche 1100 de décision de mise en route et d'arrêt du moteur thermique, et d'autre part la tâche 1200 détermination des consignes de couple des moteurs 10,12 sont des exemples non limitatifs qui permettent d'illustrer le choix selon lequel la seconde de ces fréquences est largement supérieure à la première.

Chacune des tâches 1100 et 1200 illustrées sur ces figures est décomposée en des tâches de niveau inférieur qui seront explicitées en référence aux figures 3B à 3K.

L'étape 1100 de décision de démarrage ou d'arrêt du moteur thermique est explicitée sur la figure 3B. Tout d'abord, aux étapes 1101 et 1102, il est calculé deux valeurs filtrées du couple Cdemandé demandé par le conducteur. Les filtres utilisés sont par exemple des filtres du premier ordre, de type passe-bas. La première valeur Cdemandé_filtre1 correspond à une moyenne de Cdemandé sur un intervalle très court précédant l'instant du calcul et reste représentative de la valeur instantanée Cdemandé. Au contraire, la valeur Cdemandé_filtre2 correspond à une valeur moyenne écrêtée de Cdemandé et elle est donc représentative d'une tendance à moyen terme de la demande de couple formulée par le conducteur.

Une fois ces deux valeurs calculées, sont exécutées trois tâches de niveau inférieur au cours desquelles sont déterminées des variables booléennes intermédiaires : th_roulage (tâche 1110), th_récupération (tâche 1120), th_régénération, demande_électrique et demande_thermique (tâche 1130).

Ces tâches de niveau inférieur seront explicitées par la suite.

Une fois ces valeurs déterminées, il est effectué à l'étape 1103 un test pour vérifier si le moteur thermique 10 est disponible, c'est-à-dire s'il est en état de délivrer un couple moteur. Dans l'affirmative, les variables booléennes qui viennent d'être calculées sont conservées telles que, sinon, comme on peut le voir à l'étape 1104, les valeurs booléennes th_roulage, th_régénération et th_récupération sont forcées à zéro.

La tâche 1110 de détermination de la valeur de la variable booléenne th_roulage est décrite maintenant en référence à la figure 3C. A l'étape 1111, il est tout d'abord calculé deux niveaux de seuil Cbas et Chaut auxquels vont être comparées les valeurs filtrées du couple demandé. Ces valeurs de seuil sont notamment déterminées en fonction de l'état de charge jauge_batterie de la batterie 16.

A l'étape 1112, on vérifie tout d'abord si la valeur filtrée Cdemandé_filtre1, représentative du couple instantané demandé par le conducteur, est supérieure au niveau de seuil supérieur Chaut. Dans l'affirmative, une variable booléenne intermédiaire hyst_mode_couple est forcée à la valeur « hybride » à l'étape 1113. Dans la négative, à l'étape 1114, on vérifie si les deux valeurs filtrées du couple demandé Cdemandé_filtre1 et Cdemandé_filtre2 sont inférieures simultanément au niveau inférieur de couple Cbas. Dans l'affirmative, la valeur booléenne hyst_mode_couple est forcée à l'étape 1115 à la valeur « électrique ». Dans la négative, la variable booléenne hyst_mode_couple n'est pas modifiée.

A l'étape 1116, on vérifie alors si la variable booléenne hyst_mode_couple est égale à la valeur « hybride ». Dans l'affirmative, la valeur booléenne th_roulage est forcée à 1 à l'étape 1118. Dans la négative, la valeur booléenne th_roulage est forcée à zéro à l'étape 1117.

La tâche 1120 de détermination de la valeur de la variable booléenne th_récupération sera maintenant décrite en référence à la figure 3D. A l'étape 1121, il est tout d'abord vérifié si l'état de charge de la batterie 16, représentée par la variable jauge_batterie, est inférieur à un niveau de seuil inférieur seuil_jauge_bas. Dans l'affirmative, une variable booléenne hyst_mode_batterie est forcée à la valeur « hybride » à l'étape 1122. Dans la négative, on vérifie à l'étape 1123 si la valeur jauge_batterie est supérieure à un niveau de seuil supérieur seuil_jauge_haut. Dans l'affirmative, la variable booléenne hyst_mode_batterie est forcée à la valeur « électrique » à l'étape 1124. Dans la négative, la variable hyst_mode_batterie conserve la même valeur qu'au cours de l'exécution précédente de la tâche.

A l'étape 1125, il est vérifié si la variable hyst_mode_batterie est égale à la valeur « hybride ». Dans l'affirmative, la valeur th_récupération est forcée à la valeur 1 à l'étape 1127. Dans la négative, cette variable est forcée à la valeur nulle à l'étape 1126.

La tâche 1130 est décrite en référence à la figure 3E. Cette tâche a pour but de déterminer la valeur des variables booléennes th_régénération, demande_électrique et demande_thermique.

Selon un aspect de l'invention, la stratégie de gestion de l'ensemble motopropulseur du véhicule hybride qui est ici proposée permet au conducteur de sélectionner un parmi trois modes de fonctionnement de l'ensemble motopropulseur.

Dans un mode électrique, le conducteur interdit l'utilisation du moteur thermique. Les variables booléennes hyst_mode_couple et hyst_mode_batterie sont forcées à la variable « électrique », la variable demande_électrique est forcée à la valeur « vrai », la variable demande_thermique est forcée à la valeur « faux » et la variable th_régénération est forcée à la valeur « 0 ».

Le conducteur peut aussi sélectionner un mode de fonctionnement en régénération de l'ensemble motopropulseur. Ce mode de fonctionnement impose à l'ensemble motopropulseur la mise en route du moteur thermique pour assurer, en plus de l'entraînement du véhicule, la recharge de la batterie 16. Les variables booléennes hyst_mode_couple et hyst_mode_batterie sont dans ce cas forcées à la valeur « hybride ». Les variables booléennes demande_électrique et demande_thermique sont forcées à la valeur « vrai » tandis que la variable th_régénération est forcée à la valeur « 1 ».

Le conducteur peut aussi sélectionner un mode de fonctionnement hybride de l'ensemble motopropulseur. Dans ce mode de fonctionnement, le moteur thermique 10 ne sera utilisé qu'en cas de besoin, ainsi que cela sera vu par la suite.

Dans ce mode, la variable demande_électrique est forcée à la valeur « vrai ». La variable demande_thermique est forcée à la valeur « vrai » si l'une ou l'autre des variables hyst_mode_batterie et hyst_mode_couple sont égales à la valeur « hybride ». Sinon, la variable demande_thermique est forcée à la valeur « faux ». La variable th_régénération est forcée à la valeur « 0 ».

Il va maintenant être décrit, en référence aux figures 3F à 3K, la deuxième tâche principale 1200 de cette première stratégie de gestion d'un véhicule hybride, cette deuxième tâche étant exécutée à une fréquence suffisamment rapide pour pouvoir satisfaire la demande du conducteur.

Cette deuxième tâche 1200, qui consiste en la détermination des couples de consigne Ce_ref et Ct_ref du moteur électrique et du moteur thermique, comporte elle-même deux tâches de niveau inférieur 1210 et 1220 qui seront explicitées respectivement aux figures 3G à 3H et 3I à 3K.

Comme on peut le voir à la figure 3G, la tâche 1210 a pour but la détermination de couples moteur limite pour le moteur électrique et le moteur thermique. A l'étape 1211, il est tout d'abord vérifié si le moteur thermique est disponible. Dans l'affirmative, des variables de couple limite Ctmax et Ctmin du moteur thermique se voient attribuer respectivement les valeurs Cth_traction_max et Cth_freinage_max qui sont liées notamment au régime et à la température du moteur utilisé. Dans la négative, les valeurs de Ctmax et Ctmin sont forcées à zéro à l'étape 1213.

A l'étape 1214, il est ensuite vérifié si le moteur électrique est disponible. Dans la négative, les variables Cemax et Cemin sont forcées à zéro à l'étape 1217.

Dans l'affirmative, la variable Cemin se voit attribuée à l'étape 1215 la plus grande de deux valeurs parmi :

- une valeur Cel_freinage_max, qui dépend notamment de la tension d'alimentation et de la température du moteur ;

- PbatmaxR X $\frac{1}{N}$.

La valeur du couple maximum du moteur électrique est déterminée à la tâche 1216 qui est décomposée sur la figure 3H. En effet, il est tout d'abord testé à l'étape 1216a si la variable th_régénération est égale à 1, c'est-à-dire si le conducteur a sélectionné le mode de fonctionnement en régénération de l'ensemble motopropulseur. Dans l'affirmative, on peut voir que la valeur de Cemax est forcée à zéro à l'étape 1216c, sauf si le conducteur, comme cela est vérifié à l'étape 1216b, effectue une manoeuvre de kickdown par laquelle il augmente de manière importante et rapide le couple demandé. Cette manoeuvre correspond généralement à un enfoncement rapide de la pédale d'accélérateur.

Dans ce cas, ou en cas de réponse négative au test de l'étape 1216a, la valeur Cemax est fixée à l'étape 1216d à la plus petite des valeurs :

- PbatmaxD x $\frac{1}{N}$
- Cel_traction_max.

La tâche 1220 de calcul des consignes de couple Ce_ref et Ct_ref illustrée à la figure 3I comporte deux sous-tâches 1221 et 1222 qui seront décrites respectivement en regard des figures 3J et 3K. La sous-tâche 1221 consiste en le calcul d'une valeur intermédiaire Ct_ref_int. Pour cela, il est d'abord déterminé, à l'étape 1221a, une valeur Ct_ref1 qui est égale à la plus grande de trois valeurs :

- th_roulage x Cdemandé
- th_régénération x Ct_maximum
- th_récupération x Ct_optimal.

A l'étape 1221c, cette variable Ct_ref1 est filtrée par un filtre du premier ordre de type passe-bas pour donner la variable intermédiaire Ct_ref_int.

L'étape 1222 d'ajustement de Ce_ref et de Ct_ref sera maintenant décrite en regard de la figure 3K. A l'étape 1222a, on fixe tout d'abord la valeur de Ct_ref à la valeur Ct_ref_int déterminée plus haut. Puis, à l'étape 1222b, il est vérifié si cette valeur est supérieure à la valeur Ctmax. Dans l'affirmative, à l'étape 1222c, Ct_ref est forcée à la valeur Ctmax et Rt_sup est forcée à la valeur nulle. Dans la négative, à l'étape 1222d, la valeur de Rt_sup est fixée à la différence de Ctmax-Ct_ref.

Dans les deux cas de réponse à l'étape 1222b, il est ensuite vérifié à l'étape 1222e si la valeur de Ct_ref est inférieure à la valeur de Ctmin. Dans l'affirmative, à l'étape 1222f, Ct_ref est forcée à la valeur Ctmin et Rt_inf est forcée à zéro. Dans la négative, Rt_inf est fixée égale à la différence entre Ct_ref et Ctmin à l'étape 1222g.

Dans les deux cas de réponse à l'étape 1222e, Ct_ref est alors forcée à la valeur Cdem-Ct_ref, Re_sup est forcée à la valeur Cemax-Ce_ref et la variable Re_inf est forcée à la valeur Ce_ref-Cemin à l'étape 1222h.

Ensuite à l'étape 1222i, il est vérifié si la valeur de Re_sup est négative. Dans la négative, il est procédé directement au passage 1222o. Dans l'affirmative, à l'étape 1222j, la variable D_sup est fixée à la valeur Rt_sup+Re_sup, la variable Ce_ref est fixée à la valeur Cemax, la valeur Re_sup est fixée à zéro et la variable Re_inf est fixée à la valeur de la différence entre Cemax et Cemin. Alors, à l'étape 1222k, on vérifie si la valeur D_sup est négative. Dans l'affirmative, à l'étape 1222l, la variable Ct_ref est fixée à la valeur Ct_max et la variable Rt_sup est fixée à zéro ; sinon, à l'étape 1222m, la variable Ct_ref est fixée à la valeur Ctmax-D_sup et la variable Rt_sup est fixée à la valeur D_sup.

Dans les deux cas de réponse à l'étape 1222k, ainsi que dans le cas d'une réponse négative au test de l'étape 1222i, il est alors vérifié à l'étape 1222o si la variable Re_inf est négative. Dans l'affirmative, à l'étape 1222p, la variable D_inf est fixée à la valeur Rt_inf+Re_inf, la variable Ce_ref est fixée égale à la valeur Cemin, la variable Re_sup est fixée égale à la différence de Cemax moins Cemin et la variable Re_inf est fixée à la valeur nulle.

Alors, à l'étape 1222q, il est vérifié si la variable D_inf est négative. Dans l'affirmative, à l'étape 1222s, la variable Ct_ref est fixée égale à la valeur Ctmin et la variable Rt_inf est fixée à la valeur nulle. Dans la négative, la variable Ct_ref est fixée égale à la valeur Ctmin+D_inf et la variable Rt_inf est fixée égale à la valeur D_inf.

Dans la négative, il est procédé directement à la fin de la tâche.

Comme on peut le voir de la description détaillée de cette première stratégie de gestion du véhicule hybride, lorsque le conducteur a sélectionné le mode de fonctionnement hybride pour l'ensemble motopropulseur, le démarrage du moteur thermique est demandé, lors de la tâche 1130, si l'une des variables hyst_mode_batterie et hyst_mode_couple est égale à la valeur « hybride ». Si ni l'une, ni l'autre ne sont à la valeur hybride, le moteur thermique est arrêté.

Ainsi, on peut déduire de l'étape 1213 que le moteur thermique peut démarrer si le conducteur sollicite un couple demandé à la roue suffisamment élevé pour que la variable Cdemandé_filtre1 soit supérieure au niveau du seuil haut Chaut. De même, on peut déduire des étapes 1122 et 1121 que le moteur thermique est démarré lorsque le niveau de charge de la batterie devient inférieur à un niveau de seuil inférieur. Toutefois, avec cette première stratégie, l'arrêt du moteur thermique n'est provoqué que lorsqu'à la fois les conditions de l'étape 1114 et de l'étape 1123 sont vérifiées, c'est-à-dire lorsque la batterie atteint un état de charge supérieur à un niveau de seuil supérieur et lorsque, à la fois, les valeurs filtrées instantanées et moyennes du couple demandé par le conducteur sont inférieures à un niveau de seuil bas.

Ainsi, selon cette stratégie, on voit que la décision de démarrage du moteur thermique dépend notamment du niveau de charge de la batterie, du couple instantané demandé par le conducteur, et du couple moyen demandé par le conducteur.

On peut également constater que, lorsque l'ensemble motopropulseur fonctionne en mode hybride, la valeur du couple Ct_ref qui sera demandé au moteur thermique dépend des variables th_roulage et th_récupération déterminées par les tâches 1110 et 1120. Ainsi, lorsque le niveau de charge de la batterie est précédemment devenu inférieur à un niveau de seuil bas et qu'il n'a pas encore dépassé un niveau de seuil haut, il ressort de la tâche 1120 que la valeur de th_récupération est égale à 1 de sorte que la valeur intermédiaire Ct_ref1 calculée à l'étape 1221b ne peut être inférieure au couple Ct_optimal que fournit le moteur lorsqu'il est commandé dans des conditions de rendement optimales. La valeur Ct_ref du couple de consigne imposé au moteur thermique ne peut donc pas descendre en dessous d'un niveau correspondant à ce couple optimal.

Au contraire, toujours lorsque le conducteur a sélectionné le mode de fonctionnement hybride du groupe motopropulseur, il ressort de la tâche 1110 que, lorsque la condition de l'étape 1112 a été remplie et tant que celle de l'étape 1114 ne l'a pas été, la valeur de la variable th_roulage est égale à 1 si bien que, dans ces conditions, la valeur de

Ct_ref1 calculée à l'étape 1221b ne peut être inférieure au couple demandé par le conducteur.

Par ailleurs, il ressort de la tâche 1222 que si la valeur filtrée Ct_ref_int du couple demandé par le conducteur dépasse le seuil Ctmax du couple susceptible d'être fourni par le moteur thermique, le moteur électrique est sollicité à l'étape 1222h pour fournir le couple manquant, ceci dans la limite des possibilités du moteur électrique et de la batterie.

Il sera maintenant décrit plus particulièrement en référence aux figures 4A à 4H une deuxième stratégie de gestion d'un véhicule hybride selon l'invention destiné plus particulièrement à être appliqué dans le cadre d'un véhicule hybride de type série. Cette deuxième stratégie fait appel à une série de variables qui sont regroupées et explicitées dans le tableau ci-dessous.

Notation	Signification	Unités
Cdemandé ou Cdem	couple demandé par le conducteur (positif pour l'accélération, négatif pour la décélération)	Nm
Ce_ref	Consigne de couple du moteur électrique (Positif pour la traction, négatif pour le freinage récupératif)	Nm
Ecart_C	Ecart entre Cref et Cdemandé	Nm
Ecart_prestation	Valeur filtrée de Ecart_C	Nm
Ecart_soc	Ecart entre soc et soc_ref	%
GE_demandé	Demande de démarrage ou d'arrêt du moteur thermique pour entrainer la génératrice électrique	Booléen
Ibat	Courant débité par la batterie (décharge : positif, charge : négatif)	A
Ige	Courant débité par la génératrice électrique (positif)	A
Mode_sélectionné	Mode de fonctionnement sélectionné par le conducteur (Électrique, Hybride ou Régénération)	-
N	Vitesse de rotation du moteur électrique	rad/s
Pbat_demandé	Puissance demandée à la batterie de traction (décharge : positif, charge : négatif)	W
Pbat_possible	Part de Pbat_demandé que peut fournir la batterie	W
PbatmaxD	Puissance maximale de décharge de la batterie de traction (positive)	W
PbatnaxR	Puissance maximale de recharge de la batterie de traction (négative)	W
Pel	Puissance absorbée par le moteur électrique (traction: positif, freinage récupératif : négatif)	W
Pel_demandé	Puissance électrique nécessaire pour fournir Cdemandé	W
Pel_filtreA	Valeur filtrée à temps de réponse rapide de Pel	W
Pel_filtreB	Valeur filtrée à temps de réponse lent de Pel	W
Pel_possible	Part de Pel_demandé que le système peut fournir	W
Pge_demA	Estimation intermédiaire de la valeur de Pge_ref	W
Pge_demB	Valeur de la puissance demandée à la génératrice électrique déterminant Arrêt GE demandé et Démarrage GE demandé	W
Pge_max	Puissance maximale que peut fournir la génératrice électrique	W
Pge_mini	Puissance minimale que peut fournir la génératrice électrique	W
Pge_ref	Consigne de puissance de la génératrice électrique	W

Pmec	Puissance mécanique fournie par le moteur électrique	W
Pmec_demandé	Puissance mécanique à fournir correspondant à Cdemandé	W
Pmini	Seuil de valeur absolue de la puissance en deçà duquel R n'est pas calculé	W
Pmoteur_max	Puissance maximale que peut absorber ou restituer le moteur électrique	W
R	Rendement du moteur électrique utilisé en génératrice	-
R_filtre	Valeur filtrée de R	-
soc	Etat de charge de la batterie de traction *(state of charge)*	%
soc_ref	Etat de charge de référence de la batterie de traction	%
U	Tension de la batterie de traction	%

Comme on peut le voir sur la figure 4A, l'unité centrale de gestion de l'ensemble motopropulseur est chargée de l'exécution de trois tâches principales. La première 2100 de ces tâches consiste ici dans la détermination de la consigne de couple du moteur électrique. Elle est exécutée par exemple toutes les quarante millisecondes, c'est-à-dire à une fréquence de 25 hertz. En parallèle, est exécutée la deuxième tâche 2200 qui consiste en la décision de démarrage ou d'arrêt du moteur thermique. Sa période est d'une seconde et sa fréquence de 1 hertz.

Il est par ailleurs prévu une troisième tâche principale 2300, elle aussi exécutée en parallèle, et au cours de laquelle est déterminée la consigne de puissance de la génératrice électrique Pge_ref. Sa période d'exécution est par exemple de 500 millisecondes, correspondant à une fréquence de 2 hertz pour tenir compte de l'inertie de l'ensemble formée par le moteur thermique et la génératrice.

La première de ces tâches principales est décrite en référence à la figure 4B. Comme on peut le voir sur cette figure, la tâche 2100 de détermination de la consigne de couple du moteur électrique Ce_ref commence par l'exécution de la sous-tâche 2110 de calcul de la puissance électrique nécessaire Pel_demandé.

Cette sous-tâche est décrite en référence à la figure 4C. Tout d'abord, à l'étape 2111, il est déterminé la valeur Pel de la puissance absorbée par le moteur électrique. Cette puissance est positive lorsque le moteur assure l'entraînement du véhicule et elle est négative lorsque, au cours d'un ralentissement du véhicule, le moteur électrique est utilisé en tant que génératrice pour recharger la batterie 16. Cette valeur Pel est égale à la tension du réseau d'alimentation électrique multiplié par la somme des courants fournis par la batterie d'une part et par la génératrice électrique d'autre part.

A l'étape 2112, la puissance mécanique fournie par le moteur électrique Pmec est définie comme étant le produit du couple de consigne Ce_ref par la vitesse de rotation N du moteur électrique 12. A l'étape 2113, la puissance mécanique demandée Pmec_demandé est définie comme étant égale au couple Cdemandé par le conducteur multiplié par la vitesse N de rotation du moteur électrique. A l'étape 2114, il est déterminé si la valeur absolue de la puissance mécanique Pmec est supérieure à une valeur de seuil Pmini. Dans l'affirmative, on définit à l'étape 2115 un rendement du moteur électrique qui est égal à la valeur absolue du rapport de la puissance électrique Pel divisée par la puissance mécanique Pmec. Dans la négative, la valeur de ce rendement est fixée arbitrairement à 1 à l'étape 2116.

A l'étape 2117, il est déterminé une valeur filtrée R_filtre de ce rendement, par exemple à l'aide d'un filtre du premier ordre.

A l'étape 2118, la puissance électrique demandée Pel_demandé est déterminée comme étant le produit de la valeur filtrée du rendement par la puissance mécanique demandée.

L'exécution de la tâche 2100 de détermination de la consigne de couple du moteur électrique se poursuit alors à l'étape 2101 au cours de laquelle on vérifie si la valeur absolue de la puissance électrique demandée est supérieure à un niveau de seuil Pmini. Dans la négative, le couple de consigne Ce_ref est fixé égal au couple demandé par le conducteur. Dans l'affirmative, il est d'abord déterminé la puissance Pge fournie par la génératrice. Si celle-ci débite un courant Ige, cette puissance vaut U fois Ige.

A l'étape 2103, il est calculé la puissance de traction que doit fournir la batterie 16. Cette valeur Pbat_demandé est égale à la puissance électrique nécessaire pour fournir le couple demandé moins la puissance fournie par la génératrice. A l'étape 2104, on détermine la puissance susceptible d'être fournie par la batterie comme étant la valeur minimale entre les deux valeurs suivantes :

- la puissance maximale de décharge de la batterie (PbatmaxD) et
- la valeur minimale entre
  - * la puissance demandée à la batterie (Pbat_demandé) ;
  - * la puissance maximale de recharge de la batterie (PbatmaxR).

A l'étape 2105, il est alors déterminé la puissance électrique que peut fournir le système, cette valeur étant la plus petite des deux valeurs suivantes :

- la puissance maximale du moteur thermique Pmoteur_max ; et
- la somme de la puissance susceptible d'être fournie par la batterie (Pbat_possible) avec la puissance fournie par la génératrice Pge.

Alors à l'étape 2106, le couple de référence Ce_ref est déterminé comme étant le produit du couple demandé par le conducteur par le rapport de la puissance électrique que peut fournir le système divisée par la puissance électrique demandée.

La deuxième tâche principale 2200 de cette seconde stratégie de gestion d'un véhicule hybride consiste en la décision de démarrage ou d'arrêt du moteur thermique. Comme on peut le voir à la figure 4C, cette tâche 2200 commence par l'exécution de la tâche 2310 de calcul de la puissance de recharge de la batterie qui est illustrée à la figure 4G. Comme on peut le voir sur cette figure, il est donc déterminé, aux étapes 2312, 2313, 2314 un état de charge de référence Soc_ref en fonction du mode de fonctionnement sélectionné par le conducteur du véhicule. A l'étape 2315, il est déterminé une valeur d'écart entre cet état de charge de référence Soc_ref et l'état de charge réel. A l'étape 2316, la puissance batterie demandée est définie comme étant une valeur filtrée de cet écart, par exemple par un filtre du premier ordre.

Toutefois, à l'étape 2317, il est vérifié que cette valeur calculée de la puissance de recharge de la batterie n'excède pas les puissances limites de charge et de décharge de la batterie, auquel cas la puissance de recharge de la batterie est forcée à l'une de ces valeurs limites.

La tâche de décision de démarrage ou d'arrêt du moteur thermique se poursuit alors à l'étape 2201 dans laquelle est déterminée la puissance électrique Pel de la même manière que vu plus haut à l'étape 2111. Cette puissance électrique est filtrée par un filtre du premier ordre pour obtenir à l'étape 2202 la variable Pel_filtreB.

Il est ensuite procédé à un calcul de l'écart entre le couple demandé par le conducteur et le couple effectivement appliqué aux roues motrices par le moteur électrique. Ce calcul de la valeur écart_prestation fait l'objet de la tâche 2210 illustrée à la figure 4E dans laquelle on peut voir que cette valeur est obtenue par le filtrage au travers d'un filtre de premier ordre de la différence entre le couple demandé par le conducteur Cdemandé et le couple fourni par le moteur électrique Ce_ref.

La tâche de décision du démarrage ou de l'arrêt du moteur thermique se poursuit à l'étape 2203 en déterminant la valeur de la puissance demandée à la génératrice électrique Pge_demB. Cette valeur est égale à une somme pondérée des valeurs précédemment calculées Pbat_demandé, Pel_filtreB et Ecart_prestation. À l'étape 2204, il est vérifié si cette valeur Pge_demB est supérieure à une valeur de seuil Pge_mini et si, en même temps, le mode de fonctionnement sélectionné par le conducteur est différent du moteur électrique. Si cette double condition est vérifiée, alors la variable booléenne GE_demandé est forcée à la valeur « vrai » et le moteur thermique est alors démarré pour fournir du courant électrique. Au contraire, si la double condition de l'étape 2204 n'est pas remplie, la variable GE_demandé est forcée à la valeur « faux » à l'étape 2206 si bien que le moteur thermique est commandé à l'arrêt.

Lorsque le moteur thermique est démarré, il est alors possible de le commander pour qu'il entraîne la génératrice électrique de telle manière que celle-ci produise une puissance suffisante. A cet effet, il est calculé à la tâche 2300 une valeur de consigne de la puissance de la génératrice électrique Pge_ref. Cette tâche, illustrée à la figure 4F, commence par l'exécution de la tâche de niveau inférieur 2310 qui a été décrite précédemment et qui consiste en le calcul de la puissance de recharge de la batterie. Ensuite, à l'étape 2301, il est calculé la puissance électrique Pel absorbée par le moteur électrique de la même manière que cela a été vu aux étapes 2201 et 2111. Cette valeur est alors filtrée à l'étape 2302, par exemple par un filtre du premier ordre, pour donner une valeur intermédiaire Pel_filtreA. A l'étape 2303, il est déterminé la somme pondérée Pge_demA de la puissance de recharge de la batterie Pbat_demandé avec la valeur Pel_filtreA calculée à l'étape 2302. A l'étape 2304, la puissance de consigne de la génératrice électrique Pge_ref est définie comme étant la plus petite de la valeur Pge_demA, calculée à l'étape 2303, et de la puissance maximale susceptible d'être fournie par la génératrice Pge_max.

Comme on peut le voir des étapes 2203, 2204, 2205 et 2206, la décision d'un démarrage du moteur thermique dépend notamment des trois paramètres suivants :

- l'état de charge de la batterie, car la valeur Pbat_demandé est calculée notamment en fonction de l'écart entre l'état de charge réel de la batterie et un état de charge de référence (voir étapes 2315, 2316, 2317) ;
- le couple moteur demandé, car la valeur Ecart_prestation dépend bien entendu de ce couple demandé (voir étapes 2211 et 2212) ; et
- l'écart entre la prestation fournie par le système et celle demandée par le conducteur.

REVENDICATIONS

1. Véhicule automobile à motorisation hybride, du type dans lequel un ensemble motopropulseur comporte un moteur électrique (12) et un moteur thermique (10) qui sont susceptibles de contribuer à l'entraînement du véhicule, et du type dans lequel une unité centrale de gestion exécute une première tâche (1200, 2100) comportant la détermination du couple que doit fournir chaque moteur pour que l'ensemble motopropulseur fournisse au véhicule un couple moteur conforme à un couple demandé (Cdemandé) par le conducteur du véhicule, et du type dans lequel le moteur thermique (10) est susceptible d'être arrêté, le véhicule étant alors entraîné par le seul moteur électrique (12) alimenté en courant électrique par une batterie d'accumulateurs (16),

caractérisé en ce que, au moins pour certains modes de fonctionnement (hybride) de l'ensemble motopropulseur, l'unité centrale exécute une deuxième tâche (1100, 2200) au cours de laquelle est décidé l'arrêt ou le démarrage du moteur thermique, en ce que la première tâche et la deuxième tâche sont exécutées en parallèle et en ce que la fréquence d'exécution de la deuxième tâche est inférieure à celle de la première tâche.

2. Véhicule automobile selon la revendication 1, caractérisé en ce que le conducteur peut imposer à l'ensemble motopropulseur un mode de fonctionnement électrique dans lequel le moteur thermique (10) est arrêté.

3. Véhicule automobile selon l'une quelconque des revendications précédentes, caractérisé en ce que le conducteur peut imposer à l'ensemble motopropulseur un mode de fonctionnement de régénération dans lequel le moteur thermique (10) est utilisé notamment pour assurer le

rechargement de la batterie (16).

4. Véhicule automobile selon l'une quelconque des revendications précédentes, caractérisé en ce que le conducteur peut imposer à l'ensemble motopropulseur un mode de fonctionnement hybride dans lequel l'unité centrale exécute la deuxième tâche au cours de laquelle est décidé l'arrêt ou le démarrage du moteur thermique.

5. Véhicule automobile selon la revendication 4, caractérisé en ce que la décision d'arrêt ou de démarrage du moteur thermique (10) est prise notamment en fonction d'un niveau de charge (jauge_batterie, soc) de la batterie (16).

6. Véhicule automobile selon la revendication 5, caractérisé en ce que le démarrage du moteur thermique (10) est décidé ou confirmé lorsque le niveau de charge (jauge_batterie) de la batterie (16) est inférieur à un niveau de seuil bas (seuil_jauge_bas), et en ce que l'arrêt du moteur thermique (10) est susceptible d'être décidé ou d'être confirmé lorsque le niveau de charge de la batterie est supérieur à un niveau de seuil haut (seuil_jauge_bas).

7. Véhicule automobile selon l'une quelconque des revendications 4 à 6, caractérisé en ce que la décision d'arrêt ou de démarrage du moteur thermique (10) est prise notamment en fonction du couple instantané (Cdemandé_filtre1) demandé par le conducteur.

8. Véhicule automobile selon l'une quelconque des revendications 4 à 7, caractérisé en ce que la décision d'arrêt ou de démarrage du moteur thermique (10) est prise notamment en fonction du couple moyen (Cdemandé_filtre2) demandé par le conducteur pendant un intervalle de temps prédéterminé précédant de la décision.

9. Véhicule automobile selon la revendication 7 prise en combinaison avec la revendication 8, caractérisé en ce que le

démarrage du moteur thermique (10) est décidé ou confirmé lorsque le couple instantané (Cdemandé_filtre1) demandé par le conducteur est supérieur à un niveau de seuil haut (Chaut), et en ce que l'arrêt du moteur thermique (10) est susceptible d'être décidé ou d'être confirmé lorsque le couple instantané (Cdemandé_filtre1) et le couple moyen (Cdemandé_filtre2) demandés par le conducteur sont inférieurs à un niveau de seuil bas (Cbas).

10. Véhicule automobile selon la revendication 6 prise en combinaison avec la revendication 9, caractérisé en ce que l'arrêt du moteur thermique (10) est décidé ou confirmé lorsque, à la fois, le niveau de charge (jauge_batterie) de la batterie (16) est supérieur à un niveau de seuil haut (seuil_jauge_haut) et le couple instantané (Cdemandé_filtre1) et le couple moyen (Cdemandé_filtre2) demandés par le conducteur sont inférieurs à un niveau de seuil bas (Cbas).

11. Véhicule automobile selon l'une quelconque des revendications 4 à 10, caractérisé en ce que la décision d'arrêt ou de démarrage du moteur thermique (10) est prise notamment en fonction d'un écart (Ecart_prestation) entre le couple demandé (Cdemandé) par le conducteur et le couple effectivement fourni par l'ensemble motopropulseur.

12. Véhicule automobile selon l'une quelconque des revendications précédentes prise en combinaison avec l'une au moins des revendications 2 à 4, caractérisé en ce que, en fonctionnement du mode de fonctionnement sélectionné par le conducteur, il est fixé un niveau de consigne de charge (soc_ref) de la batterie (16).

13. Véhicule automobile selon l'une quelconque des revendications précédentes, caractérisé en ce que l'ensemble motopropulseur est un ensemble hybride série dans lequel les roues motrices du véhicule sont entraînées exclusivement par

le moteur électrique (12) qui est alimenté par du courant électrique provenant de la batterie (16) qui est rechargée par une génératrice (26) entraînée par le moteur thermique (10).

14. Véhicule automobile selon la revendication 13 prise en combinaison avec la revendication 12, caractérisé en ce qu'il est déterminé la puissance électrique (Pbat_demandé) à fournir à la batterie (16) en fonction d'un écart (Ecart_soc) entre les niveaux réel (soc) et de référence (soc_ref) de charge de la batterie, en tenant compte de valeurs limites de puissance de charge (PbatmaxR) et de décharge (PbatmaxD) de la batterie (16).

15. Véhicule automobile selon la revendication 14, caractérisé en ce que le démarrage du moteur thermique (10) est déterminé en fonction de la puissance électrique (Pbat_demandé) à fournir à la batterie (16), de la puissance électrique absorbée (Pel_filtreB) par le moteur électrique (12) et en fonction d'un écart (Ecart_prestation) entre la valeur du couple demandé par le conducteur et la valeur du couple fourni par le moteur électrique (12).

16. Véhicule automobile selon la revendication 14 ou 15, caractérisé en ce qu'il est déterminé un niveau de consigne (Pge_ref) de la puissance fournie par la génératrice (26) en fonction de la puissance réelle (U*Ige) fournie par la génératrice (26), de la puissance réelle (U*Ibat) fournie par la batterie (16), et de la puissance (Pbat_demandé) à fournir à la batterie (16), en tenant compte la puissance maximale (Pge_max) susceptible d'être fournie par la génératrice (26).

17. Véhicule automobile selon l'une quelconque des revendications précédentes 13 à 15, caractérisé en ce qu'il est déterminé une puissance électrique nécessaire (Pel_demandé) en fonction du couple moteur (Cdemandé) demandé par le conducteur, en tenant compte, au moins lorsque ce couple est

supérieur en valeur absolue à une valeur minimale, d'un rendement du moteur électrique (R).

18. Véhicule automobile selon la revendication 16, caractérisé en ce qu'il est déterminé une valeur de consigne (Cref) du couple fourni par le moteur électrique (12) en fonction du couple moteur demandé par le conducteur multiplié par, au moins lorsque la puissance électrique nécessaire (Pel_demandé) est supérieure en valeur absolue à une valeur de seuil (Pmini), du rapport de la puissance électrique (Pel_possible) susceptible d'être fournie au moteur électrique (12) divisée par la puissance électrique nécessaire (Pel_possible), la puissance électrique (Pel_possible) susceptible d'être fournie au moteur électrique (12) tenant compte de la puissance électrique nécessaire (Pel_demandé), de la puissance réelle (Pge) fournie par la génératrice, de la puissance (Pbat_possible) susceptible d'être fournie par la batterie (16), et de la puissance maximale (Pmoteur_max) susceptible d'être absorbée par le moteur.

19. Véhicule automobile selon l'une quelconque des revendications 1 à 12, caractérisé en ce que l'ensemble motopropulseur est un ensemble hybride en parallèle dans lequel le moteur électrique (12) et le moteur thermique (10) entraînent chacun soit au moins une même roue motrice soit des roues motrices différentes.

20. Véhicule automobile selon la revendication 19 prise en combinaison avec la revendication 3, caractérisé en ce que lorsque l'ensemble motopropulseur fonctionne en mode de régénération, le moteur électrique (10) ne délivre un couple moteur que si le conducteur provoque une hausse brutale du couple demandé (kickdown).

21. Véhicule automobile selon l'une des revendications 19 ou 20 prise en combinaison avec la revendication 3,

caractérisé en ce que lorsque l'ensemble motopropulseur fonctionne en mode de régénération, le moteur thermique (10) est commandé pour fournir un couple maximal (Ct_maximum).

22. Véhicule automobile selon l'une quelconque des revendications 19 à 21 prise en combinaison avec la revendication 4, caractérisé en ce que lorsque l'ensemble motopropulseur fonctionne en mode hybride et que le niveau de charge (jauge_batterie) de la batterie (16) est précédemment devenu inférieur à un niveau de seuil bas (seuil_jauge_bas) et n'a pas encore dépassé un niveau de seuil haut (seuil_jauge_haut), le moteur thermique (10) est commandé pour fournir un couple de consigne (Ct_ref1) au moins égal à un couple optimal (Ct_optimal) correspondant à des conditions de rendement optimales du moteur thermique.

23. Véhicule automobile selon l'une quelconque des revendications précédentes 19 à 22 prise en combinaison avec la revendication 4, caractérisé en ce que lorsque l'ensemble motopropulseur fonctionne en mode hybride et que le couple instantané (Cdemandé_filtre1) demandé par le conducteur est précédemment devenu supérieur à un niveau de seuil haut (Chaut) sans être redevenu inférieur à un niveau de seuil bas (Cbas) en même temps que le niveau moyen (Cdemandé_filtre2) est inférieur au niveau de seuil bas (Cbas), le moteur thermique (10) est commandé pour fournir un couple de consigne au moins égal à une valeur filtrée du couple demandé par le conducteur.

24 Véhicule automobile selon l'une quelconque des revendications précédentes 19 à 23, caractérisé en ce que, si une valeur filtrée (Ct_ref_int) du couple demandé par le conducteur est supérieure au couple maximal (Ct_max) du moteur thermique (10), le moteur électrique (12) est sollicité pour fournir, dans la mesure du possible, la quantité de couple manquante (Cdem - Ctref).

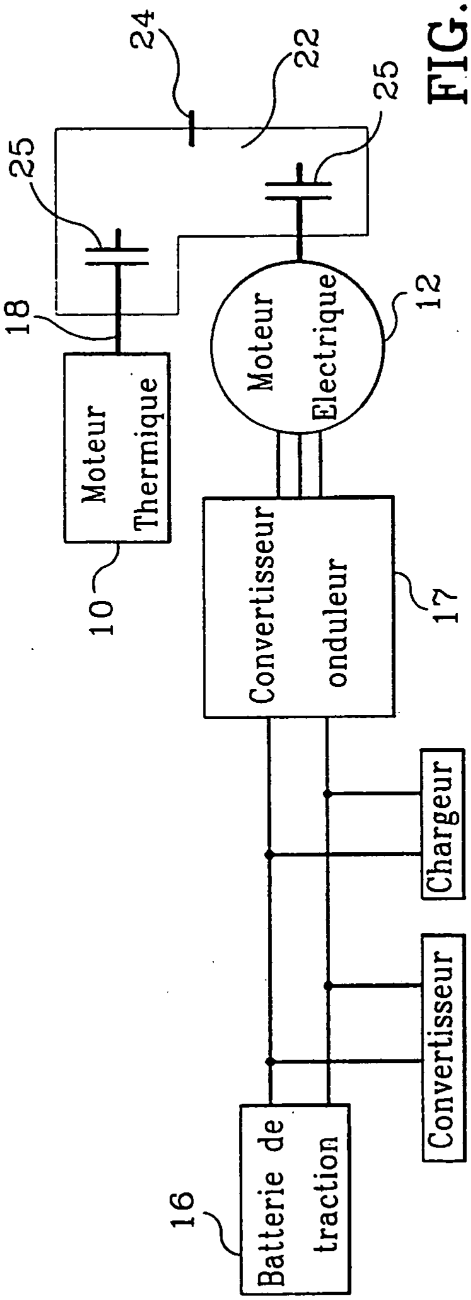

24
22
25
25
18
Moteur Thermique
10
Moteur Electrique
12
Convertisseur onduleur
17
Chargeur
Convertisseur
Batterie de traction
16

FIG.1

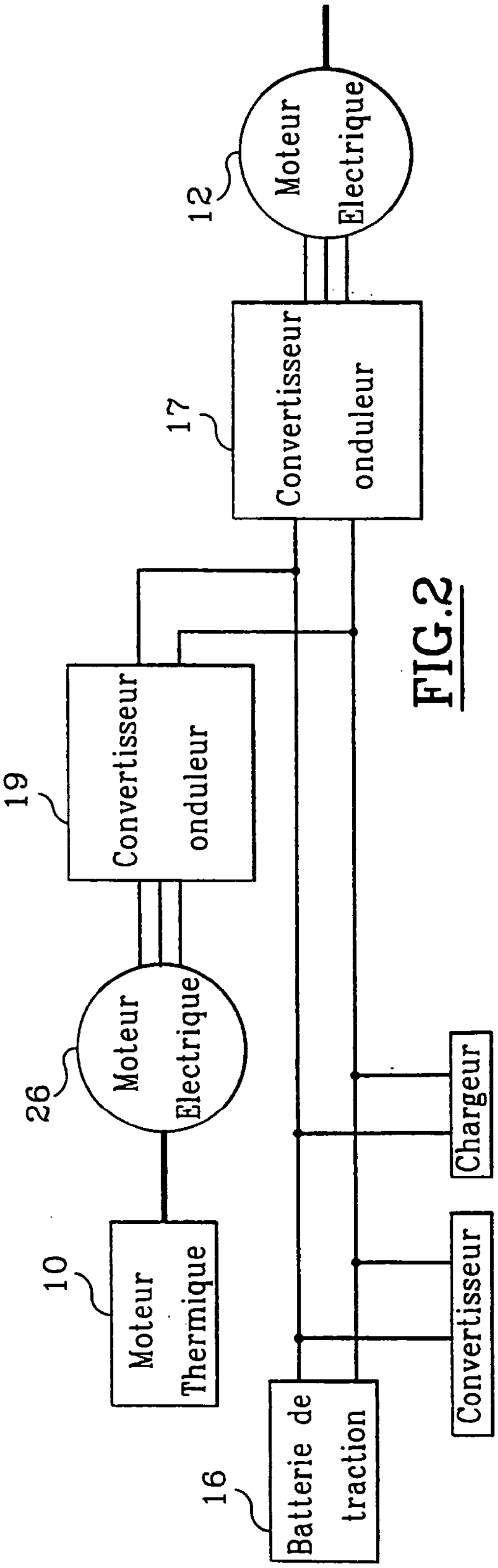

12
Moteur Electrique
17
Convertisseur onduleur
19
Convertisseur onduleur
26
Moteur Electrique
10
Moteur Thermique
Chargeur
Convertisseur
16
Batterie de traction

FIG.2

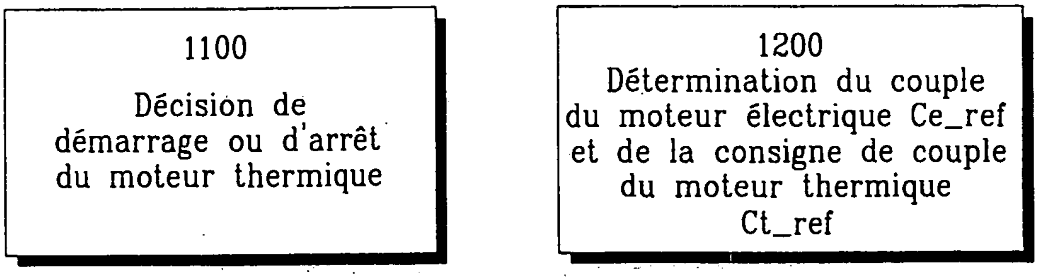

1100
Décision de démarrage ou d'arrêt du moteur thermique
1200
Détermination du couple du moteur électrique Ce_ref et de la consigne de couple du moteur thermique Ct_ref

FIG.3A

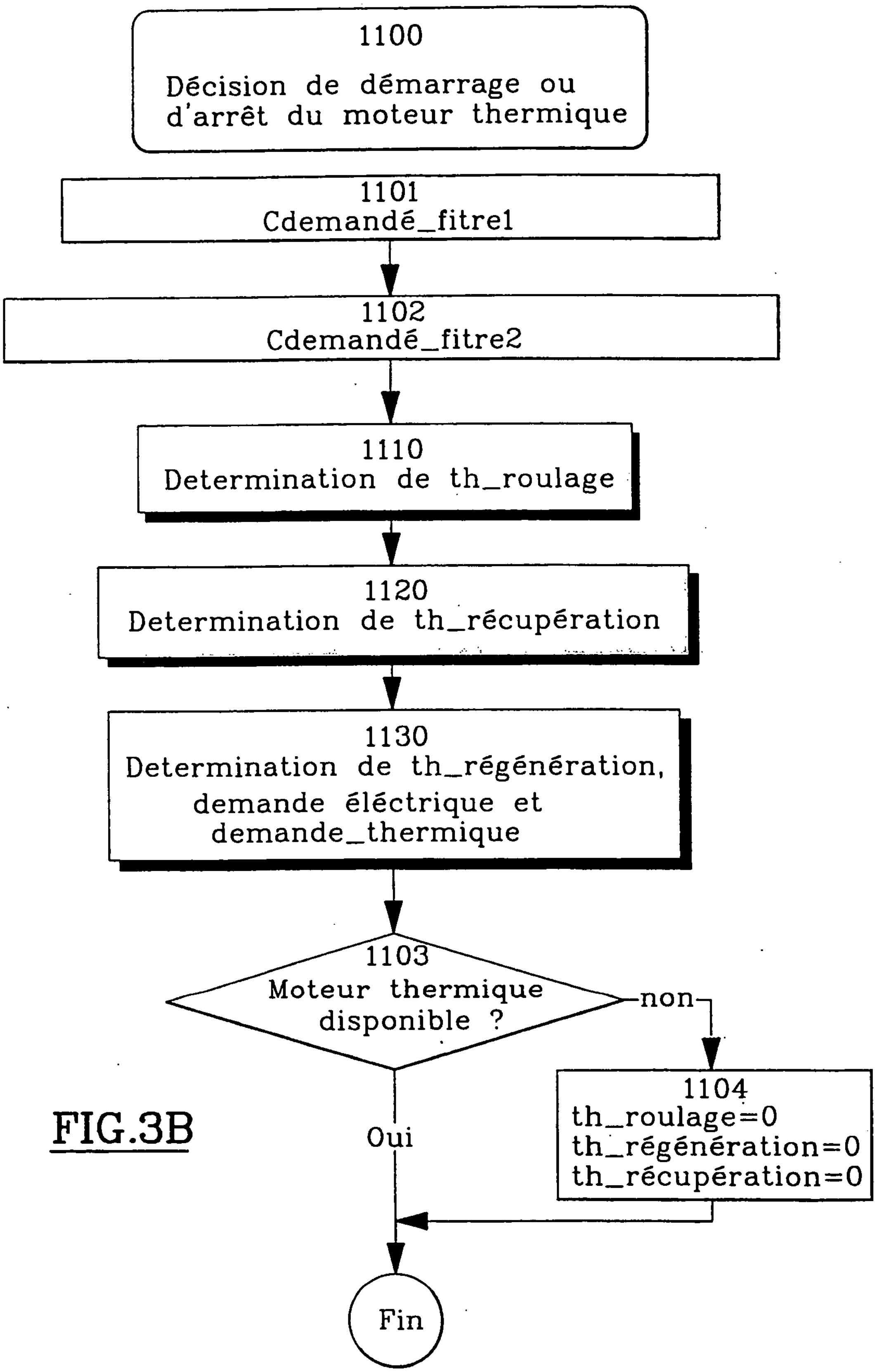

1100
Décision de démarrage ou d'arrêt du moteur thermique
1101
Cdemandé_fitre1
1102
Cdemandé_fitre2
1110
Determination de th_roulage
1120
Determination de th_récupération
1130
Determination de th_régénération, demande éléctrique et demande_thermique
1103
Moteur thermique disponible ?
non
Oui
1104
th_roulage=0
th_régénération=0
th_récupération=0
Fin

FIG.3B

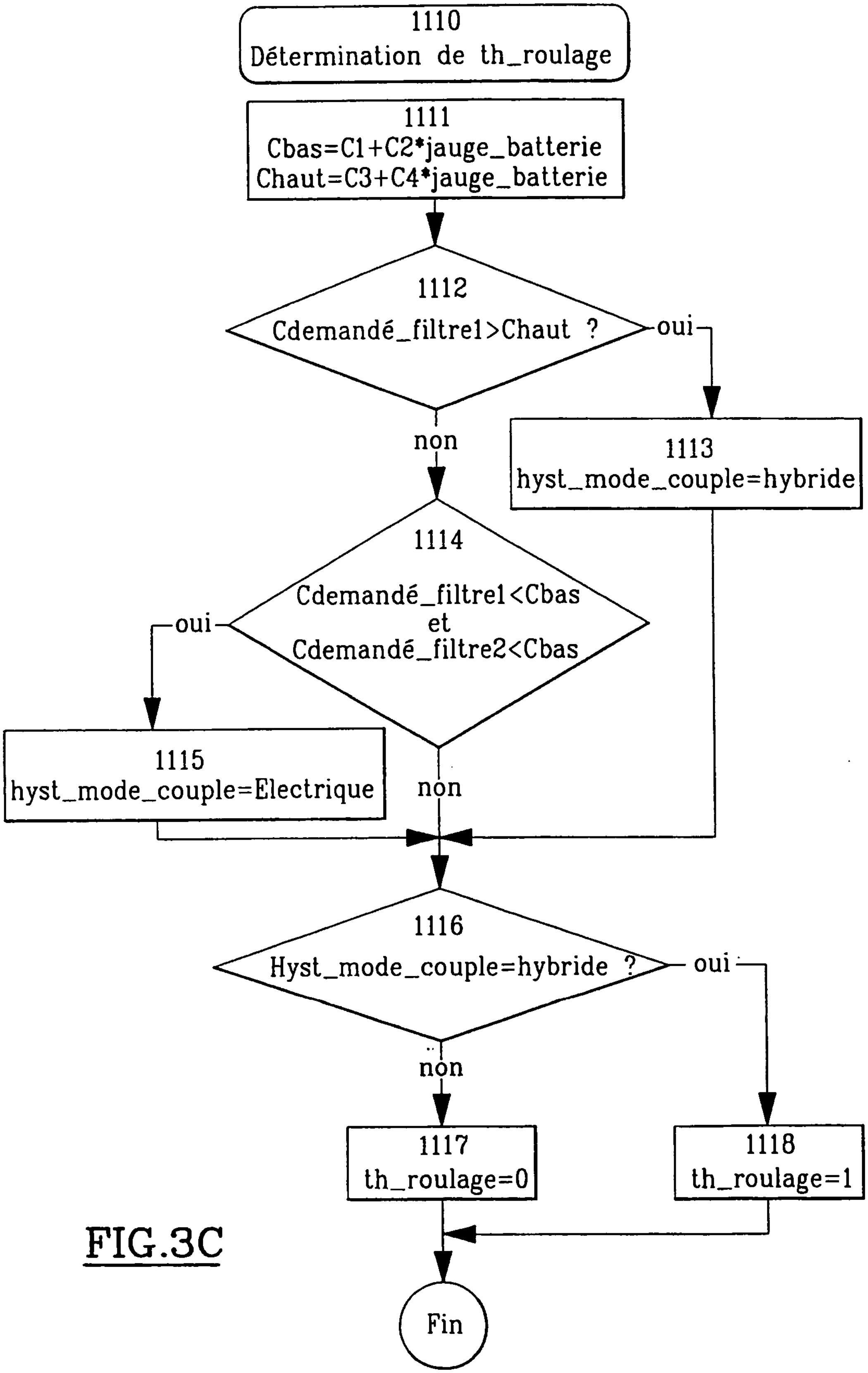

1110
Détermination de th_roulage
1111
Cbas=C1+C2*jauge_batterie
Chaut=C3+C4*jauge_batterie
1112
Cdemandé_filtre1>Chaut ?
oui
1113
hyst_mode_couple=hybride
non
1114
Cdemandé_filtre1<Cbas
et
Cdemandé_filtre2<Cbas
oui
1115
hyst_mode_couple=Electrique
non
1116
Hyst_mode_couple=hybride ?
oui
non
1117
th_roulage=0
1118
th_roulage=1
Fin

FIG.3C

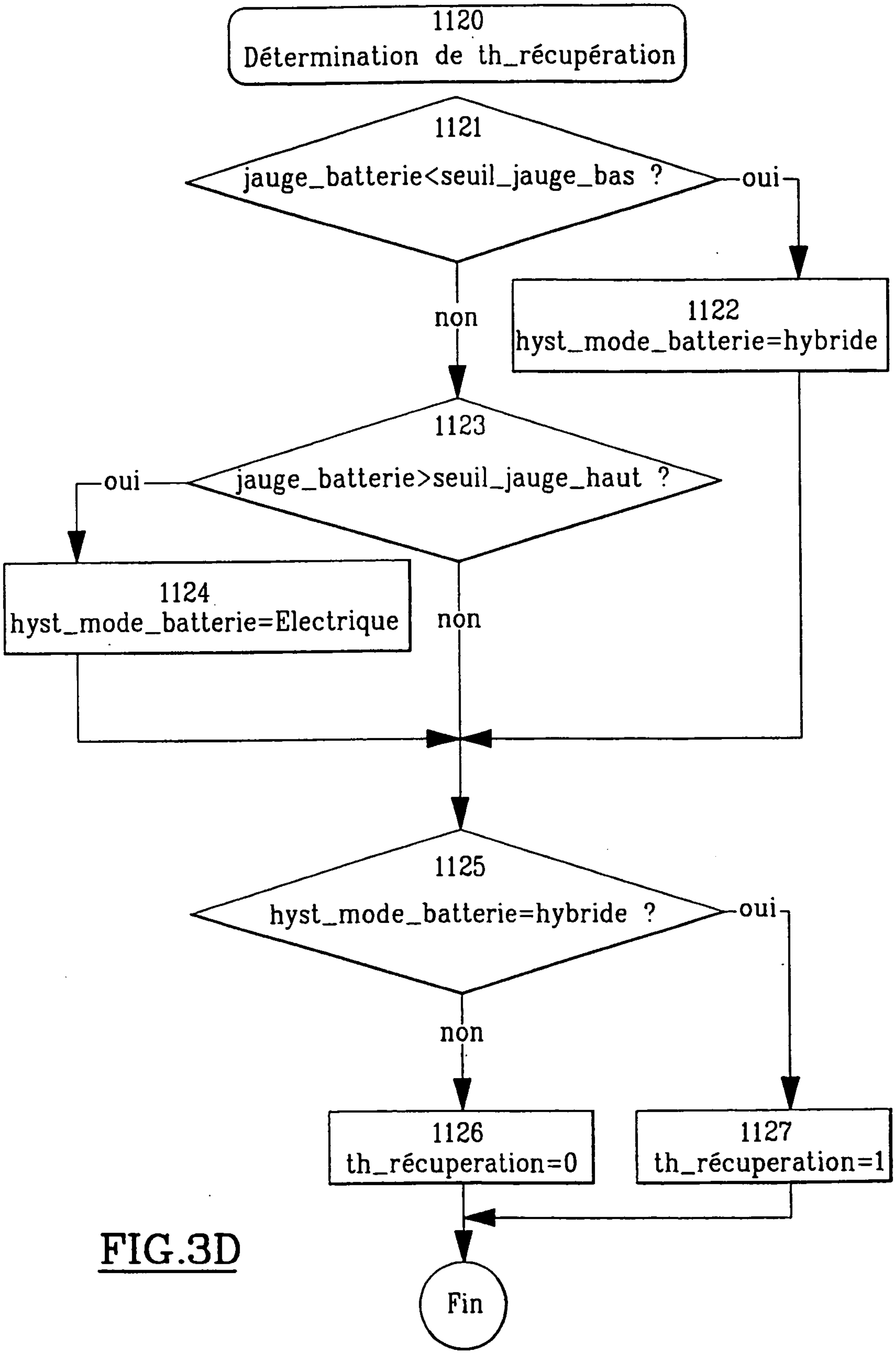
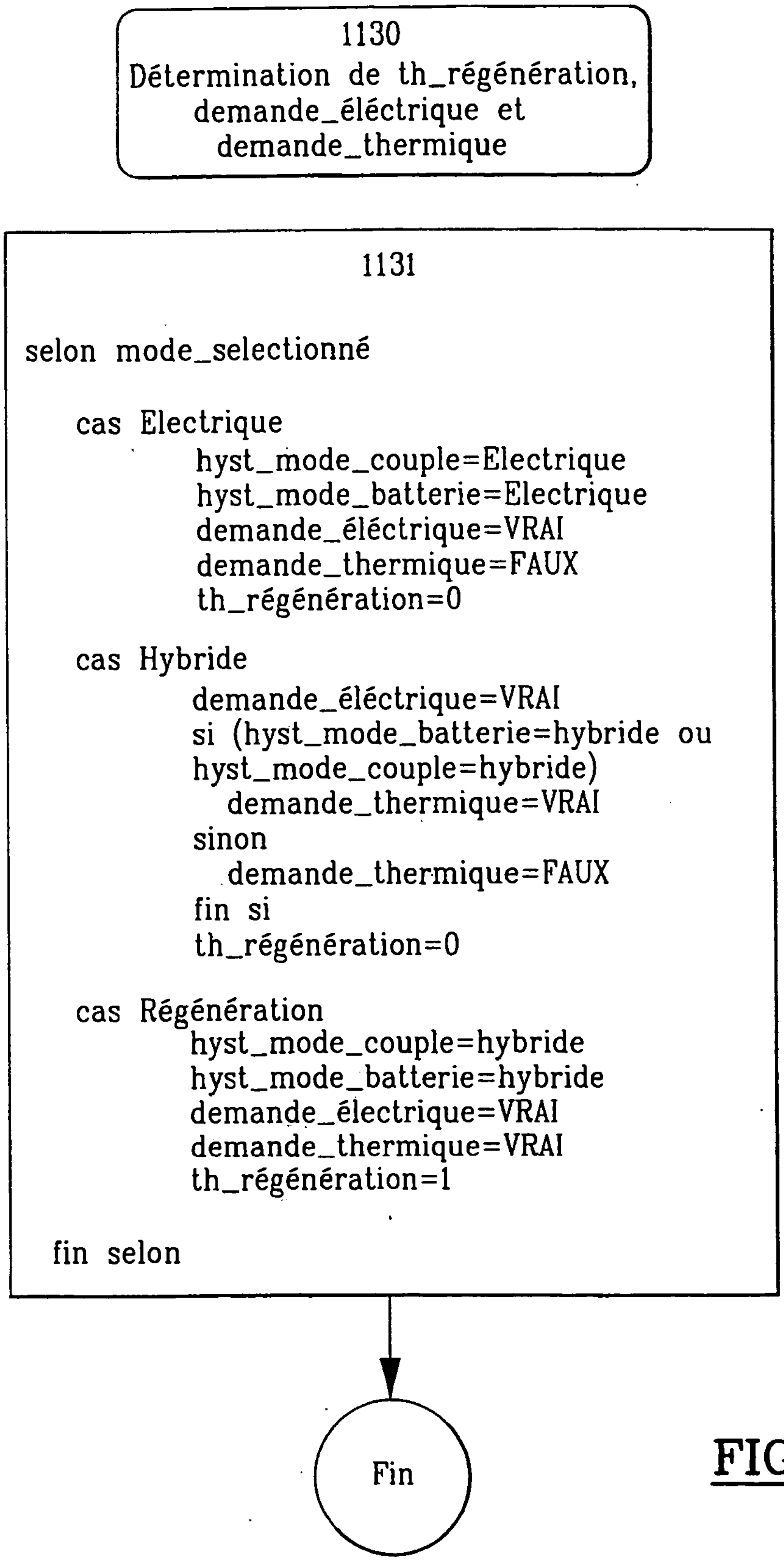

1120
Détermination de th_récupération
1121
jauge_batterie<seuil_jauge_bas ?
oui
non
1122
hyst_mode_batterie=hybride
1123
jauge_batterie>seuil_jauge_haut ?
oui
non
1124
hyst_mode_batterie=Electrique
1125
hyst_mode_batterie=hybride ?
oui
non
1126
th_récuperation=0
1127
th_récuperation=1
Fin

FIG.3D



```
selon mode_selectionné

  cas Electrique
      hyst_mode_couple=Electrique
      hyst_mode_batterie=Electrique
      demande_éléctrique=VRAI
      demande_thermique=FAUX
      th_régénération=0

  cas Hybride
      demande_éléctrique=VRAI
      si (hyst_mode_batterie=hybride ou
      hyst_mode_couple=hybride)
        demande_thermique=VRAI
      sinon
        demande_thermique=FAUX
      fin si
      th_régénération=0

  cas Régénération
      hyst_mode_couple=hybride
      hyst_mode_batterie=hybride
      demande_électrique=VRAI
      demande_thermique=VRAI
      th_régénération=1

 fin selon
```

FIG.3E

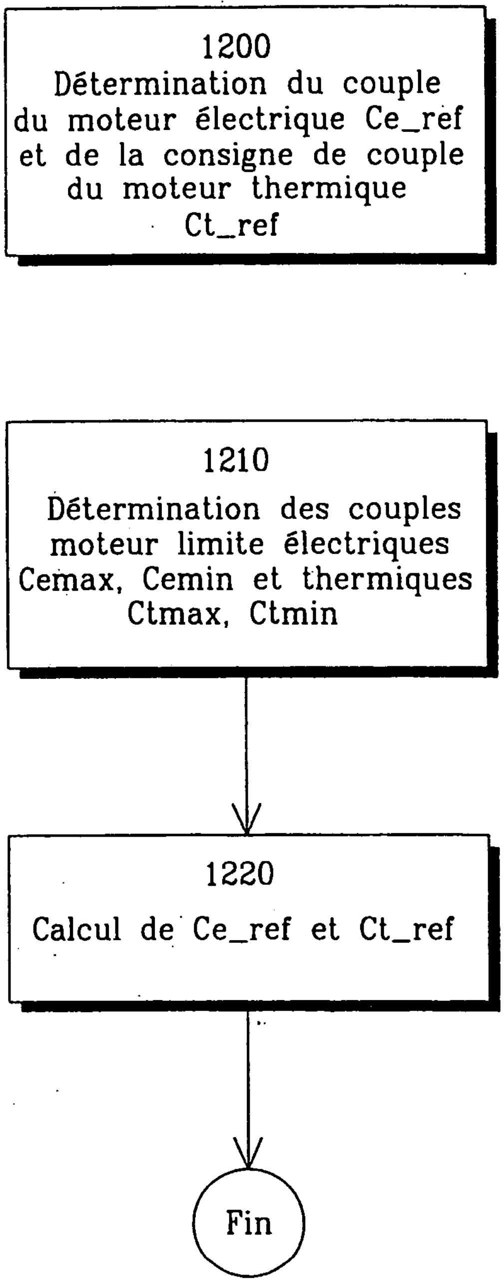

1200
Détermination du couple du moteur électrique Ce_ref et de la consigne de couple du moteur thermique Ct_ref
1210
Détermination des couples moteur limite électriques Cemax, Cemin et thermiques Ctmax, Ctmin
1220
Calcul de Ce_ref et Ct_ref
Fin

FIG.3F

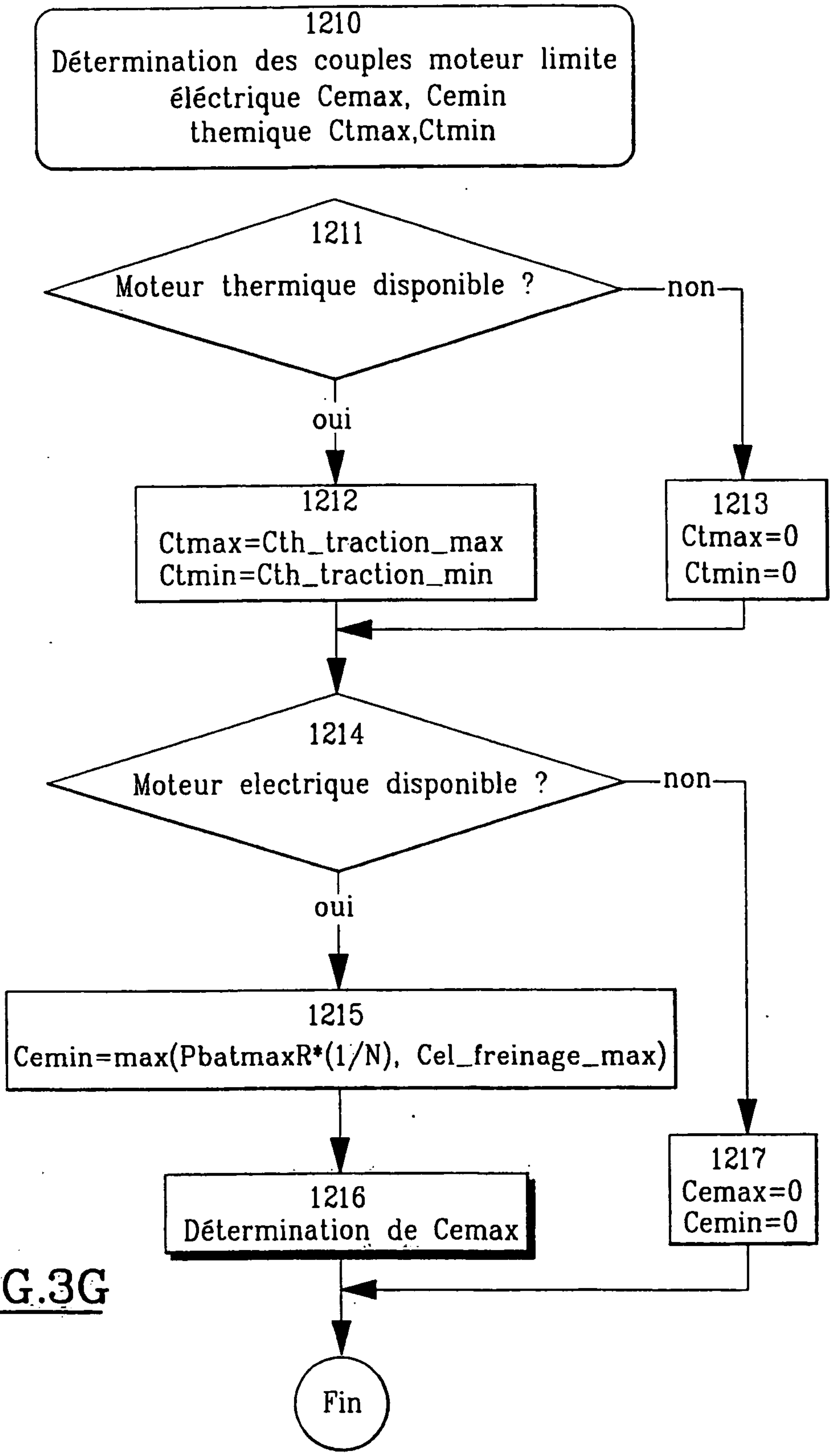

1210
Détermination des couples moteur limite
éléctrique Cemax, Cemin
themique Ctmax,Ctmin
1211
Moteur thermique disponible ?
non
oui
1212
Ctmax=Cth_traction_max
Ctmin=Cth_traction_min
1213
Ctmax=0
Ctmin=0
1214
Moteur electrique disponible ?
non
oui
1215
Cemin=max(PbatmaxR*(1/N), Cel_freinage_max)
1216
Détermination de Cemax
1217
Cemax=0
Cemin=0
Fin

FIG.3G

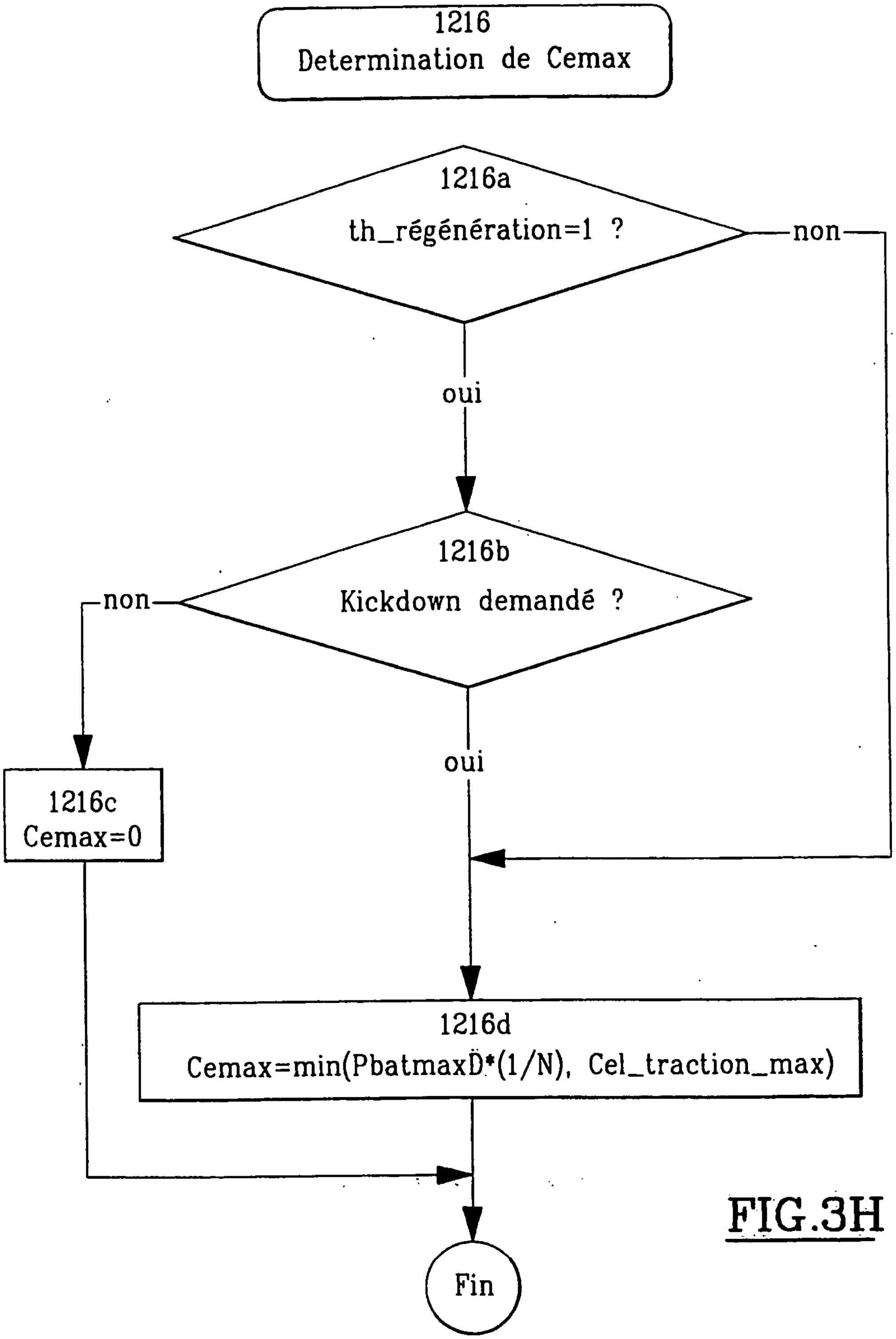

1216
Determination de Cemax
1216a
th_régénération=1 ?
non
oui
1216b
Kickdown demandé ?
non
oui
1216c
Cemax=0
1216d
Cemax=min(PbatmaxD*(1/N), Cel_traction_max)
Fin

FIG.3H

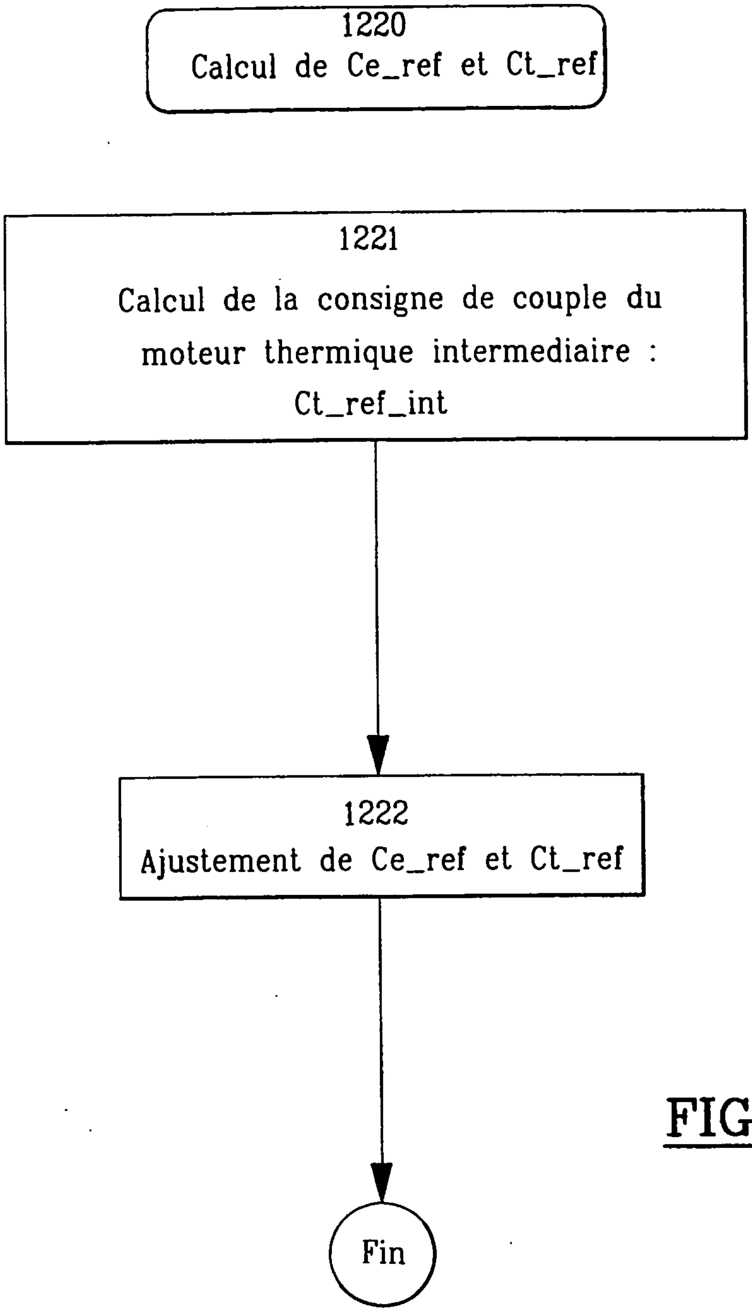

1220
Calcul de Ce_ref et Ct_ref
1221
Calcul de la consigne de couple du moteur thermique intermediaire : Ct_ref_int
1222
Ajustement de Ce_ref et Ct_ref
Fin

FIG.3I

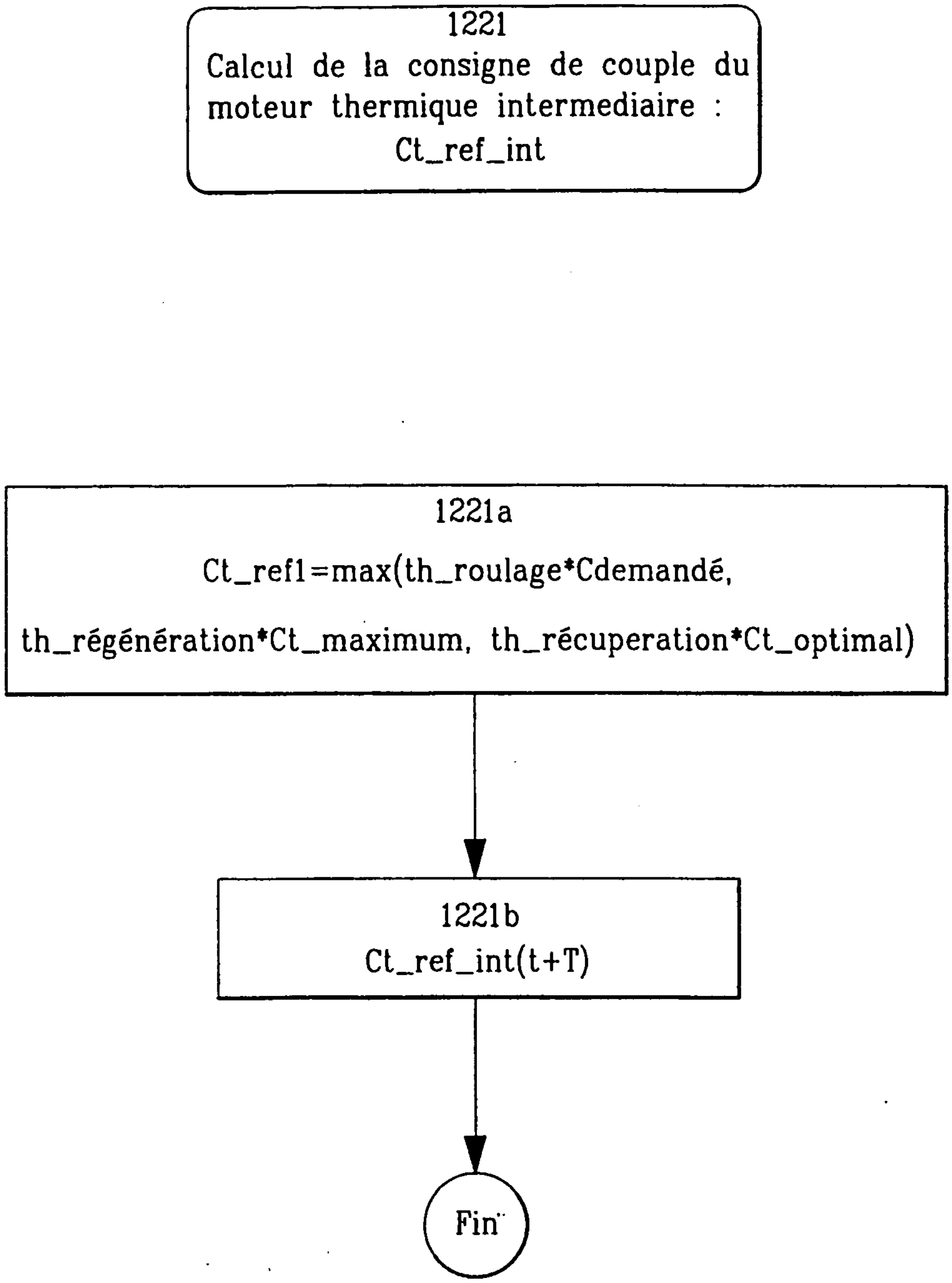

1221
Calcul de la consigne de couple du moteur thermique intermediaire : Ct_ref_int
1221a
Ct_ref1=max(th_roulage*Cdemandé,
th_régénération*Ct_maximum, th_récuperation*Ct_optimal)
1221b
Ct_ref_int(t+T)
Fin

FIG.3J

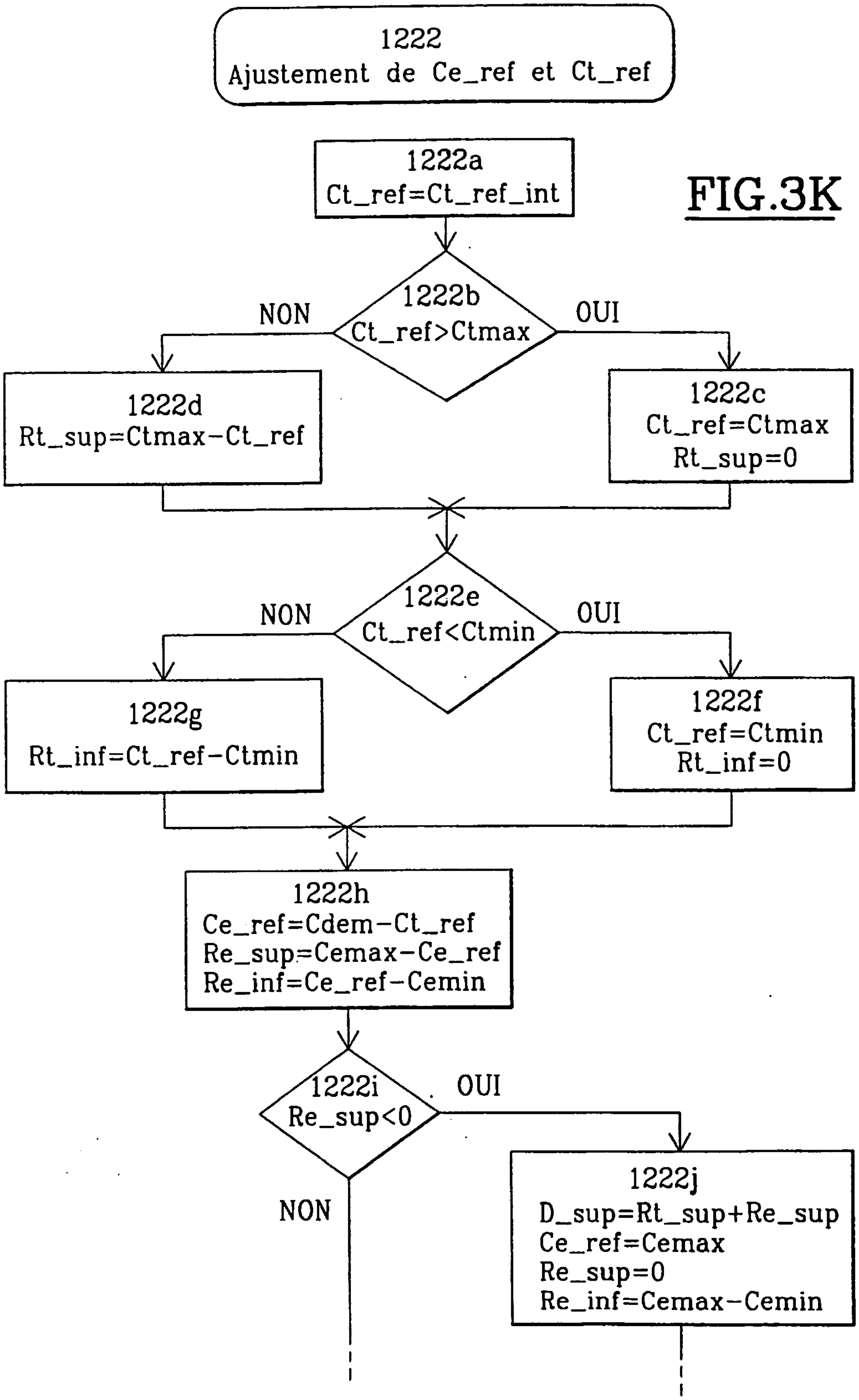
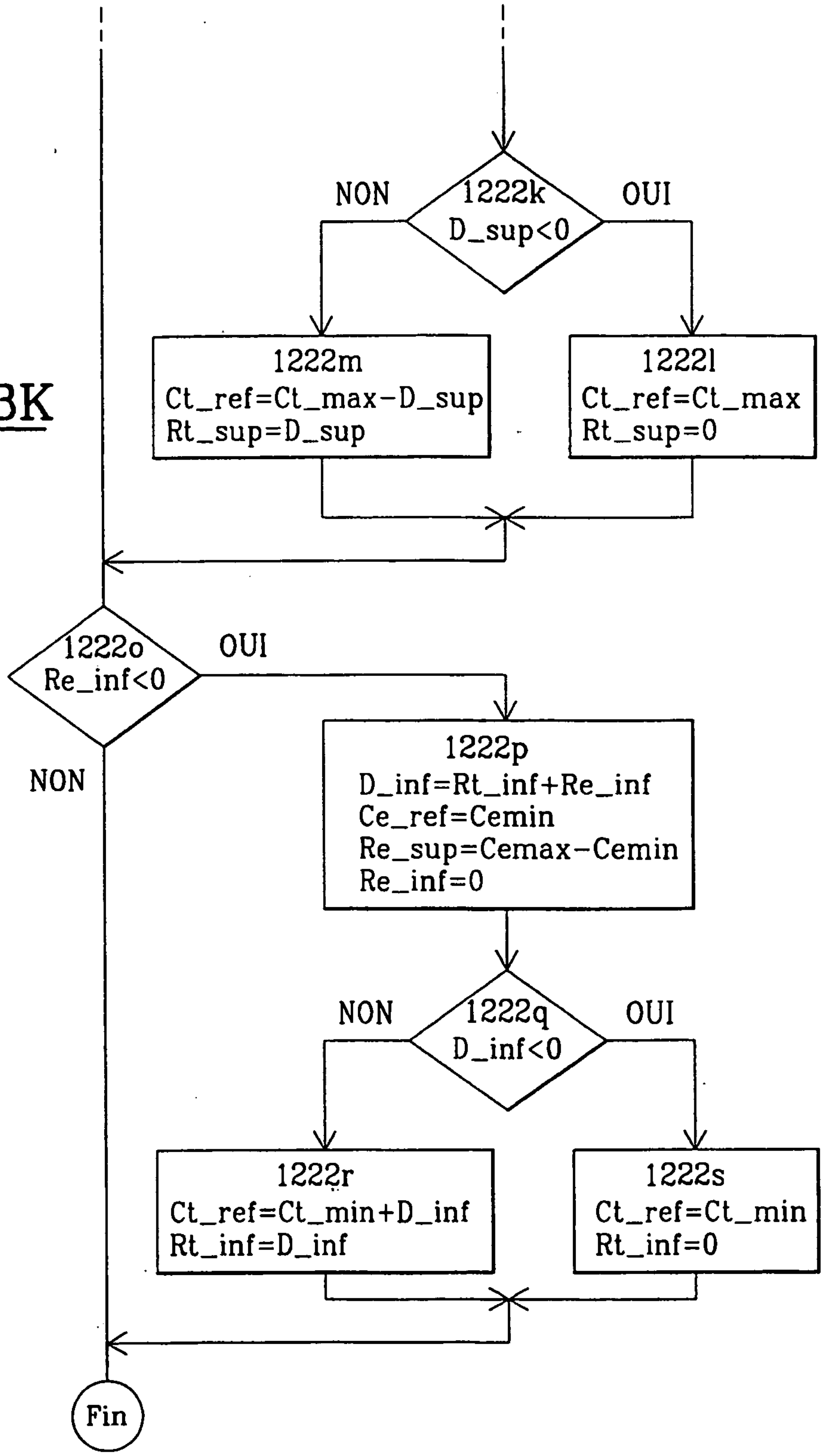


FIG.3K

FEUILLE DE REMPLACEMENT (REGLE 26)

FIG.3K


1222k
D_sup<0
NON
OUI
1222m
Ct_ref=Ct_max−D_sup
Rt_sup=D_sup
1222l
Ct_ref=Ct_max
Rt_sup=0
1222o
Re_inf<0
OUI
NON
1222p
D_inf=Rt_inf+Re_inf
Ce_ref=Cemin
Re_sup=Cemax−Cemin
Re_inf=0
1222q
D_inf<0
NON
OUI
1222r
Ct_ref=Ct_min+D_inf
Rt_inf=D_inf
1222s
Ct_ref=Ct_min
Rt_inf=0
Fin

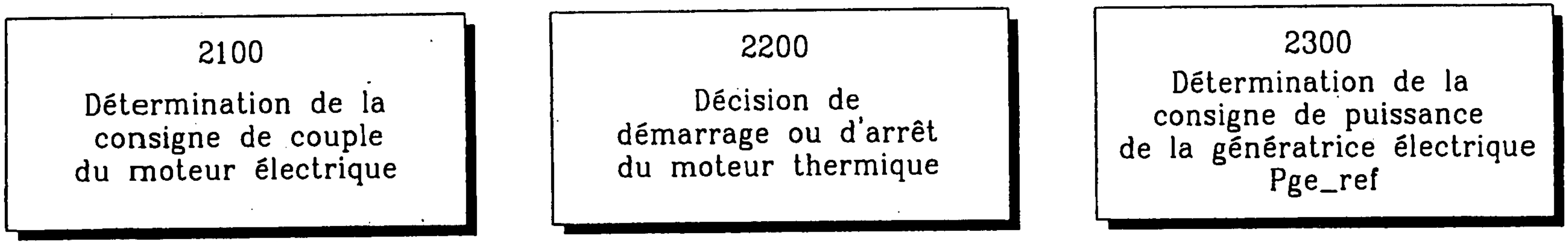

2100
Détermination de la
consigne de couple
du moteur électrique
2200
Décision de
démarrage ou d'arrêt
du moteur thermique
2300
Détermination de la
consigne de puissance
de la génératrice électrique
Pge_ref

FIG.4A

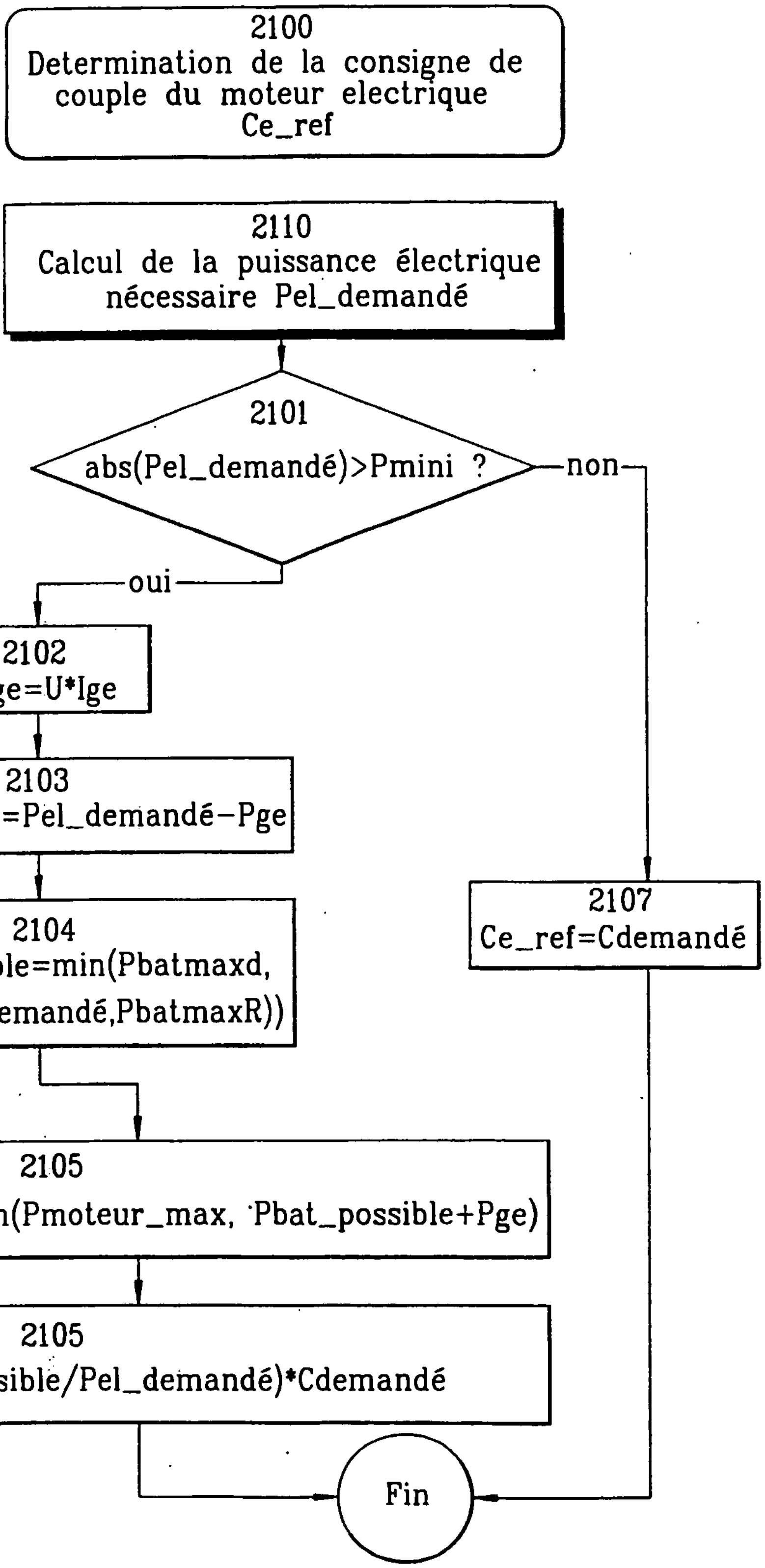

2100
Determination de la consigne de couple du moteur electrique Ce_ref
2110
Calcul de la puissance électrique nécessaire Pel_demandé
2101
abs(Pel_demandé)>Pmini ?
non
oui
2102
Pge=U*Ige
2103
Pbat_demandé=Pel_demandé-Pge
2104
Pbat_possible=min(Pbatmaxd, max(Pbat_demandé,PbatmaxR))
2105
Pel_possible=min(Pmoteur_max, Pbat_possible+Pge)
2105
Ce_ref=(pel_possible/Pel_demandé)*Cdemandé
2107
Ce_ref=Cdemandé
Fin

FIG.4B

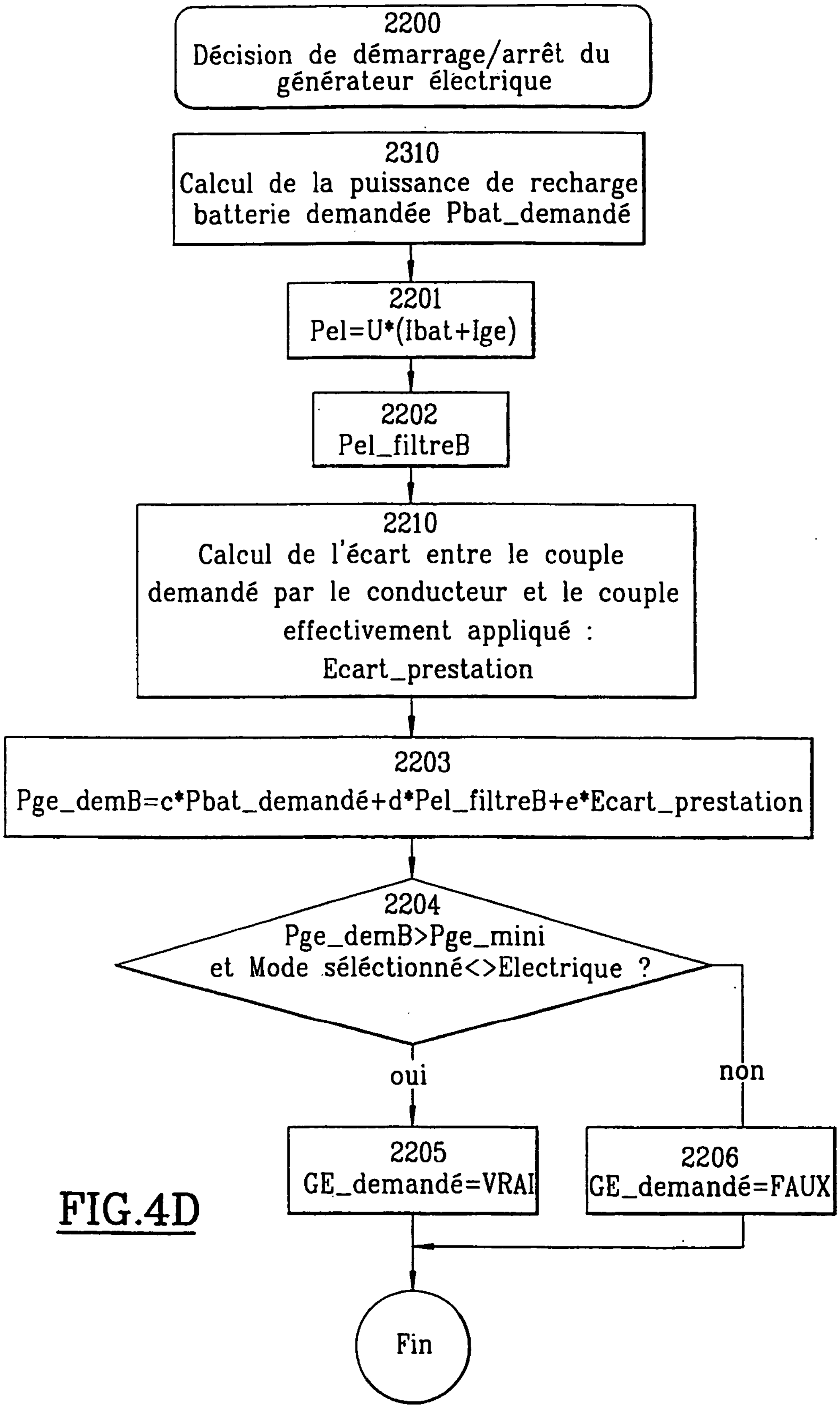

2200
Décision de démarrage/arrêt du générateur électrique
2310
Calcul de la puissance de recharge batterie demandée Pbat_demandé
2201
Pel=U*(Ibat+Ige)
2202
Pel_filtreB
2210
Calcul de l'écart entre le couple demandé par le conducteur et le couple effectivement appliqué : Ecart_prestation
2203
Pge_demB=c*Pbat_demandé+d*Pel_filtreB+e*Ecart_prestation
2204
Pge_demB>Pge_mini et Mode séléctionné<>Electrique ?
oui
non
2205
GE_demandé=VRAI
2206
GE_demandé=FAUX
Fin

FIG.4D

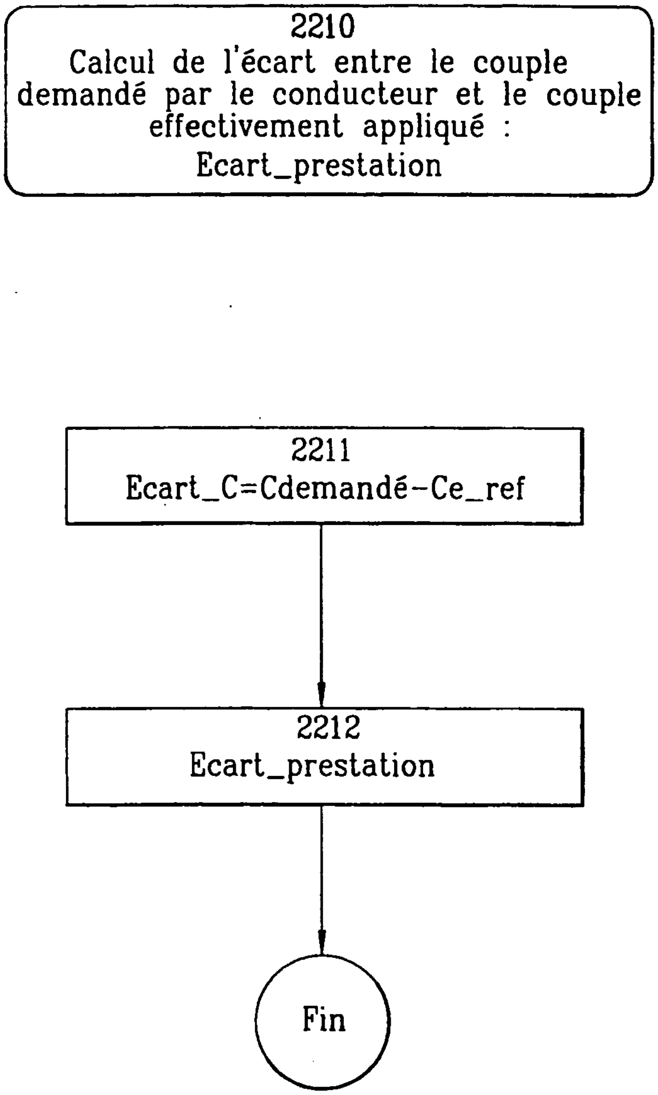

2210
Calcul de l'écart entre le couple demandé par le conducteur et le couple effectivement appliqué :
Ecart_prestation
2211
Ecart_C=Cdemandé-Ce_ref
2212
Ecart_prestation
Fin

FIG.4E

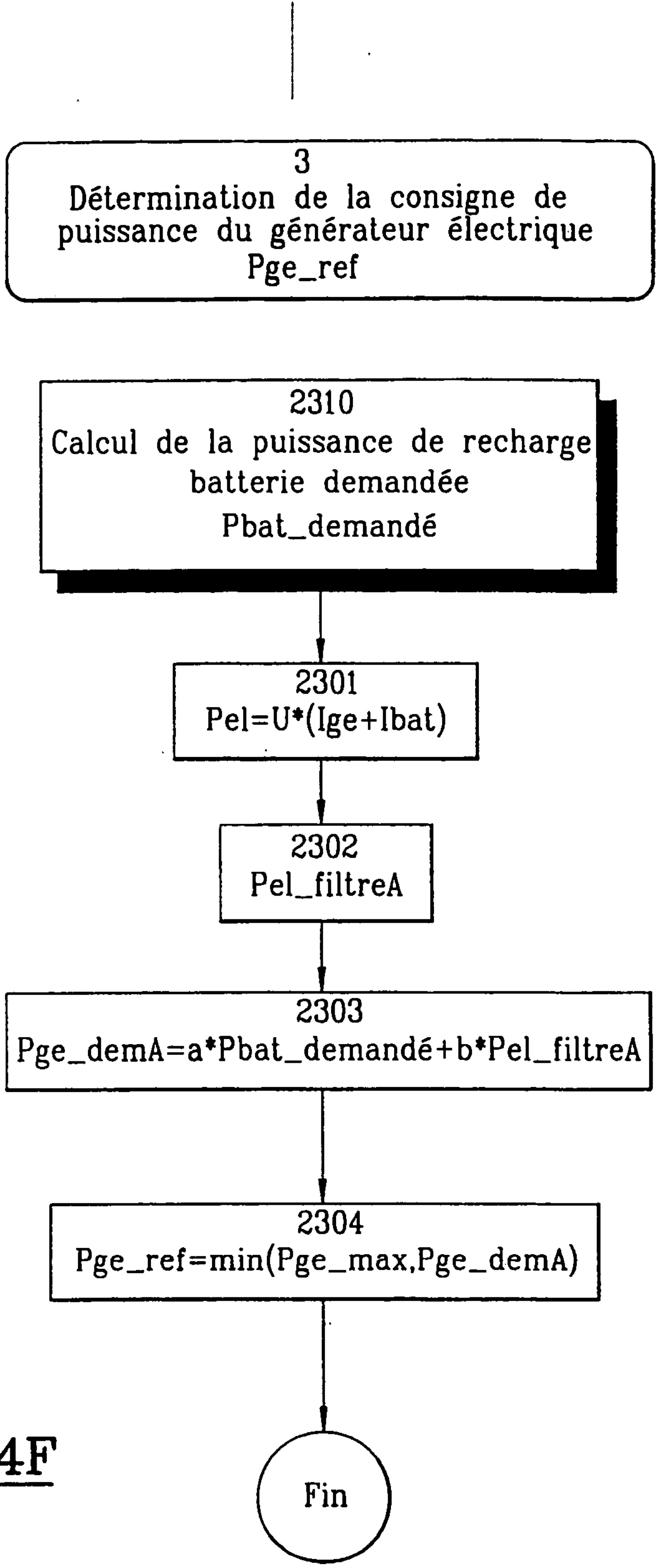

3
Détermination de la consigne de puissance du générateur électrique
Pge_ref
2310
Calcul de la puissance de recharge batterie demandée
Pbat_demandé
2301
Pel=U*(Ige+Ibat)
2302
Pel_filtreA
2303
Pge_demA=a*Pbat_demandé+b*Pel_filtreA
2304
Pge_ref=min(Pge_max,Pge_demA)
Fin

FIG.4F

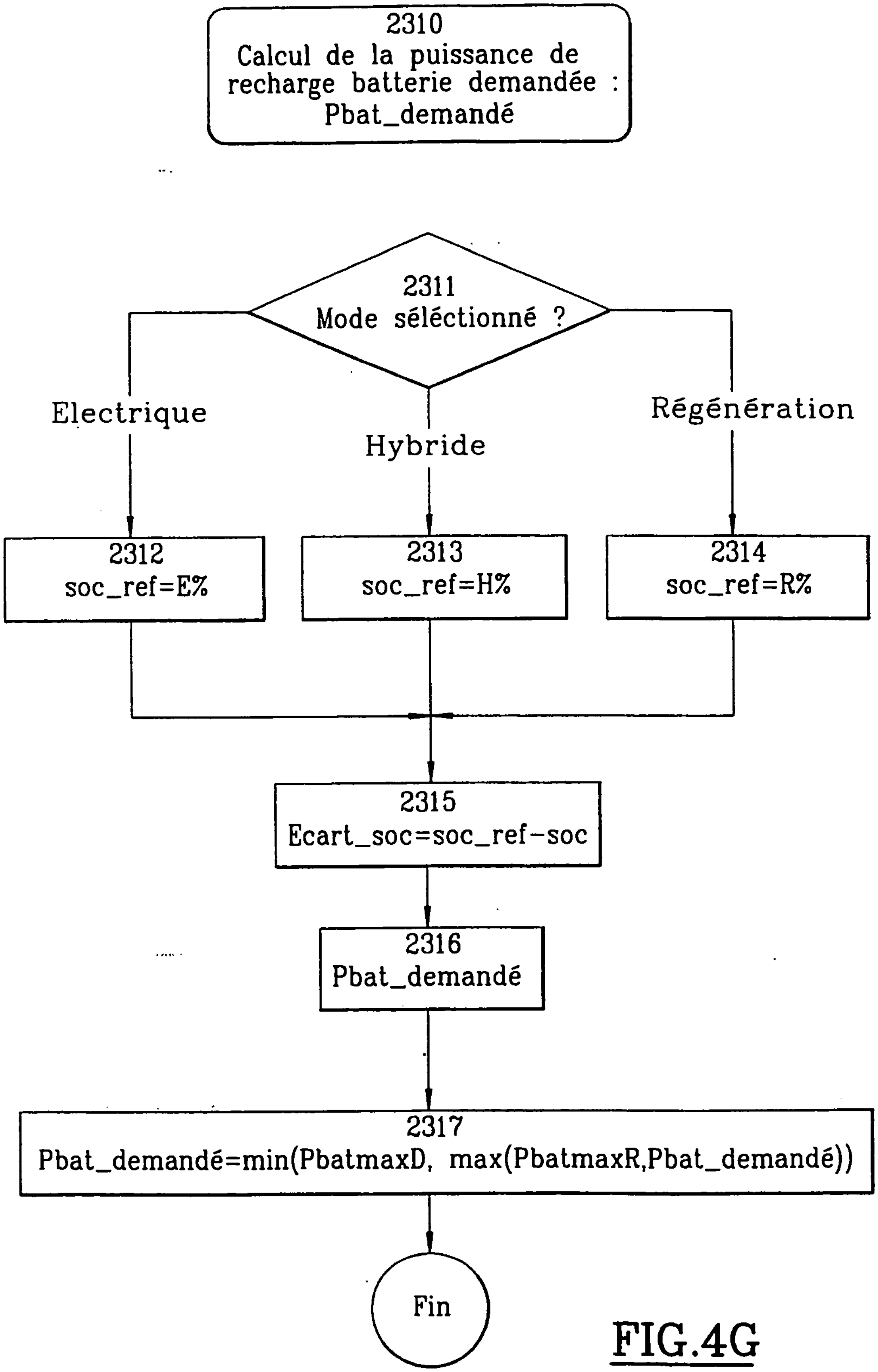

2310
Calcul de la puissance de recharge batterie demandée : Pbat_demandé
2311
Mode séléctionné ?
Electrique
Hybride
Régénération
2312
soc_ref=E%
2313
soc_ref=H%
2314
soc_ref=R%
2315
Ecart_soc=soc_ref-soc
2316
Pbat_demandé
2317
Pbat_demandé=min(PbatmaxD, max(PbatmaxR,Pbat_demandé))
Fin

FIG.4G

INTERNATIONAL SEARCH REPORT

International Application No
PCT/FR 98/02403

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B60K6/04

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B60K B60L

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 197 12 246 A (TOYOTA MOTOR CO LTD) 6 November 1997	1,19
Y	see page 2, line 19 - line 29; claims 1,4-7; figures 6,7	13
A	see page 3, line 28 - line 44 ---	2-4
Y	EP 0 781 680 A (DENSO CORP) 2 July 1997	13
A	see page 3, line 10 - line 38; claim 1; figure 1 ---	1-4,19
A	DE 43 24 010 A (DAIMLER BENZ AG) 19 January 1995 see column 1, line 21 - column 2, line 15 see column 3, line 10 - line 17; figure 1 see column 8, line 18 - line 34 -----	1-4,13, 19

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search 15 February 1999	Date of mailing of the international search report 22/02/1999
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Daehnhardt, A

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RAPPORT DE RECHERCHE INTERNATIONALE

mande Internationale No

PCT/FR 98/02403

A. CLASSEMENT DE L'OBJET DE LA DEMANDE

CIB 6 B60K6/04

Selon la classification internationale des brevets (CIB) ou à la fois selon la classification nationale et la CIB

B. DOMAINES SUR LESQUELS LA RECHERCHE A PORTE

Documentation minimale consultée (système de classification suivi des symboles de classement)

CIB 6 B60K B60L

Documentation consultée autre que la documentation minimale dans la mesure où ces documents relèvent des domaines sur lesquels a porté la recherche

Base de données électronique consultée au cours de la recherche internationale (nom de la base de données, et si réalisable, termes de recherche utilisés)

C. DOCUMENTS CONSIDERES COMME PERTINENTS

Catégorie °	Identification des documents cités, avec, le cas échéant, l'indication des passages pertinents	no. des revendications visées
X	DE 197 12 246 A (TOYOTA MOTOR CO LTD) 6 novembre 1997	1,19
Y	voir page 2, ligne 19 - ligne 29; revendications 1,4-7; figures 6,7	13
A	voir page 3, ligne 28 - ligne 44 ---	2-4
Y	EP 0 781 680 A (DENSO CORP) 2 juillet 1997	13
A	voir page 3, ligne 10 - ligne 38; revendication 1; figure 1 ---	1-4,19
A	DE 43 24 010 A (DAIMLER BENZ AG) 19 janvier 1995 voir colonne 1, ligne 21 - colonne 2, ligne 15 voir colonne 3, ligne 10 - ligne 17; figure 1 voir colonne 8, ligne 18 - ligne 34 -----	1-4,13, 19

☐ Voir la suite du cadre C pour la fin de la liste des documents

☒ Les documents de familles de brevets sont indiqués en annexe

° Catégories spéciales de documents cités:

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"E" document antérieur, mais publié à la date de dépôt international ou après cette date

"L" document pouvant jeter un doute sur une revendication de priorité ou cité pour déterminer la date de publication d'une autre citation ou pour une raison spéciale (telle qu'indiquée)

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"T" document ultérieur publié après la date de dépôt international ou la date de priorité et n'appartenenant pas à l'état de la technique pertinent, mais cité pour comprendre le principe ou la théorie constituant la base de l'invention

"X" document particulièrement pertinent; l'inven tion revendiquée ne peut être considérée comme nouvelle ou comme impliquant une activité inventive par rapport au document considéré isolément

"Y" document particulièrement pertinent; l'inven tion revendiquée ne peut être considérée comme impliquant une activité inventive lorsque le document est associé à un ou plusieurs autres documents de même nature, cette combinaison étant évidente pour une personne du métier

"&" document qui fait partie de la même famille de brevets

Date à laquelle la recherche internationale a été effectivement achevée 15 février 1999	Date d'expédition du présent rapport de recherche internationale 22/02/1999
Nom et adresse postale de l'administration chargée de la recherche internationale Office Européen des Brevets, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Fonctionnaire autorisé Daehnhardt, A

1

Formulaire PCT/ISA/210 (deuxième feuille) (juillet 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

ernational Application No

PCT/FR 98/02403

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 19712246 A	06-11-1997	JP 9257121 A	30-09-1997
		JP 9322312 A	12-12-1997
EP 0781680 A	02-07-1997	JP 9203332 A	05-08-1997
		US 5789881 A	04-08-1998
DE 4324010 A	19-01-1995	NONE	

Form PCT/ISA/210 (patent family annex) (July 1992)

RAPPORT DE RECHERCHE INTERNATIONALE

Renseignements relatifs aux membres de familles de brevets

mande Internationale No

PCT/FR 98/02403

Document brevet cité au rapport de recherche	Date de publication	Membre(s) de la famille de brevet(s)	Date de publication
DE 19712246 A	06-11-1997	JP 9257121 A	30-09-1997
		JP 9322312 A	12-12-1997
EP 0781680 A	02-07-1997	JP 9203332 A	05-08-1997
		US 5789881 A	04-08-1998
DE 4324010 A	19-01-1995	AUCUN	

Formulaire PCT/ISA/210 (annexe familles de brevets) (juillet 1992)

Motor vehicle with hybrid motorization

The invention relates to a motor vehicle with hybrid motorization comprising refined power management means.

The invention relates more particularly to a motor vehicle with hybrid motorization, of the type in which a powertrain assembly comprises an electric engine and a heat engine which are able to contribute to the driving of the vehicle, and of the type in which a central management unit executes a first task comprising determining the torque that each engine must supply for the powertrain assembly to supply the vehicle with a motive torque conforming to a torque requested by the driver of the vehicle, and of the type in which the heat engine is able to be stopped, the vehicle then being driven only by the electric engine powered by electric current from a battery.

In the search for vehicles that are less polluting than the motor vehicles that comprise only a single heat engine, vehicles with hybrid motorization appear as a particularly interesting alternative to strictly electric-powered vehicles.

In practice, the latter offer the advantage of not themselves emitting any toxic substances while being both particularly silent and economic to use. However, the electric vehicles take their power only from the accumulator batteries that they have on board. Now, given the poor performance levels of currently known accumulator batteries, at least those able to be used at reasonable cost in a motor vehicle, electric vehicles can store only a relatively low quantity of energy, despite a consistent weight, which gives them both poor autonomy and poor performance.

Thus, the hybrid motorization solution comprising a heat engine able to participate in the driving of the vehicle makes it possible to produce vehicles offering far higher performance and autonomy levels, satisfactory for normal use of the vehicle.

There are two main types of hybrid vehicles.

In series hybrid vehicles, only the electric engine is able to directly drive the drive wheels of the vehicle, possibly through a gearbox, a differential and/or a clutch. The electric engine takes its power from a battery charged by an electric generator which is driven by the heat engine.

In this type of hybrid vehicle, the electric engine is therefore always operating and the heat engine can be either stopped, with the vehicle then operating in pure electric mode, or running so that the generator produces electricity to power the electric engine and/or charge the batteries.

In a parallel hybrid vehicle, the heat engine and the electric engine are both linked, normally via a two-input gearbox, to the drive wheels of the vehicle. Normally, a clutch is placed between each engine and the drive wheels to enable the engine to be decoupled when the latter is not used for driving purposes. The parallel hybrid type motor vehicles can therefore be driven using only the electric engine, or using only the heat engine, or even using both engines simultaneously. Moreover, in certain configurations, it is possible to use the electric engine to start the heat engine and the electric engine can also be "inverted" so that, the heat engine rotating the electric engine, possibly at the same time as it is rotating the drive wheels of the vehicle, is responsible for charging the batteries.

It should be noted that there is a variant of the parallel hybrid vehicles in which each of the two heat and electric engines is coupled not to the same axle, but to different axles.

Whatever the type of hybrid vehicle considered, it is therefore necessary to manage as effectively as possible the control of each of the heat and electric engines to ensure that the vehicle is driven according to the needs of the driver who at all times determines the motive torque needed to propel the vehicle to accelerate or decelerate the vehicle, or maintain the vehicle at a steady speed.

In particular, the choice of whether or not to use the heat engine is particularly crucial because it can be used to determine the autonomy of the vehicle, its performance levels, all in as much as the starting of the heat engine is actually possible, which can, for example, be prohibited in certain areas where traffic is particularly dense or at certain periods to limit pollution.

Moreover, it is necessary for the power distribution transfers supplied by each of the engines to be conducted "transparently" for the driver, that is, producing a minimum of disturbances and jerks.

Thus, the invention proposes a motor vehicle of the type described previously, characterized in that, at least for certain operating modes of the powertrain assembly, the central unit executes a second task during which it is decided to stop or start the heat engine, in that the first task and the second task are executed in parallel and in that the frequency of execution of the second task is less than that of the first task.

According to other characteristics of the invention:

- the driver can impose on the powertrain assembly an electric operating mode in which the heat engine is stopped;

- the driver can impose on the powertrain assembly a regeneration operating mode in which the heat engine is used in particular to charge the battery;

- the driver can impose on the powertrain assembly a hybrid operating mode in which the central unit executes the second task during which it is decided to stop or start the heat engine;

- the decision to stop or start the heat engine is taken in particular according to a state of charge of the battery;

- the starting of the heat engine is decided or confirmed when the state of charge of the battery is less than a low threshold level, and the stopping of the heat engine is able to be decided or confirmed when the state of charge of the battery is greater than a high threshold level;

- the decision to stop or start the heat engine is taken in particular according to the instantaneous torque requested by the driver;

- the decision to stop or start the heat engine is taken in particular according to the average torque requested by the driver during a predetermined time interval preceding the decision;

- the starting of the heat engine is decided or confirmed when the instantaneous torque requested by the driver is greater than a high threshold level, and in that the stopping of the heat engine is able to be decided or confirmed when the instantaneous torque and the average torque requested by the driver are less than a low threshold level;

- the stopping of the heat engine is decided or confirmed when, at the same time, the state of charge of the battery is greater than a high threshold level and the instantaneous torque and the average torque requested by the driver are less than a low threshold level;

- the decision to stop or start the heat engine is taken in particular according to a difference between the torque requested by the driver and the torque actually supplied by the powertrain assembly;

- during operation of the operating mode selected by the driver, a charge set point level of the battery is fixed;

- the powertrain assembly is a series hybrid assembly in which the drive wheels of the vehicle are driven exclusively by the electric engine which is powered by electric current from either the battery or from a generator driven by the heat engine;

- the electrical power to be supplied to the battery is determined according to a difference between the real and reference states of charge of the battery, taking into account limiting charge and discharge power values of the battery;

- the starting of the heat engine is determined according to the electrical power to be supplied to the battery, the electrical power absorbed by the electric engine and according to a difference between the value of the torque requested by the driver and the value of the torque supplied by the electric engine;

- a set point level for the power supplied by the generator is determined according to the real power supplied by the generator, the real power supplied by the battery, and the power to be supplied to the battery, taking into account the maximum power able to be supplied by the generator;

- a necessary electrical power is determined according to the motive torque requested by the driver, taking into account, at least when this torque is greater as an absolute value than a minimum value, the efficiency of the electric engine;

- a set point value for the torque supplied by the electric engine is determined according to the motive torque requested by the driver multiplied, at least when the necessary electrical power is greater as an absolute value than a threshold value, by the ratio of the electrical power able to be supplied to the electric engine divided by the necessary electrical power, the electrical power able to be supplied to the electric engine taking into account the necessary electrical power, the real power supplied by the generator, the power able to be supplied by the battery, and the maximum power able to be absorbed by the engine;

- the powertrain assembly is a parallel hybrid assembly in which the electric engine and the heat engine each drive either at least one and the same drive wheel or different drive wheels;

- the powertrain assembly operates in regeneration mode, the electric engine delivers a motive torque only if the driver provokes an abrupt rise in the requested torque;

- when the powertrain assembly is operating in regeneration mode, the heat engine is ordered to supply a maximum torque;

- when the powertrain assembly is operating in hybrid mode and the state of charge of the battery has previously fallen below a low threshold level and has not yet exceeded a high threshold level, the heat engine is ordered to supply a set point torque at least equal to an optimal torque corresponding to optimal efficiency conditions of the heat engine;

- when the powertrain assembly is operating in hybrid mode and the instantaneous torque requested by the driver has previously risen above a high threshold level without returning below a low threshold level at the same time as the average level is less than the low threshold level, the heat engine is ordered to supply a set point torque at least equal to a filtered value of the torque requested by the driver; and

- if a filtered value of the torque requested by the driver is greater than the maximum torque of the heat engine, the electric engine is called upon to supply, as far as possible, the quantity of torque lacking.

Other features and advantages of the invention will become apparent from reading the detailed description that follows, which should be interpreted with reference to the appended drawings in which:

- figure 1 is a schematic view illustrating the architecture of a motor vehicle with hybrid motorization, of parallel type;

- figure 2 is a view similar to that of figure 1 illustrating a series type hybrid vehicle;

- figures 3A to 3K are flow diagrams illustrating a first strategy for the management of a hybrid vehicle according to the teachings of the invention, more specifically intended for a parallel type hybrid vehicle; and

- figures 4A to 4H illustrate a flow diagram of a management strategy according to the invention, more specifically intended for a series type hybrid vehicle.

In a vehicle with parallel hybrid motorization, of the type of the one illustrated in figure 1, a heat engine 10 and an electric engine 12 are both able to directly drive the drive wheels of the vehicle.

The heat engine 10 is normally an internal combustion engine with reciprocating pistons or rotary pistons or even of turbine type. It is powered chemically by a hydrocarbon type liquid or gas fuel.

The electric engine 12 is electrically linked to a battery 16 borne by the vehicle, possibly via an inverting converter 17. The two engines 10, 12 each rotate an input shaft 18, 20 of a power distribution unit 22 of which the output shaft(s) 24 rotate the drive wheels. The power distribution unit 22 can comprise, for example, a gearbox, a differential and, optionally, placed between at least one of the engines and the corresponding input shaft 18, 20, a clutch device 25 which is used to couple or decouple at will the engine from the power distribution unit 22.

The duly equipped vehicle can therefore be driven either using only the heat engine 10, or using only the electric engine 12, or using both engines simultaneously. If necessary, the heat engine can have its power distributed between on the one hand driving the drive wheels 14, and on the other hand rotating the "inverted" electric engine which is then converted into an electricity generator for charging the battery 16.

Similarly, the electric engine 12 can, if necessary, be used to start the heat engine 10.

In the series type hybrid vehicle illustrated in figure 2, only the electric engine 12 is linked directly to the drive wheels, possibly via a power distribution unit (not shown). The electric engine 12 can be powered with electrical energy by the battery 16 or by an electricity generator 26 which is driven by the electric engine 12.

In all cases, inverting 17 and rectifying 19 converters can be provided if the electric engine needs to be powered by alternating current.

Preferably, to manage the driving of the vehicle, each of the main elements of the vehicle is provided with a local control unit, each of these local units being in turn controlled by a central management unit which is used to centralize the information concerning the status of each of the units, information concerning the status of the vehicle and information concerning the requirements of the driver.

The main purpose of the central management unit is to control the two engines 10, 12 so as to make best use of the energy of the vehicle that is stored either in electrical form in the batteries, or in the form of hydrocarbon fuel. Another aim of this management is to respond at all times in the most satisfactory way possible to the requirements of the driver concerning acceleration and deceleration of the vehicle, this requirement preferably being represented by a motor torque Trequested on the drive wheels.

Two main tasks are executed cyclically by the central management unit, namely, on the one hand the decision to start or stop the heat engine 10 and, on the other hand, the determination of the torque or power set points that the electric engine and the heat engine must supply in order to drive the vehicle according to the requirements of the driver.

According to the invention, these two tasks are performed in parallel and they are executed at different frequencies.

Thus, the task involving determining the torque set points to be supplied by the electric engine and the heat engine will, for example, be executed every 40 milliseconds whereas the task for deciding to start or stop the heat engine will, for example, be performed every second.

Decoupling these two tasks in this way provides for a management of the power supplied by the powertrain assembly formed by the two engines 10, 12 which responds virtually instantaneously to the instructions of the driver. Furthermore, making the decision to start and stop the heat engine independently of the instantaneous power management prevents these start and stop phases, which are both aggravated sources of pollution and sources of instability to the total power supplied by the engines, which can be reflected in jerks felt by the driver and the passengers of the vehicle, from being multiplied.

The management strategy for the hybrid vehicle according to the invention will be more specifically described below according to two embodiments, one of which is more particularly suited to a parallel type hybrid vehicle illustrated in figure 1, and the other of which is more particularly suited to a series type hybrid vehicle illustrated in figure 2.

The first of these two strategies uses a series of variables which are listed and explained in the table below.

Notation	**Meaning**	**Units**
C1 to C4	Constants for calculating Tlow and Thigh according to battery gauge	Nm
Tlow	Lower torque threshold for determining h_running	Nm
Trequested	Torque requested by the driver (positive for acceleration, negative for deceleration)	Nm
Trequested_filter1	Rapid response time filtered value of Trequested	Nm
Trequested_filter2	Slow response time filtered value of Trequested	Nm
Te_ref	Electric motive torque set point (positive for traction, negative for regenerative braking)	Nm
Tel_braking_max	Maximum regenerative braking torque allowable by the electric engine (negative)	Nm
Tel_traction_max	Maximum traction torque allowable by the electric engine (positive)	Nm
Temax	Maximum electric torque given the state of the battery and mode_selected (positive)	Nm
Temin	Minimum electric torque given the state of the battery and mode_selected (negative)	Nm
Thigh	Upper torque threshold for determining h_running	Nm
Th_maximum	Maximum torque of the heat engine, used in Regeneration mode	Nm
Th_optimal	Torque of the heat engine corresponding to its minimum specific consumption	Nm
Th_ref	Heat motive torque set point (positive for traction, negative for engine braking)	Nm
Th_ref_int	Intermediate estimate of the Th_ref value	Nm
Th_ref1	Intermediate estimate of the Th_ref value	Nm
Th_braking_max	Maximum engine braking torque allowable by the heat engine (negative)	Nm
Th_traction_max	Maximum traction torque allowable by the heat engine (positive)	Nm
Thmax	Maximum electrical torque given mode_selected (positive)	Nm

Thmin	Minimum electrical torque given mode selected (negative)	Nm
D lower	Intermediate value in calculating Th ref	Nm
D higher	Intermediate value in calculating Th ref	Nm
Request electric	Electric engine start request	Boolean
Request heat	Heat engine start request	Boolean
Battery_mode_hyst	Intermediate quantity for determining h_recovery (electric, hybrid)	-
Torque_mode_hyst	Intermediate quantity for determining h_running (electric, hybrid)	-
battery gauge	State of charge of the traction battery	%
Kickdown requested	Request for additional electrical acceleration (regeneration mode)	Boolean
mode_selected	Operating mode selected by the driver (electrical, hybrid or regeneration)	-
N	Electric motor rotation speed	rad/s
PbatMaxD	Maximum discharge power of traction battery (positive)	W
PbatmaxR	Maximum recharge power of traction battery (negative)	W
Re_lower	Intermediate value in calculating Th_ref (see diagram below)	Nm
Re_upper	Intermediate value in calculating Th_ref (see diagram below)	Nm
Rh_lower	Intermediate value in calculating Th_ref (see diagram below)	Nm
Rh_upper	Intermediate value in calculating Th_ref (see diagram below)	Nm
gauge_low_ threshold	Battery gauge low threshold for determining h_recovery	%
gauge_high_ threshold	Battery gauge high threshold for determining h_recovery	%
h_recovery	Determines whether the heat engine contributes to charging the battery	Boolean
h_regeneration	Determines whether the heat engine contributes to strongly charging the battery	Boolean
h running	Determines whether the heat engine contributes to running	Boolean

Figure 3A illustrates the two main tasks that are executed in parallel with each other, at different frequencies. Of course, the frequencies of 1 Hertz and 25 Hertz given here for on the one hand the task 1100 for deciding to start or stop the heat engine, and on the other hand the task 1200 for determining the torque set points of the engines 10, 12 are nonlimiting examples used to illustrate the choice according to which the second of these frequencies is significantly greater than the first.

Each of the tasks 1100 and 1200 illustrated in these figures is broken down into lower level tasks which will be explained with reference to figures 3B to 3K.

The step 1100 for deciding to start or stop the heat engine is explained in figure 3B. First of all, in the steps 1101 and 1102, two filtered values of the torque Trequested requested by the driver are calculated. The filters used are, for example, first order filters, of low-pass type. The first value Trequested_filter1 corresponds to an average of Trequested over a very short interval preceding the time of calculation and remains representative of the instantaneous value Trequested. However, the value Trequested_filter2 corresponds to a smoothed average value of Trequested and is therefore representative of a medium term trend of the torque request expressed by the driver.

Once these two values have been calculated, three lower level tasks are executed in which are determined the intermediate boolean variables: h_running (task 1110), h_recovery (task 1120), h_regeneration, request_electric and request_heat (task 1130).

These lower level tasks will be explained below.

Once these values have been determined, a test is carried out in step 1103 to check whether the heat engine 10 is available, that is, whether it is in a state to deliver a motive torque. If it is, the boolean variables that have just been calculated are retained unchanged, otherwise, as can be seen in step 1104, the boolean values h_running, h_regeneration and h_recovery are forced to zero.

The task 1110 for determining the value of the boolean variable h_running is now described with reference to figure 3C. In the step 1111, two threshold levels Tlow and Thigh, with which the filtered values of the requested torque will be compared, are first calculated. These threshold values are mainly determined according to the state of charge battery_gauge of the battery 16.

In the step 1112, a check is first of all made to see whether the filtered value Trequested_filter1, representative of the instantaneous torque requested by the driver, is greater than the upper threshold level Thigh. If it is, an intermediate boolean variable torque_mode_hyst is forced to the value "hybrid" in the step 1113. If not, in the step 1114, a check is made to see whether the two filtered values of the requested torque Trequested_filter1 and Trequested_filter2 are both simultaneously lower than the lower torque level Tlow. If they are, the boolean value torque_mode_hyst is forced in the step 1115 to the value "electric". If not, the boolean variable torque_mode_hyst is unchanged.

In the step 1116, a check is then made to see whether the boolean variable torque_mode_hyst is equal to the value "hybrid". If it is, the boolean value h_running is forced to 1 in the step 1118. If not, the boolean value h_running is forced to zero in the step 1117.

The task 1120 for determining the value of the boolean variable h_recovery will now be described with reference to figure 3D. In the step 1121, a check is first carried out to see whether the state of charge of the battery 16, represented by the variable battery_gauge, is less than a lower threshold value gauge_low_threshold. If it is, a boolean variable battery_mode_hyst is forced to the value "hybrid" in the step 1122. If not, a check is made in the step 1123 to see whether the battery_gauge value is greater than an upper threshold level gauge_high_threshold. If it is, the boolean variable battery_mode_hyst is forced to the value "electric" in the step 1124. If not, the variable battery_mode_hyst retains the same value as during the previous execution of the task.

In the step 1125, a check is made to see whether the variable battery_mode_hyst is equal to the value "hybrid". If it is, the h_recovery value is forced to the value 1 in the step 1127. If not, this variable is forced to the value zero in the step 1126.

The task 1130 is described with reference to figure 3E. The purpose of this task is to determine the value of the boolean variables h_regeneration, request_electric and request_heat.

According to an aspect of the invention, the management strategy for the powertrain assembly of the hybrid vehicle that is proposed here is used by the driver to select one of three operating modes for the powertrain assembly.

→ In an electric mode, the driver prohibits the use of the heat engine. The boolean variables torque_mode_hyst and battery_mode_hyst are forced to the variable "electric", the variable request_electric is forced to the value "true", the variable request_heat is forced to the value "false" and the variable h_regeneration is forced to the value "0".

The driver can also select a regeneration operating mode for the powertrain assembly. This operating mode forces the powertrain assembly to start the heat engine in order, in addition to driving the vehicle, to charge the battery 16. The boolean variables torque_mode_hyst and battery_mode_hyst are in this case forced to the value "hybrid". The boolean variables request_electric and request_heat are forced to the value "true" while the variable h_regeneration is forced to the value "1".

The driver can also select a hybrid operating mode for the powertrain assembly. In this operating mode, the heat engine 10 will be used only if needed, as will be seen below.

In this mode, the variable request_electric is forced to the value "true". The variable request_heat is forced to the value "true" if one or other of the variables battery_mode_hyst and torque_mode_hyst is equal to the value "hybrid". Otherwise, the variable request_heat is forced to the value "false". The variable h_regeneration is forced to the value "0".

There now follows a description, with reference to figures 3F to 3K, of the second main task 1200 of this first strategy for managing a hybrid vehicle, this second task being executed at a frequency fast enough to be able to satisfy the requirements of the driver.

This second task 1200, which consists in determining the set point torques Te_ref and Th_ref for the electric engine and the heat engine, itself comprises two lower level tasks 1210 and 1220 which will be explained respectively in Figures 3G to 3H and 3I to 3K.

As can be seen in Figure 3G, the purpose of the task 1210 is to determine the limiting motive torques for the electric engine and the heat engine. In the step 1211, a check is first of all made to see whether the heat engine is available. If it is, limiting torque variables Thmax and Thmin for the heat engine are respectively assigned the values Th_traction_max and

Th_braking_max which are linked in particular to the speed and the temperature of the engine used. If not, the values of Thmax and Thmin are forced to zero in the step 1213.

In the step 1214, a check is then made to see whether the electric engine is available. If not, the variables Temax and Temin are forced to zero in the step 1217.

If it is, the variable Temin is assigned in the step 1215 the higher of the following two values:

- a value Tel_braking_max, which depends in particular on the power supply voltage and temperature of the engine;

- $\text{PbatmaxR} \times \frac{1}{N}$.

The maximum torque value of the electric engine is determined in the task 1216 which is broken down in figure 3H. In practice, a check is first of all carried out in the step 1216a to see whether the variable h_regeneration is equal to 1, that is, whether the driver has selected the regeneration operating mode for the powertrain assembly. If so, it can be seen that the value of Temax is forced to zero in the step 1216c, unless the driver, as is checked in the step 1216b, performs a kickdown maneuver by which he significantly and quickly increases the requested torque. This maneuver normally corresponds to a rapid depression of the accelerator pedal.

In this case, or in the case of a negative response to the test of step 1216a, the value Temax is set in the step 1216d to the smaller of the values:

- $\text{PbatmaxD} \times \frac{1}{N}$.

- Tel_traction_max.

The task 1220 for calculating torque set points Te_ref and Th_ref illustrated in figure 3I comprises two subtasks 1221 and 1222 which will be described respectively in light of figures 3J and 3K. The subtask 1221 consists in calculating an intermediate value Th_ref_int. For this, a value Th_ref1, which is equal to the greatest of the following three values:

- h_running x Trequested
- h_regeneration x Th_maximum
- h_recovery x Th_optimal,

is first of all determined in the step 1221a.

In the step 1221c, this variable Th_ref1 is filtered by a low-pass type first-order filter to give the intermediate variable Th_ref_int.

The step 1222 for adjusting Te_ref and Th_ref will now be described with reference to figure 3K. In the step 1222a, the value of Th_ref is first of all set to the value Th_ref_int determined above. Then, in the step 1222b, a check is made to see whether this value is greater than the value Thmax. If it is, in the step 1222c, Ct_ref is forced to the value Thmax and Rh_upper is forced to the value zero. If not, in the step 1222d, the value of Rh_upper is set to the difference of Thmax-Th_ref.

In both cases of response to the step 1222b, a check is then carried out in the step 1222e to see whether the value of Th_ref is lower than the value of Thmin. If it is, in the step 1222f, Th_ref is forced to the value Thmin and Rh_lower is forced to zero. If not, Rh_lower is set to be equal to the difference between Th_ref and Thmin in the step 1222g.

In both cases of response to the step 1222e, Th_ref is then forced to the value Treq-Th_ref, Re_upper is forced to the value Temax-Te_ref and the variable Re_lower is forced to the value Te_ref-Temin in the step 1222h.

Then, in the step 1222i, a check is made to see whether the value of Re_upper is negative. If not, the procedure goes direct to the step 1222o. If it is, in the step 1222j, the variable D_upper is set to the value Rh_upper+Re_upper, the variable Te_ref is set to the value Temax, the value of Re_upper is set to zero and the variable Re_lower is set to the value of the difference between Temax and Temin. Then, in the step 1222k, a check is made to see whether the value D_upper is negative. If it is, in the step 1222l, the variable Th_ref is set to the value Th_max and the variable Rh_upper is set to zero; otherwise, in the step 1222m, the variable Th_ref is set to the value Thmax-D_upper and the variable Rh_upper is set to the value D_upper.

In both cases of response to the step 1222k, and in the case of a negative response to the test of step 1222i, a check is then made in the step 1222o to see whether the variable Re_lower is negative. If it is, in the step 1222p, the variable D_lower is set to the value Rh_lower+Re_lower, the variable Te_ref is set to be equal to the value Temin, the variable Re_upper is set to be equal to the difference of Temax minus Temin and the variable Re_lower is set to the value zero.

Then, in the step 1222q, a check is made to see whether the variable D_lower is negative. If it is, in the step 1222s, the variable Th_ref is set to be equal to the value Th_min and the variable Rh_lower is set to the value zero. If not, the variable Th_ref is set to be equal to the value Thmin+D_lower and the variable Rh_lower is set to be equal to the value D_lower.

If not, the procedure goes direct to the end of the task.

As can be seen from the detailed description of this first hybrid vehicle management strategy, when the driver has selected the hybrid operating mode for the powertrain assembly, the starting of the heat engine is requested, in the task 1130, if one of the variables battery_mode_hyst and torque_mode_hyst is equal to the value "hybrid". If neither one nor the other is set to the value "hybrid", the heat engine is stopped.

Thus, it can be deduced from step 1213 that the heat engine can start if the driver commands a torque requested of the wheel that is high enough for the variable Trequested_filter1 to be greater than the high threshold level Thigh. Similarly, it can be deduced from the steps 1122 and 1121 that the heat engine is started when the state of charge of the battery falls below a lower threshold level. However, with this first strategy, the stopping of the heat engine is provoked only when both the conditions of the step 1114 and of the step 1123 are satisfied, that is, when the battery reaches a state of charge greater than a higher threshold level and when, at the same time, the instantaneous and average filtered values of the torque requested by the driver are less than a low threshold level.

2 values for threshold

Thus, according to this strategy, it can be seen that the decision to start the heat engine depends in particular on the state of charge of the battery, the instantaneous torque requested by the driver and the average torque requested by the driver.

It can also be observed that, when the powertrain assembly is operating in hybrid mode, the value of the torque Th_ref which will be requested of the heat engine depends on the variables h_running and h_recovery determined by the tasks 1110 and 1120. Thus, when the state of charge of the battery has previously fallen below a low threshold level and has not yet exceeded a high threshold level, the outcome of the task 1120 is that the value of h_recovery is equal to 1 such that the intermediate value Th_ref1 calculated in the step 1221b cannot be lower than the torque Ct_optimal supplied by the engine when it is ordered in optimal efficiency conditions. The value Th_ref of the set point torque imposed on the heat engine cannot therefore fall below a level corresponding to this optimal torque.

However, again when the driver has selected the hybrid operating mode for the powertrain assembly, the outcome of the task 1110 is that, when the condition of the step 1112 has been satisfied and that of the step 1114 has not, the value of the variable h_running is equal to 1 so that, in these conditions, the value of Th_ref1 calculated in the step 1221b cannot be less than the torque requested by the driver.

Moreover, the outcome of the task 1222 is that if the filtered value Th_ref_int of the torque requested by the driver exceeds the threshold Thmax of the torque able to be supplied by the heat engine, the electric engine is required in the step 1222h to supply the lacking torque, and this within the limits of the capabilities of the electric engine and the battery.

There now follows a description, with reference to figures 4A to 4H, more particularly of a second strategy for managing a hybrid vehicle according to the invention intended more specifically for a series type hybrid vehicle. This second strategy uses a series of variables that are listed and explained in the table below.

Notation	**Meaning**	**Units**

Trequested or Treq	Torque requested by the driver (positive for acceleration, negative for deceleration)	Nm
Te_ref	Torque set point of the electric engine (positive for traction, negative for regenerative braking)	Nm
Difference_T	Difference between Tref and Trequested	Nm
Service_ difference	Filtered value of Difference_T	Nm
Difference_soc	Difference between soc and soc_ref	%
GE_requested	Request to start or stop the heat engine for driving the electricity generator	Boolean
Ibat	Current output by the battery (discharge: positive, charge: negative)	A
Ige	Current output by the electricity generator (positive)	A
Mode_selected	Operating mode selected by the driver (electric, hybrid or regeneration)	-
N	Rotation speed of the electric engine	rad/s
Pbat_requested	Power requested of the traction battery (discharge: positive, charge: negative)	W
Pbat_possible	Proportion of Pbat_requested that the battery can supply	W
PbatmaxD	Maximum discharge power of the traction battery (positive)	W
PbatmaxR	Maximum charge power of the traction battery (negative)	W
Pel	Power absorbed by the electric engine (traction: positive, regenerative braking: negative)	W
Pel_requested	Electrical power required to supply Crequested	W
Pel_filterA	Rapid response time filtered value of Pel	W
Pel_filterB	Slow response time filtered value of Pel	W
Pel_possible	Proportion of Pel_requested that the system can supply	W
Pge_reqA	Intermediate estimate of the Pge_ref value	W
Pge_reqB	Value of the power requested of the electricity generator determining Stop_GE_requested and start_GE_requested	W
Pge_max	Maximum power that the electricity generator can supply	W
Pge_min	Minimum power that the electricity generator can supply	W
Pge_ref	Power set point of the electricity generator	W
Pmec	Mechanical power supplied by the electric engine	W
Pmec_requested	Mechanical power to be supplied corresponding to Trequested	W

Pmin	Absolute value threshold of the power below which R is not calculated	W
Pengine_max	Maximum power that the electric engine can absorb or restore	W
R	Efficiency of the electric engine used as a generator	-
R filter	Filtered value of R	-
soc	State of charge of the traction battery	%
soc ref	Reference state of charge of the traction battery	%
U	Traction battery voltage	%

As can be seen in figure 4A, the central management unit of the powertrain assembly is required to execute three main tasks. The first 2100 of these tasks consists in this case in determining the torque set point of the electric engine. It is executed, for example, every 40 milliseconds, that is, at a frequency of 25 hertz. The second task 2200, which consists in deciding to start or stop the heat engine, is executed in parallel. Its interval is one second and its frequency is 1 hertz.

There is also a third main task 2300, which is also executed in parallel, and during which the power set point of the electricity generator Pge_ref is determined. Its execution period is, for example, 500 milliseconds, corresponding to a frequency of 2 hertz to take account of the inertia of the assembly formed by the heat engine and the generator.

The first of these main tasks is described with reference to figure 4B. As can be seen in this figure, the task 2100 for determining the torque set point of the electric engine Te_ref begins with the execution of the sub-task 2110 for calculating the necessary electrical power Pel_requested.

This sub-task is described with reference to figure 4C. First of all, in the step 2111, the value Pel of the power absorbed by the electric engine is determined.

This power is positive when the engine is driving the vehicle and is negative when, during a slowing down of the vehicle, the electric engine is used as a generator to charge the battery 16. This value Pel is equal to the voltage of the electrical power supply network multiplied by the sum of the currents supplied by the battery on the one hand and by the electricity generator on the other hand.

In the step 2112, the mechanical power supplied by the electric engine Pmec is defined as being the product of the set-point torque Te_ref multiplied by the rotation speed N of the electric engine 12. In the step 2113, the mechanical power requested Pmec_requested is defined as being equal to the torque Trequested by the driver multiplied by the rotation speed N of the electric engine. In the step 2114, it is determined whether the absolute value of the mechanical power Pmec is greater than a threshold value Pmin. If it is, in the step 2115, an efficiency of the electric engine is defined which is equal to the absolute value of the ratio of the electrical power Pel divided by the mechanical power Pmec. If not, the value of this efficiency is set arbitrarily to 1 in the step 2116.

In the step 2117, a filtered value R_filter of this efficiency is determined, for example using a first order filter.

In the step 2118, the electrical power requested Pel_requested is determined as being the product of the filtered value of the efficiency multiplied by the mechanical power requested.

The execution of the task 2100 for determining the torque set-point for the electric engine is then continued in the step 2101 during which a check is made to see whether the absolute value of the electrical power requested is greater than a threshold level Pmin.

If not, the set-point torque Te_ref is set to be equal to the torque requested by the driver. If it is, the power Pge supplied by the generator is first of all determined. If the latter is outputting a current Ige, this power is U times Ige.

In the step 2103, the traction power that the battery 16 must supply is calculated. This value Pbat_requested is equal to the electrical power needed to supply the torque requested minus the power supplied by the generator. In the step 2104, the power able to be supplied by the battery is determined as being the minimum value between the two following two values:

- the maximum discharge power of the battery (PbatmaxD) and

- the minimum value between:

  * the power requested of the battery (Pbat_requested);

  * the maximum charge power of the battery (PbatmaxR).

In the step 2105, the electrical power that the system must supply is then determined, this value being the smaller of the following two values:

- the maximum power of the heat engine Pengine_max; and

- the sum of the power able to be supplied by the battery (Pbat_possible) and the power supplied by the generator Pge.

Then, in the step 2106, the reference torque Te_ref is determined as being the product of the torque requested by the driver multiplied by the ratio of the electrical power that the system can supply divided by the electrical power requested.

The second main task 2200 of this second hybrid vehicle management strategy consists in deciding to start or stop the heat engine. As can be seen in figure 4C, this task 2200 begins with the execution of the task 2310 to calculate the charge power of the battery which is illustrated in figure 4G. As can be seen in this figure, in the steps 2312, 2313, 2314, a reference state of charge Soc_ref is determined according to the operating mode selected by the driver of the vehicle. In the step 2315, a difference value between this reference state of charge Soc_ref and the real state of charge is determined. In the step 2316, the battery power requested is defined as being a filtered value of this difference, for example using a first order filter.

However, in the step 2317, a check is made to ensure that this calculated battery charge power value does not exceed the limiting battery charge and discharge powers, in which case the battery charge power is forced to one of these limit values.

The task for deciding to start (41) or stop the heat engine then continues at step 2201 in which the electrical power Pel is determined in the same way as seen above in the step 2111. This electrical power is filtered by a first order filter to obtain, in the step 2202, the variable Pel_filterB.

A calculation is then made to work out the difference between the torque requested by the driver and the torque actually applied to the drive wheels by the electric engine. This calculation of the value service_difference is the subject of the task 2210 illustrated in figure 4E in which it can be seen that this value is obtained by filtering, through a first order filter, the difference between the torque requested by the driver Trequested and the torque supplied by the electric engine Te_ref.

The task for deciding to start or stop the heat engine continues with the step 2203 by determining the value of the power requested of the electricity generator Pge_reqB. This value is equal to the weighted sum of the previously calculated values Pbat_requested, Pel_filterB and Service_difference. In the step 2204, a check is made to see whether this value Pge_reqB is greater than a threshold value Pge_min and if, at the same time, the operating mode selected by the driver is other than the electric engine mode. If this dual condition is satisfied, then the boolean variable GE_requested is forced to the value "true" and the heat engine is then started to supply the electric current. If not, if the dual condition of the step 2204 is not satisfied, the variable GE_requested is forced to the value "false" in the step 2206 so that the heat engine is ordered to stop.

When the heat engine is started, it is then possible to control it so that it drives the electricity generator so that the latter produces a sufficient power. To this end, in the task 2300, a power set point value of the electricity generator Pge_ref is calculated. This task, illustrated in figure 4F, begins with execution of the lower level task 2310 which was described previously and consists in calculating the battery charge power. Then, in the step 2301, the electrical power Pel absorbed by the electric engine is calculated, in the same way as was seen in the steps 2201 and 2111. This value is then filtered in the step 2302, for example via a first-order filter, to give an intermediate value Pel_filterA. In the step 2303, the weighted sum Pge_reqA of the battery charge power Pbat_requested is determined with the value Pel_filterA calculated in the step 2302. In the step 2304, the set-point power of the electricity generator Pge_ref is defined as being the smaller of the value Pge_reqA, calculated in the step 2303, and the maximum power able to be supplied by the generator Pge_max.

As can be seen in the steps 2203, 2204, 2205 and 2206, the decision to start the heat engine depends in particular on the following three parameters:

- the state of charge of the battery, because the value Pbat_requested is calculated in particular according to the difference between the real state of charge of the battery and a reference state of charge (see steps 2315, 2316, 2317);

- the motive torque requested, because the value Service_difference depends naturally on this requested torque (see steps 2211 and 2212); and

- the difference between the service supplied by the system and that requested by the driver.

CLAIMS

1. A motor vehicle with hybrid motorization, of the type in which a powertrain assembly comprises an electric engine (12) and a heat engine (10) which are able to contribute to the driving of the vehicle, and of the type in which a central management unit executes a first task (1200, 2100) comprising determining the torque that each engine must supply for the powertrain assembly to supply the vehicle with a motive torque conforming to a torque requested (Trequested) by the driver of the vehicle, and of the type wherein the heat engine (10) is able to be stopped, the vehicle then being driven only by the electric engine (12) powered by electric current from a battery (16), characterized in that, at least for certain (hybrid) operating modes of the powertrain assembly, the central unit executes a second task (1100, 2200) during which it is decided to stop or start the heat engine, in that the first task and the second task are executed in parallel and in that the frequency of execution of the second task is less than that of the first task.

2. The motor vehicle as claimed in claim 1, characterized in that the driver can impose on the powertrain assembly an electric operating mode in which the heat engine (10) is stopped.

3. The motor vehicle as claimed in either of the preceding claims, characterized in that the driver can impose on the powertrain assembly a regeneration operating mode in which the heat engine (10) is used in particular to charge the battery (16).

4. The motor vehicle as claimed in any one of the preceding claims, characterized in that the driver can impose on the powertrain assembly a hybrid operating mode in which the central unit executes the second task during which it is decided to stop or start the heat engine.

5. The motor vehicle as claimed in claim 4, characterized in that the decision to stop or start the heat engine (10) is taken in particular according to a state of charge (battery_gauge, soc) of the battery (16).

6. The motor vehicle as claimed in claim 5, characterized in that the starting of the heat engine (10) is decided or confirmed when the state of charge (battery_gauge) of the battery (16) is less than a low threshold level (gauge_low_threshold), and in that the stopping of the heat engine (10) is able to be decided or confirmed when the state of charge of the battery is greater than a high threshold level (gauge_low_threshold).

7. The motor vehicle as claimed in any one of claims 4 to 6, characterized in that the decision to stop or start the heat engine (10) is taken in particular according to the instantaneous torque (Trequested_filter1) requested by the driver.

8. The motor vehicle as claimed in any one of claims 4 to 7, characterized in that the decision to stop or start the heat engine (10) is taken in particular according to the average torque (Trequested_filter2) requested by the driver during a predetermined time interval preceding the decision.

9. The motor vehicle as claimed in claim 7 taken in combination with claim 8, characterized in that the starting of the heat engine (10) is decided or confirmed when the instantaneous torque (Trequested_filter1) requested by the driver is greater than a high threshold level (Thigh), and in that the stopping of the heat engine (10) is able to be decided or confirmed when the instantaneous torque (Trequested_filter1) and the average torque (Trequested_filter2) requested by the driver are less than a low threshold level (Tlow).

10. The motor vehicle as claimed in claim 6 taken in combination with claim 9, characterized in that the stopping of the heat engine (10) is decided or confirmed when, at the same time, the state of charge (battery_gauge) of the battery (16) is greater than a high threshold level (gauge_high_threshold) and the instantaneous torque (Trequested_filter1) and the average torque (Trequested_filter2) requested by the driver are less than a low threshold level (Tlow).

11. The motor vehicle as claimed in any one of claims 4 to 10, characterized in that the decision to stop or start the heat engine (10) is taken in particular according to a difference (Service_difference) between the torque requested (Trequested) by the driver and the torque actually supplied by the powertrain assembly.

12. The motor vehicle as claimed in any one of the preceding claims taken in combination with at least one of claims 2 to 4, characterized in that, during operation of the operating mode selected by the driver, a charge set point level (soc_ref) of attery (16) is fixed

13. The motor vehicle as claimed in any one of the preceding claims, characterized in that the powertrain assembly is a series hybrid assembly in which the drive wheels of the vehicle are driven exclusively by the electric engine (12) which is powered by electric current from the battery (16) which is charged by a generator (16) driven by the heat engine (10).

14. The motor vehicle as claimed in claim 13 taken in combination with claim 12, characterized in that the electrical power (Pbat_requested) to be supplied to the battery (16) is determined according to a difference (Difference_soc) between the real (soc) and reference (soc_ref) states of charge of the battery, taking into account limiting charge (PbatmaxR) and discharge (PbatmaxD) power values of the battery (16).

15. The motor vehicle as claimed in claim 14, characterized in that the starting of the heat engine (10) is determined according to the electrical power (Pbat_requested) to be supplied to the battery (16), the electrical power absorbed (Pel_filterB) by the electric engine (12) and according to a difference (Service_difference) between the value of the torque requested by the driver and the value of the torque supplied by the electric engine (12).

16. The motor vehicle as claimed in claim 14 or 15, characterized in that a set point level (Pge_ref) for the power supplied by the generator (26) is determined according to the real power (U*Ige) supplied by the generator (26), the real power (U*Ibat) supplied by the battery (16), and the power (Pbat_requested) to be supplied to the battery (16), taking into account the maximum

power (Pge_max) able to be supplied by the generator (26).

17. The motor vehicle as claimed in any one of the preceding claims 13 to 15, characterized in that a necessary electrical power (Pel_requested) is determined according to the motive torque (Crequested) requested by the driver, taking into account, at least when this torque is greater as an absolute value than a minimum value, the efficiency of the electric engine (R).

18. The motor vehicle as claimed in claim 16, characterized in that a set point value (Tref) for the torque supplied by the electric engine (12) is determined according to the motive torque requested by the driver multiplied, at least when the necessary electrical power (Pel_requested) is greater as an absolute value than a threshold value (Pmin), by the ratio of the electrical power (Pel_possible) able to be supplied to the electric engine (12) divided by the necessary electrical power (Pel_possible), the electrical power (Pel_possible) able to be supplied to the electric engine (12) taking into account the necessary electrical power (Pel_requested), the real power (Pge) supplied by the generator, the power (Pbat_possible) able to be supplied by the battery (16), and the maximum power (Pengine_max) able to be absorbed by the engine.

19. The motor vehicle as claimed in any one of claims 1 to 12, characterized in that the powertrain assembly is a parallel hybrid assembly in which the electric engine (12) and the heat engine (10) each drive either at least one and the same drive wheel or different drive wheels.

20. The motor vehicle as claimed in claim 19 taken in combination with claim 3, characterized in that when the powertrain assembly is operating in regeneration mode, the electric engine (10) delivers a motive torque only if the driver provokes an abrupt rise in the requested torque (kickdown).

21. The motor vehicle as claimed in either of claims 19 and 20, taken in combination with claim 3, characterized in that when the powertrain assembly is operating in regeneration mode, the heat engine (10) is ordered to supply a maximum torque (Th_maximum).

22. The motor vehicle as claimed in any one of claims 19 to 21 taken in combination with claim 4, characterized in that when the powertrain assembly is operating in hybrid mode and the state of charge (battery_gauge) of the battery (16) has previously fallen below a low threshold level (gauge_low_threshold) and has not yet exceeded a high threshold level (gauge_high_threshold), the heat engine (10) is ordered to supply a set point torque (Th_ref1) at least equal to an optimum torque (Th_optimal) corresponding to optimal efficiency conditions of the heat engine.

23. The motor vehicle as claimed in any one of the preceding claims 19 to 22 taken in combination with claim 4, characterized in that when the powertrain assembly is operating in hybrid mode and the instantaneous torque (Trequested_filter1) requested by the driver has previously risen above a high threshold level (Thigh) without returning below a low threshold level (Tlow) at the same time as the average level (Trequested_filter2) is less than the low threshold level (Tlow), the heat engine (10) is ordered to supply a set point

torque at least equal to a filtered value of the torque requested by the driver.

24. The motor vehicle as claimed in any one the preceding claims 19 to 23, characterized in that, if a filtered value (Th_ref_int) of the torque requested by the driver is greater than the maximum torque (Th_max) of the heat engine (10), the electric engine (12) is required to supply, wherever possible, the quantity of torque lacking (Treq - Thref).

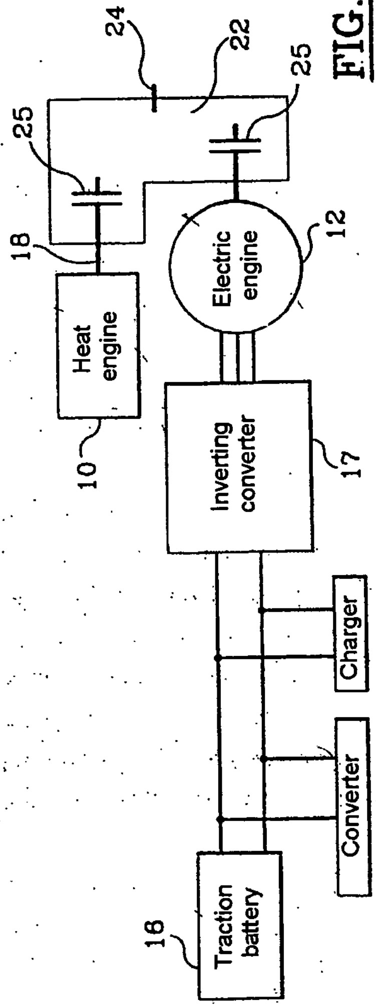


FIG.1

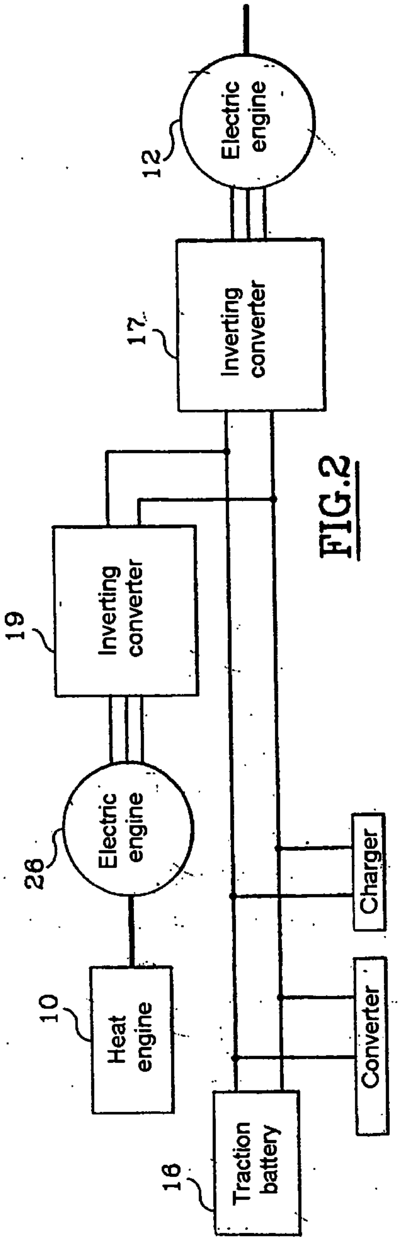


FIG.2

REPLACEMENT SHEET (RULE 26)

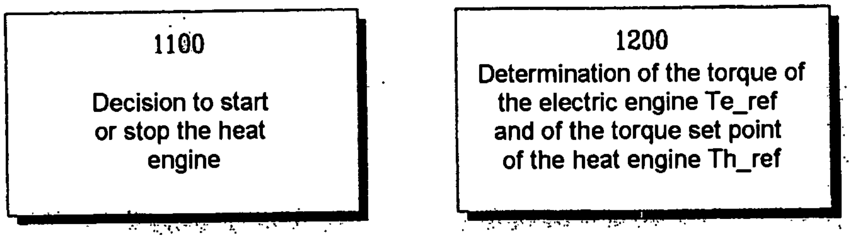

1100
Decision to start or stop the heat engine
1200
Determination of the torque of the electric engine Te_ref and of the torque set point of the heat engine Th_ref

FIG.3A

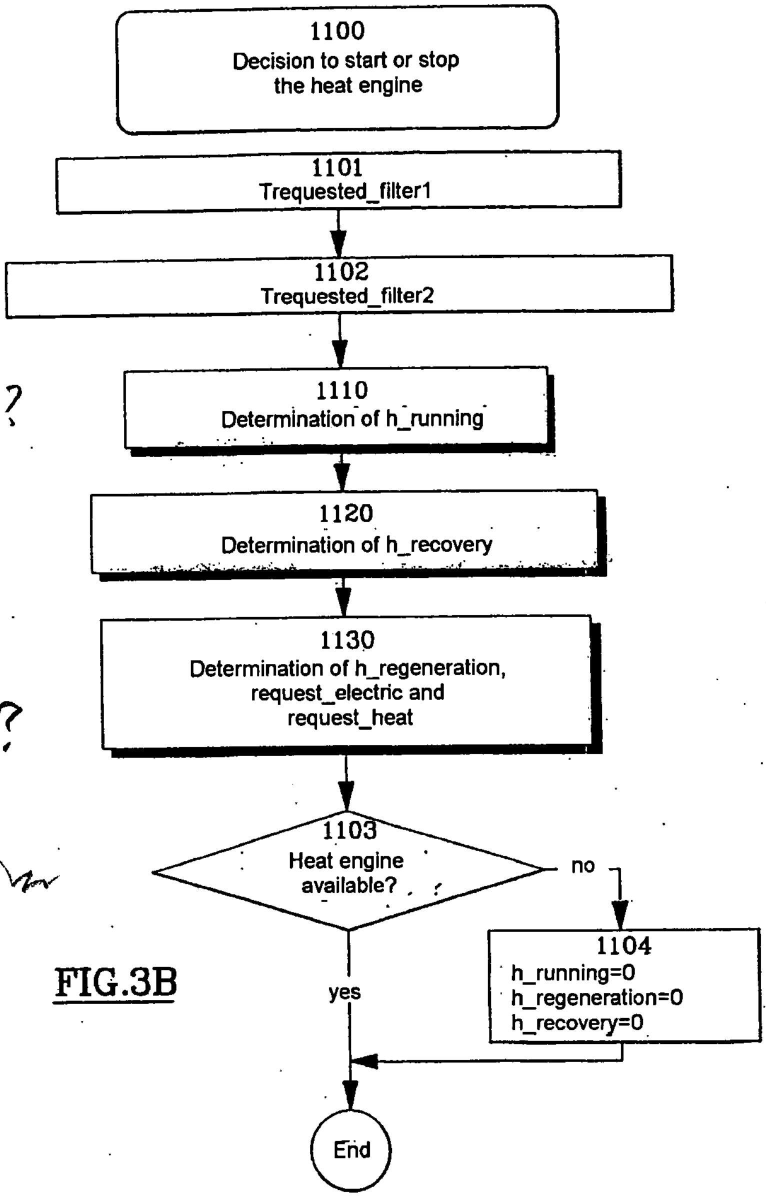


FIG.3B

Trequested = Torque required by driver

is engine running?

is engine charging battery?

is ICE stopping charging battery?

can ICE deliver torque?

ICE run between
these values

Tlow + Thigh adjst. by SOC

14: 1°- why?

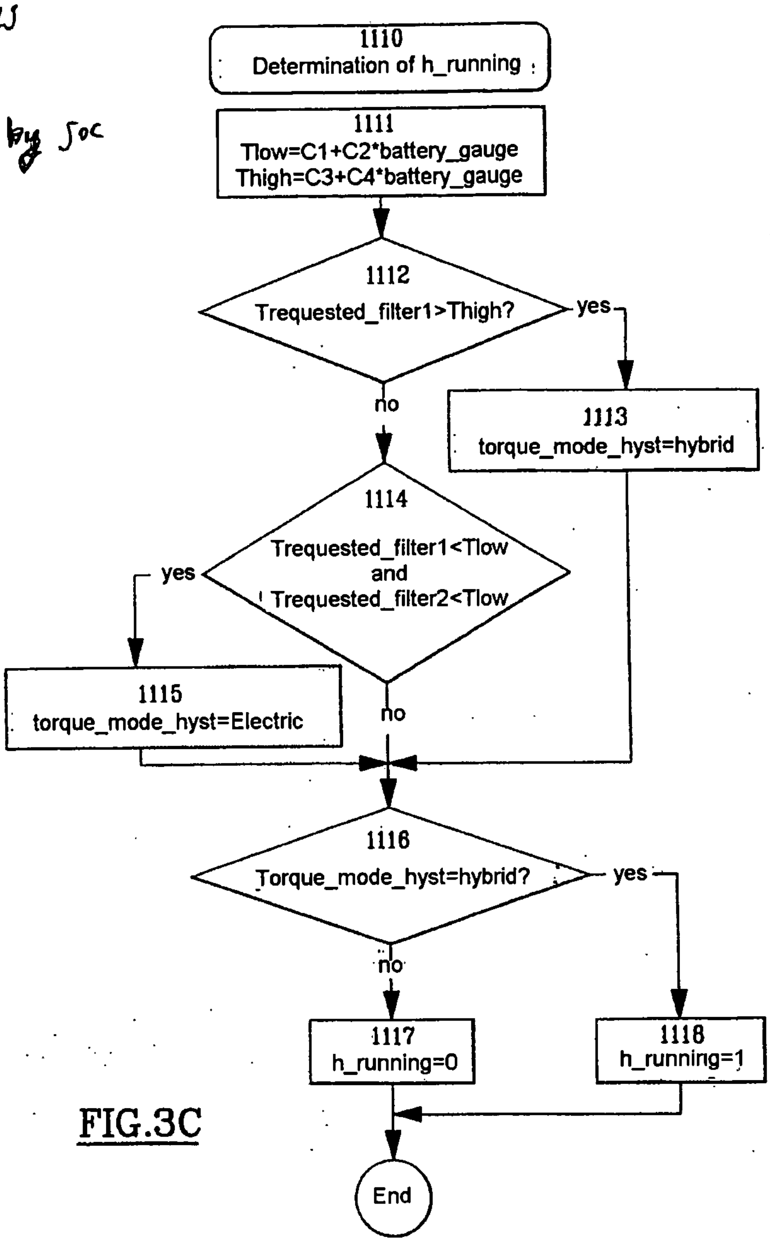


FIG.3C

whether engine
is to charge battery

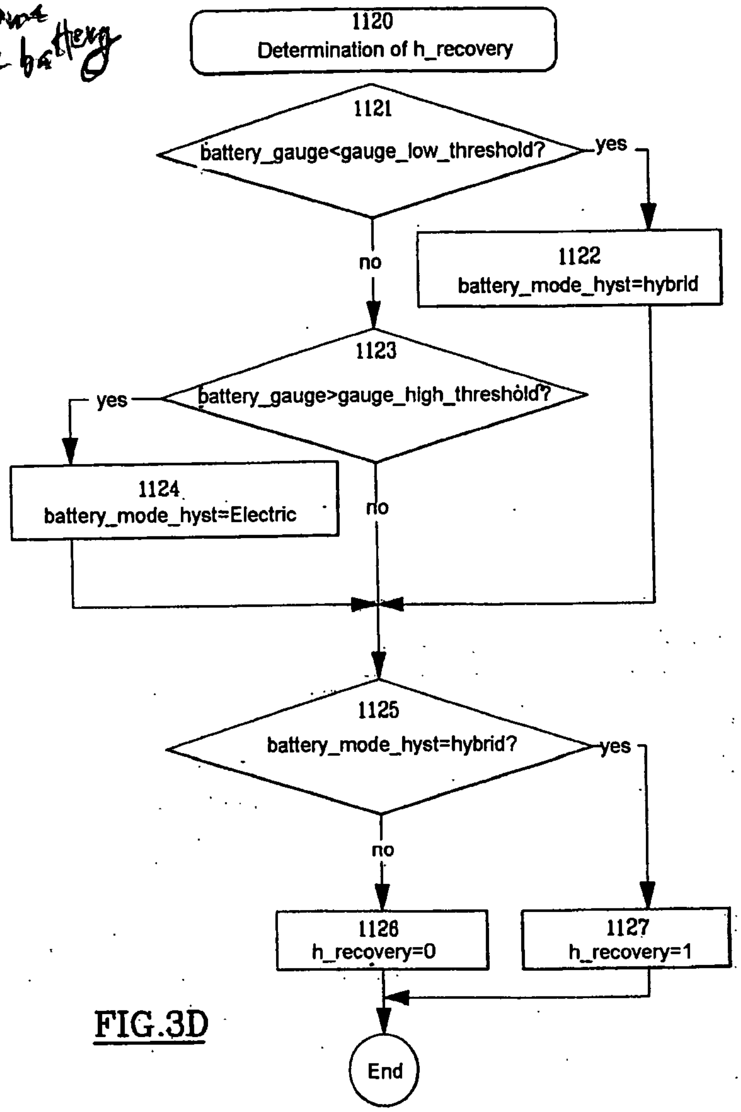
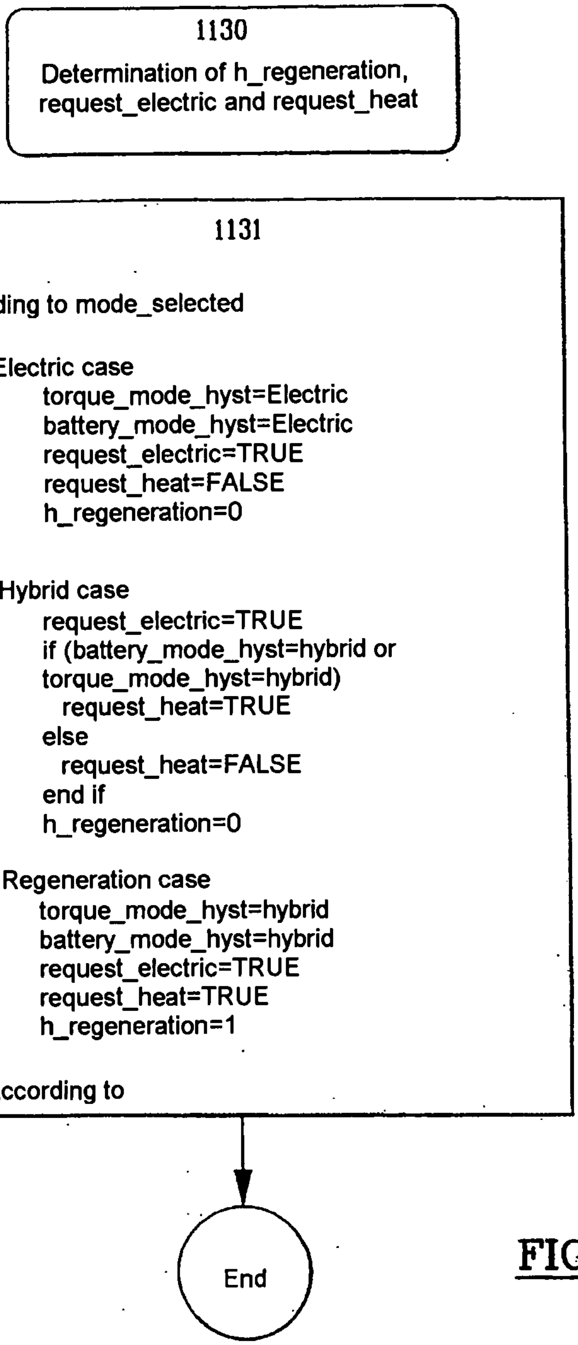


FIG.3D

REPLACEMENT SHEET (RULE 26)



```
according to mode_selected

    Electric case
        torque_mode_hyst=Electric
        battery_mode_hyst=Electric
        request_electric=TRUE
        request_heat=FALSE
        h_regeneration=0


    Hybrid case
        request_electric=TRUE
        if (battery_mode_hyst=hybrid or
        torque_mode_hyst=hybrid)
          request_heat=TRUE
        else
          request_heat=FALSE
        end if
        h_regeneration=0

    Regeneration case
        torque_mode_hyst=hybrid
        battery_mode_hyst=hybrid
        request_electric=TRUE
        request_heat=TRUE
        h_regeneration=1

end according to
```

FIG.3E

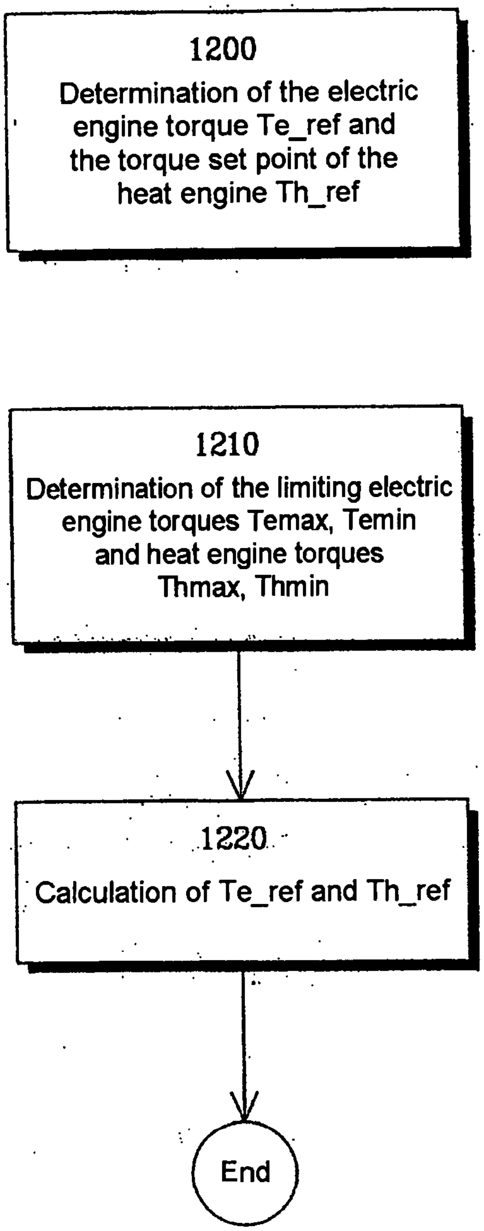

1200
Determination of the electric engine torque Te_ref and the torque set point of the heat engine Th_ref
1210
Determination of the limiting electric engine torques Temax, Temin and heat engine torques Thmax, Thmin
1220
Calculation of Te_ref and Th_ref
End

FIG.3F

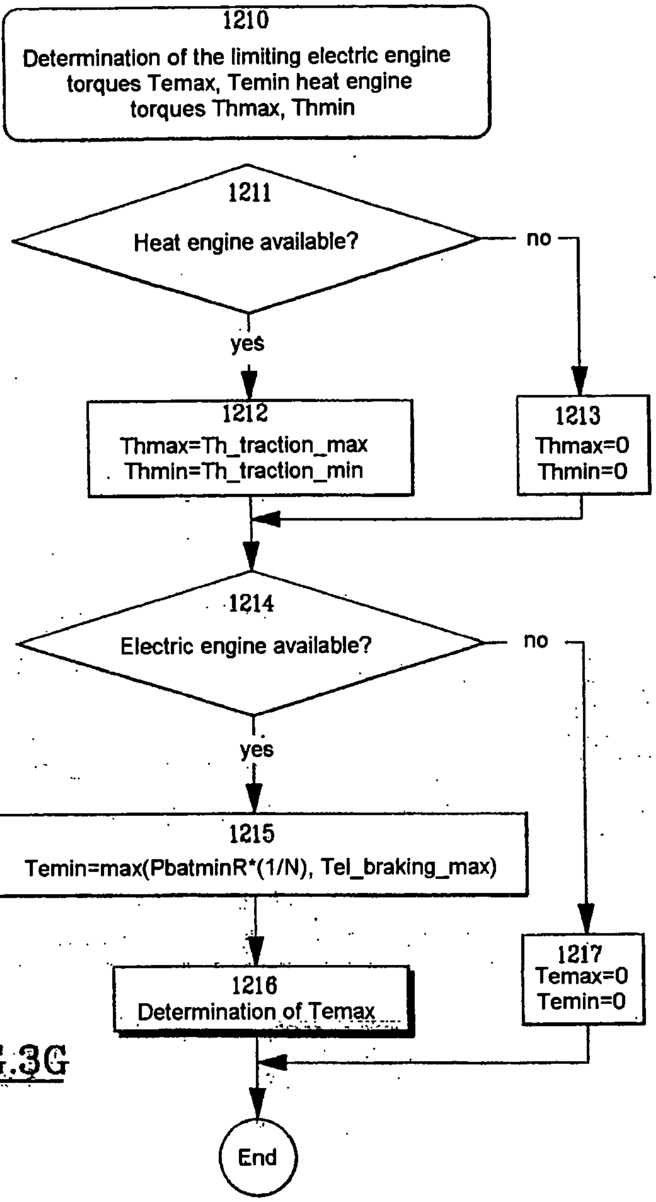


FIG.3G

REPLACEMENT SHEET (RULE 26)

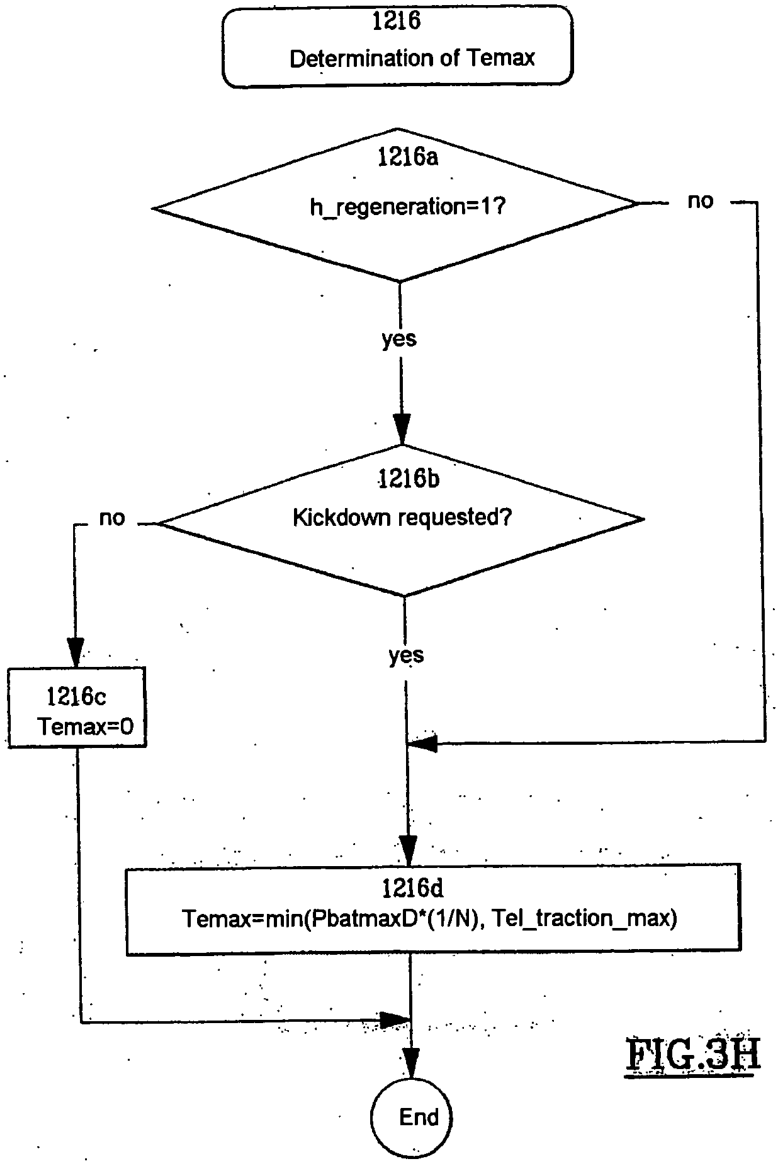

1216
Determination of Temax
1216a
h_regeneration=1?
no
yes
1216b
Kickdown requested?
no
yes
1216c
Temax=0
1216d
Temax=min(PbatmaxD*(1/N), Tel_traction_max)
End

FIG.3H

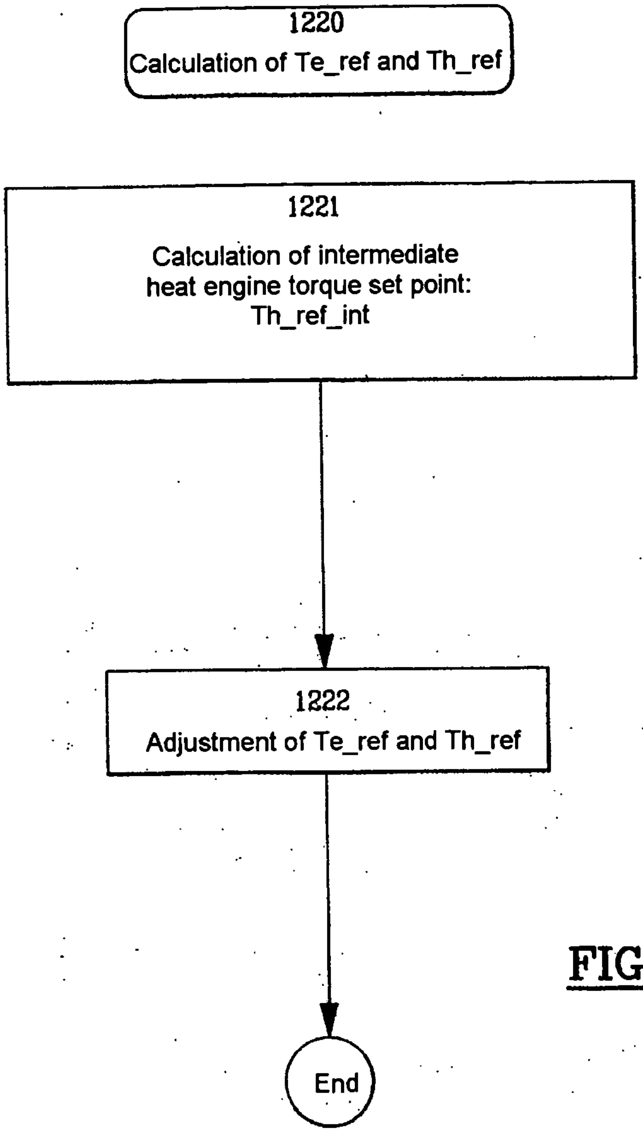

1220
Calculation of Te_ref and Th_ref
1221
Calculation of intermediate heat engine torque set point: Th_ref_int
1222
Adjustment of Te_ref and Th_ref
End

FIG.3I

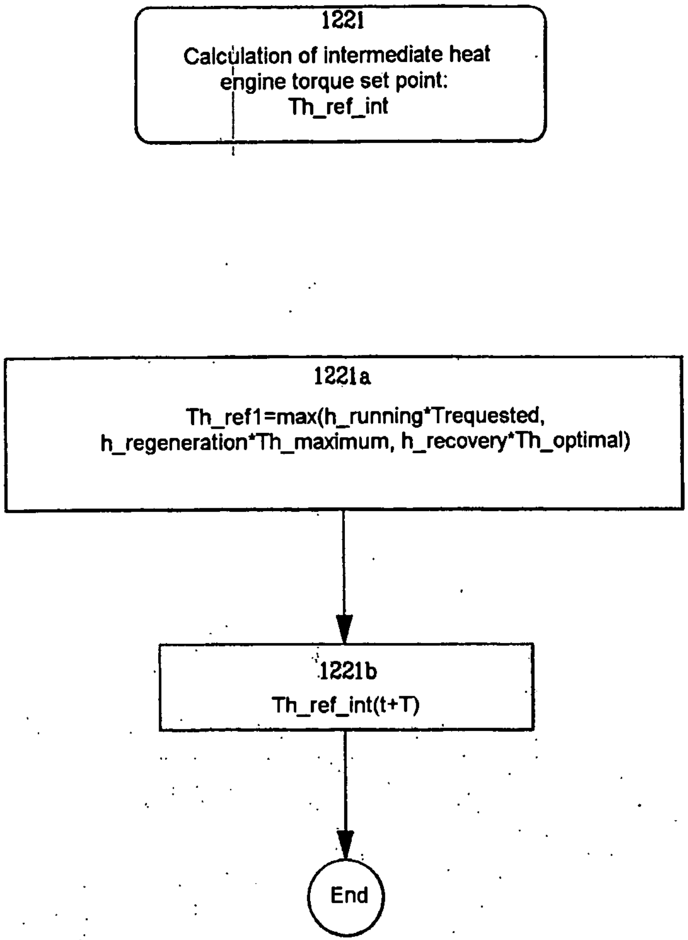

1221
Calculation of intermediate heat engine torque set point:
Th_ref_int
1221a
Th_ref1=max(h_running*Trequested, h_regeneration*Th_maximum, h_recovery*Th_optimal)
1221b
Th_ref_int(t+T)
End

FIG.3J

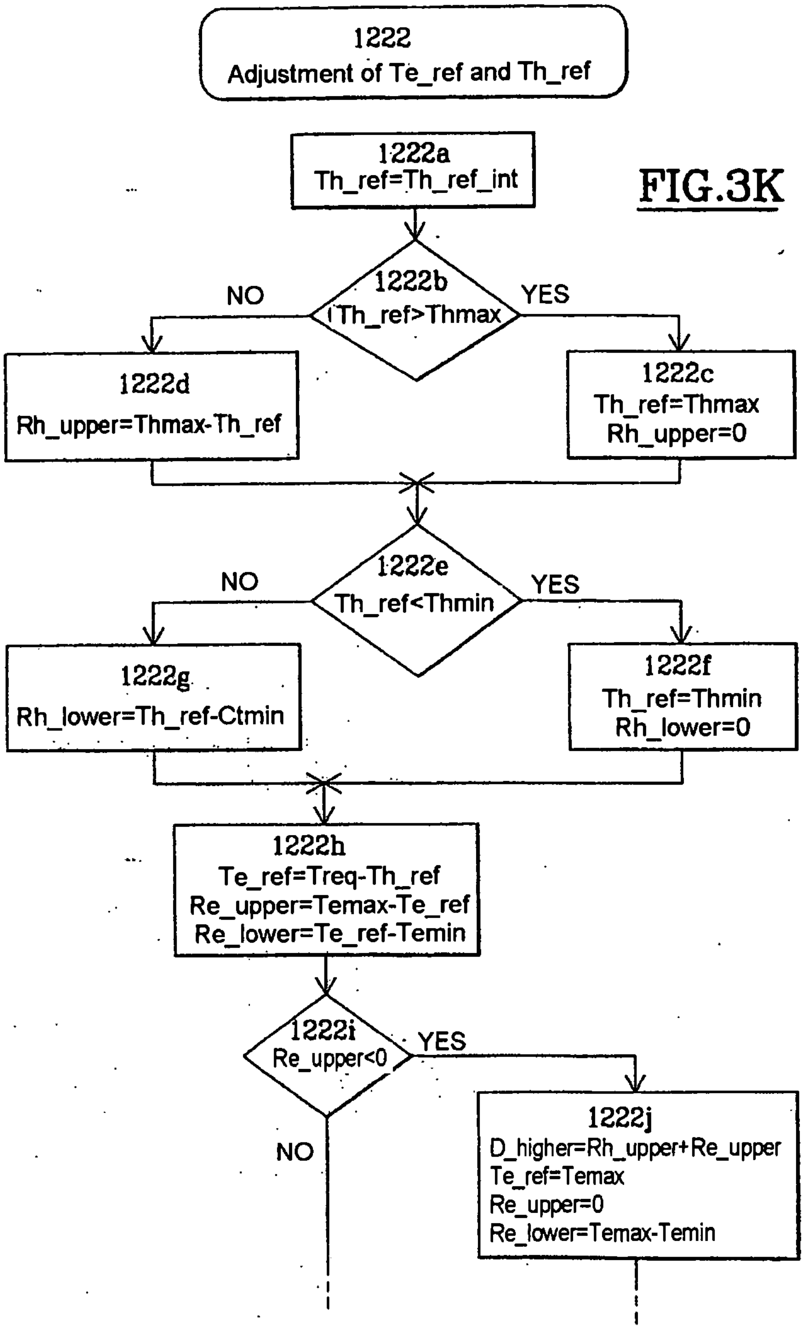
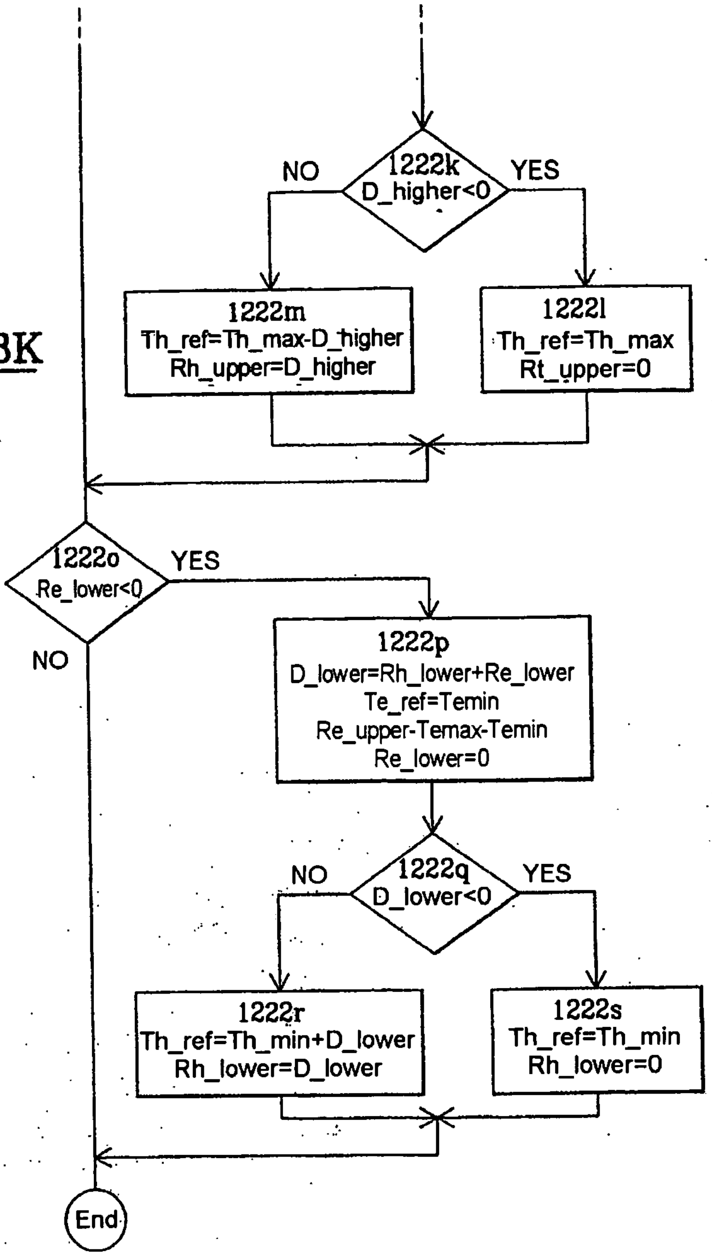

1222
Adjustment of Te_ref and Th_ref
1222a
Th_ref=Th_ref_int
1222b
Th_ref>Thmax
NO
YES
1222d
Rh_upper=Thmax-Th_ref
1222c
Th_ref=Thmax
Rh_upper=0
1222e
Th_ref<Thmin
NO
YES
1222g
Rh_lower=Th_ref-Ctmin
1222f
Th_ref=Thmin
Rh_lower=0
1222h
Te_ref=Treq-Th_ref
Re_upper=Temax-Te_ref
Re_lower=Te_ref-Temin
1222i
Re_upper<0
YES
NO
1222j
D_higher=Rh_upper+Re_upper
Te_ref=Temax
Re_upper=0
Re_lower=Temax-Temin

FIG.3K

FIG.3K



REPLACEMENT SHEET (RULE 26)

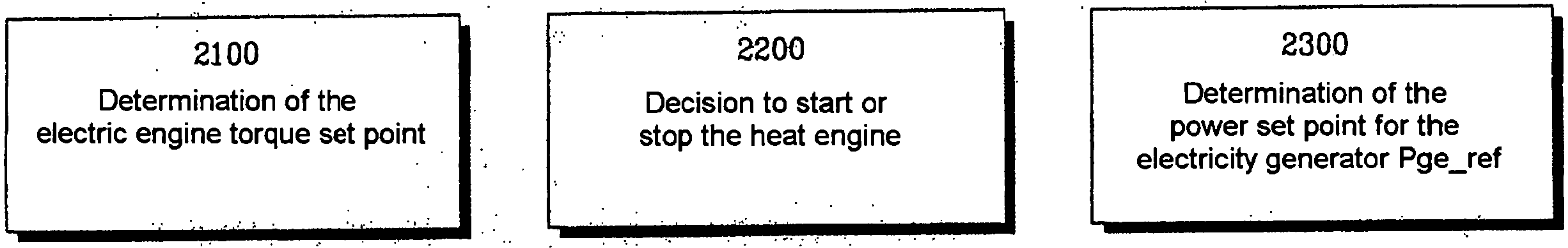
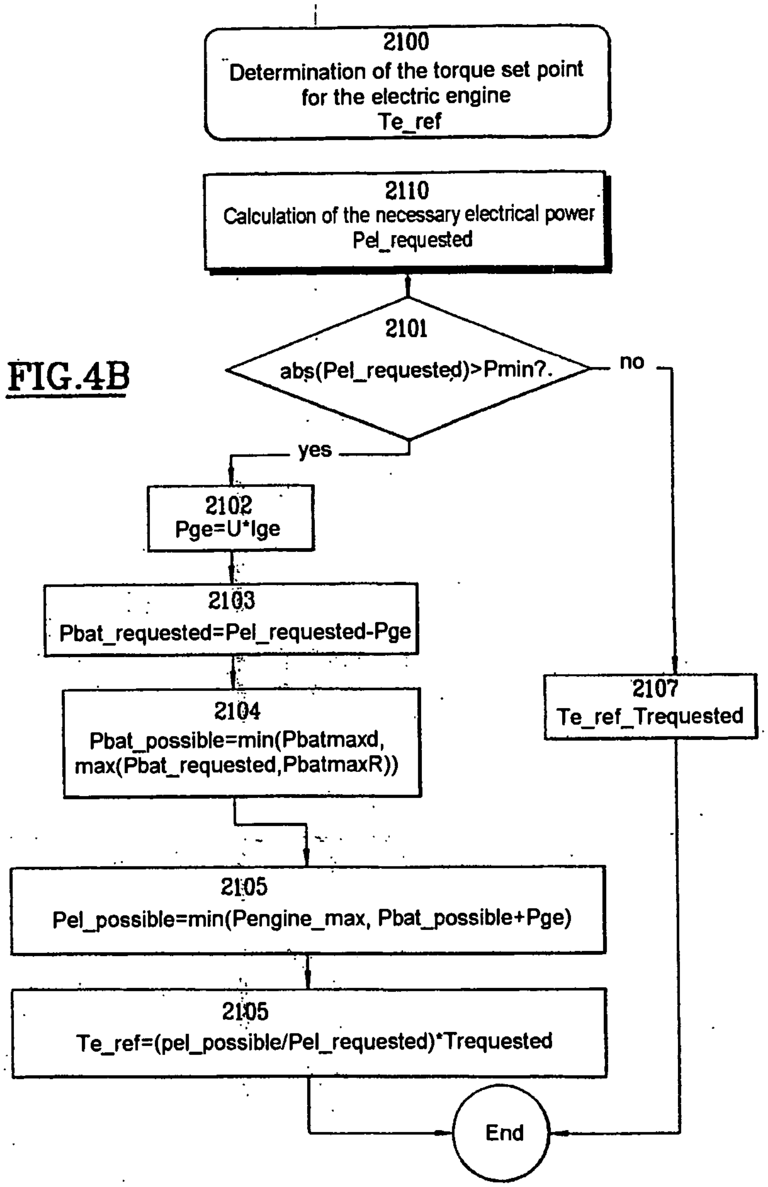

2100
Determination of the
electric engine torque set point
2200
Decision to start or
stop the heat engine
2300
Determination of the
power set point for the
electricity generator Pge_ref

FIG.4A

FIG.4B


2100
Determination of the torque set point for the electric engine Te_ref
2110
Calculation of the necessary electrical power Pel_requested
2101
abs(Pel_requested)>Pmin?.
no
yes
2102
Pge=U*Ige
2103
Pbat_requested=Pel_requested-Pge
2104
Pbat_possible=min(Pbatmaxd, max(Pbat_requested,PbatmaxR))
2105
Pel_possible=min(Pengine_max, Pbat_possible+Pge)
2105
Te_ref=(pel_possible/Pel_requested)*Trequested
2107
Te_ref_Trequested
End

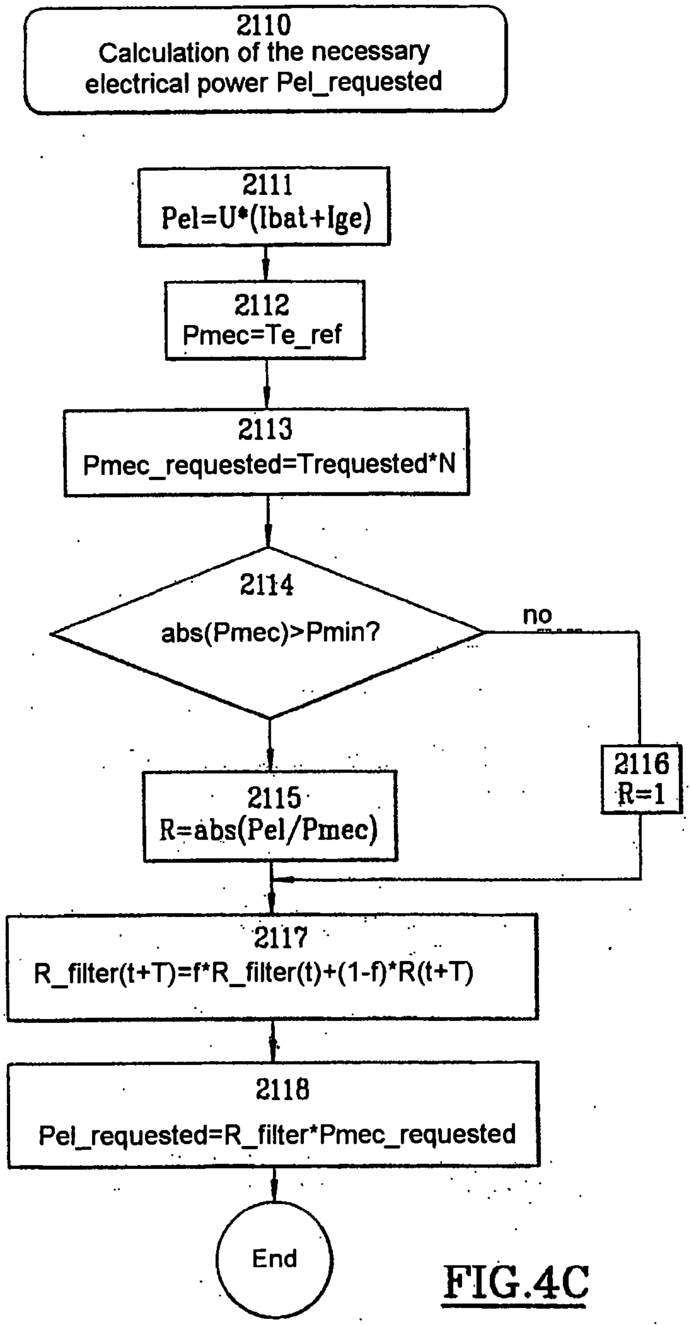


FIG.4C

REPLACEMENT SHEET (RULE 26)

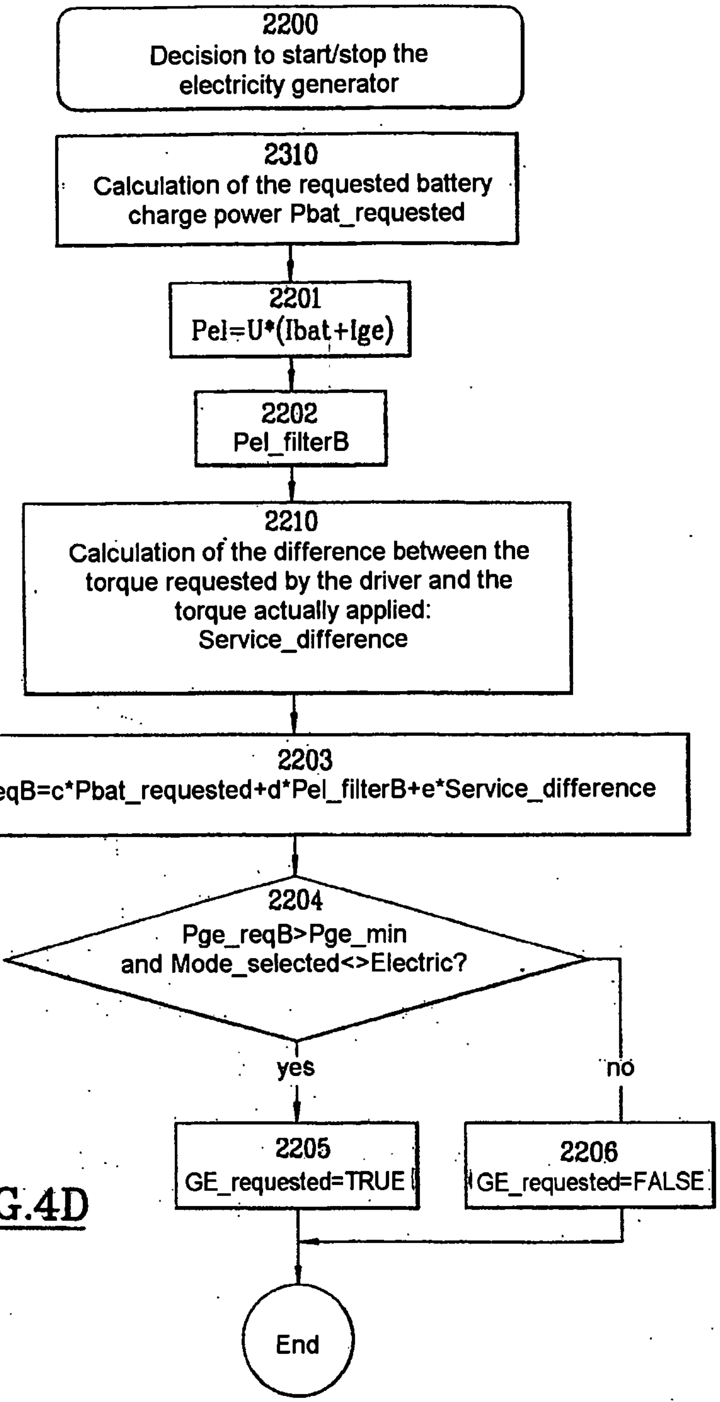

2200
Decision to start/stop the electricity generator
2310
Calculation of the requested battery charge power Pbat_requested
2201
Pel=U*(Ibat+Ige)
2202
Pel_filterB
2210
Calculation of the difference between the torque requested by the driver and the torque actually applied: Service_difference
2203
Pge_reqB=c*Pbat_requested+d*Pel_filterB+e*Service_difference
2204
Pge_reqB>Pge_min and Mode_selected<>Electric?
yes
no
2205
GE_requested=TRUE
2206
GE_requested=FALSE
End

FIG.4D

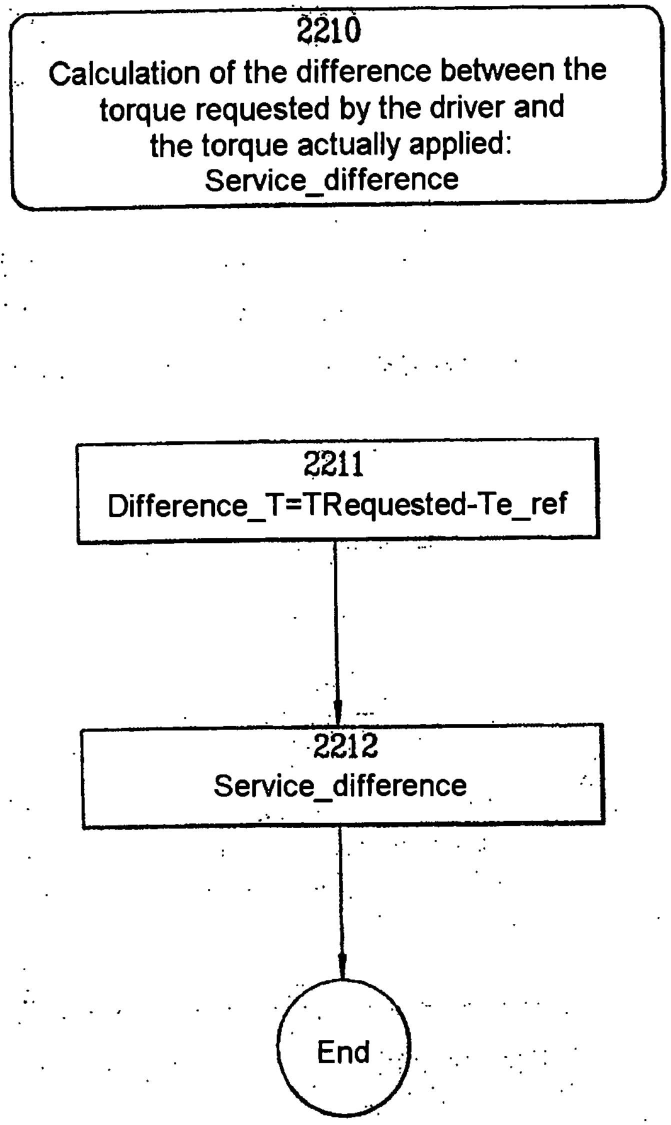

2210
Calculation of the difference between the torque requested by the driver and the torque actually applied: Service_difference
2211
Difference_T=TRequested-Te_ref
2212
Service_difference
End

FIG.4E

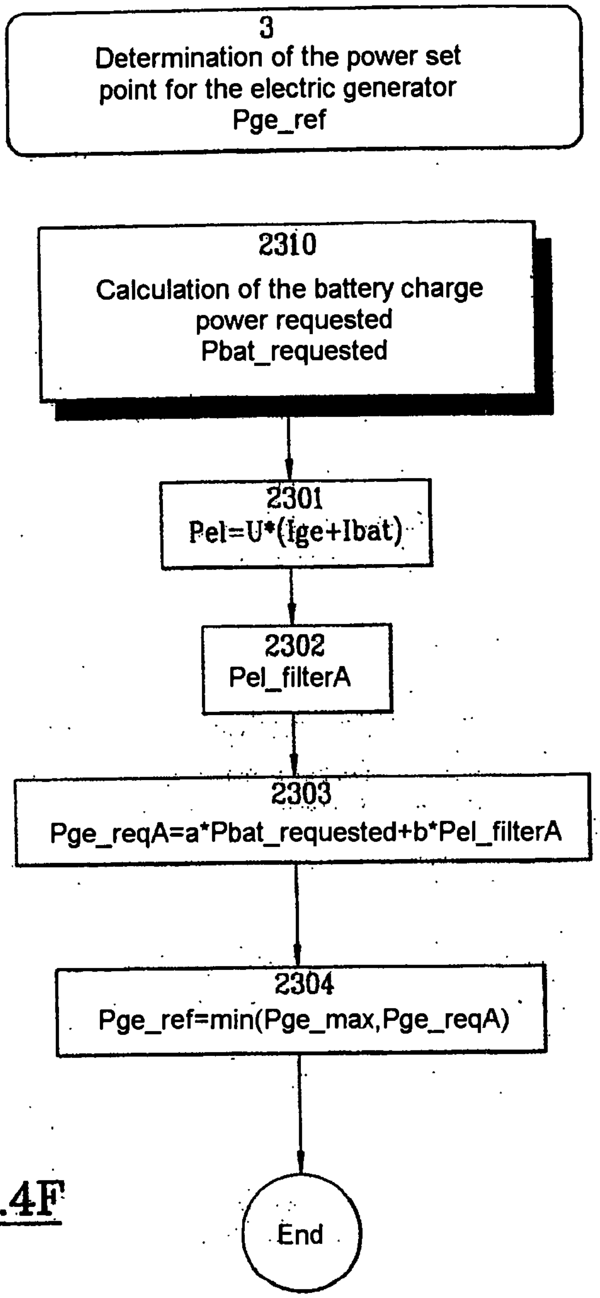

3
Determination of the power set point for the electric generator Pge_ref
2310
Calculation of the battery charge power requested Pbat_requested
2301
Pel=U*(Ige+Ibat)
2302
Pel_filterA
2303
Pge_reqA=a*Pbat_requested+b*Pel_filterA
2304
Pge_ref=min(Pge_max,Pge_reqA)
End

FIG.4F

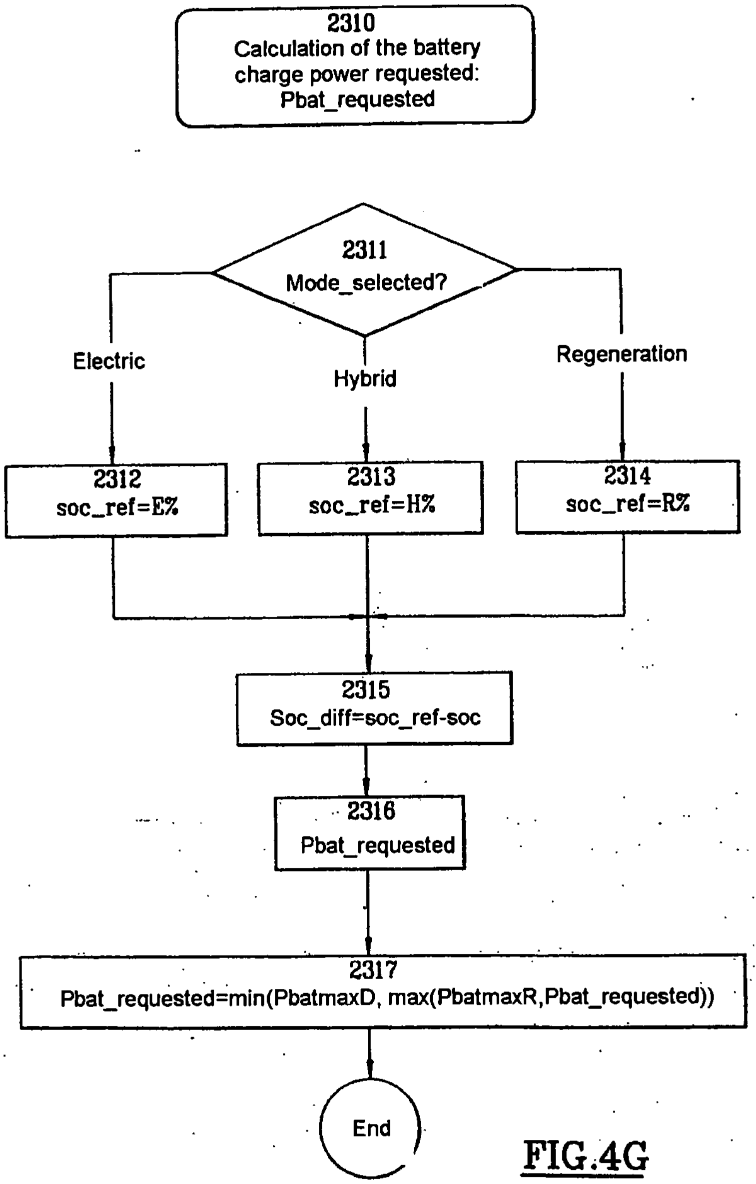

2310
Calculation of the battery charge power requested: Pbat_requested
2311
Mode_selected?
Electric
Hybrid
Regeneration
2312
soc_ref=E%
2313
soc_ref=H%
2314
soc_ref=R%
2315
Soc_diff=soc_ref-soc
2316
Pbat_requested
2317
Pbat_requested=min(PbatmaxD, max(PbatmaxR,Pbat_requested))
End

FIG.4G

Translator's Report/Comments

Your ref: `P038141EP:REJ/GJS/CLM` Your order of (date) 25/05/05

In translating the above text we have noted the following apparent errors/unclear passages:

Page/line*	Comment
4/26 5/7-8	"et en ce que l'arrêt..." should read "et l'arrêt ..."
12 (table)	"Seuil Faut de jauge" → "Seuil haut de jauge"
14/6	"valeur booléenne hyst_mode_couple" should read "variable booléenne ..."
14/11-12	"valeur booléenne th_roulage" should read "variable booléenne ..."
14/30	"la valeur th_récupération" should read "la variable th_récupération"
15/12	"variable « électrique »" should read "valeur « électrique »"
29/19	"seuil_jauge_bas" should perhaps read "seuil_jauge_haut"
5/21 30/25-26	"en fonctionnement du mode de ..." should perhaps read "en fonction du mode de ..."

* This identification refers to the source text. Please note that the first paragraph is taken to be, where relevant, the end portion of a paragraph starting on the preceding page. Where the paragraph is stated, the line number relates to the particular paragraph. Where no paragraph is stated, the line number refers to the page margin line number.

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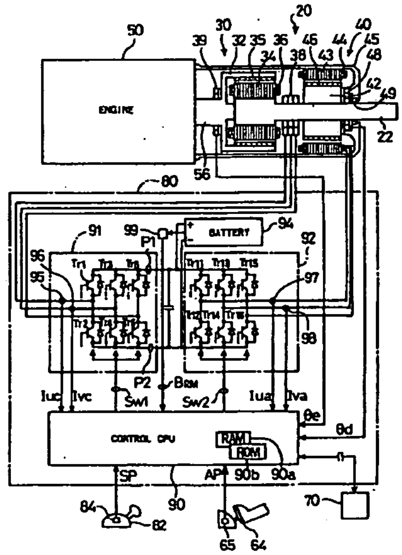
(54) Hybrid vehicle power output apparatus and method of controlling the same at engine idle

(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



EP 0 743 211 A2

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2.13.8/3.4

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:

$$Pd = Te^* \times Ne^* \tag{14}$$

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:

$$Ta^* = Td^* - Te^* \tag{15}$$

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:

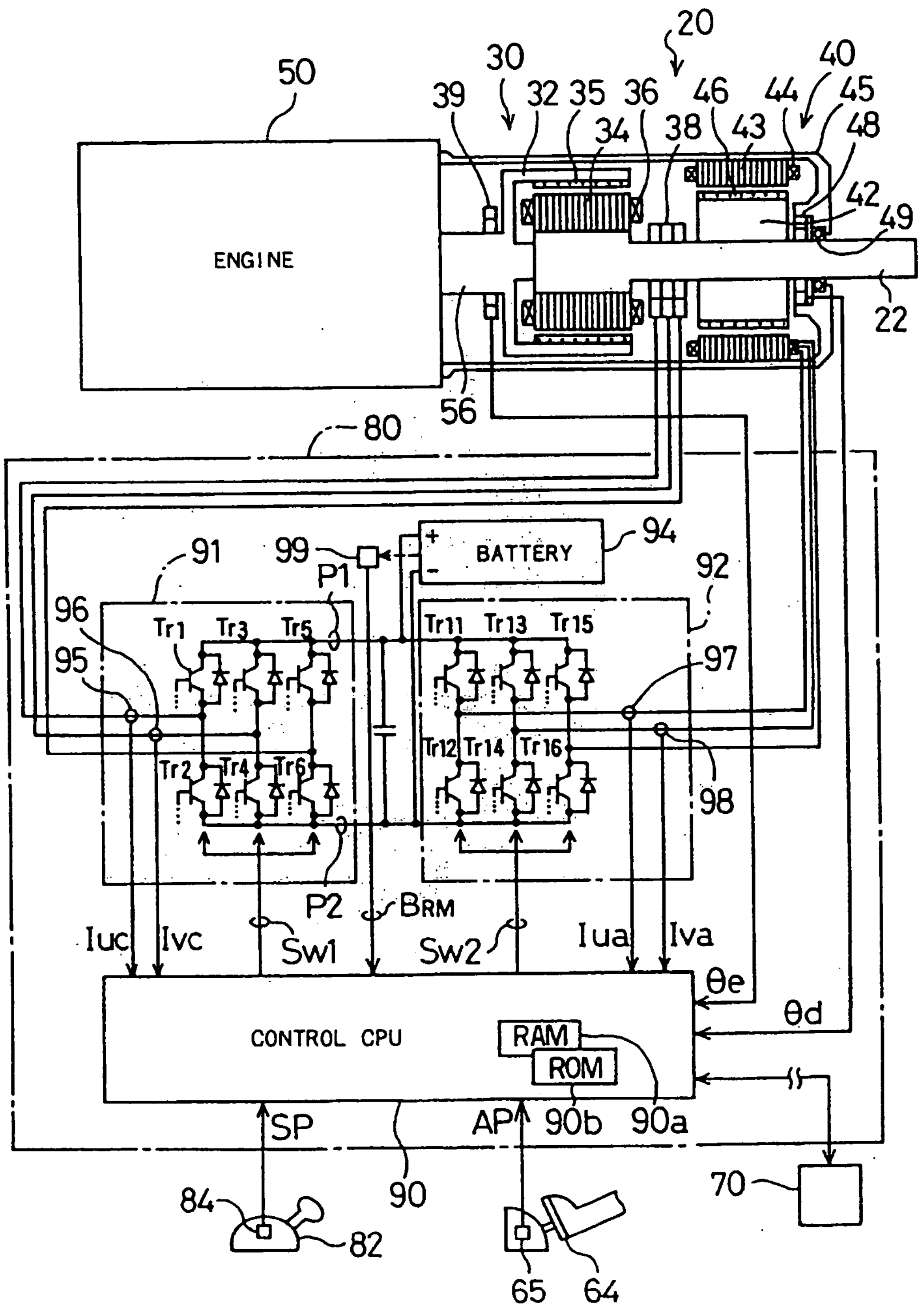
(a) providing an engine having an output shaft; engine driving means for driving said engine; a first motor comprising a first rotor connected with said output shaft of said engine and a second rotor connected with said drive shaft, said second rotor being coaxial to and rotatable relative to said first 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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ENGINE
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BATTERY
+
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P1
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Tr1
Tr3
Tr5
Tr11
Tr13
Tr15
97
Tr2
Tr4
Tr6
Tr12
Tr14
Tr16
98
P2
BRM
Iuc
Ivc
Sw1
Sw2
Iua
Iva
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θd
CONTROL CPU
RAM
ROM
SP
AP
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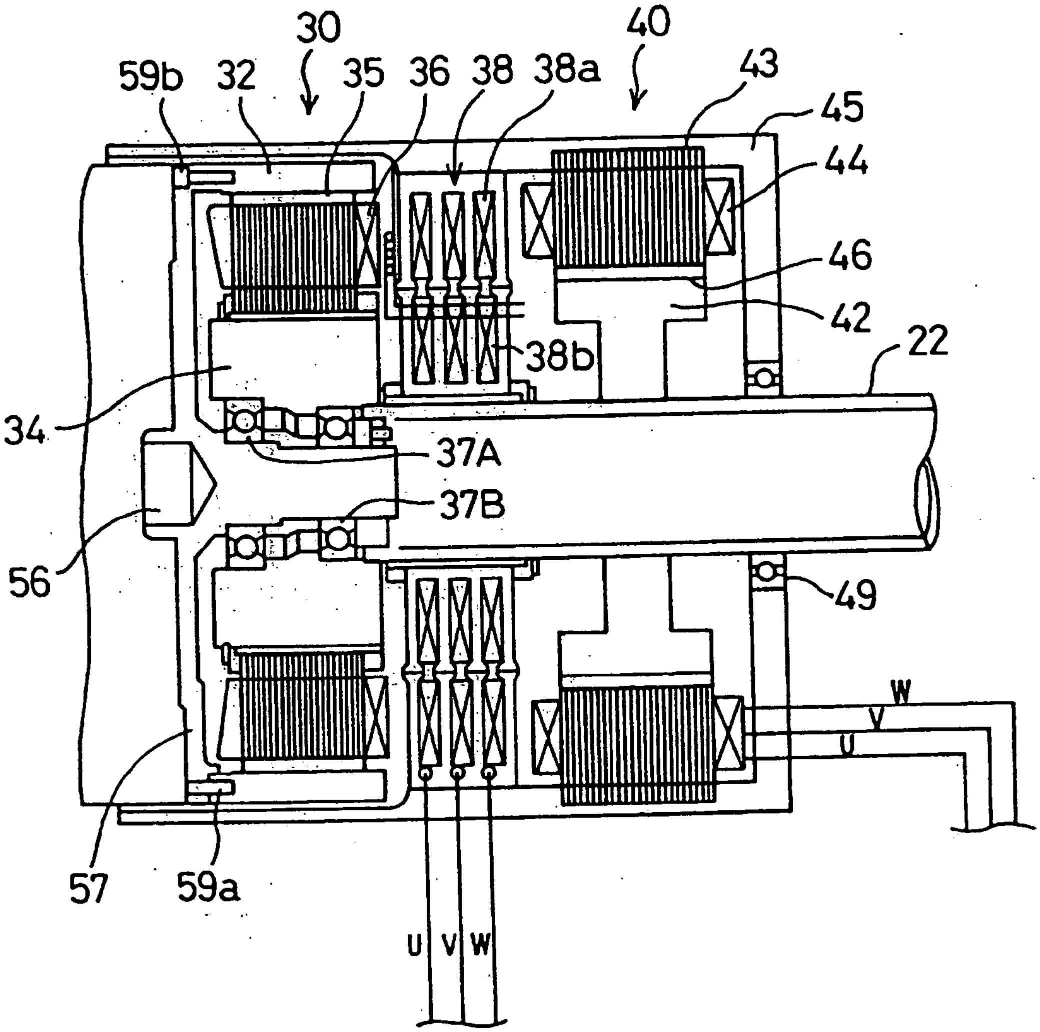
Fig. 2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V
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59a
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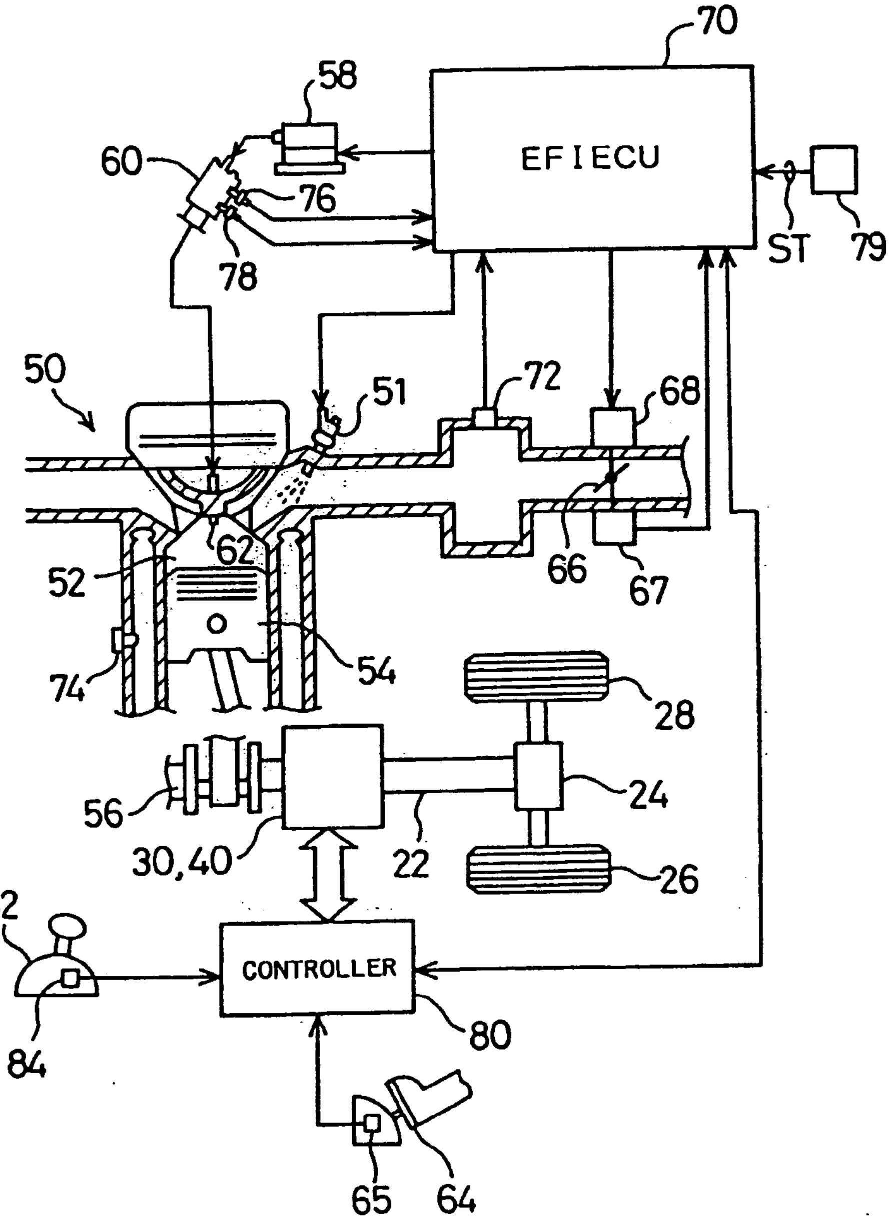
V
W

Fig. 3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CONTROLLER
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Fig. 4

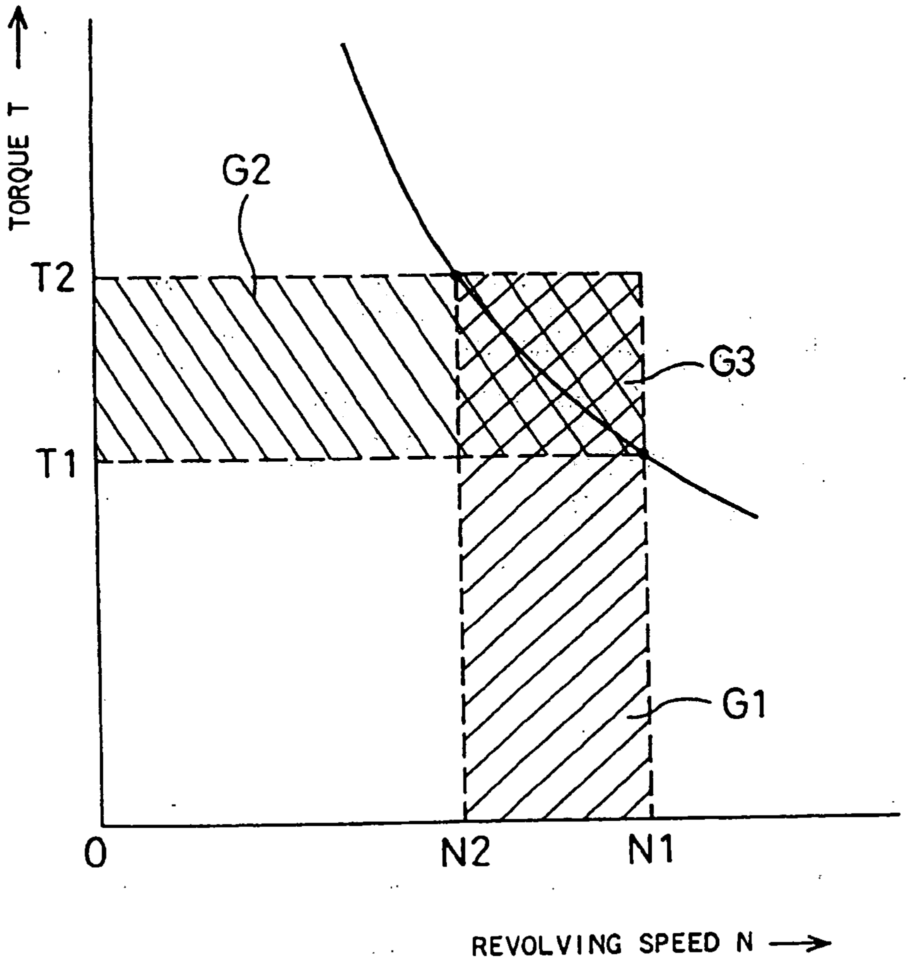


Fig. 5

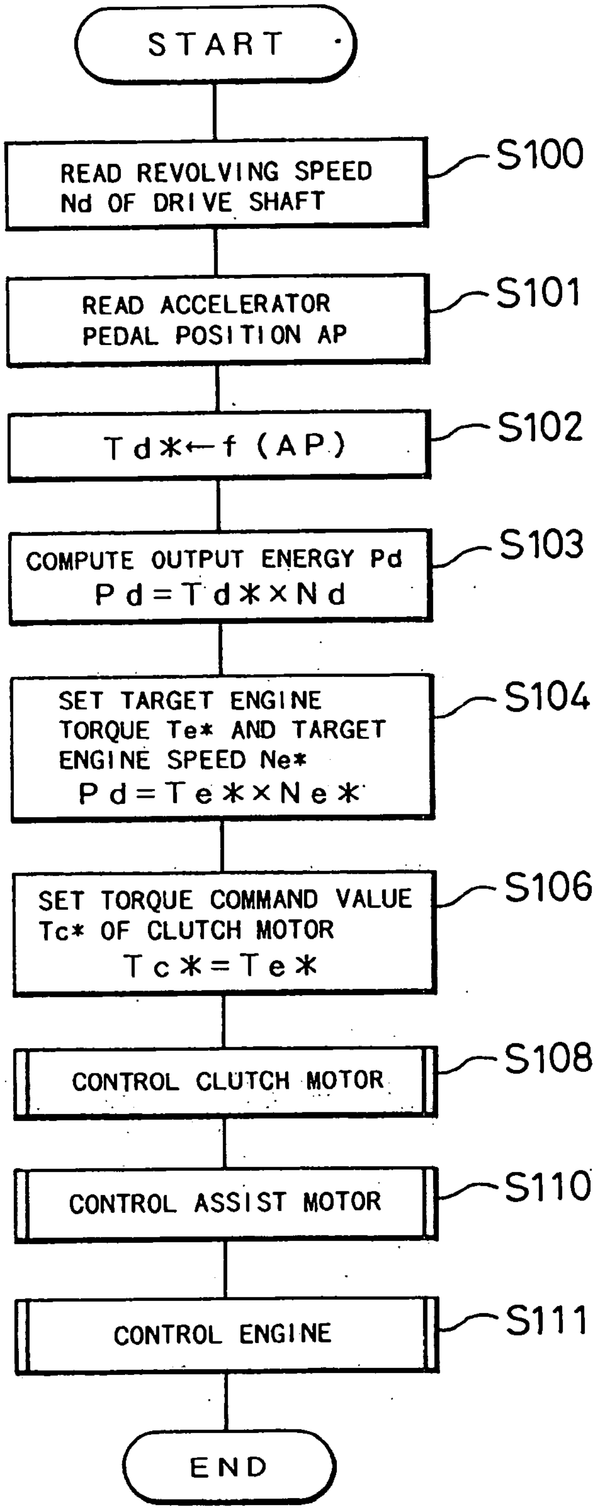

START
READ REVOLVING SPEED Nd OF DRIVE SHAFT
S100
READ ACCELERATOR PEDAL POSITION AP
S101
Td*←f (AP)
S102
COMPUTE OUTPUT ENERGY Pd
Pd=Td*×Nd
S103
SET TARGET ENGINE TORQUE Te* AND TARGET ENGINE SPEED Ne*
Pd=Te*×Ne*
S104
SET TORQUE COMMAND VALUE Tc* OF CLUTCH MOTOR
Tc*=Te*
S106
CONTROL CLUTCH MOTOR
S108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

Fig. 6

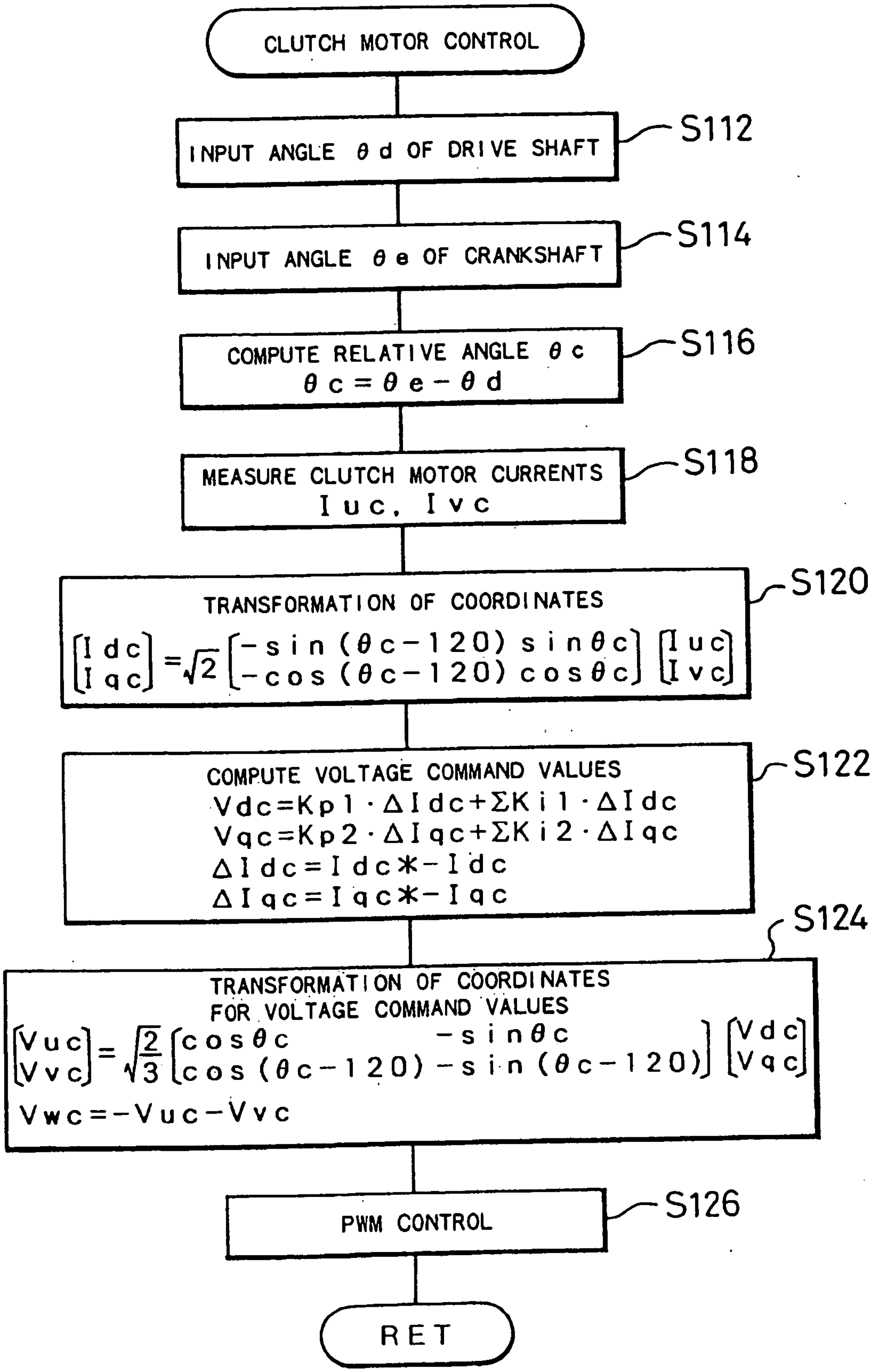

CLUTCH MOTOR CONTROL
INPUT ANGLE θd OF DRIVE SHAFT
S112
INPUT ANGLE θe OF CRANKSHAFT
S114
COMPUTE RELATIVE ANGLE θc
θc=θe−θd
S116
MEASURE CLUTCH MOTOR CURRENTS
Iuc, Ivc
S118
TRANSFORMATION OF COORDINATES
$\begin{bmatrix} Idc \\ Iqc \end{bmatrix} = \sqrt{2} \begin{bmatrix} -\sin(\theta c-120) & \sin\theta c \\ -\cos(\theta c-120) & \cos\theta c \end{bmatrix} \begin{bmatrix} Iuc \\ Ivc \end{bmatrix}$
S120
COMPUTE VOLTAGE COMMAND VALUES
$Vdc=Kp1\cdot\Delta Idc+\Sigma Ki1\cdot\Delta Idc$
$Vqc=Kp2\cdot\Delta Iqc+\Sigma Ki2\cdot\Delta Iqc$
$\Delta Idc=Idc^{*}-Idc$
$\Delta Iqc=Iqc^{*}-Iqc$
S122
TRANSFORMATION OF COORDINATES
FOR VOLTAGE COMMAND VALUES
$\begin{bmatrix} Vuc \\ Vvc \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos\theta c & -\sin\theta c \\ \cos(\theta c-120) & -\sin(\theta c-120) \end{bmatrix} \begin{bmatrix} Vdc \\ Vqc \end{bmatrix}$
$Vwc=-Vuc-Vvc$
S124
PWM CONTROL
S126
RET

Fig. 7

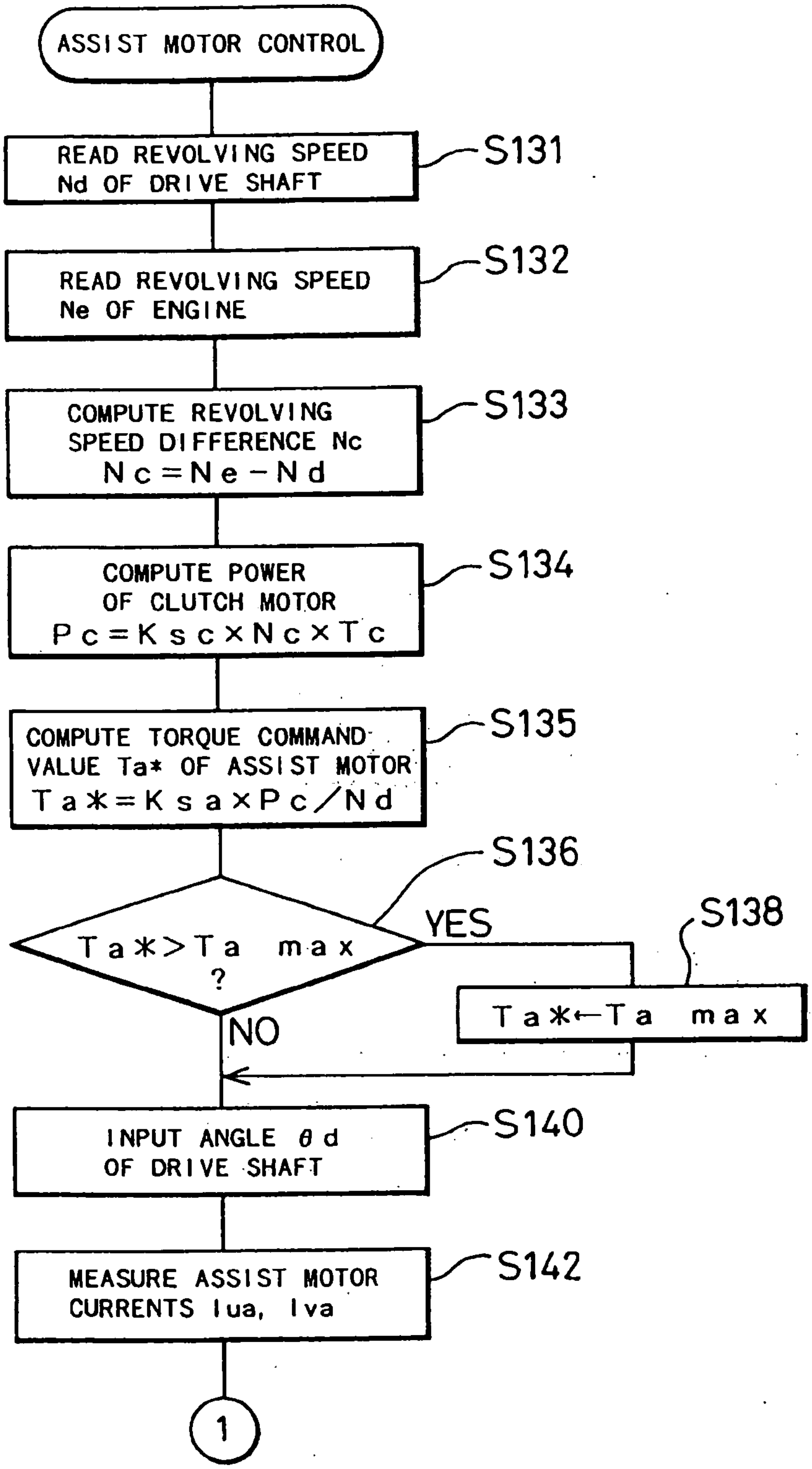

ASSIST MOTOR CONTROL
READ REVOLVING SPEED Nd OF DRIVE SHAFT
S131
READ REVOLVING SPEED Ne OF ENGINE
S132
COMPUTE REVOLVING SPEED DIFFERENCE Nc
Nc=Ne−Nd
S133
COMPUTE POWER OF CLUTCH MOTOR
Pc=Ksc×Nc×Tc
S134
COMPUTE TORQUE COMMAND VALUE Ta* OF ASSIST MOTOR
Ta*=Ksa×Pc/Nd
S135
Ta*>Ta max ?
S136
YES
NO
Ta*←Ta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

Fig. 8

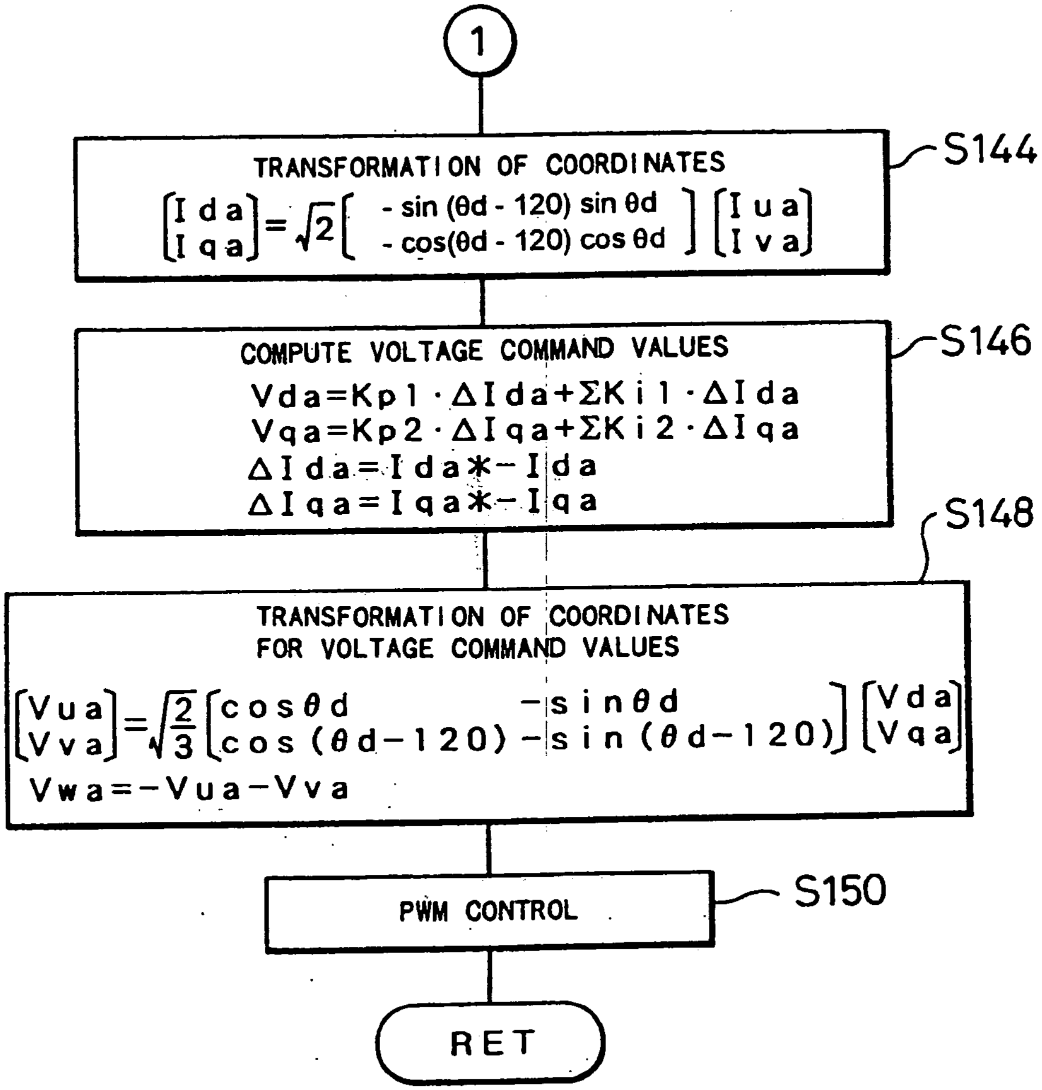

1
TRANSFORMATION OF COORDINATES
$\begin{bmatrix} Ida \\ Iqa \end{bmatrix} = \sqrt{2} \begin{bmatrix} -\sin(\theta d - 120) & \sin\theta d \\ -\cos(\theta d - 120) & \cos\theta d \end{bmatrix} \begin{bmatrix} Iua \\ Iva \end{bmatrix}$
S144
COMPUTE VOLTAGE COMMAND VALUES
$Vda = Kp1 \cdot \Delta Ida + \Sigma Ki1 \cdot \Delta Ida$
$Vqa = Kp2 \cdot \Delta Iqa + \Sigma Ki2 \cdot \Delta Iqa$
$\Delta Ida = Ida* - Ida$
$\Delta Iqa = Iqa* - Iqa$
S146
TRANSFORMATION OF COORDINATES FOR VOLTAGE COMMAND VALUES
$\begin{bmatrix} Vua \\ Vva \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos\theta d & -\sin\theta d \\ \cos(\theta d - 120) & -\sin(\theta d - 120) \end{bmatrix} \begin{bmatrix} Vda \\ Vqa \end{bmatrix}$
$Vwa = -Vua - Vva$
S148
PWM CONTROL
S150
RET

Fig. 9

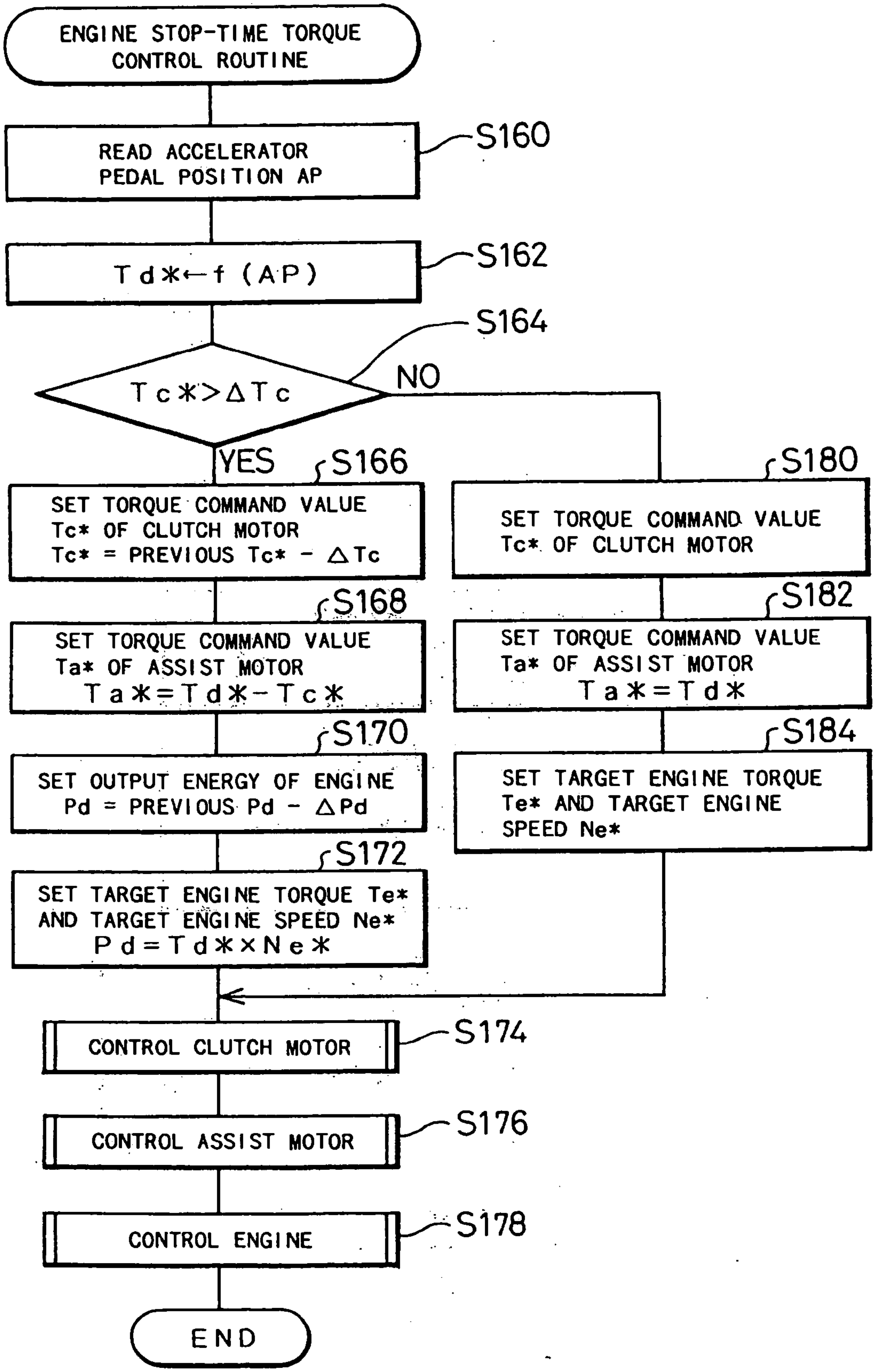

ENGINE STOP-TIME TORQUE CONTROL ROUTINE
READ ACCELERATOR PEDAL POSITION AP
S160
Td*←f (AP)
S162
S164
Tc*>ΔTc
NO
YES
S166
SET TORQUE COMMAND VALUE Tc* OF CLUTCH MOTOR Tc* = PREVIOUS Tc* − ΔTc
S168
SET TORQUE COMMAND VALUE Ta* OF ASSIST MOTOR Ta*=Td*−Tc*
S170
SET OUTPUT ENERGY OF ENGINE Pd = PREVIOUS Pd − 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

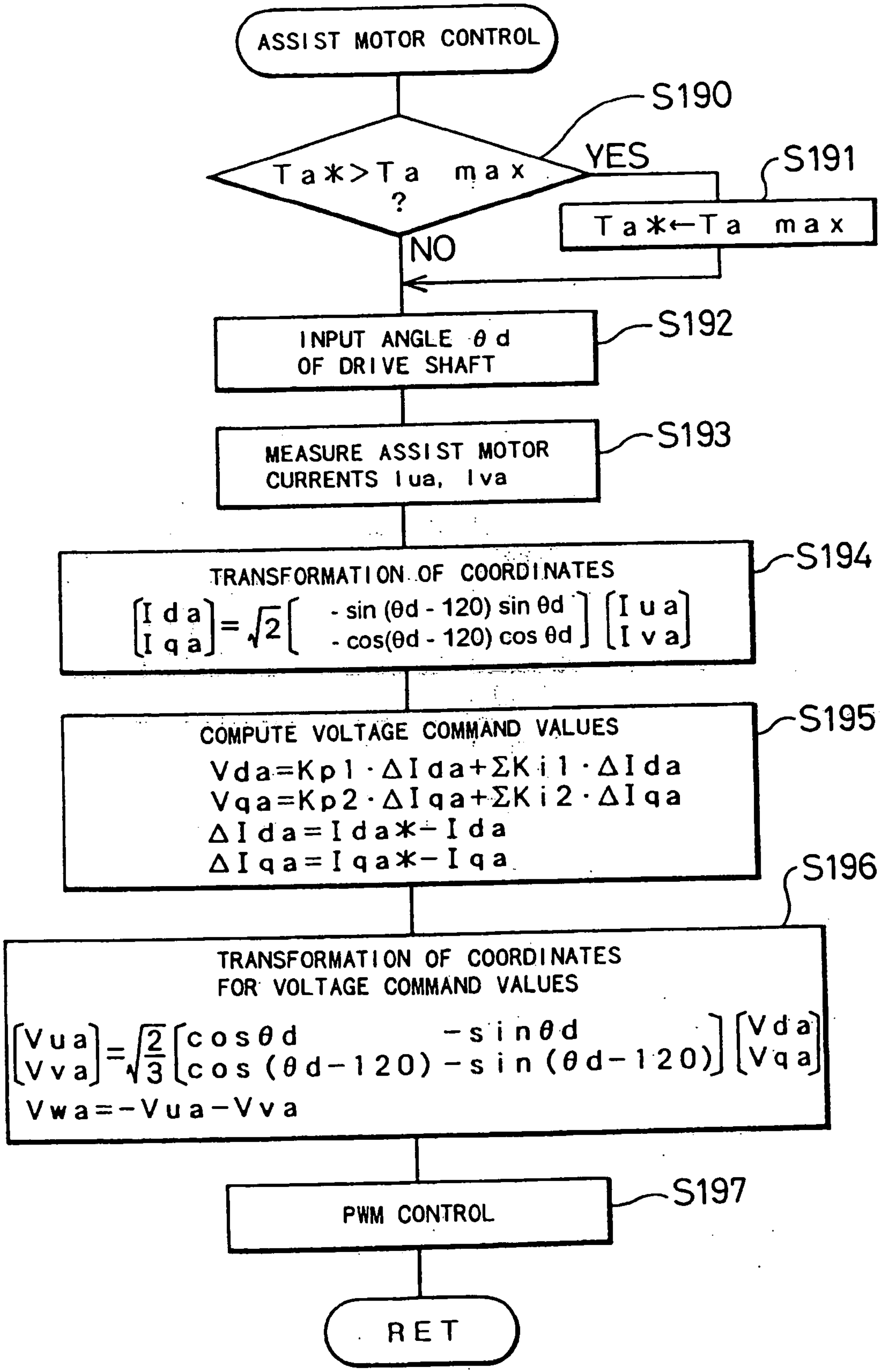

ASSIST MOTOR CONTROL
S190
Ta*>Ta max ?
YES
S191
Ta*←Ta max
NO
S192
INPUT ANGLE θd OF DRIVE SHAFT
S193
MEASURE ASSIST MOTOR CURRENTS Iua, Iva
S194
TRANSFORMATION OF COORDINATES
[Ida; Iqa] = √2 [-sin(θd - 120) sin θd; -cos(θd - 120) cos θd] [Iua; Iva]
S195
COMPUTE VOLTAGE COMMAND VALUES
Vda=Kp1·ΔIda+ΣKi1·ΔIda
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

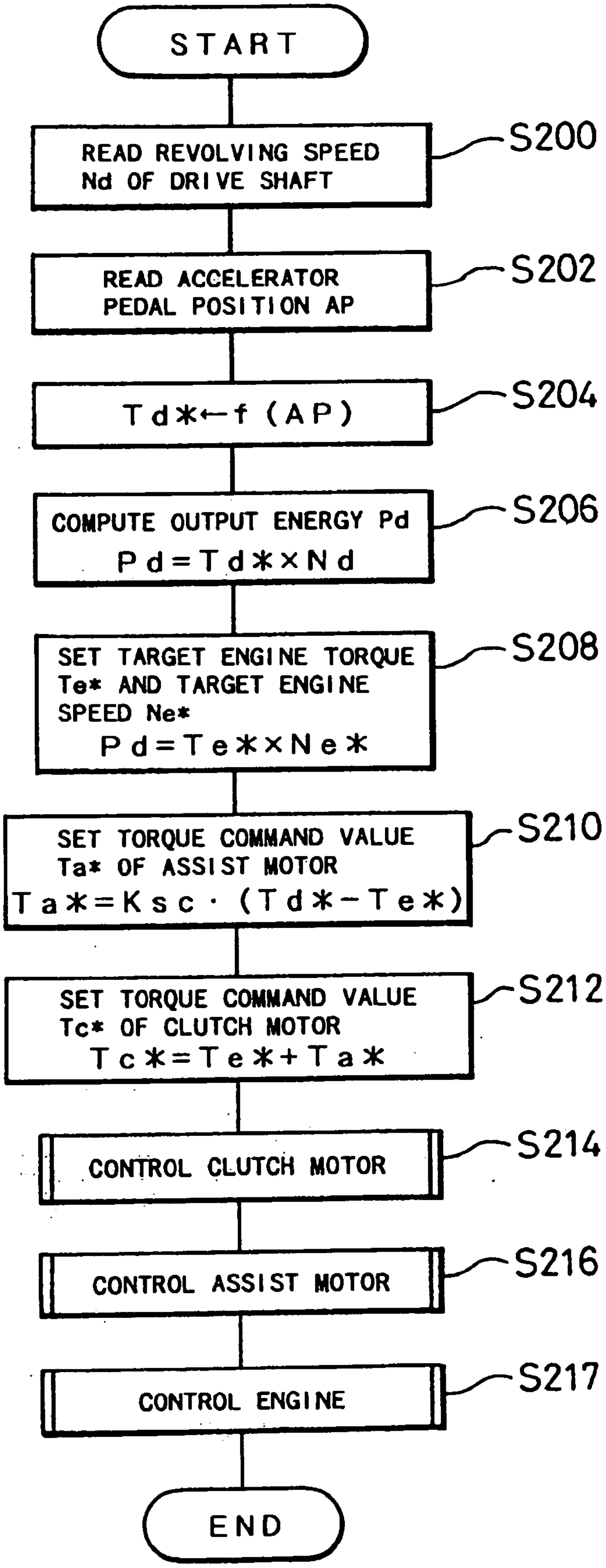
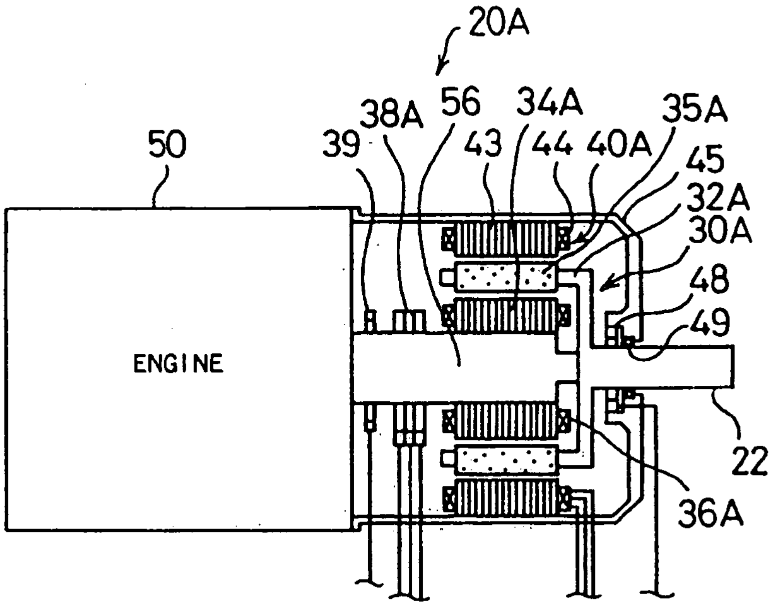

START
READ REVOLVING SPEED Nd OF DRIVE SHAFT
S200
READ ACCELERATOR PEDAL POSITION AP
S202
Td*←f (AP)
S204
COMPUTE OUTPUT ENERGY Pd
Pd=Td*×Nd
S206
SET TARGET ENGINE TORQUE Te* AND TARGET ENGINE SPEED Ne*
Pd=Te*×Ne*
S208
SET TORQUE COMMAND VALUE Ta* OF ASSIST MOTOR
Ta*=Ksc·(Td*−Te*)
S210
SET TORQUE COMMAND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

Fig. 11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ENGINE
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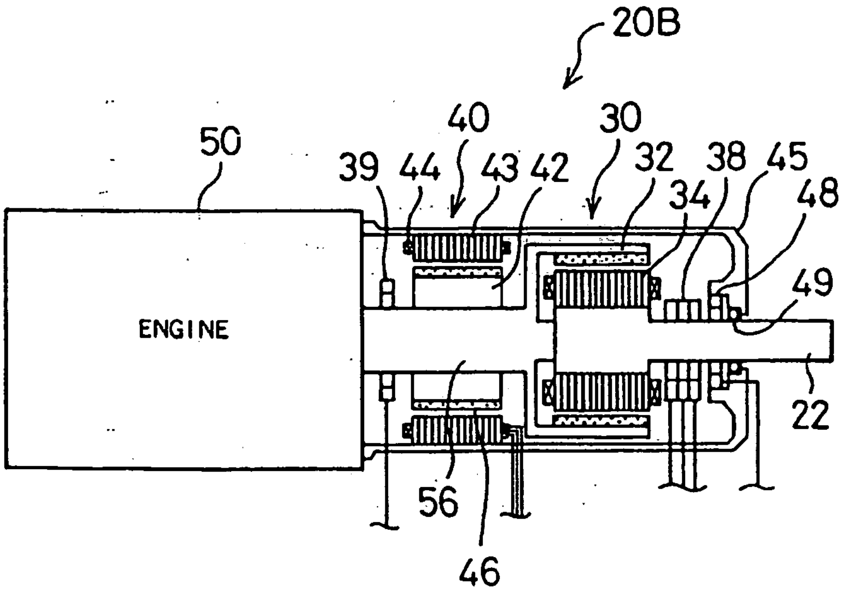
36A

Fig. 12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ENGINE
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Fig. 14

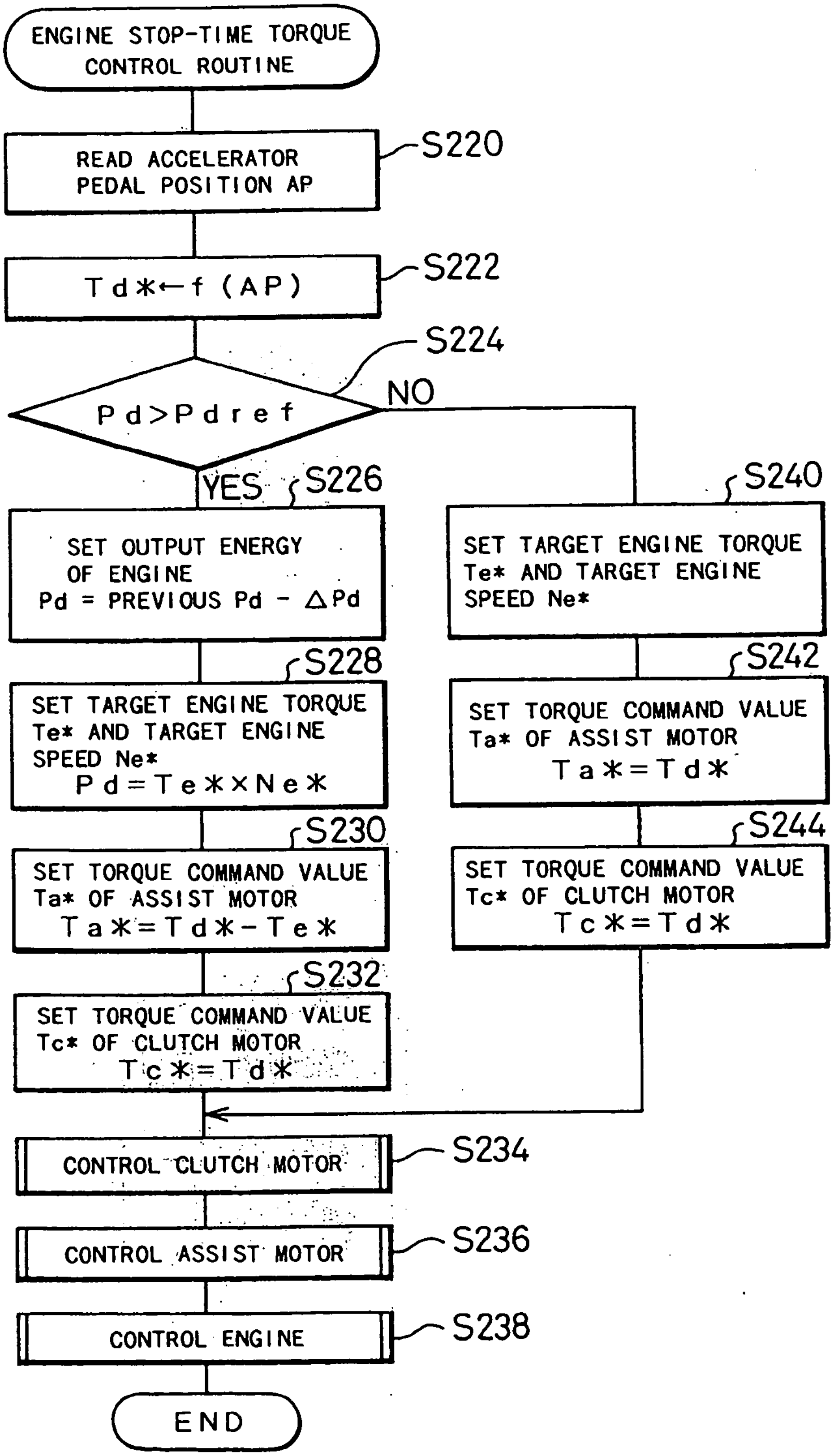
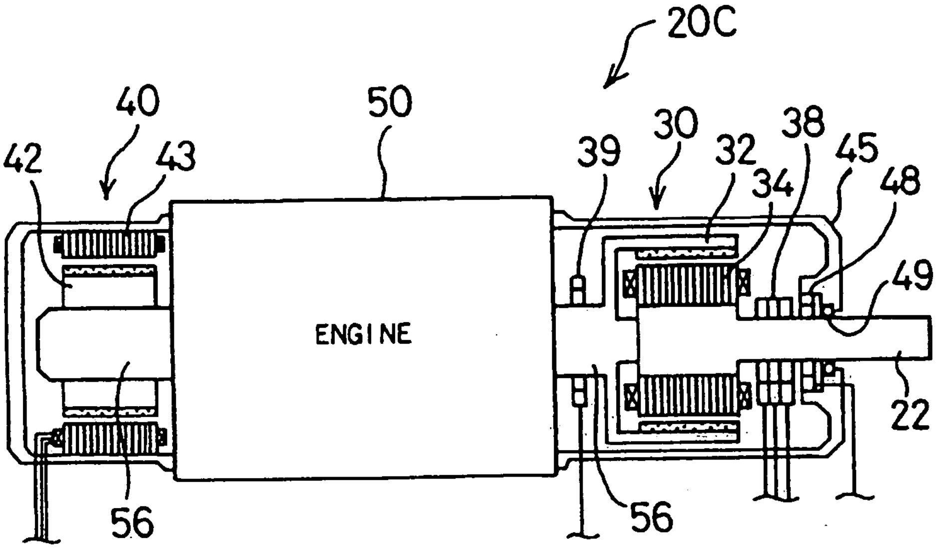

ENGINE STOP-TIME TORQUE CONTROL ROUTINE
S220
READ ACCELERATOR PEDAL POSITION AP
S222
Td*←f (AP)
S224
Pd>Pdref
NO
YES
S226
SET OUTPUT ENERGY OF ENGINE Pd = PREVIOUS Pd − ΔPd
S228
SET TARGET ENGINE TORQUE Te* AND TARGET ENGINE SPEED Ne* Pd=Te*×Ne*
S230
SET TORQUE COMMAND VALUE Ta* OF ASSIST MOTOR Ta*=Td*−Te*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

Fig. 15



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ENGINE
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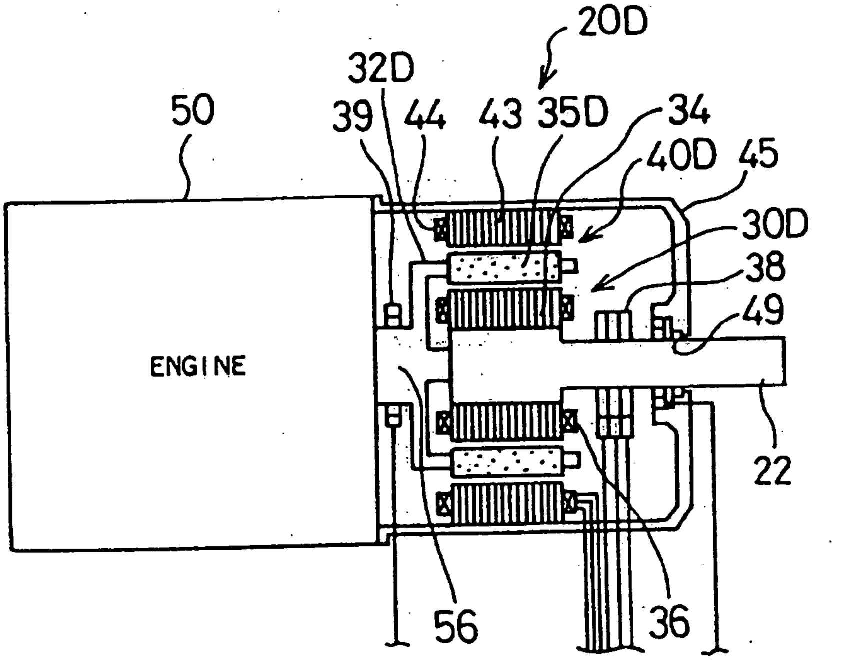
Fig. 16



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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

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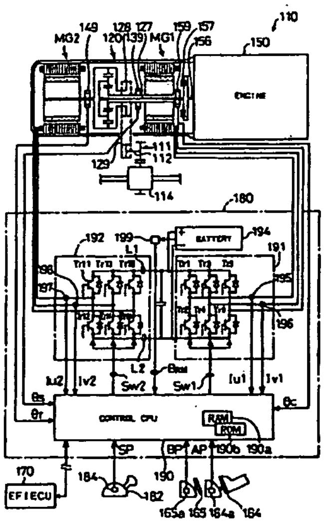
(54) Power output apparatus, engine controller, and methods of controlling power output apparatus and engine

(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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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;

Fig. 19 schematically illustrates still another power output apparatus 110B as another modified example;
Fig. 20 schematically illustrates structure of another power output apparatus 110' as a second embodiment according to the present invention;
Fig. 21 illustrates an exemplified structure of an open-close timing changing mechanism 153;
Fig. 22 is a flowchart showing an engine stop control routine carried out in the second embodiment;
Fig. 23 is a graph showing the reduction torque STGmn plotted against the vehicle speed;
Fig. 24 is a graph showing the processing time mntg of slower speed reduction plotted against the vehicle speed;
Fig. 25 is a flowchart showing an open-loop control routine;
Fig. 26 is a flowchart showing a processing routine to prevent undershoot;
Fig. 27 is a graph showing an example of the control process carried out in the second embodiment;
Fig. 28 schematically illustrates structure of a four-wheel-drive vehicle with a power output apparatus 110C incorporated therein; and
Fig. 29 schematically illustrates another power output apparatus 310 as another 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:

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

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.

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

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:

$$Tes = Te \times \frac{\rho}{1+\rho} \tag{3}$$

$$Ter = Te \times \frac{1}{1+\rho} \tag{4}$$

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*.

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

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.

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

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).

$$\Delta Id1 = Id1^{*}-Id1 \tag{8}$$

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

$$Vd1 = Kp1 \cdot \Delta Id1 + \Sigma\ Ki1 \cdot \Delta Id1 \tag{9}$$

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

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:

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

$$Vw1 = -Vu1-Vv1$$

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

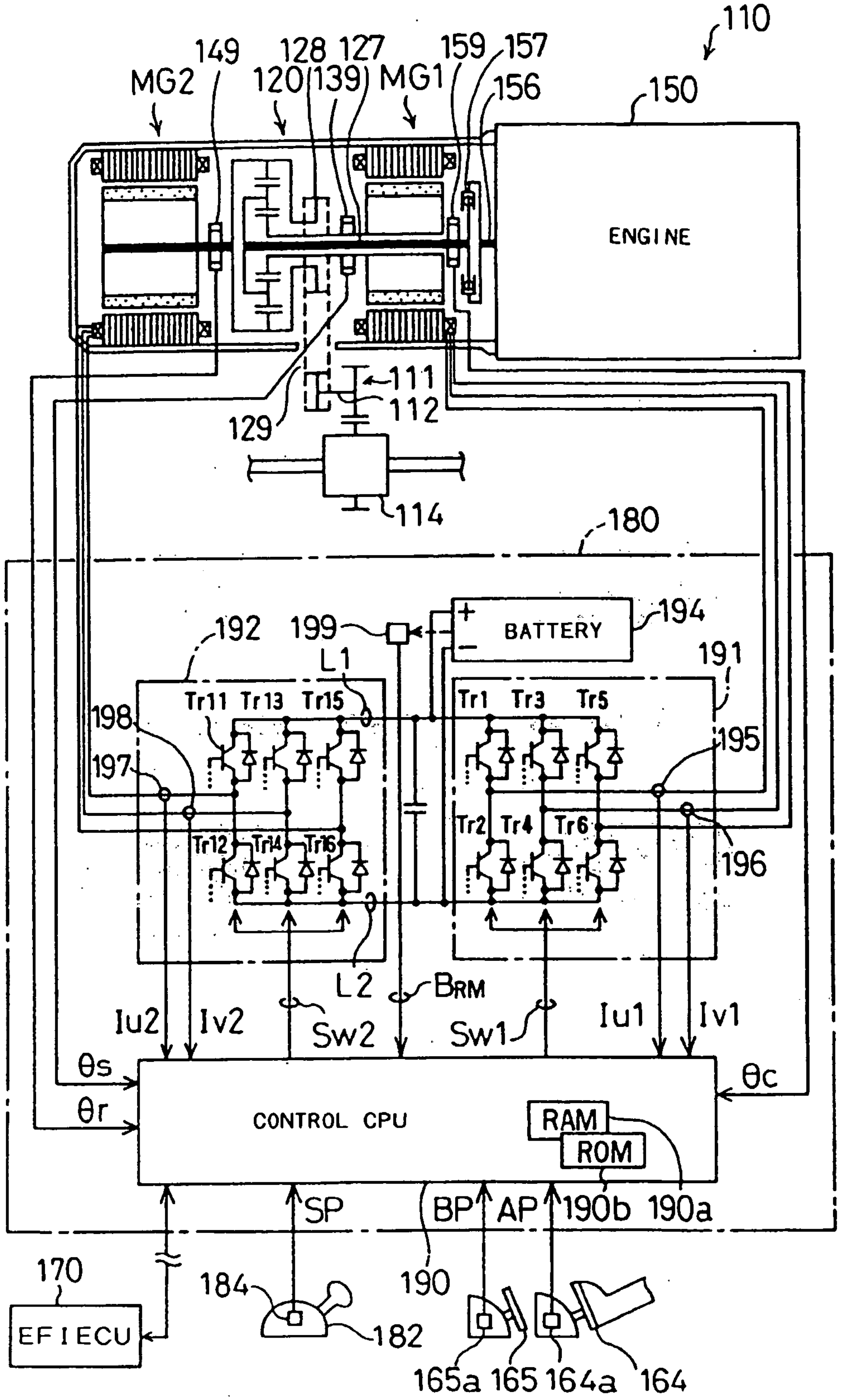

110
149
128
127
159
157
MG2
120
139
MG1
156
150
ENGINE
111
112
129
114
180
192
199
BATTERY
194
L1
191
Tr11
Tr13
Tr15
Tr1
Tr3
Tr5
198
195
197
Tr12
Tr14
Tr16
Tr2
Tr4
Tr6
196
L2
BRM
Iu2
Iv2
Sw2
Sw1
Iu1
Iv1
θs
θr
θc
CONTROL CPU
RAM
ROM
SP
BP
AP
190b
190a
170
184
190
EFIECU
182
165a
165
164a
164

Fig. 2

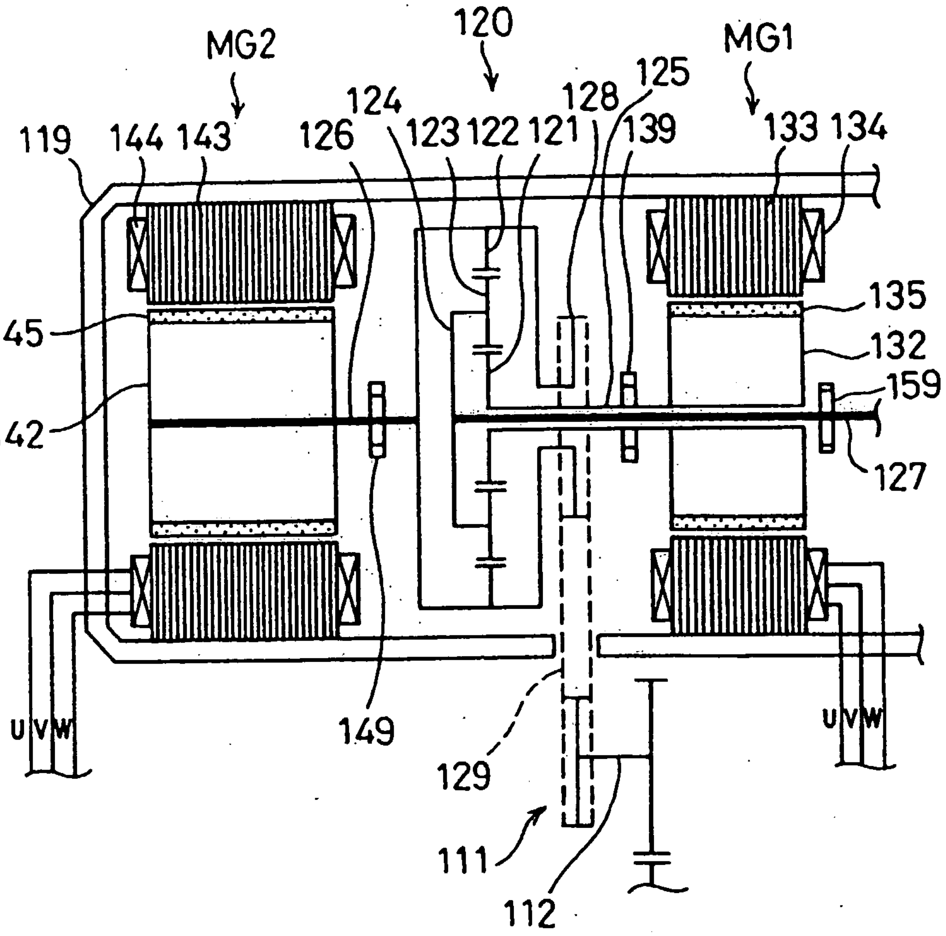

MG2
120
MG1
125
128
124
119
144
143
126
123
122
121
139
133
134
135
145
132
159
142
127
U
V
W
149
U
V
W
129
111
112

Fig. 3

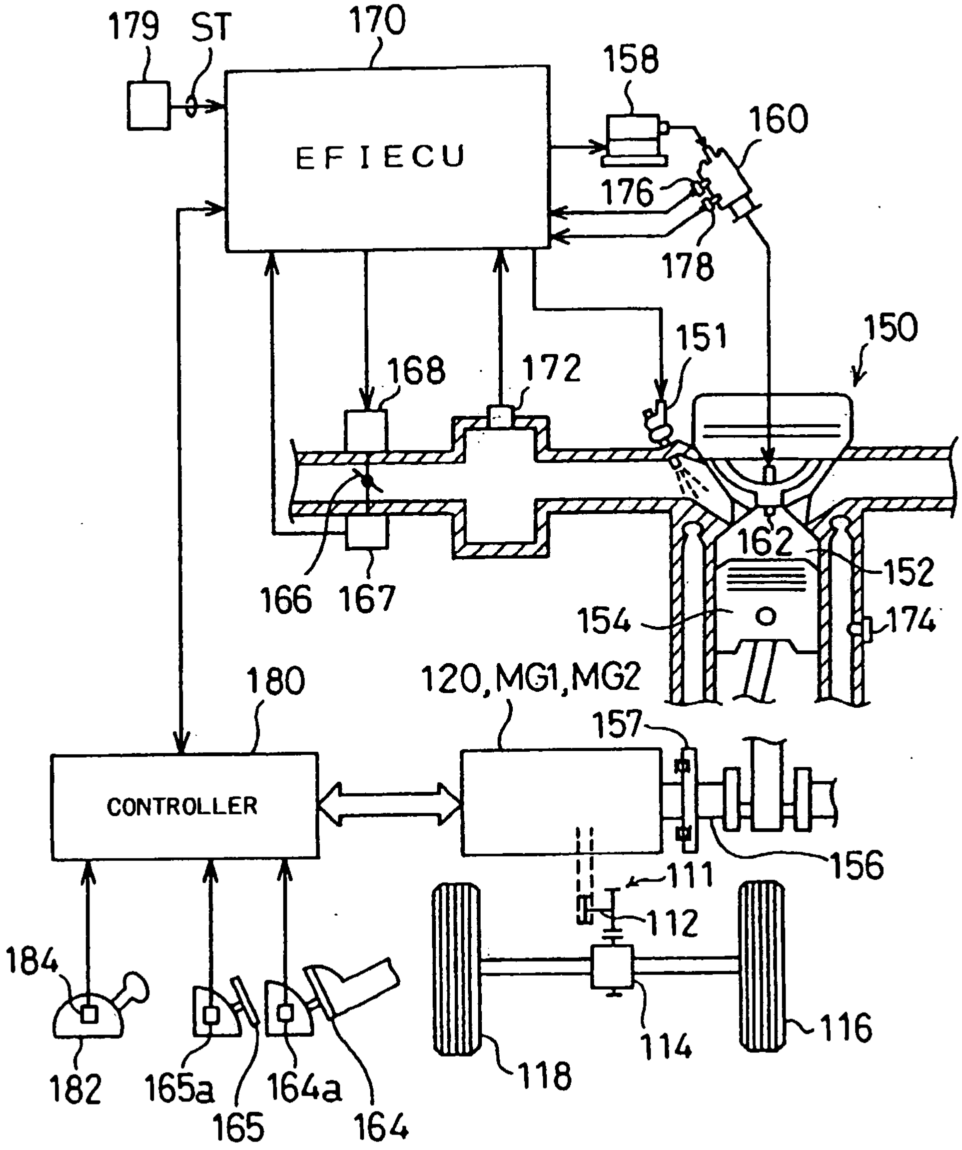

179
ST
170
EFIECU
158
160
176
178
151
150
168
172
166
167
162
152
154
174
180
120,MG1,MG2
157
CONTROLLER
156
111
112
114
116
118
184
182
165a
165
164a
164

Fig. 4

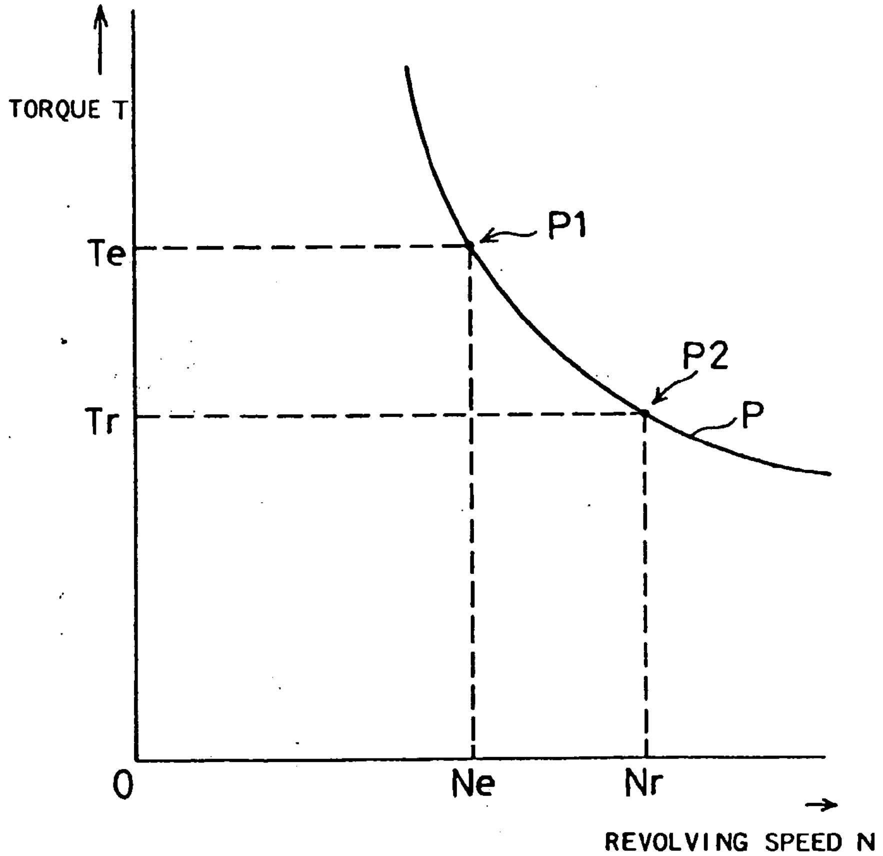


Fig. 5

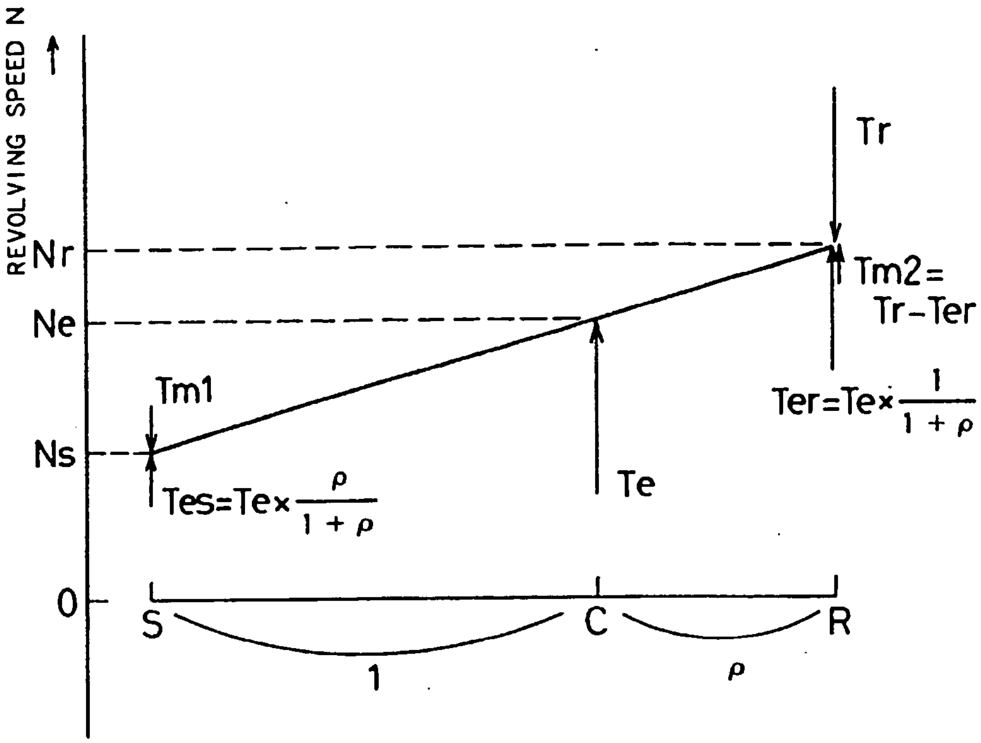

REVOLVING SPEED N
Nr
Ne
Ns
0
Tr
Tm2=
Tr-Ter
Ter=Te×$\frac{1}{1+\rho}$
Tm1
Tes=Te×$\frac{\rho}{1+\rho}$
Te
S
C
R
1
ρ

Fig. 6

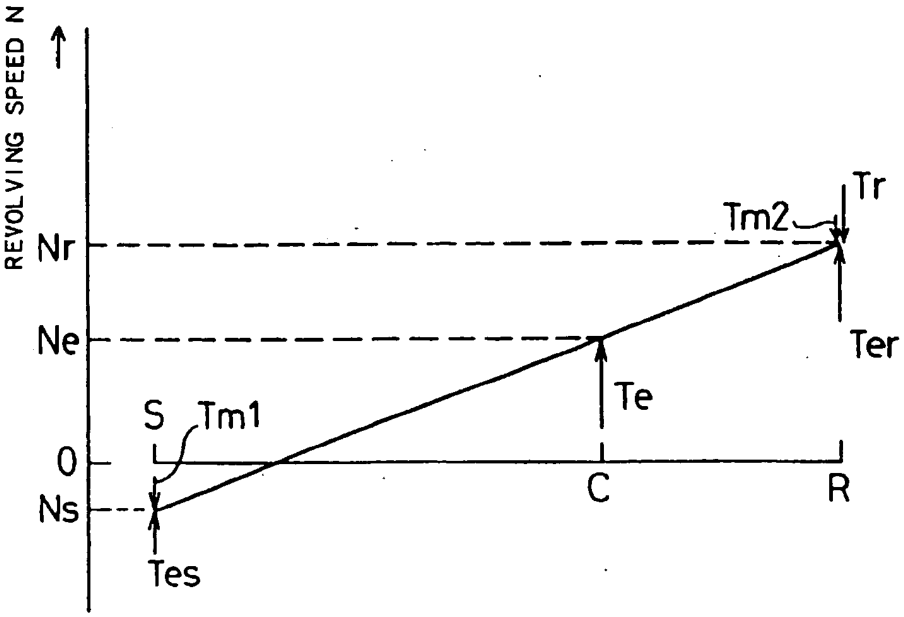

REVOLVING SPEED N
Nr
Ne
0
Ns
Tr
Tm2
Ter
Te
S
Tm1
C
R
Tes

Fig. 7

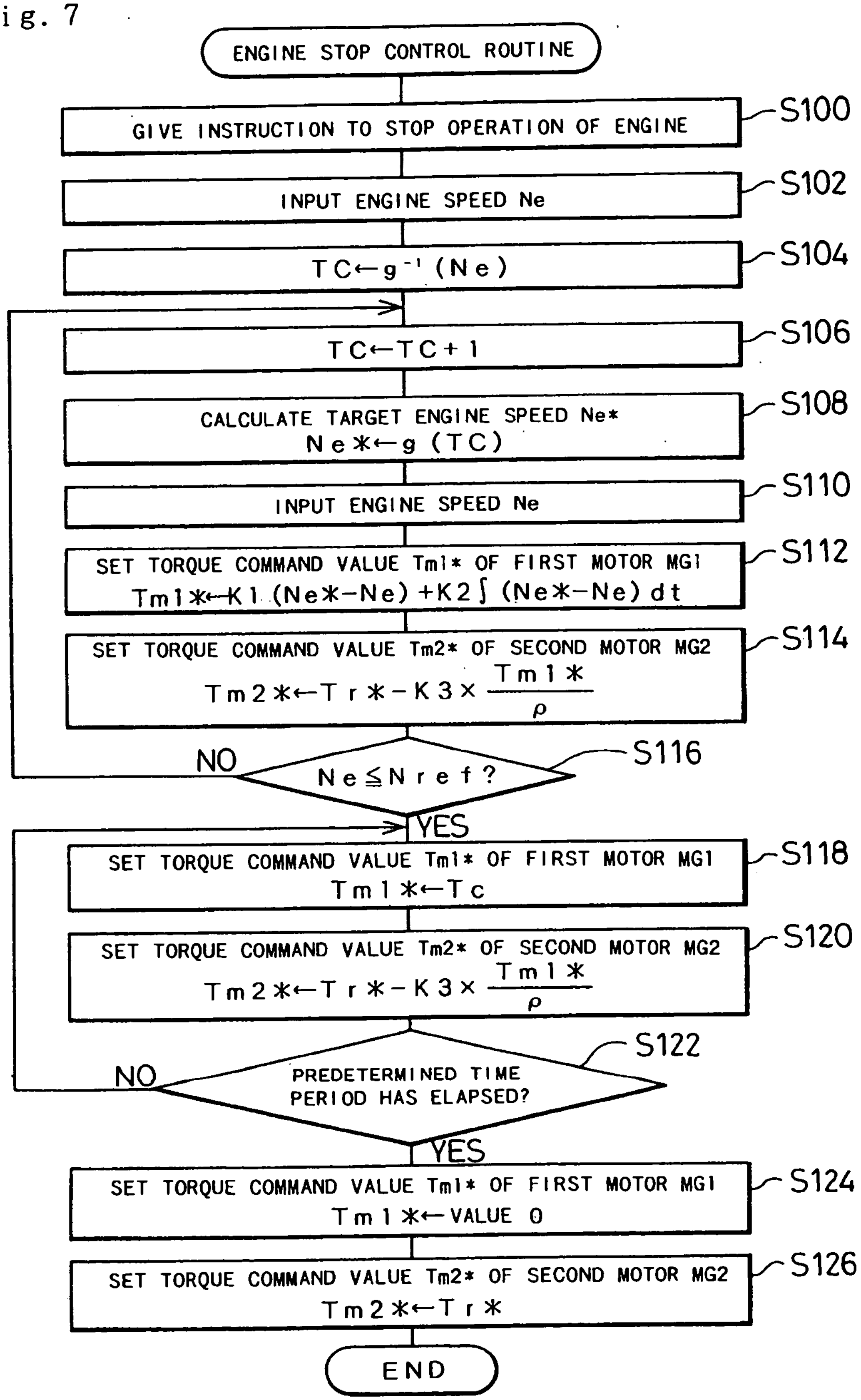

ENGINE STOP CONTROL ROUTINE
GIVE INSTRUCTION TO STOP OPERATION OF ENGINE
S100
INPUT ENGINE SPEED Ne
S102
TC←g⁻¹(Ne)
S104
TC←TC+1
S106
CALCULATE TARGET ENGINE SPEED Ne*
Ne*←g(TC)
S108
INPUT ENGINE SPEED Ne
S110
SET TORQUE COMMAND VALUE Tm1* OF FIRST MOTOR MG1
Tm1*←K1(Ne*−Ne)+K2∫(Ne*−Ne)dt
S112
SET TORQUE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

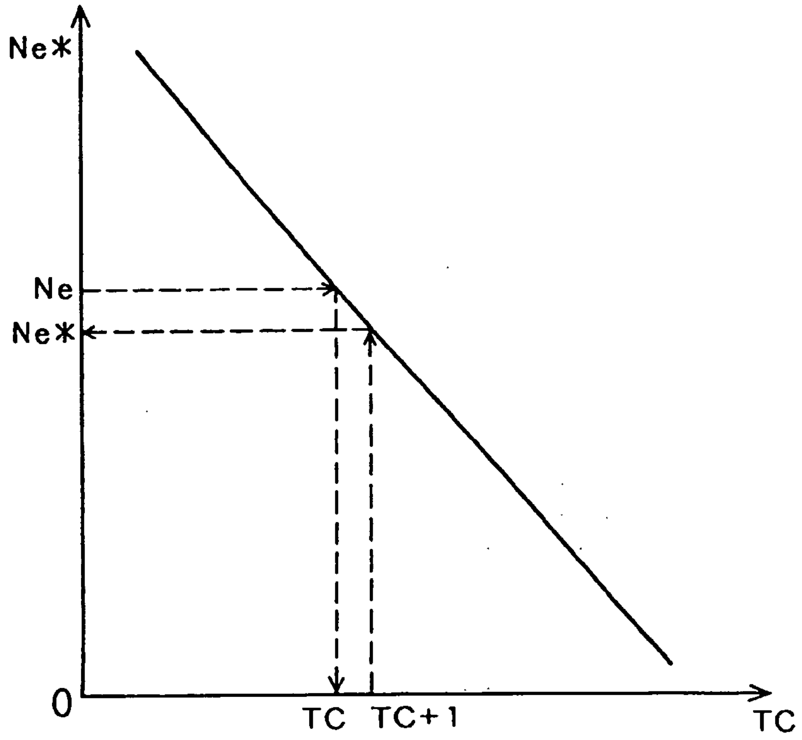


Fig.9

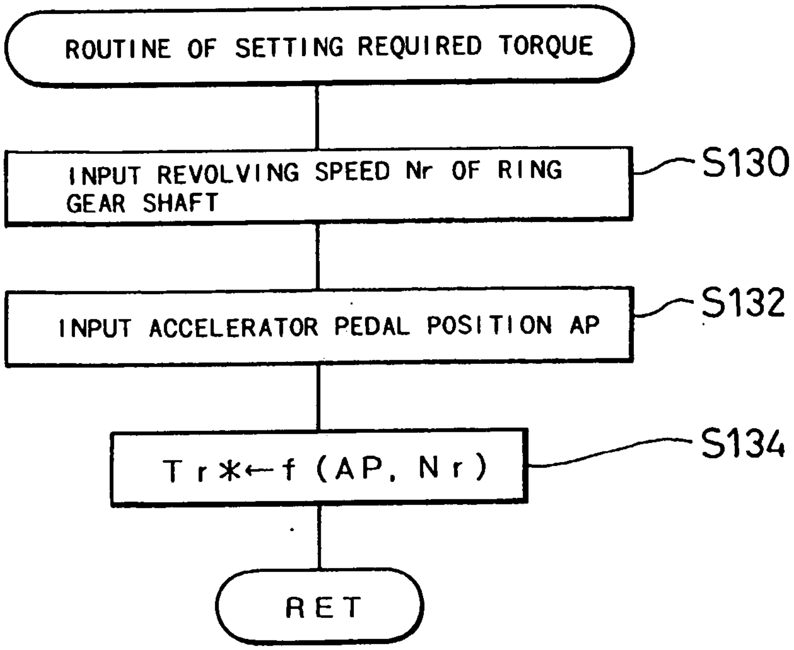

ROUTINE OF SETTING REQUIRED TORQUE
INPUT REVOLVING SPEED Nr OF RING GEAR SHAFT
S130
INPUT ACCELERATOR PEDAL POSITION AP
S132
Tr*←f (AP, Nr)
S134
RET

Fig. 10

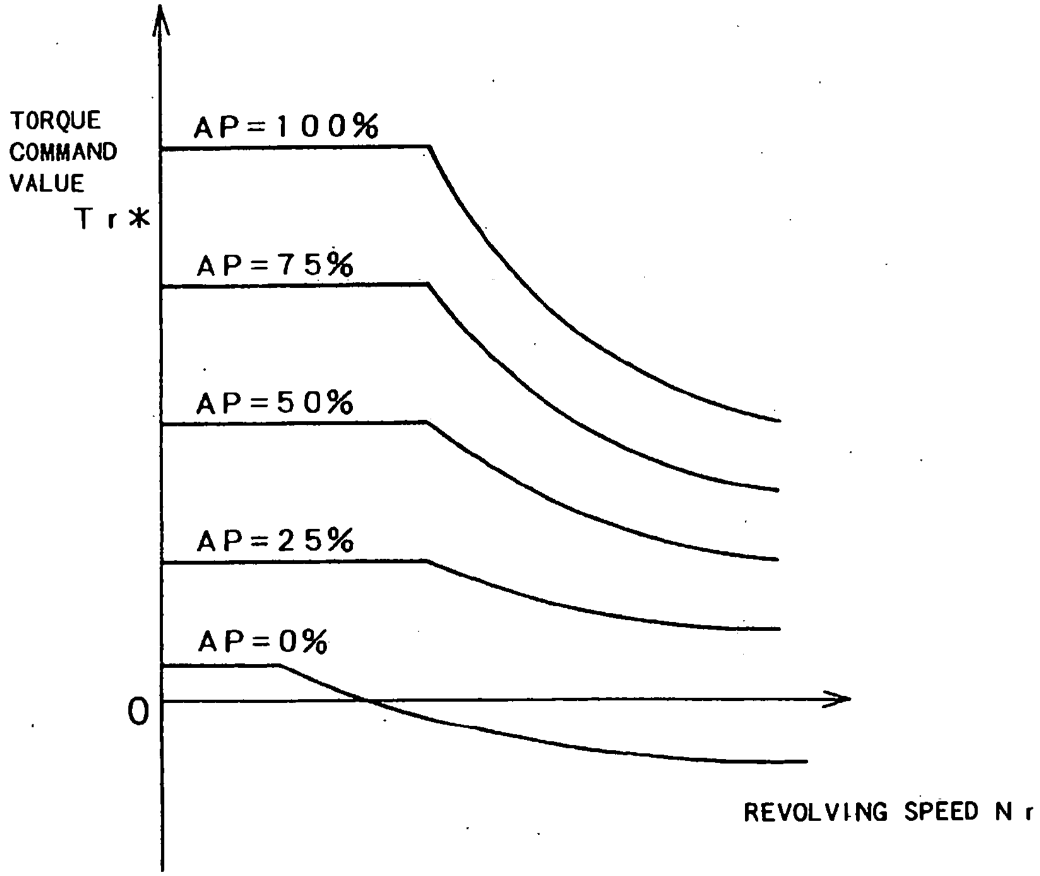

TORQUE COMMAND VALUE
Tr*
AP=100%
AP=75%
AP=50%
AP=25%
AP=0%
0
REVOLVING SPEED Nr

Fig. 11

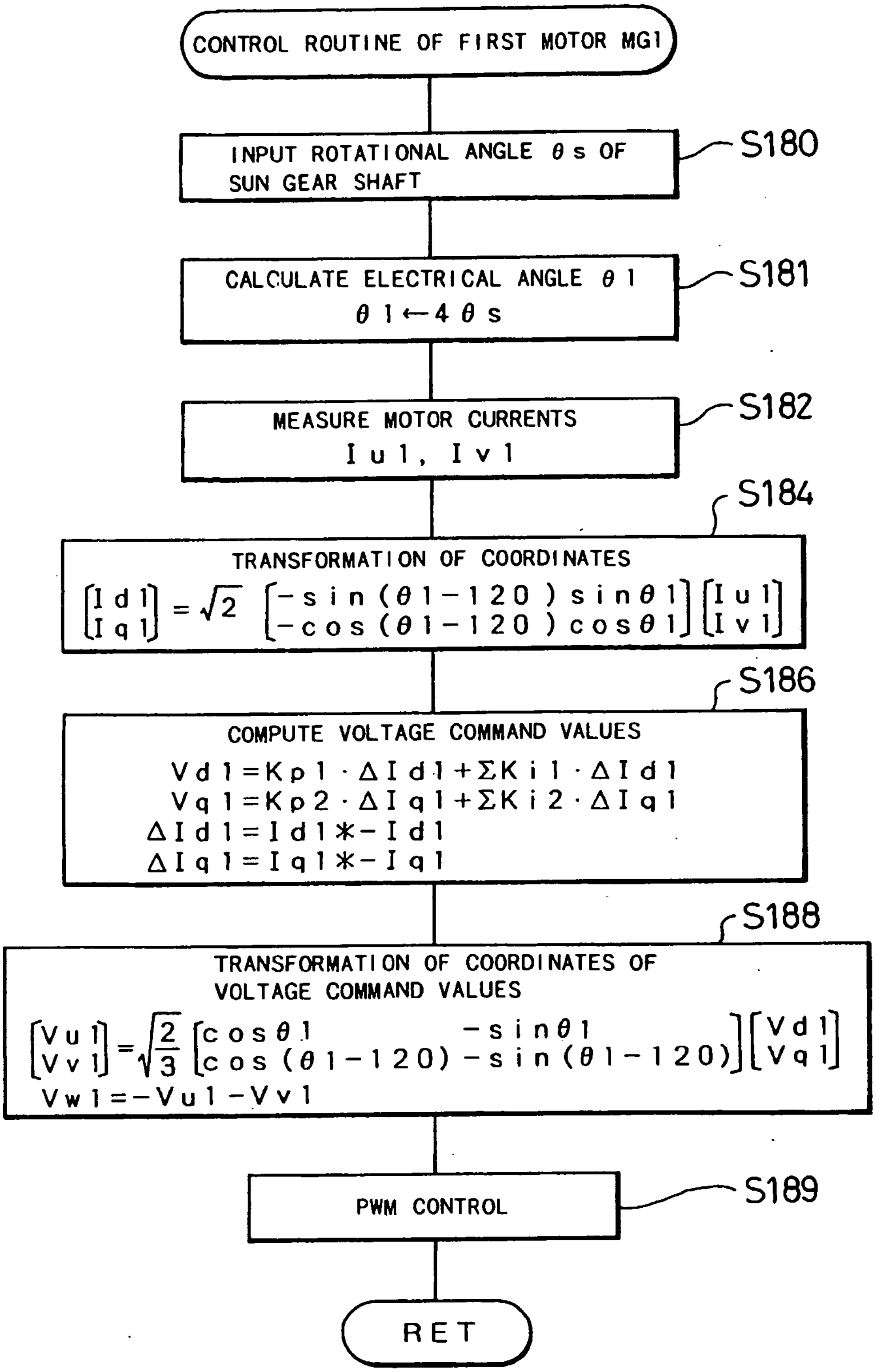

CONTROL ROUTINE OF FIRST MOTOR MG1
INPUT ROTATIONAL ANGLE θs OF SUN GEAR SHAFT
S180
CALCULATE ELECTRICAL ANGLE θ1
θ1←4θs
S181
MEASURE MOTOR CURRENTS
Iu1, Iv1
S182
S184
TRANSFORMATION OF COORDINATES
$\begin{bmatrix} Id1 \\ Iq1 \end{bmatrix} = \sqrt{2} \begin{bmatrix} -\sin(\theta1-120) & \sin\theta1 \\ -\cos(\theta1-120) & \cos\theta1 \end{bmatrix} \begin{bmatrix} Iu1 \\ Iv1 \end{bmatrix}$
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
$\begin{bmatrix} Vu1 \\ Vv1 \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos\theta1 & -\sin\theta1 \\ \cos(\theta1-120) & -\sin(\theta1-120) \end{bmatrix} \begin{bmatrix} Vd1 \\ Vq1 \end{bmatrix}$
$Vw1 = -Vu1 - Vv1$
PWM CONTROL
S189
RET

Fig. 12

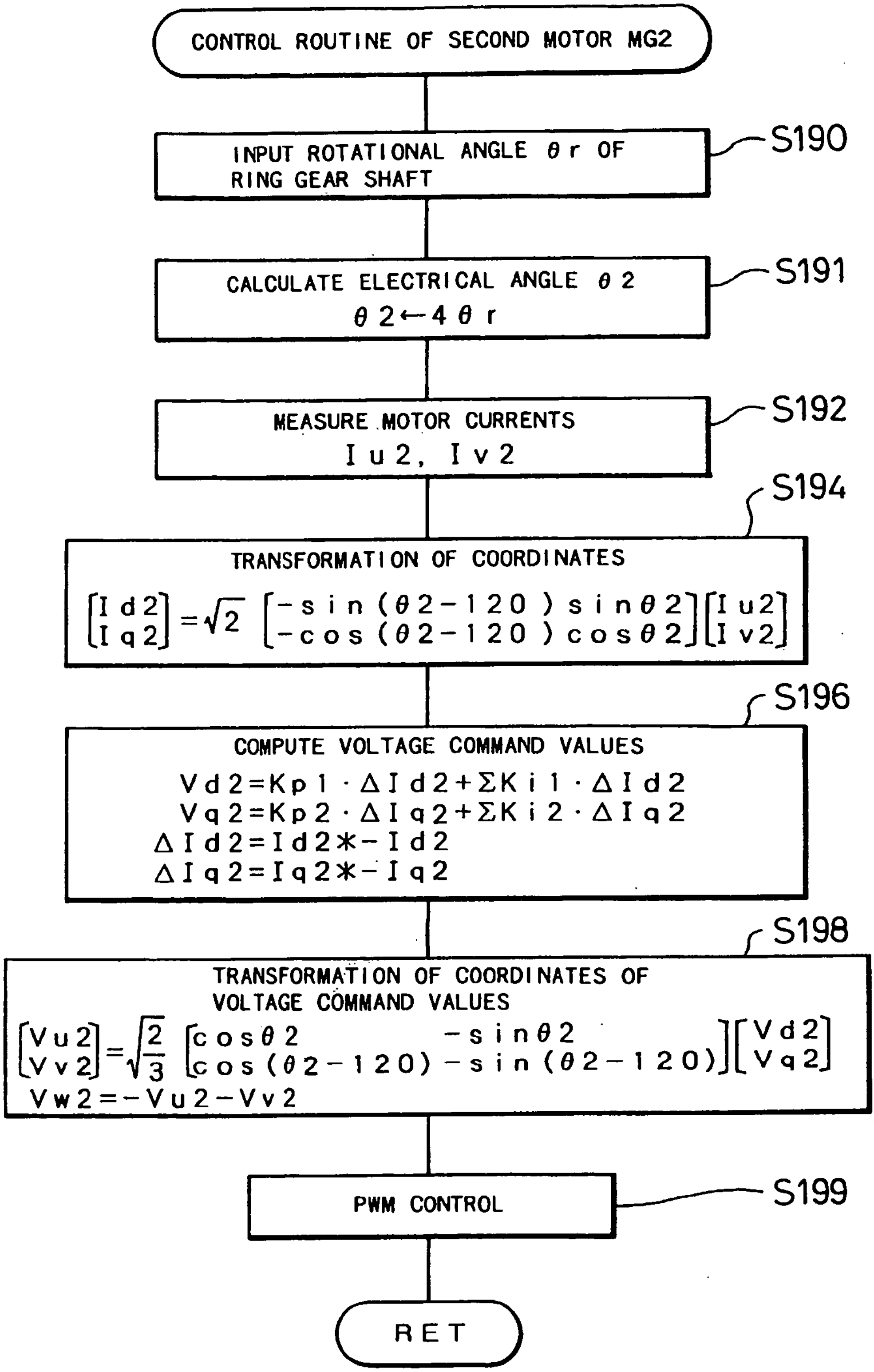

CONTROL ROUTINE OF SECOND MOTOR MG2
INPUT ROTATIONAL ANGLE θr OF RING GEAR SHAFT
S190
CALCULATE ELECTRICAL ANGLE θ2
θ2←4θr
S191
MEASURE MOTOR CURRENTS
Iu2, Iv2
S192
S194
TRANSFORMATION OF COORDINATES
$\begin{bmatrix} Id2 \\ Iq2 \end{bmatrix} = \sqrt{2} \begin{bmatrix} -\sin(\theta 2-120) & \sin\theta 2 \\ -\cos(\theta 2-120) & \cos\theta 2 \end{bmatrix} \begin{bmatrix} Iu2 \\ Iv2 \end{bmatrix}$
S196
COMPUTE VOLTAGE COMMAND VALUES
$Vd2 = Kp1 \cdot \Delta Id2 + \Sigma Ki1 \cdot \Delta Id2$
$Vq2 = Kp2 \cdot \Delta Iq2 + \Sigma Ki2 \cdot \Delta Iq2$
$\Delta Id2 = Id2* - Id2$
$\Delta Iq2 = Iq2* - Iq2$
S198
TRANSFORMATION OF COORDINATES OF VOLTAGE COMMAND VALUES
$\begin{bmatrix} Vu2 \\ Vv2 \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos\theta 2 & -\sin\theta 2 \\ \cos(\theta 2-120) & -\sin(\theta 2-120) \end{bmatrix} \begin{bmatrix} Vd2 \\ Vq2 \end{bmatrix}$
$Vw2 = -Vu2 - Vv2$
PWM CONTROL
S199
RET

Fig. 13

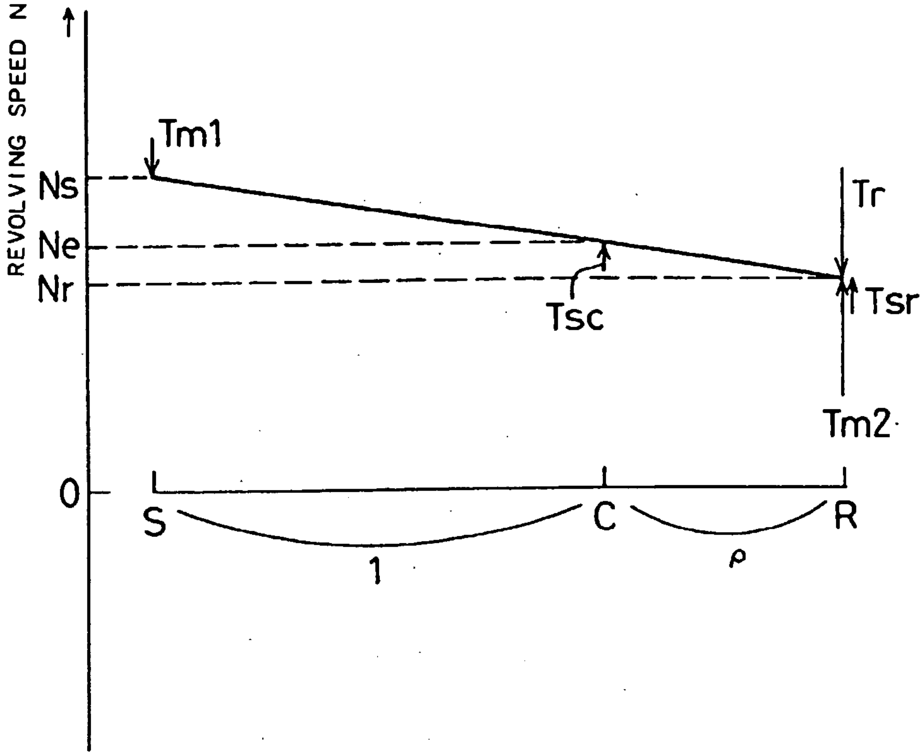

REVOLVING SPEED N
Tm1
Ns
Ne
Nr
Tr
Tsr
Tsc
Tm2
0
S
C
R
1
ρ

Fig. 14

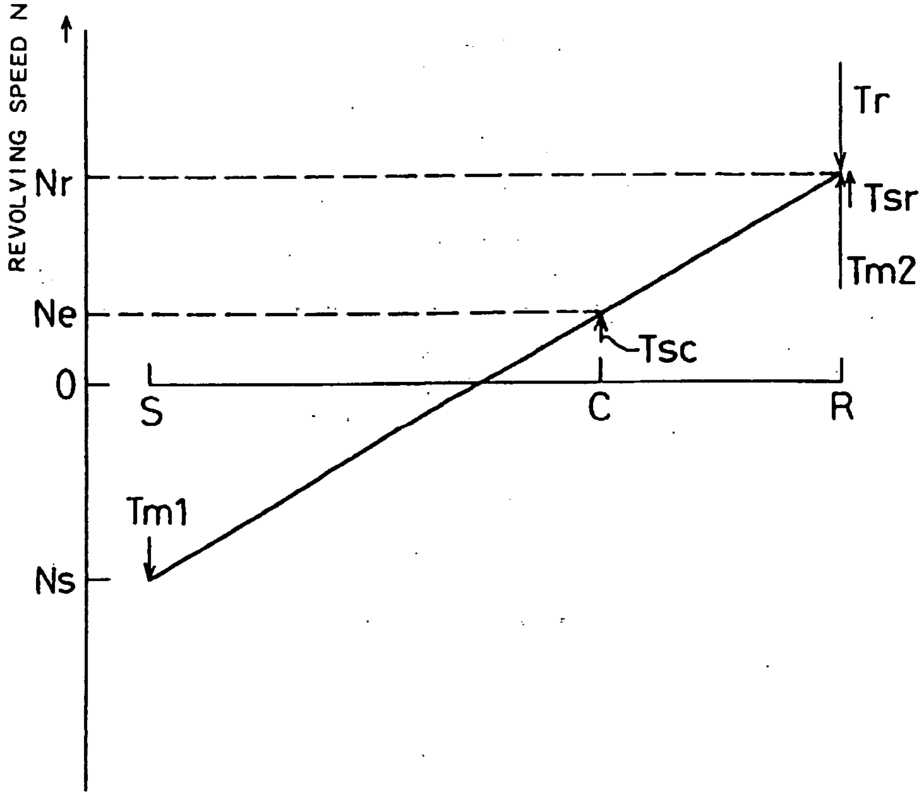

REVOLVING SPEED N
Tr
Nr
Tsr
Tm2
Ne
Tsc
0
S
C
R
Tm1
Ns

Fig. 15

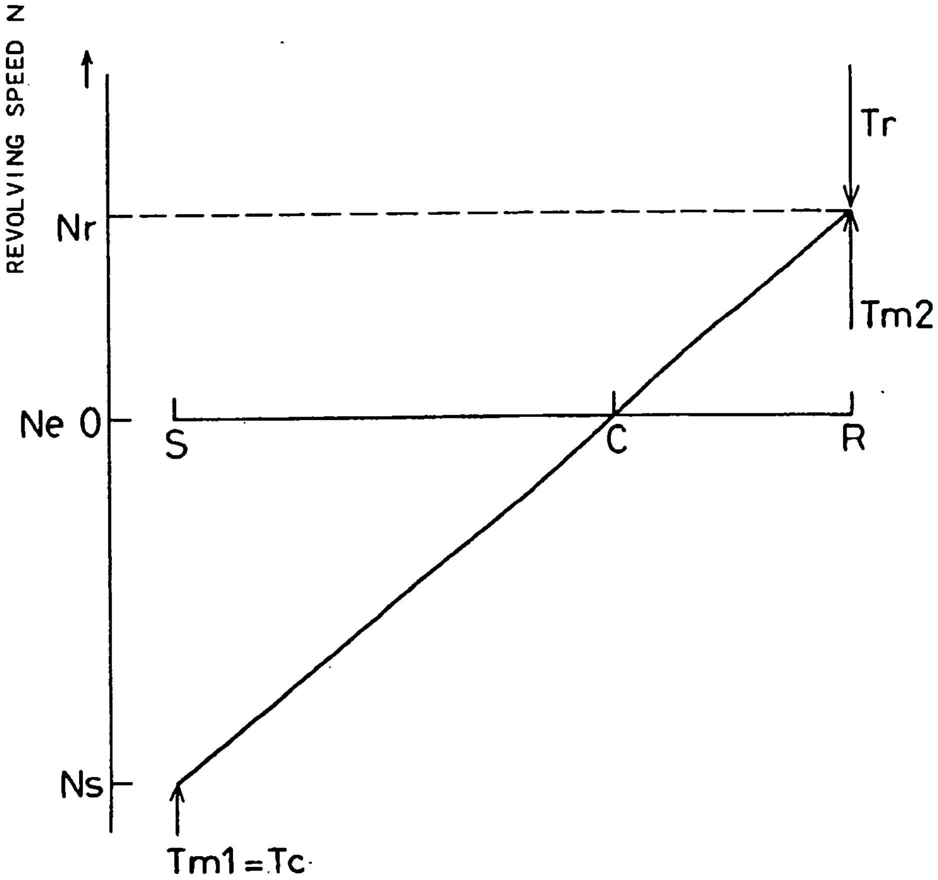


Fig. 16

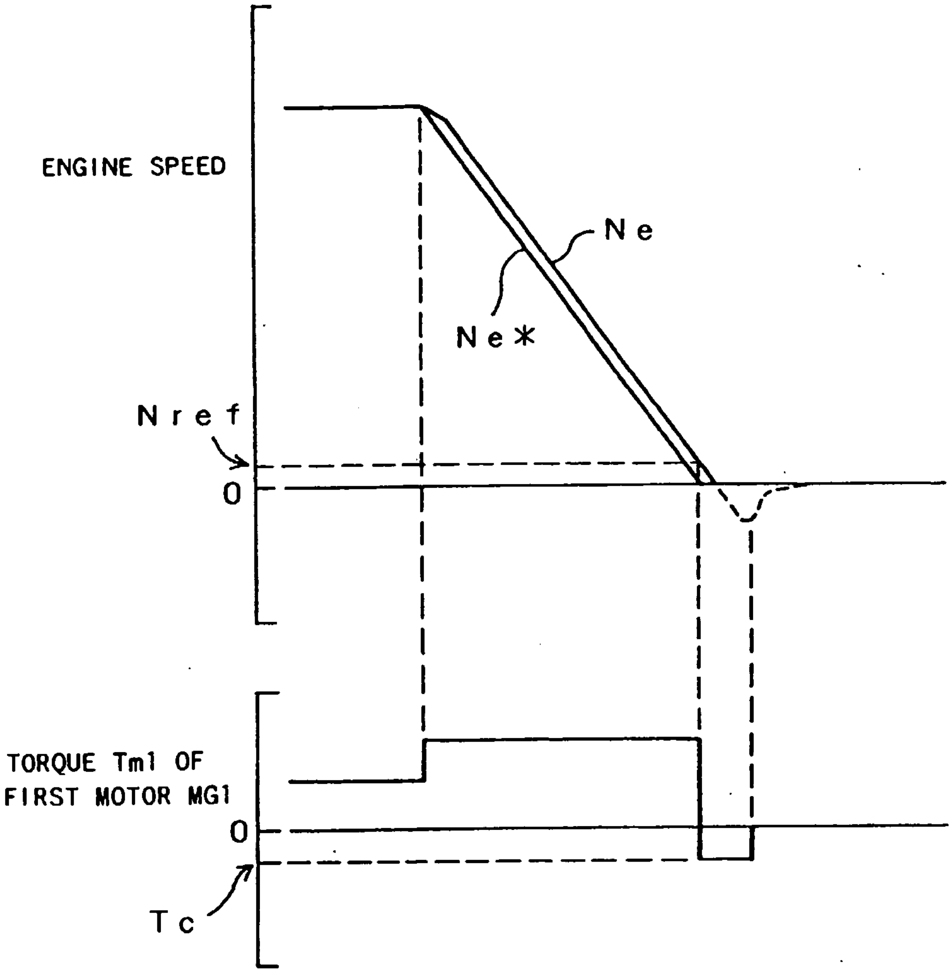


Fig. 17

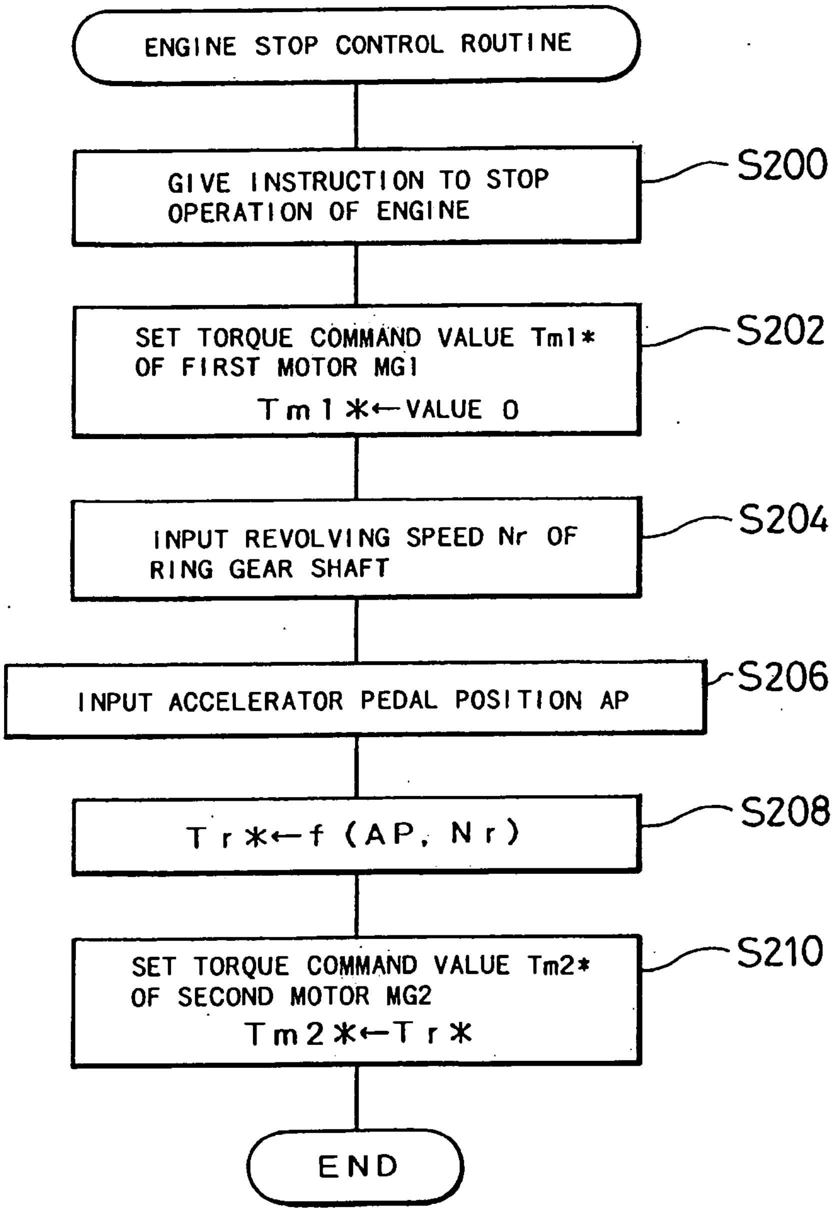

ENGINE STOP CONTROL ROUTINE
GIVE INSTRUCTION TO STOP OPERATION OF ENGINE
S200
SET TORQUE COMMAND VALUE Tm1* OF FIRST MOTOR MG1
Tm1*←VALUE 0
S202
INPUT REVOLVING SPEED Nr OF RING GEAR SHAFT
S204
INPUT ACCELERATOR PEDAL POSITION AP
S206
Tr*←f (AP, Nr)
S208
SET TORQUE COMMAND VALUE Tm2* OF SECOND MOTOR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

Fig. 18

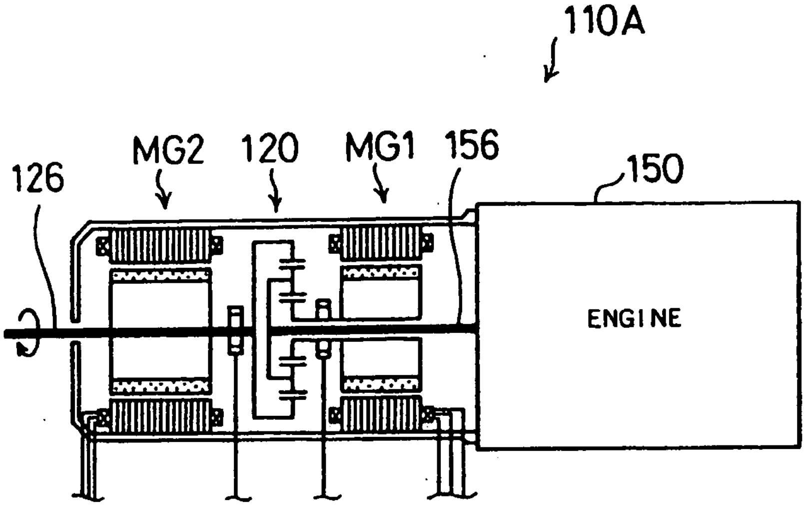

110A
MG2
120
MG1
156
126
150
ENGINE

Fig. 19

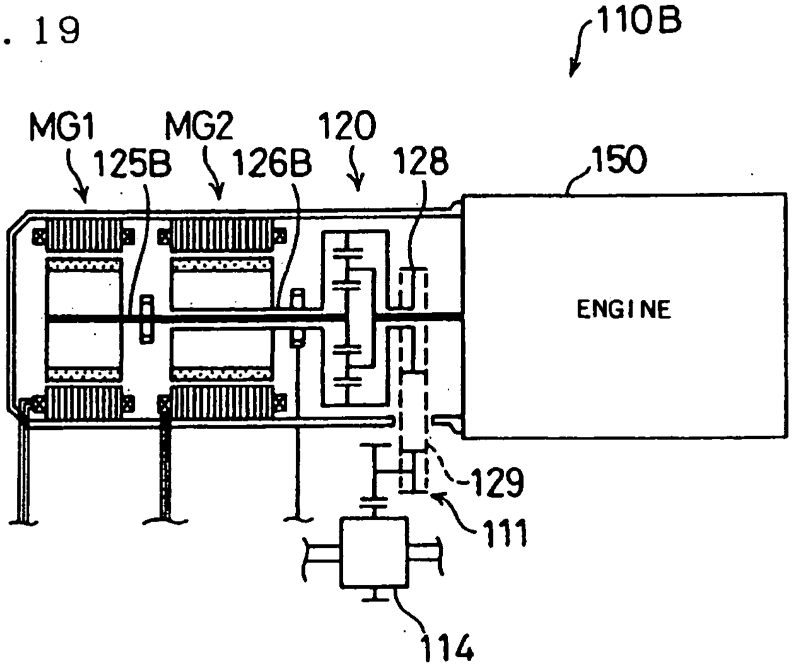

110B
MG1
MG2
120
125B
126B
128
150
ENGINE
129
111
114

Fig. 20

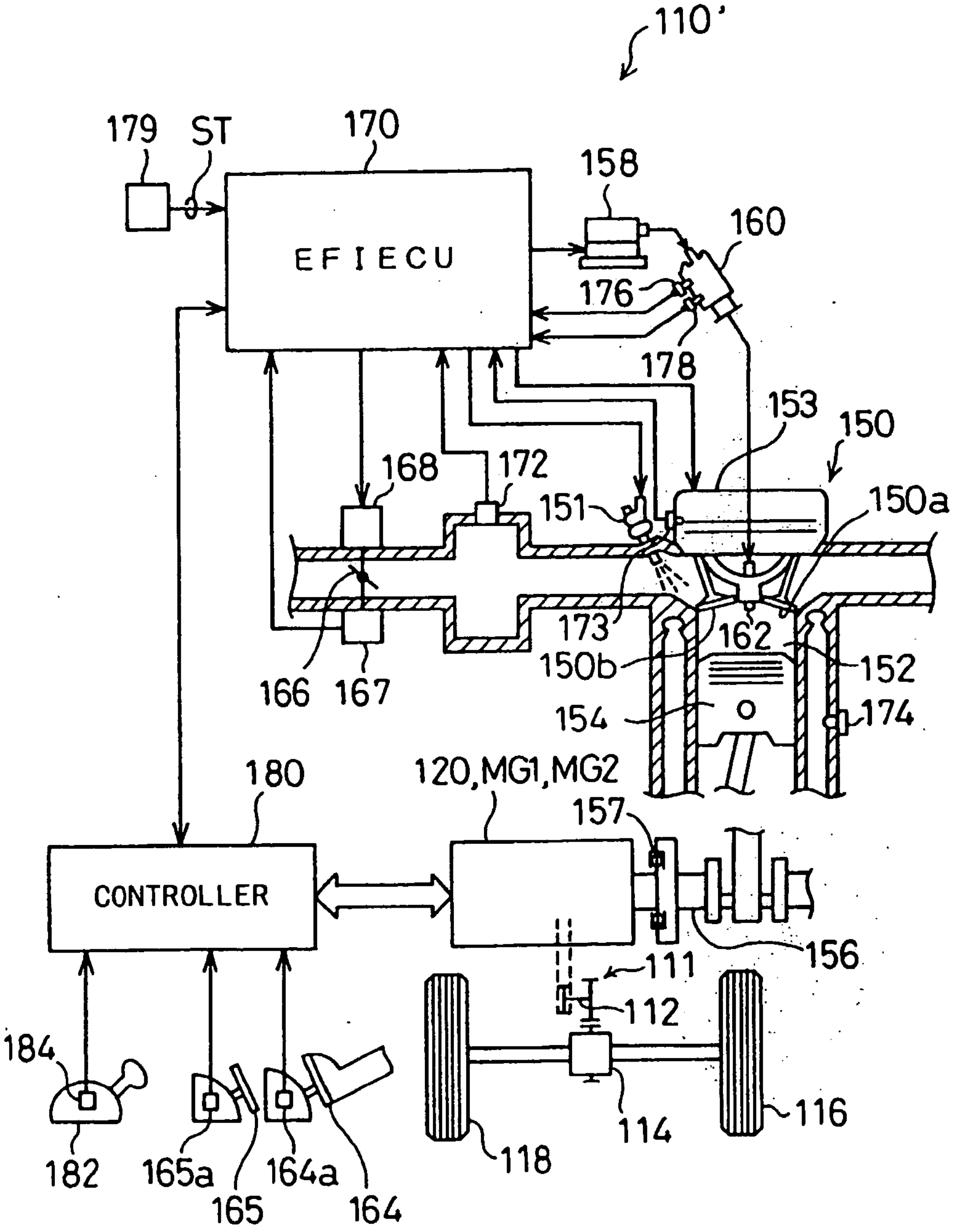

110'
179
ST
170
EFIECU
158
160
176
178
153
150
168
172
151
150a
173
162
152
150b
166
167
154
174
180
120,MG1,MG2
157
CONTROLLER
156
111
112
184
114
116
182
165a
165
164a
164
118

Fig. 21

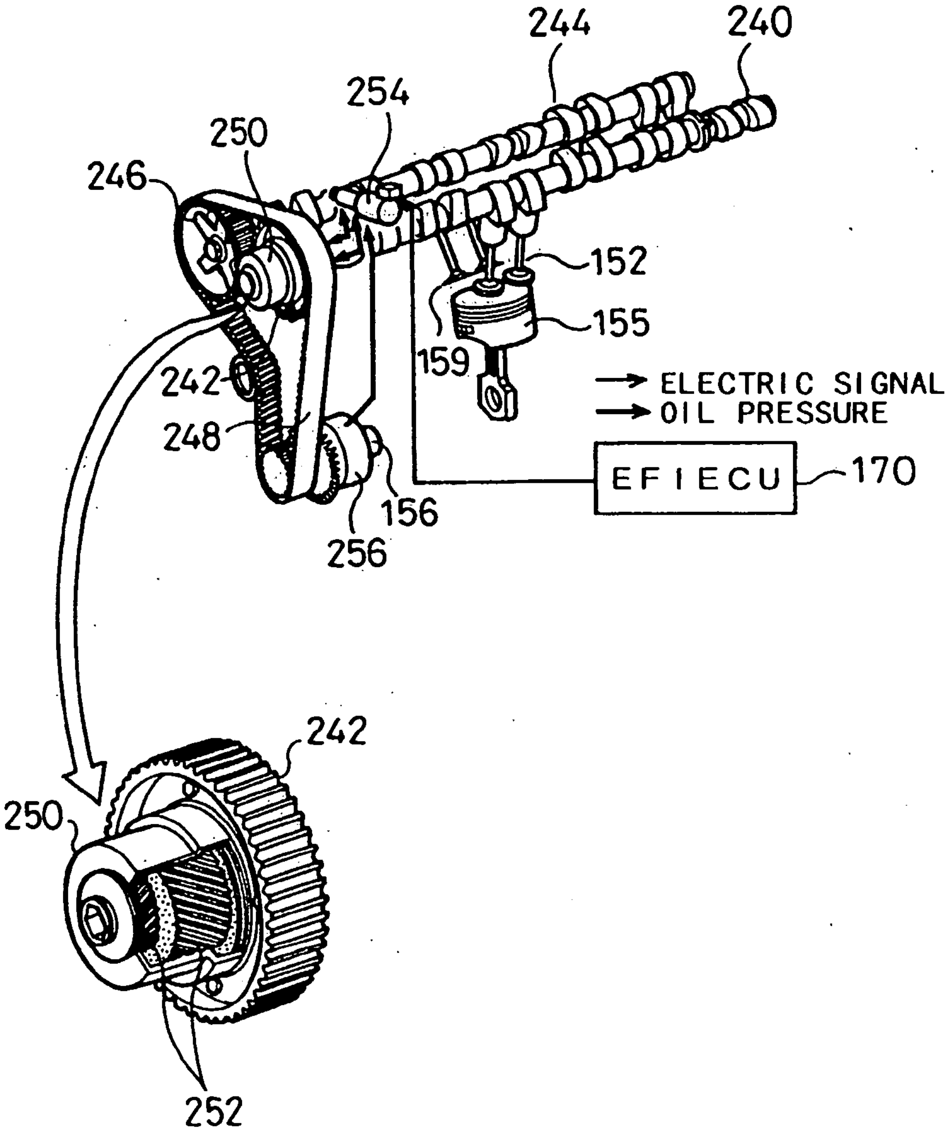

244
240
254
250
246
152
155
159
242
→ ELECTRIC SIGNAL
→ OIL PRESSURE
248
EFI ECU
170
156
256
242
250
252

Fig. 22

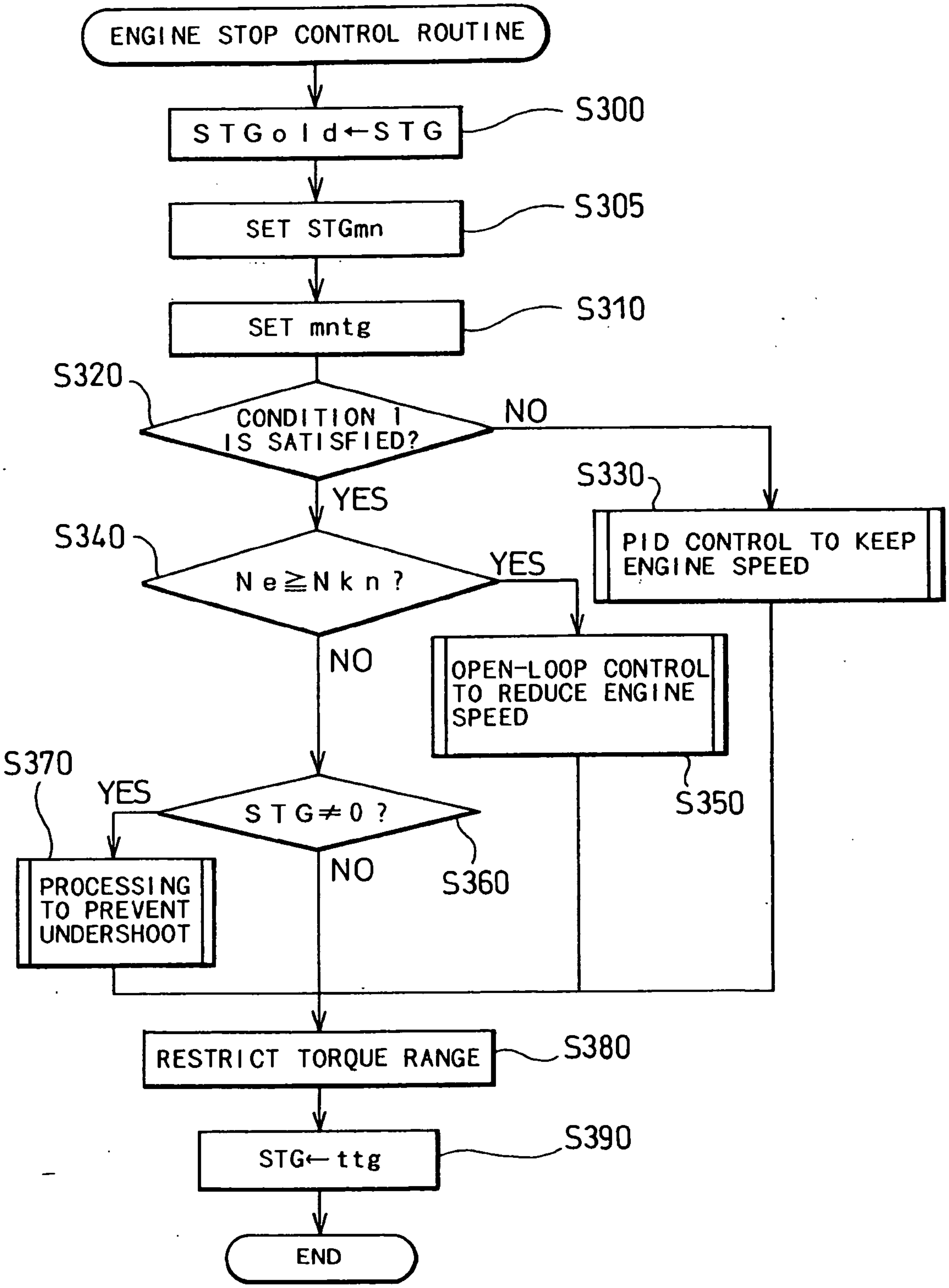

ENGINE STOP CONTROL ROUTINE
STGold←STG
S300
SET STGmn
S305
SET mntg
S310
S320
CONDITION 1 IS SATISFIED?
NO
YES
S330
PID CONTROL TO KEEP ENGINE SPEED
S340
Ne≧Nkn ?
YES
NO
OPEN-LOOP CONTROL TO REDUCE ENGINE SPEED
S350
S370
YES
STG≠0 ?
NO
S360
PROCESSING TO PREVENT UNDERSHOOT
RESTRICT TORQUE RANGE
S380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

Fig. 23

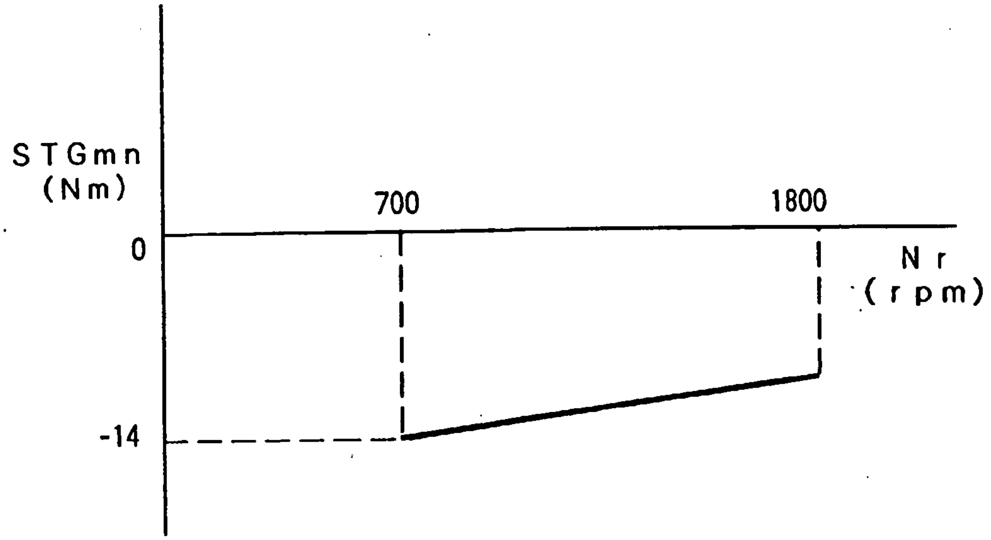


Fig. 24

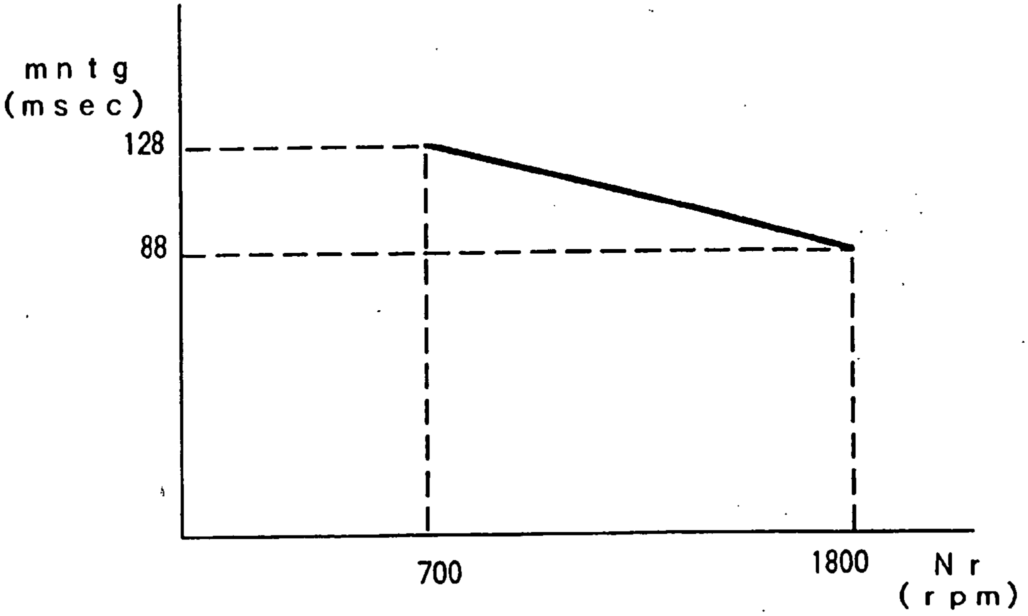


Fig. 25

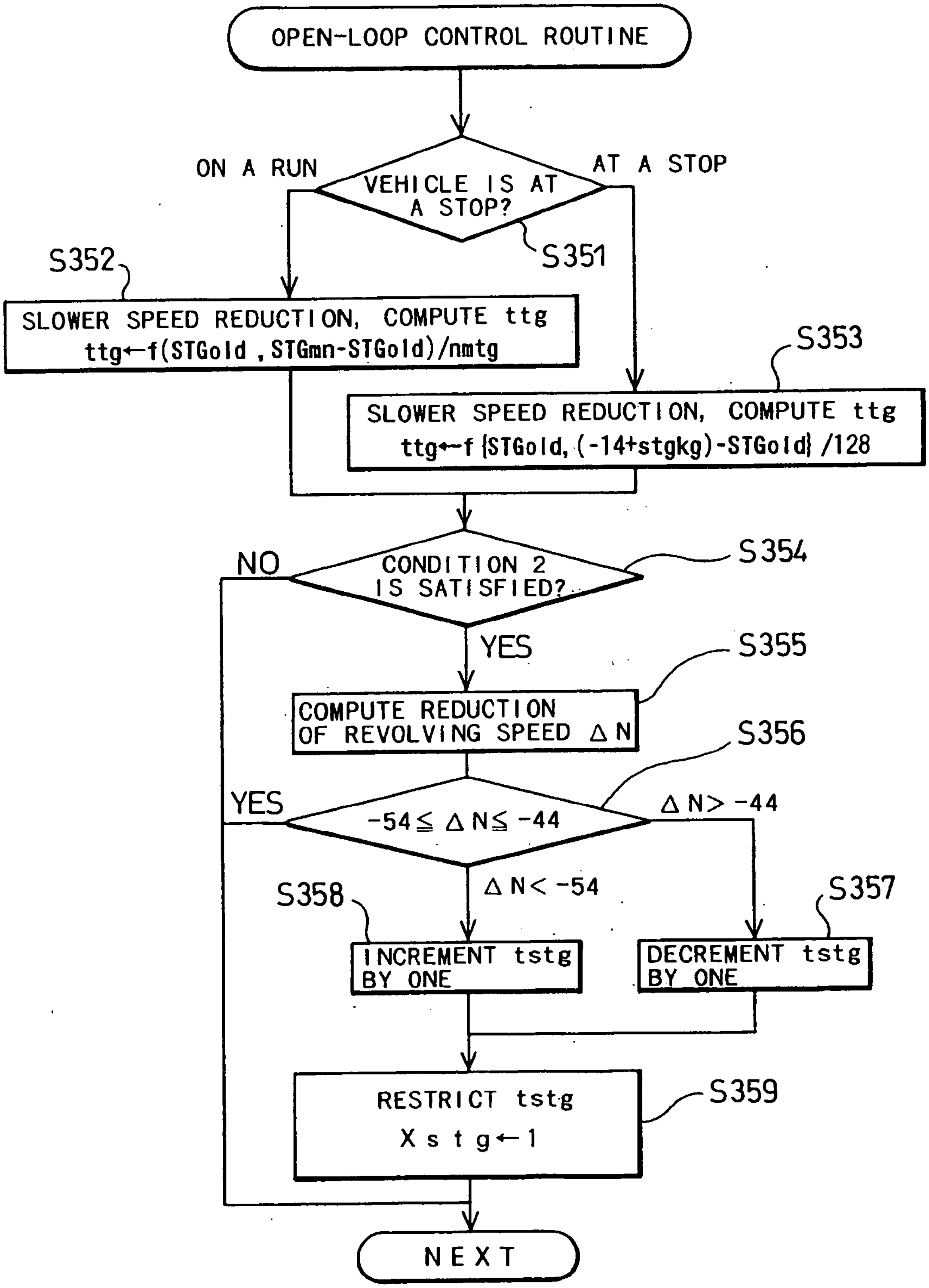

OPEN-LOOP CONTROL ROUTINE
VEHICLE IS AT A STOP?
S351
ON A RUN
AT A STOP
S352
SLOWER SPEED REDUCTION, COMPUTE ttg
ttg←f(STGold, STGmn-STGold)/nmtg
S353
SLOWER SPEED REDUCTION, COMPUTE ttg
ttg←f {STGold, (-14+stgkg)-STGold} /128
CONDITION 2 IS SATISFIED?
S354
NO
YES
S355
COMPUTE REDUCTION OF REVOLVING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

Fig. 26

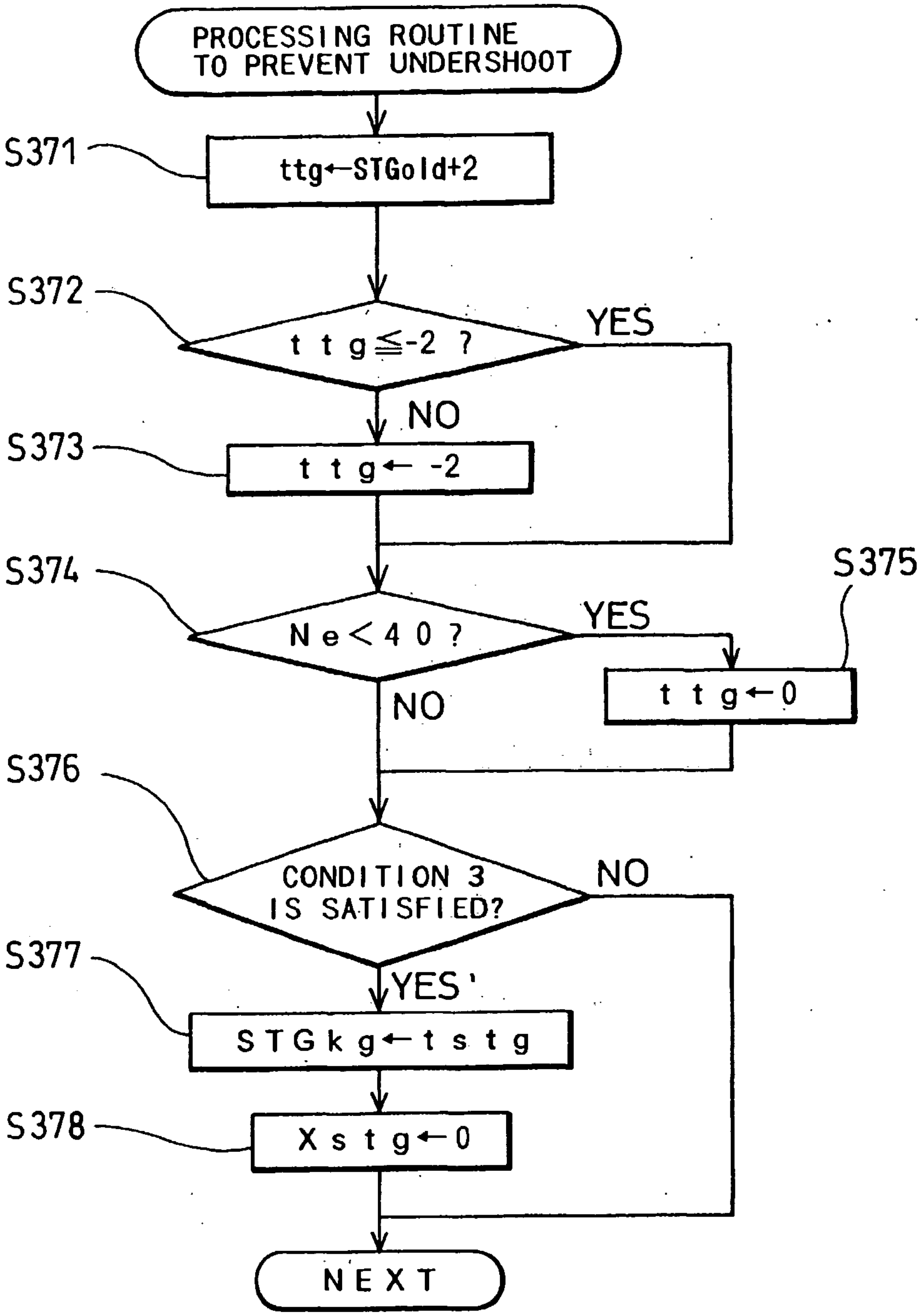

PROCESSING ROUTINE TO PREVENT UNDERSHOOT
S371
ttg←STGold+2
S372
ttg≦-2 ?
YES
NO
S373
ttg← -2
S374
Ne<40 ?
YES
S375
ttg←0
NO
S376
CONDITION 3 IS SATISFIED?
NO
S377
YES
STGkg←tstg
S378
Xstg←0
NEXT

Fig. 27

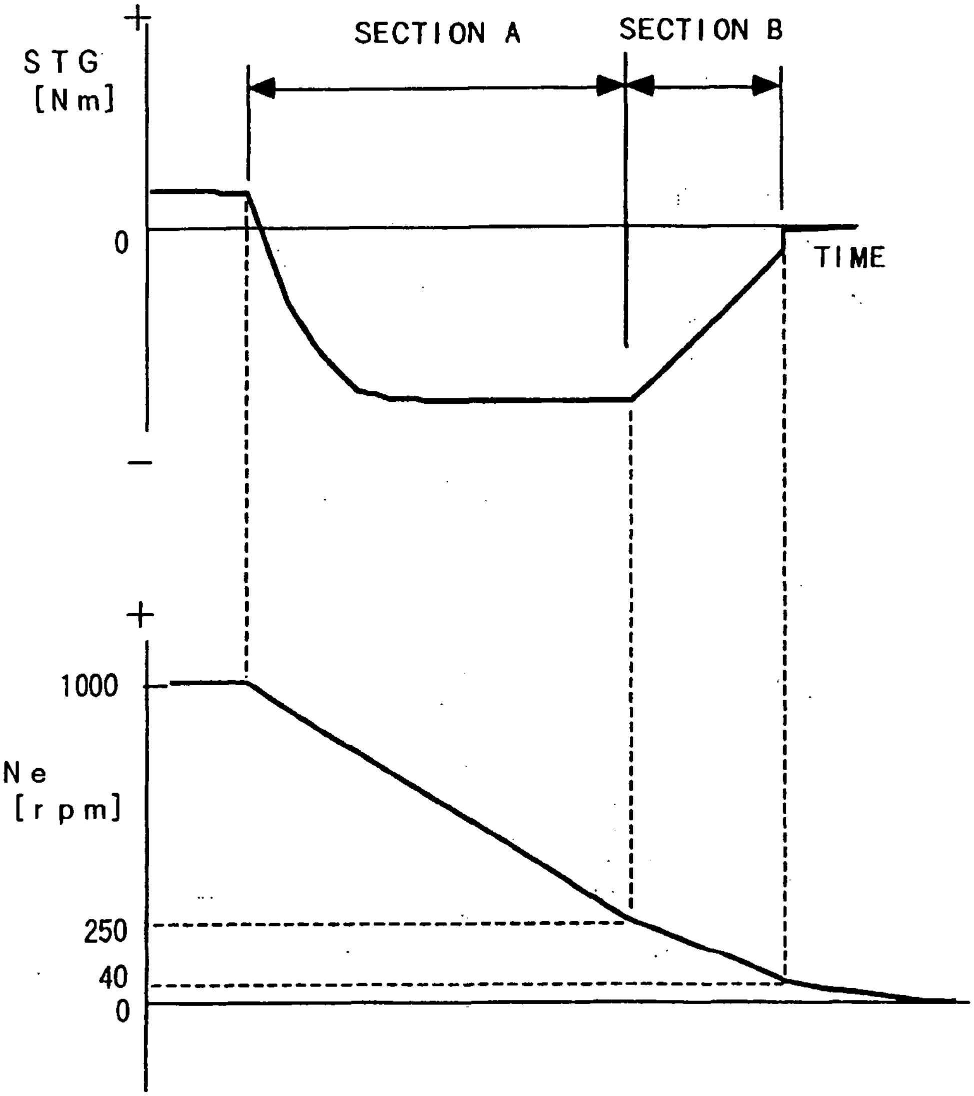
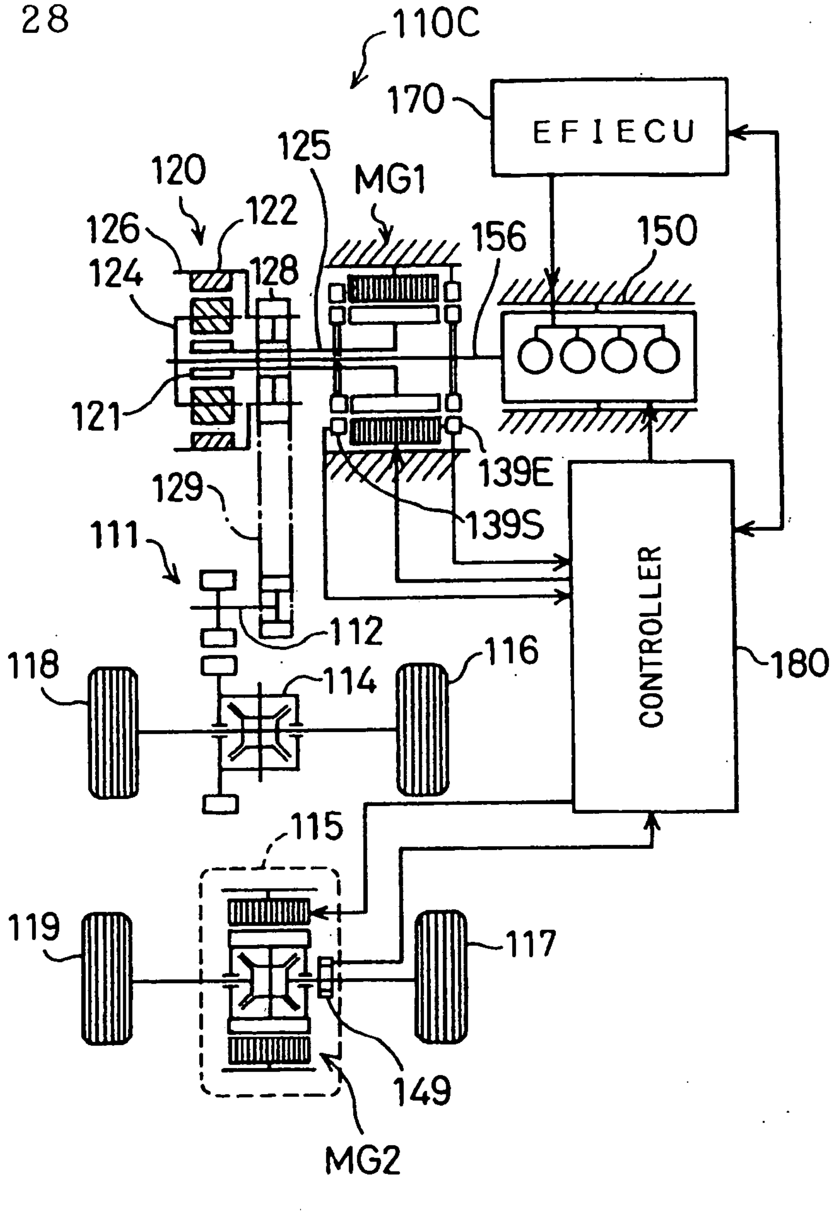


Fig. 28


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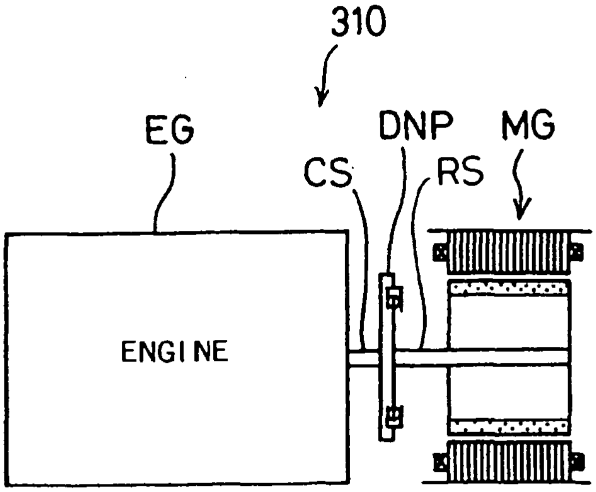
149
MG2

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 T	JP 08 295140 A (AQUEOUS RES:KK) 12 November 1996 * figures 2,7-9 * & US 5 788 006 A * claims 2,3 *	1,11,19, 20	
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	
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	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
B60K B60L H02K F02D F16F F02B

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
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 97 11 8748

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The members are as contained in the European Patent Office EDP file on
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23-04-1999

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		WO 9636507 A	21-11-1996
		JP 9175203 A	08-07-1997
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		JP 9047096 A	14-02-1997
		JP 9047011 A	14-02-1997
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RÉPUBLIQUE FRANÇAISE

INSTITUT NATIONAL
DE LA PROPRIÉTÉ INDUSTRIELLE

PARIS

⑪ N° de publication : **2 419 832**
(A n'utiliser que pour les commandes de reproduction).

A1

DEMANDE DE BREVET D'INVENTION

㉑ **N° 78 08080**

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(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.

㉝㉜㉛ 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, 60640 Guiscard.

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 IO Km pendant 5 à IO 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 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.

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 ...

amélioration du rendement et de l'encombrement, par le genre et la disposition des engrenages qu'il comporte, à savoir: pour la boîte 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 boîte 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.

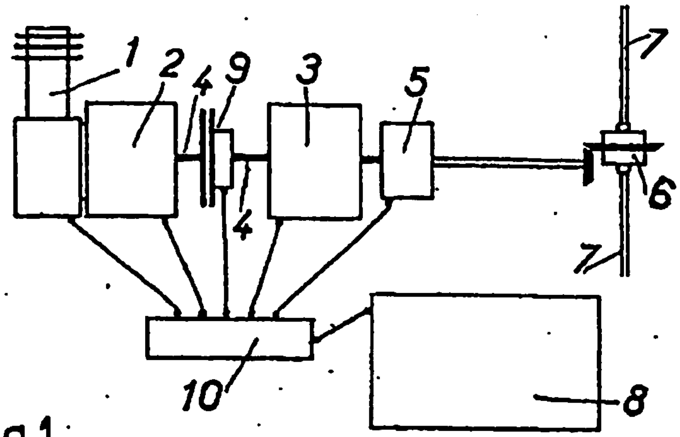

fig 1

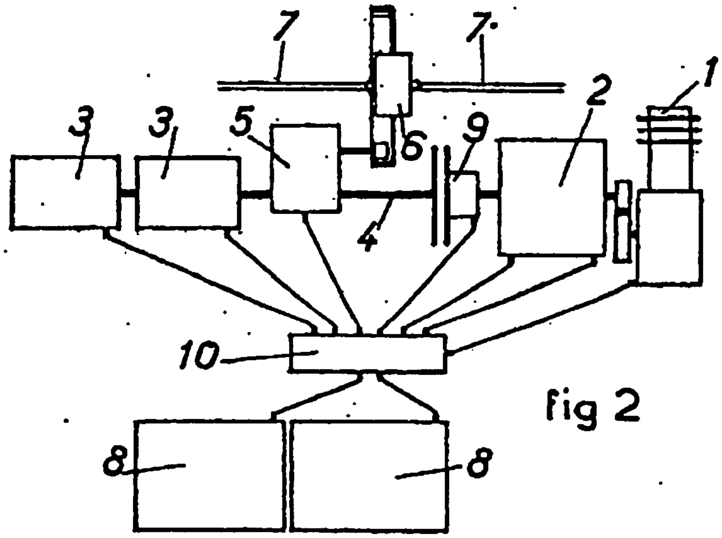

fig 2

TRANSPERFECT | TRANSLATIONS

ATLANTA
BOSTON
BRUSSELS
CHICAGO
DALLAS
DENVER
FRANKFURT
HONG KONG
HOUSTON
LONDON
LOS ANGELES
MIAMI
MINNEAPOLIS
NEW YORK
PARIS
PHILADELPHIA
SAN DIEGO
SAN FRANCISCO
SEATTLE
WASHINGTON, DC

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Sworn to before me this
1st day of March, 2004

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FRENCH REPUBLIC NATIONAL INDUSTRIAL PROPERTY INSTITUTE PARIS	11 Publication no. (To be used only for reproduction orders.)	*2 419 832*

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:

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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 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

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.

Sole drawing

[see source for figures 1 and 2]

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(54)発明の名称　電気自動車用補機電池充電装置

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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。

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

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

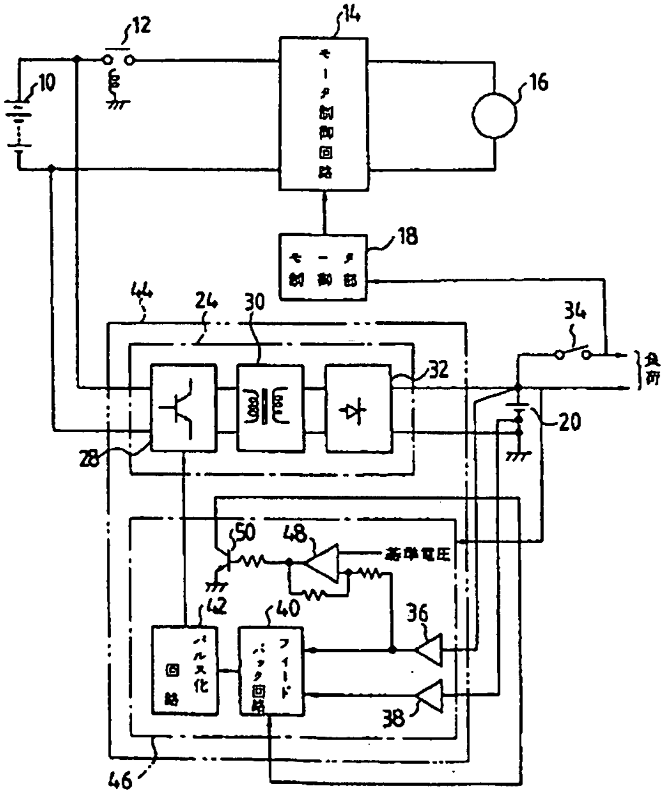
第１図は、本発明の第１実施例に係る電気自動車用補機電池充電装置の構成を示す構成図、

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。

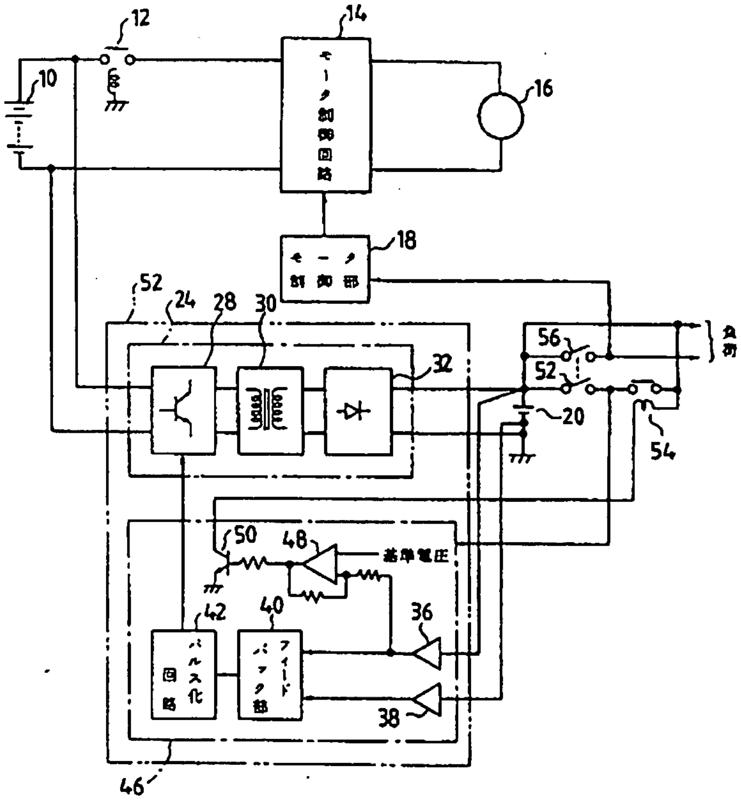
１０ … 主電池
１６ … モータ
２０ … 補機電池
２４ … ＤＣ－ＤＣコンバータ
３４，５２，５６ … キースイッチ
３６ … 電圧検出アンプ
４０ … フィードバック回路
４２ … パルス化回路
４６ … ＤＣ－ＤＣコンバータ制御部
４８ … コンパレータ
５０ … トランジスタ

出願人 トヨタ自動車株式会社
代理人 弁理士 吉 田 研 二
(外２名)〔D-35〕



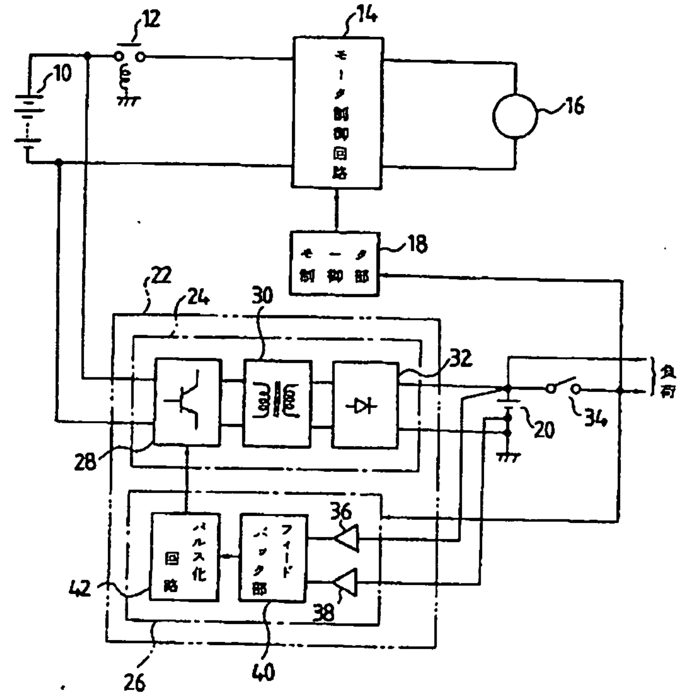
第1実施例の構成

第1図



第2実施例の構成

第2図


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

Date: May 13, 2004

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

⑲日本国特許庁（JP）　⑪特許出願公告
⑫特許公報（B2）　平5－64531
(51)Int.Cl.^{5}　識別記号　庁内整理番号　(24)(44)公告　平成5年(1993)9月14日
H 02 J 7/00　303 C　9060－5G
R　9060－5G
発明の数 1 （全5頁）

(54)発明の名称　電気自動車の補機バッテリー充電装置

(21)特　願　昭59－197704　(65)公　開　昭61－76034
(22)出　願　昭59(1984)9月20日　(43)昭61(1986)4月18日

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(74)代理人　弁理士　足立　勉
審査官　吉村　博之

(57)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。

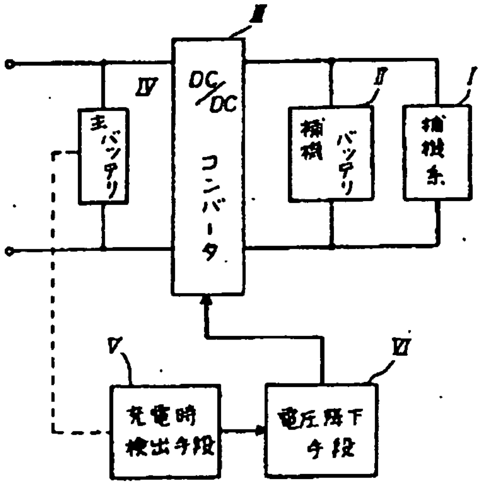
従つて、車両が走行中など通常の負荷状態であれば主バッテリーからの電力はDC−DCコンバータによつて補機バッテリーよりも高い電圧に変圧されて負荷および補機バッテリーに伝送されるので、補機バッテリーは充分に充電を受けることができるとともに高負荷に対処することができる。しかも、車両が充電中となり、負荷が軽い状態となつたことを充電時検出手段が検出すると、電圧降下手段によつて自動的に主バッテリーからの電力供給電圧は補機バッテリーよりも僅かに高い電圧にまで降下されて実行される。これにより、補機バッテリーは主バッテリーからの電力のほとんど全てを供給されるにも拘らず過充電に至ることはなく、主バッテリーの電力の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

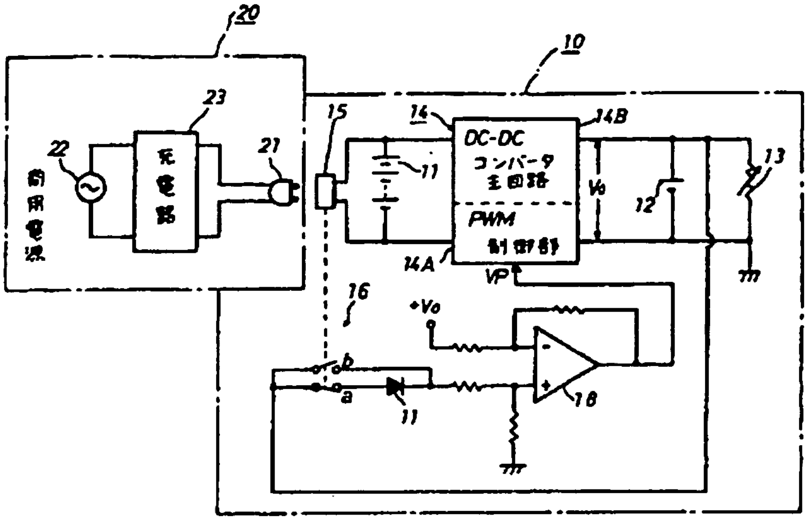
第１図は本発明の基本的構成図、第２図はその一実施例の回路ブロック図を示す。

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.

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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.

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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7字加入
6字削
5字削

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

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ーソレノイドバルブ、18ー油圧スイッチ、19ー比較器、20ーANDゲート、25ーインバータ、27ー界磁コイル、31ーコイル

実用新案
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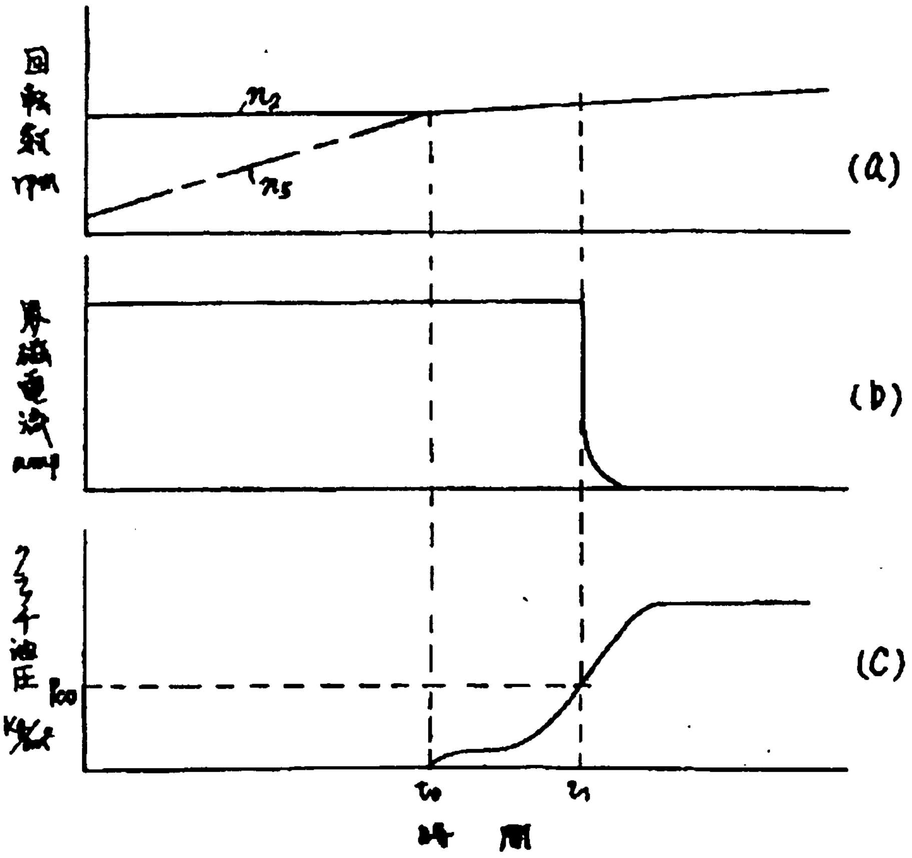
代理人　石山　博

同　中平　治

第3図



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実用新案
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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~~

6. 前記以外の考案者、~~実用新案登録出願人~~および代理人

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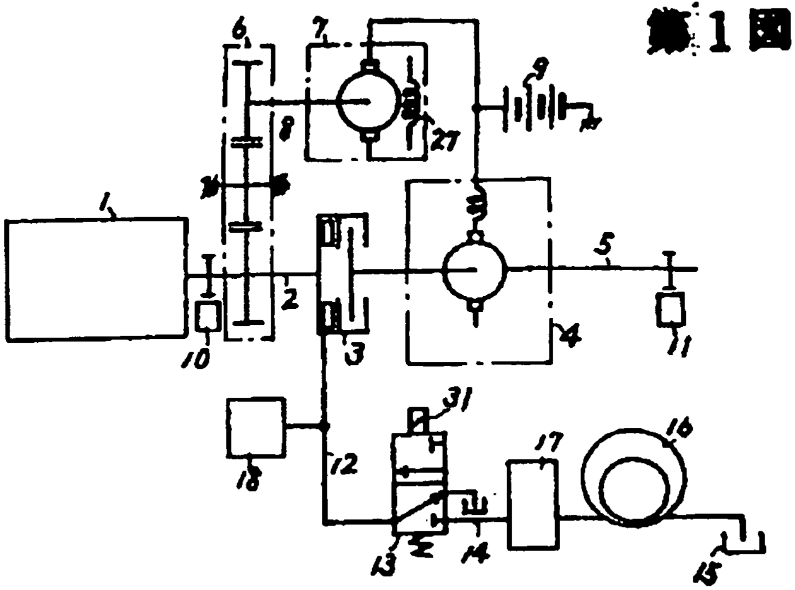
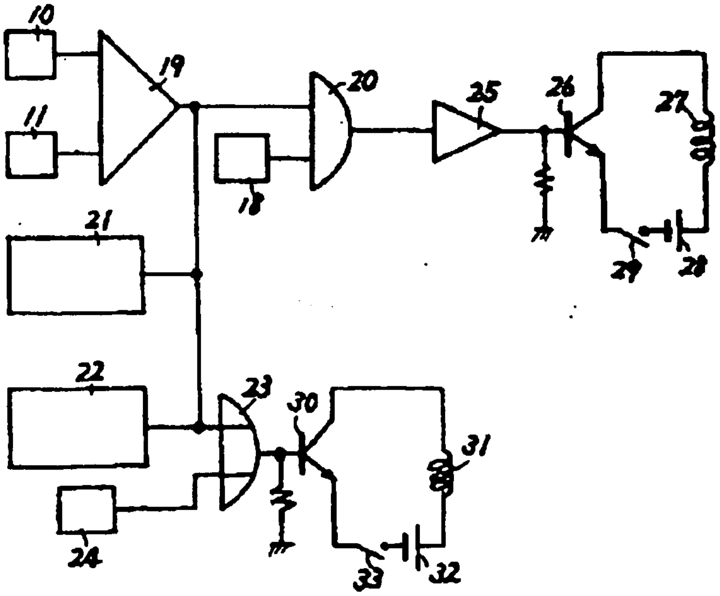
第1図



第2図



103220 1/2 実用新案登録出願人 トヨタ自動車工業株式会社
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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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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 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（フクゴウデンキジドウシャヨウ）

2. 特許請求の範囲に記載された発明の数　4

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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才3の要素の回転が拘束されて、前記才2の直流電動機の動力が前記才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才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才　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才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押え、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善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。

才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、才2図に才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は才1のクラッチ4のクラッチドラム5と才2のクラッチ6のクラッチハブ7に連結され、才1のクラッチ4のクラッチハブ8が才1の中間軸9を介して遊星歯車装置20の才1のサンギヤ21に連結され、才2のクラッチ6のクラッチドラム10が才2の中間軸11を介してその才2のサンギヤ22に連結され、更に才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は才1、才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、これらのうちの才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、才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才1のサンギヤ21の歯数z_{21}と才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、才1、才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の才2のサンギヤ22と一体的な才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。こうして才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の才2のサンギヤ22の回転を拘束すると、才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からの動力がオ1のクラッチ4の作動によりオ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からの動力が夫々オ2のサンギヤ22またはリングギヤ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はキャリヤ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、この場合オ3図に示されるようにオ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、オ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、零からオ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を経てオ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以下の場合はオ2の直流電動機37が、0.3以上の場合はオ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。

続くオ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。更にオ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。

また最後の第6図に於て差動歯車装置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、第2のピニオンギヤ23′がキャリヤ27を介して第1の中間軸9に連結され、第1のピニオンギヤ24′を支承するキャリヤ26が第2のピニオンギヤ23′と噛合する第2のリングギヤ25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。また差動歯車装置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。

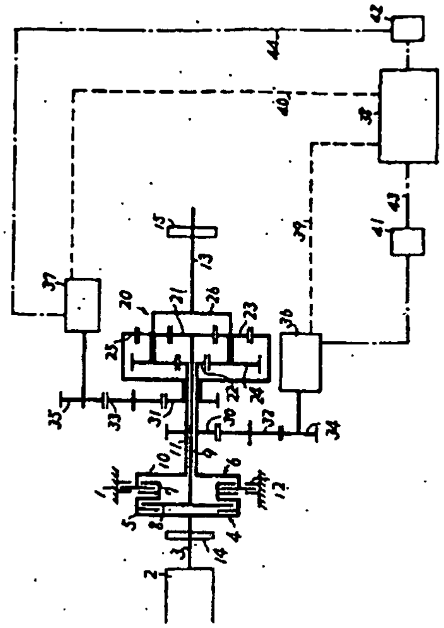
4　図面の簡単な説明

第1図は本発明のギヤトレーンの一例を示す構成図、第2図は第1図に於ける自動変速機構部分の構成を示す縦断面図、第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、第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、第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、第6図は本発明のギヤトレーンの他の例

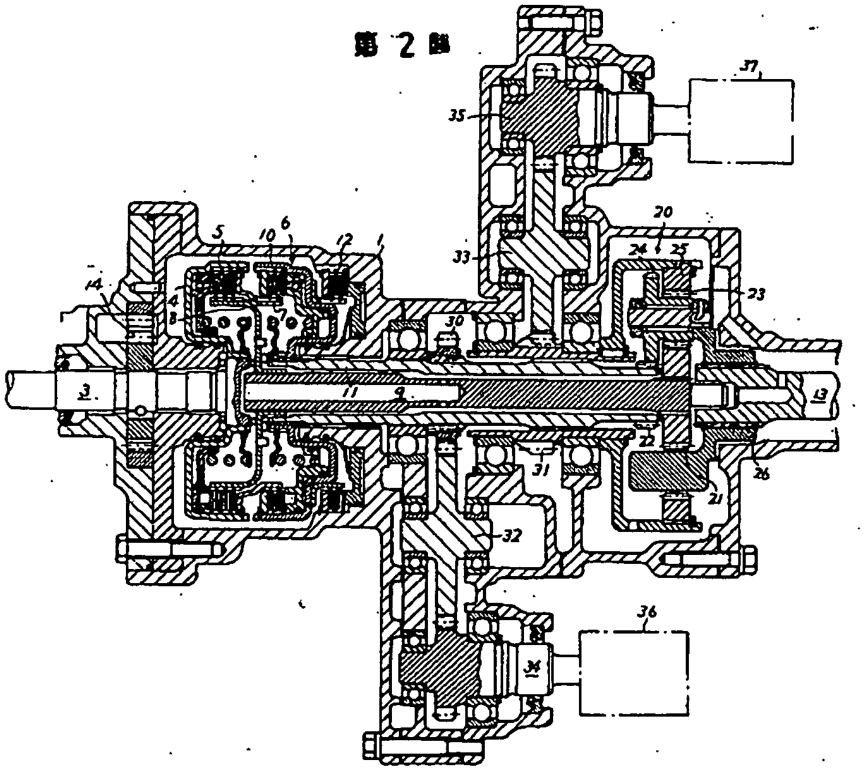
を示す構成図である。

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

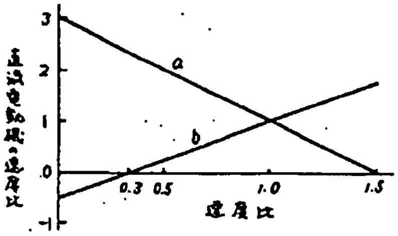
第1図



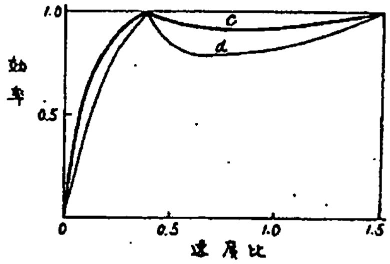
第2図



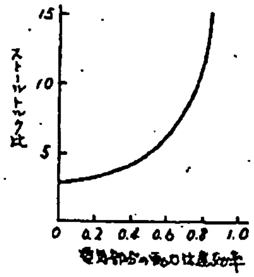
第 3 圖



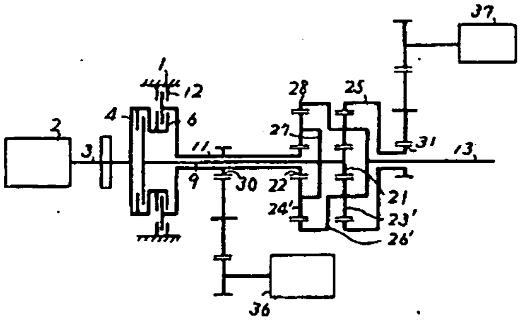
第 4 圖



第 5 圖



第 6 圖



4 添附書類の目録　1字訂正

(1) 願書副本　1 通

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(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~~　2行削除

~~( ) 優先権証明書及び訳文　各 通~~

5 前記以外の~~発明者、特許出願人および~~代理人　1字訂正 1字削除

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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

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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	79 A1
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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 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.

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
~~( ) Request for examination of the application~~	~~1~~

1 line deleted

(2) Specification	1
(3) Figures	1
(4) Power of Attorney	1
~~( ) Priority Assertions~~	~~1~~
~~( ) Certification and Translation of Priority Assertions~~	

2 lines deleted

~~6~~7 ~~Inventors, applicants or~~ agents other than mentioned above

12 characters corrected

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特許願

(2000円)　昭和48年7月21日

特許庁長官　三宅幸夫殿

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結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−E，E各モードをそれぞれの運転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E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6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35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50と連結している。一方において、電動機50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50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~~150~~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140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153に噛合う歯車152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3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73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523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570は遊星歯車機構350のリング歯車358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452,455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5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160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155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（$1+\rho$）／ρ 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量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。$e=\mathrm{Max}$（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ほとんど零になり、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3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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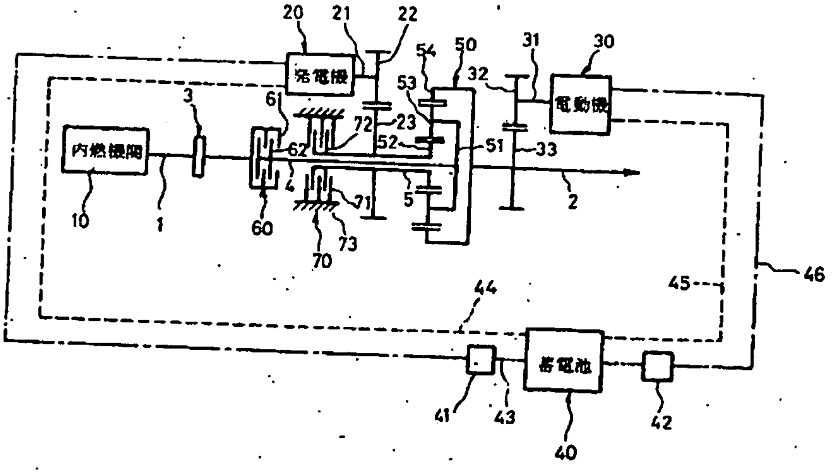
第1図



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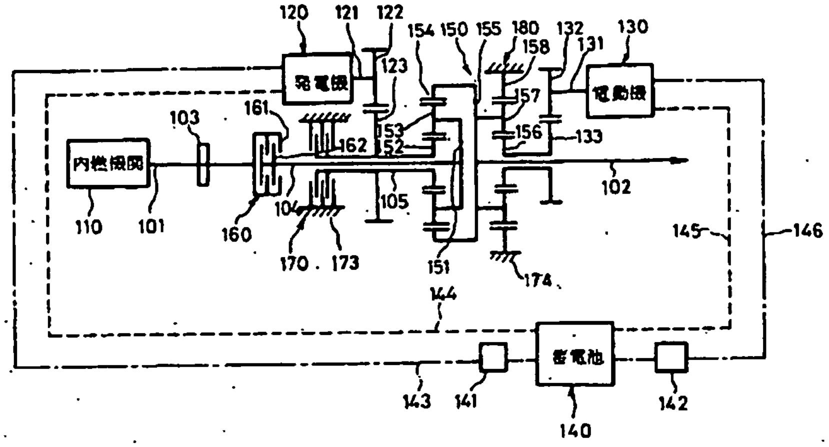
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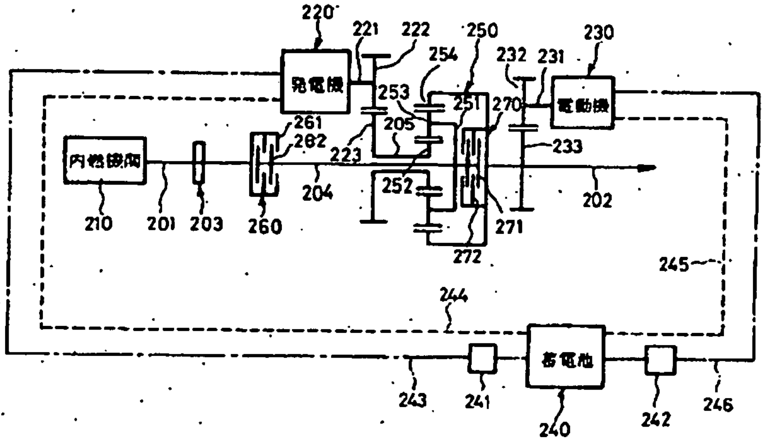
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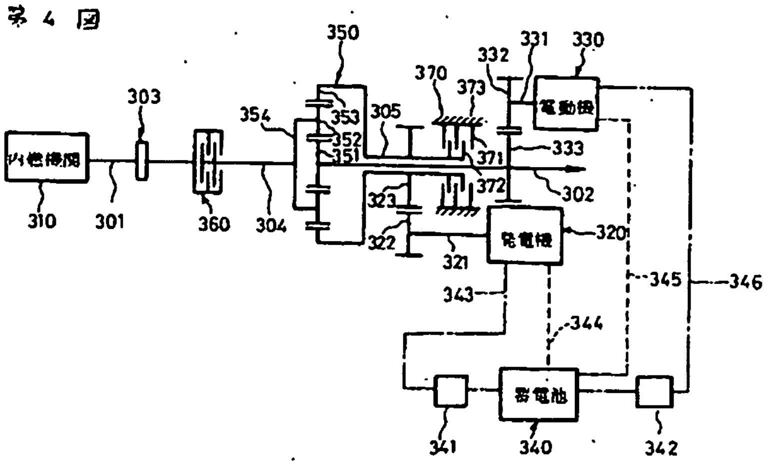
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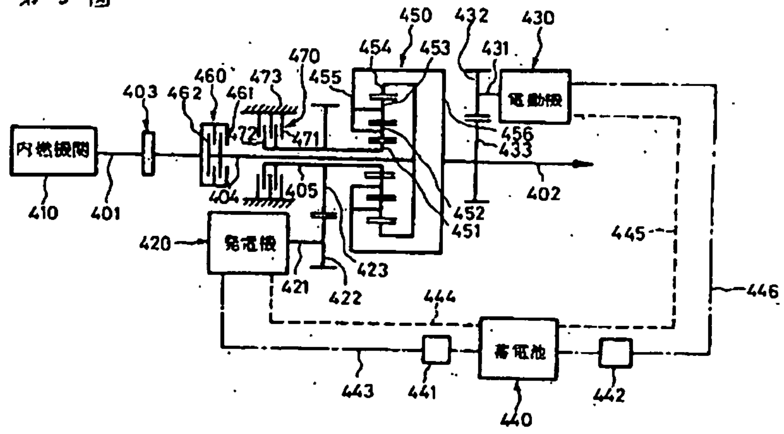
第 5 図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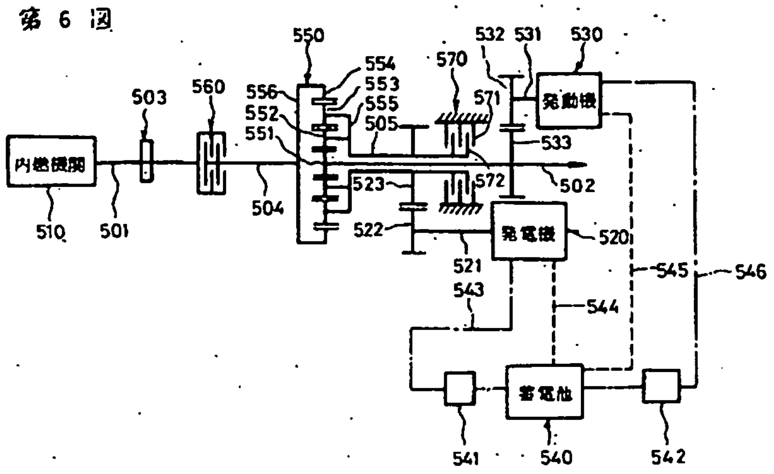
第 6 図



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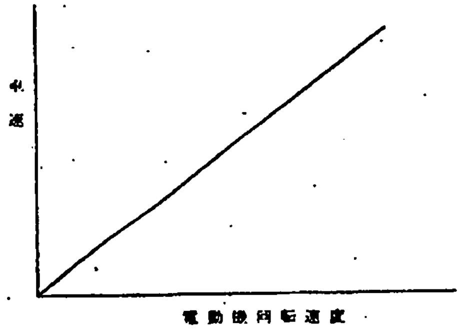

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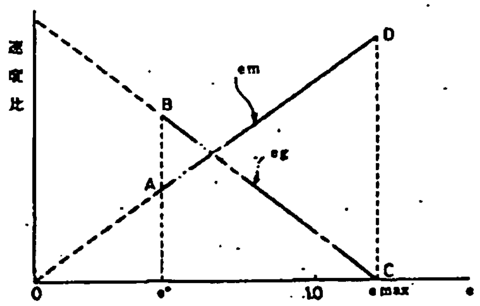
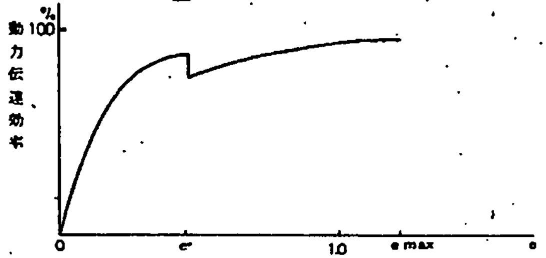


第 9 図



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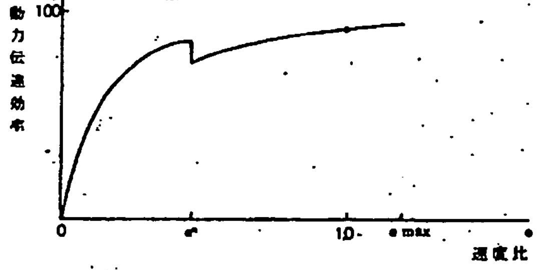

6.添附書類の目録

(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.

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Date: May 17, 2004

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Patent Application

(¥ 2000)

7/20/1973

Patent examiner: Yukio Miyake

1. Name of Invention
   Hybrid Electric Vehicle Gear transmission device
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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

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

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

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

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(3.10/3.09/3.3.3)

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).

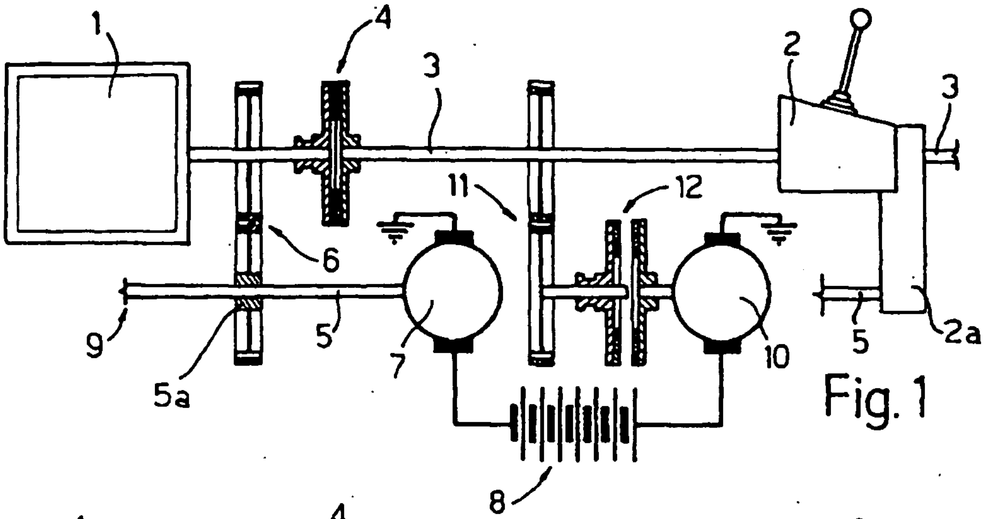

Fig. 1

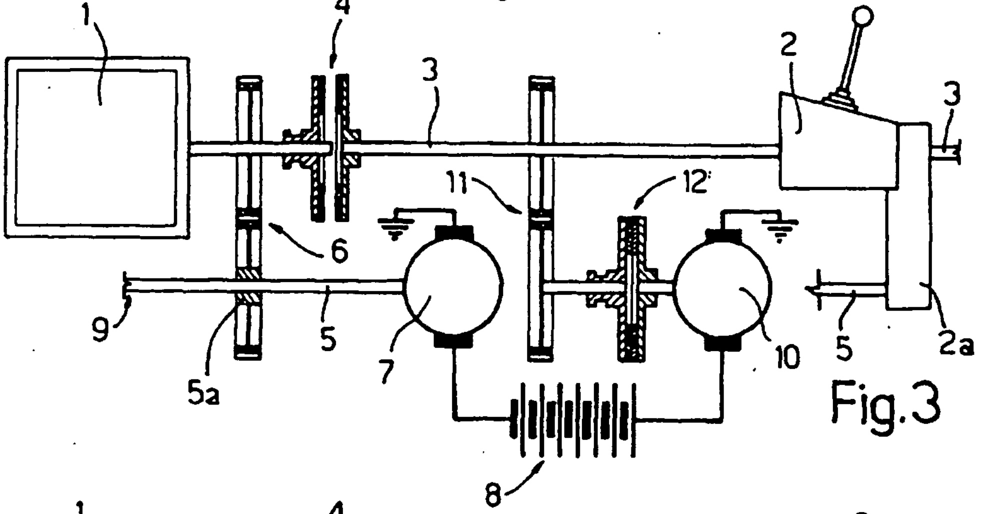

Fig.3

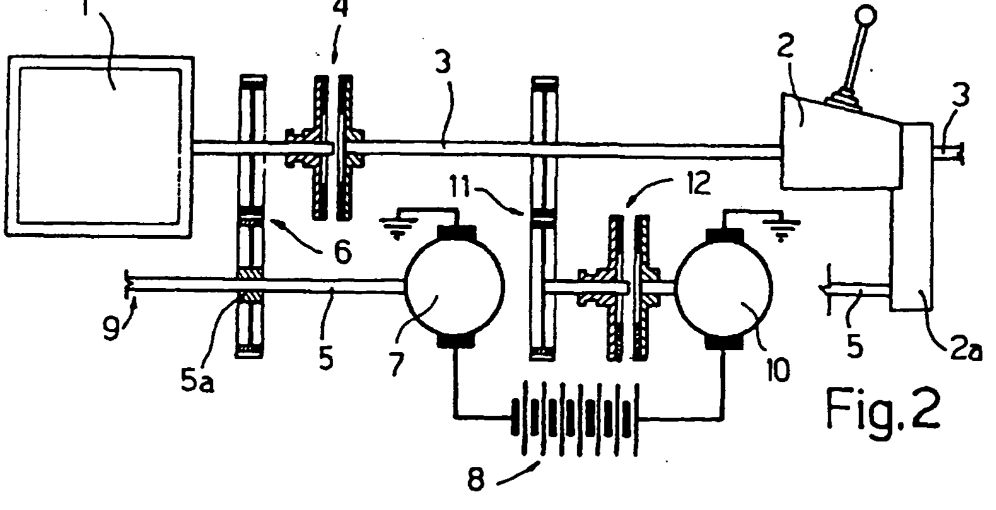

Fig.2

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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。

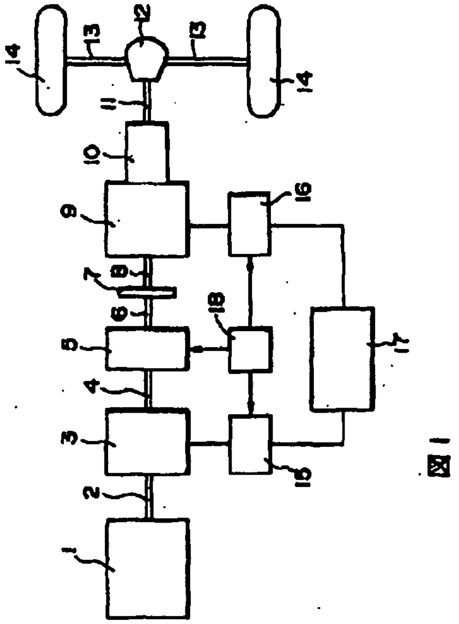


図1

【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】

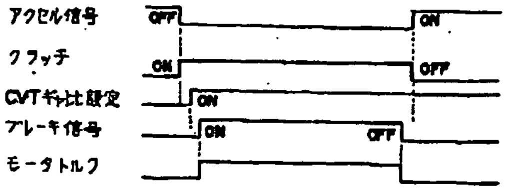


図５

【図1】

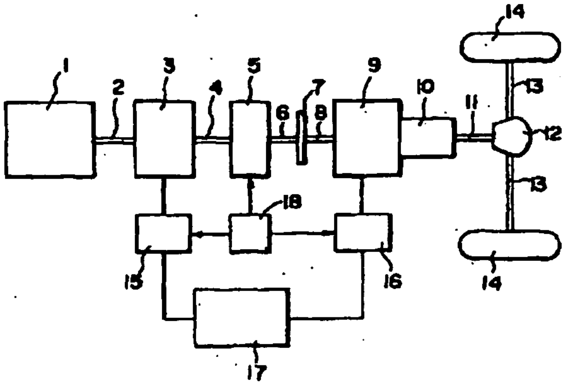
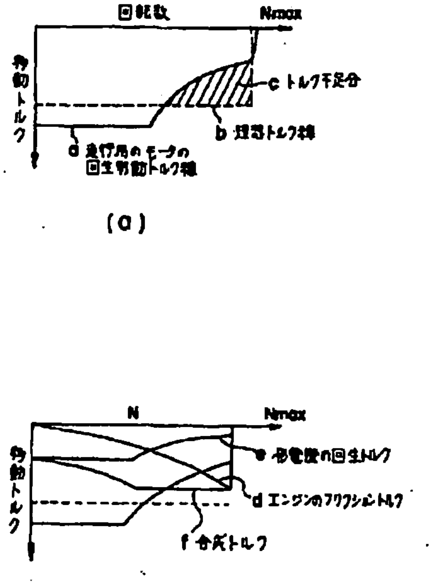


図1

【図3】

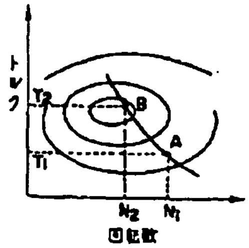


(a)

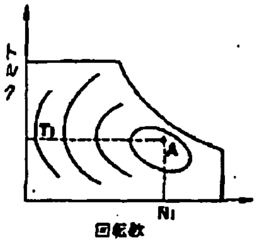
(b)

図3

【図2】



(a) エンジン



(b) モータ

図2

【図4】

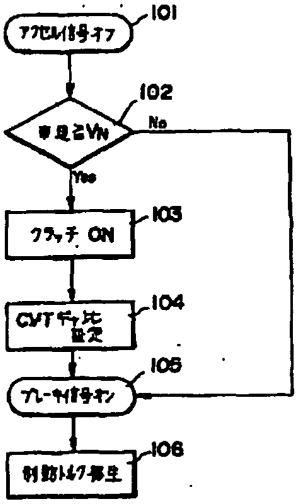


図4　フローチャート

フロントページの続き

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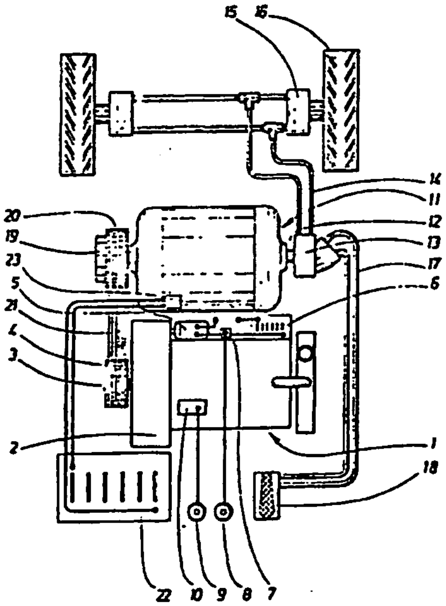
(54) Title: PROPULSION ARRANGEMENT FOR VEHICLES



(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.

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.

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.

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.

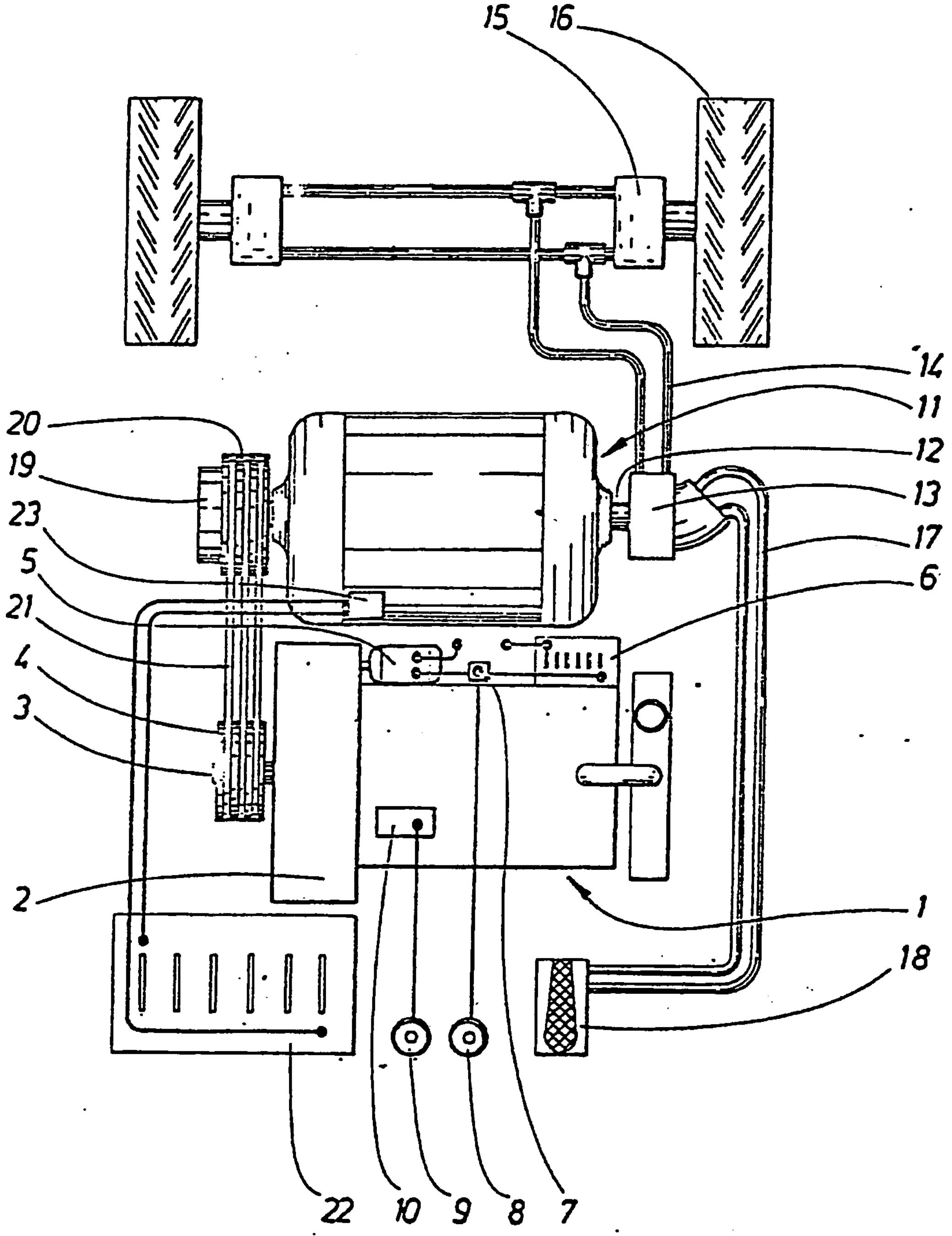

FIG. 1

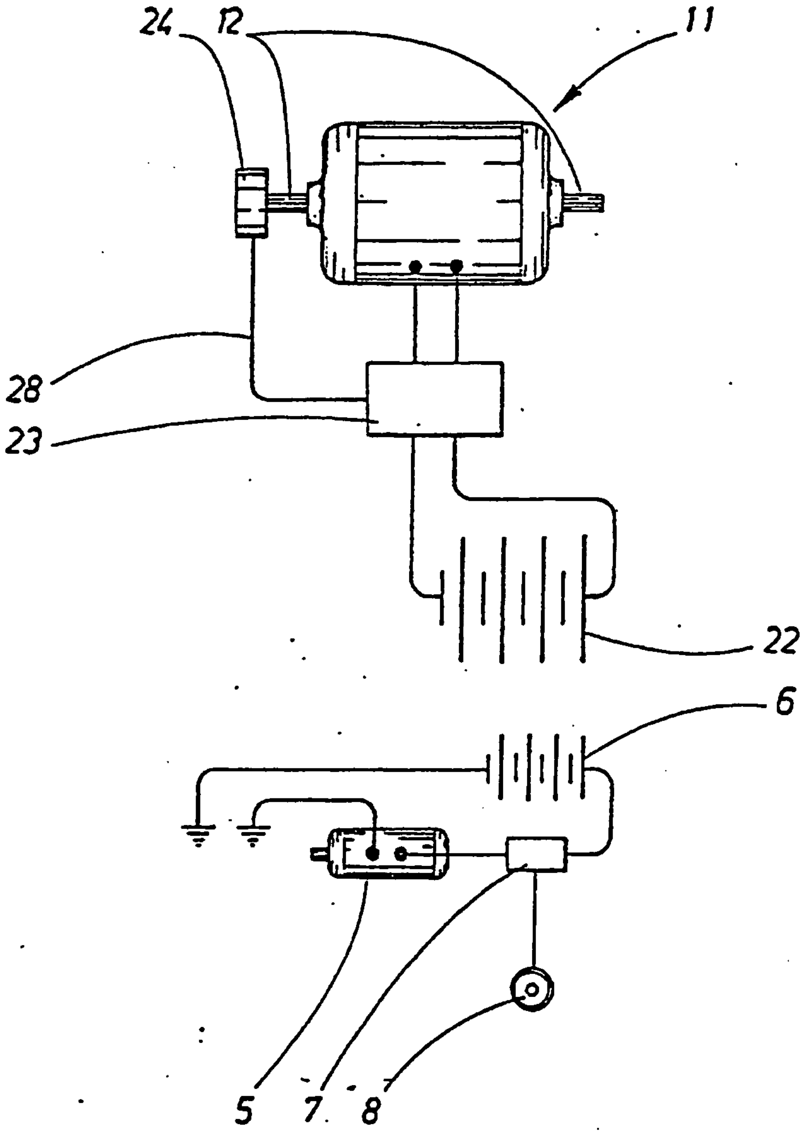

FIG.2

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INTERNATIONAL SEARCH REPORT

International Application No PCT/SE81/0028

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)	

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"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] 1981-12-03	Date of Mailing of this International Search Report [2]
International Searching Authority [1] Swedish Patent Office	Signature of Authorized Officer [10] 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
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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
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1/5

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 | 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.

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	S50 30223	7/1973	Japan			X	
DD	WO 82 01170	4/1982	PCT				
DD	0510582	12/1995	EPO				
DD	4297330	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
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 0 1 2005
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	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 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

,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

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)

(Legal Instruments Examiner) (Date)

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
	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
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	25		55		85		115		145		175		205
	26		56		86		116		146		176		206
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	28		58		88		118		148		178		208
	29		59		89		119		149		179		209
	30		60		90		120		150		180		210

U.S. Patent and Trademark Office

Part of Paper No. 20051024

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		10/29/05	DD

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner
180	65.2	3/16/05	DD
	65.4		
Updated		10/29/05	DD

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR
EAST text search	11/29/2004	DD

U.S. Patent and Trademark Office

Part of Paper No. 20041130

PRINTER RUSH
(PTO ASSISTANCE)

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

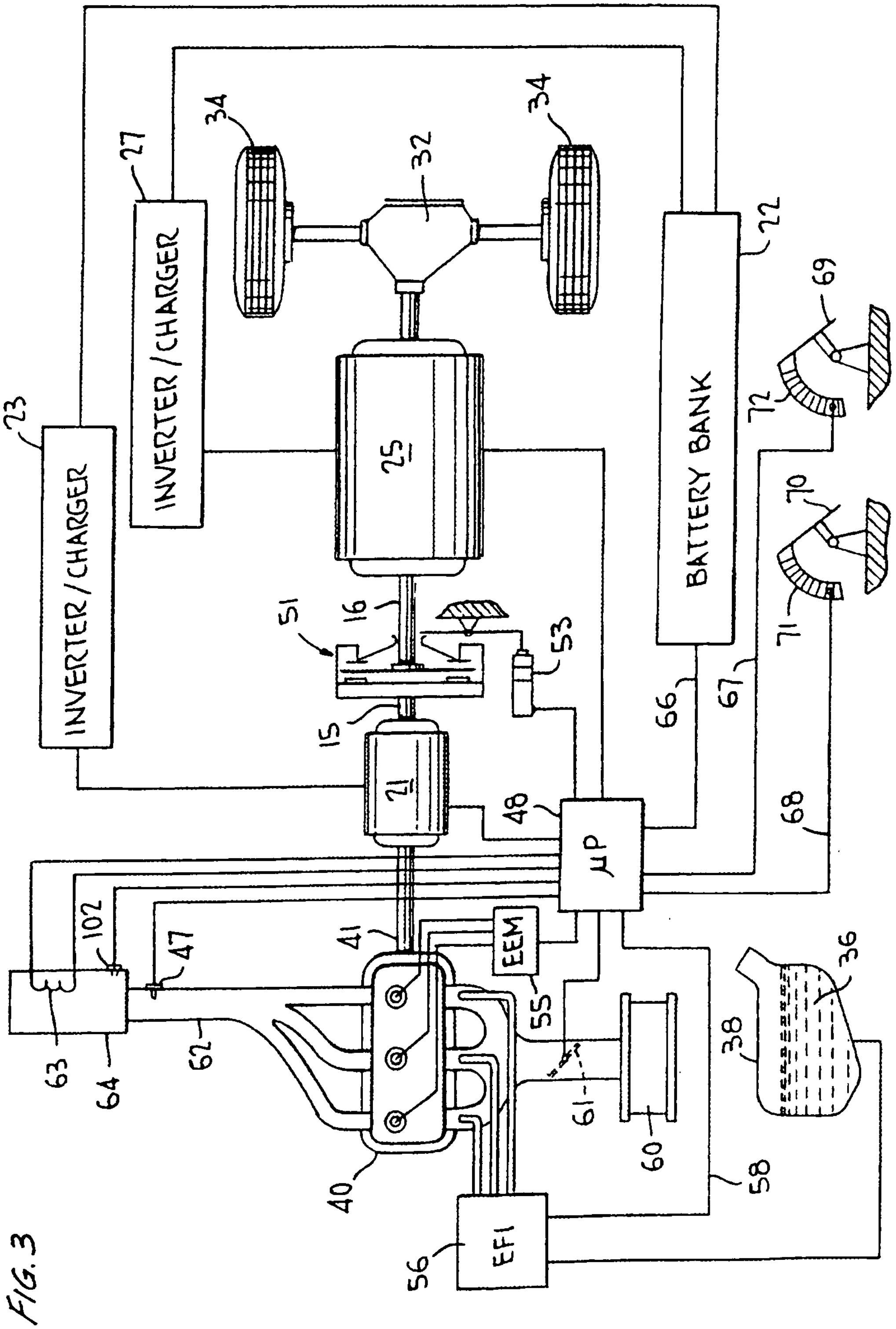
[XRUSH] **RESPONSE:**

Dwg corrected

INITIALS:

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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INVERTER / CHARGER
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INVERTER / CHARGER
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34
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BATTERY BANK
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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

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 neccssary to the same account number.

As indicated above, enclosed herewith are the following items:

☒ 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

January 19, 2006
Signature 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

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 19 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	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.

UNITED STATES PATENT AND TRADEMARK OFFICE

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 26 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).

OIPE IAP14
MAR 2 8 2006
PATENT & TRADEMARK OFFICE

ZFW

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

OIPE IAP14
MAR 28 2006
PATENT & TRADEMARK OFFICE

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:

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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.

Respectfully submitted,

March 27, 2006
Dated:

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

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
	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	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	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

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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
	4646896	3/1987	Hammond et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	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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MAR 2 8 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	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

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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 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	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

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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PATENT & TRADEMARK OFFICE

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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
	5412293	5/1995	Minesawa et al			
	5883484	3/1999	Akao			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO
	8214592	8.20.1996	Japan			abst.	
	1066383	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

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MAR 2 8 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
	913846	3/1909	Pieper			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	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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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	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

10/382577UA

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 ☐
Doc Code: Artifact Artifact Type Code: S
content unspecified or combined 1
Doc Code: Artifact Artifact Type Code: U

☐ Stapled Set(s) Color Documents or B/W Photographs
Doc Code: Artifact Artifact Type Code: C

☐ Microfilm(s)
Doc Code: Artifact Artifact Type Code: F

☐ Video tape(s)
Doc Code: Artifact Artifact Type Code: V

☐ Model(s)
Doc Code: Artifact Artifact Type Code: M

☐ Bound Document(s)
Doc Code: Artifact Artifact Type Code: B

☐ Confidential Information Disclosure Statement or Other Documents marked Proprietary, Trade Secrets, Subject to Protective Order, Material Submitted under MPEP 724.02, etc.
Doc Code: Artifact Artifact Type Code X

☐ Other, description: ______________________
Doc Code: Artifact Artifact Type Code: Z

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

PTO/SB/06 (08-03)
Approved for use through 7/31/2006. OMB 0651-0032
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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

	(Column 1)	(Column 2)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE	FEE		RATE	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		(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE	ADDI-TIONAL FEE		RATE	ADDI-TIONAL FEE
	Total (37 CFR 1.16(c))	* 41	Minus	** 124	=	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		(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE	ADDI-TIONAL FEE		RATE	ADDI-TIONAL 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		(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE	ADDI-TIONAL FEE		RATE	ADDI-TIONAL 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 [illegible] 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.

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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

OIPE IAP100
JUL 0 7 2006
PATENT & TRADEMARK OFFICE

JFW

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: N/A
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:

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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Dated

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1 of 12

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	6281660	08/2001	Abe			previously cited
	~~5515937~~	~~5/1996~~	~~Adler et al~~			
DD	5336932	4/1994	Barske			
DD	6170587	1/2001	Bullock			
DD	5887674	3/1999	Gray			
DD	4762191	8/88	Hagin et al			previously cited
	~~6315068~~	~~11/2001~~	~~Hoshiya et al~~			
DD	5856709	1/1999	Ibaraki et al			
DD	6204636	3/2001	Kinoshita et al			
DD	6225784	5/2001	Kinoshita et al			
DD	6232748	5/2001	Kinoshita et al			prev. cited
	~~6019698~~	~~2/2000~~	~~Lawrie~~			

RECEIVED JUN 0 2 2004 GROUP 3600

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 11/24/04

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.

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
	~~5993350~~	~~11/1999~~	~~Lawrie et al~~			
	~~5979257~~	~~11/1999~~	~~Lawrie~~			
	~~6006620~~	~~12/1999~~	~~Lawrie et al~~			
DD	6291953	9/2001	Lovatt et al			
DD	6332257	12/2001	Reed Jr. et al			
DD	5943918	8/1999	Reed Jr. et al			
	~~5755302~~	~~5/1998~~	~~Lutz et al~~			on page
DD	6142907	11/2000	Minowa			
DD	6328670	12/2001	Minowa			
DD	6119799	9/2000	Morisawa			
DD	5984034	11/1999	Morisawa			
DD	6334498	1/2002	Morisawa			

previously cited

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 11/29/07

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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
DD	5895333	4/1999	Morisawa			
DD	6306057	10/2001	Morisawa			
DD	6344008	2/2002	Nagano			
DD	6090007	7/2000	Nakajima			
DD	6328671	12/2001	Nakajima			
DD	5660077	8/1997	Nekola			
DD	6203468	3/2001	Nitta			
DD	6321150	11/2001	Nitta			
DD	5944630	8/1999	Omote			
DD	6070680	6/2000	Oyama			
DD	6123642	9/2000	Saito			
DD	6158541	12/2000	Tabata			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

DD	Published application US 2001/0037905, ~~of~~ Nogi et al. ~~Nov~~ 11/2001

EXAMINER

DATE CONSIDERED 11/29/04

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X

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	Wakuta			
DD	5890470	4/1999	Woon			
DD	6328122	12/2001	Yamada			
DD	6278195	8/2001	Yamaguchi et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	4864626	9/1973	Japan			part.	
DD	4929642	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

DATE CONSIDERED 11/29/04

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CANCELLED

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	6247437	6/2001	Yamaguchi et al			
DD	5967940	10/1999	Yamaguchi et al			
DD	5081365	1/1992	Field et al			
DD	6044922	4/2000	Field			
DD	6481516	11/2002	Field et al			
	~~3719881~~	~~3/1971~~	~~Shibata et al~~			cited on pg 10
DD	4187436	2/1980	Etienne			
DD	57~~7~~22502	3/1998	Kubo			
DD	6231135	5/2001	Bower et al			
DD	6357541	3/2002	Matsuda et al			
DD	6265692	7/2001	Umebayahi et al			
DD	5497941	3/1996	Numazawa et al			

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	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	5355105	05/1978	Japan			part	
DD	467703	3/1992	Japan			"	
DD	6245317	2/1993	Japan			"	
DD	4297330	10/1992	Japan			"	
DD	51103220	8/1976	Japan				

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DD Mayrhofer et al "A Hybrid Drive Based on a Structure Variable Arrangement" (1994)

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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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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			
DD	5406126	8/1995	Hadley et al			
DD	5669842	9/1997	Schmidt			
DD	5771478	6/1998	Tsukamoto			
DD	5833570	11/1998	Tabata			
DD	5951614	9/1999	Tabata			
DD	5875691	3/1999	Hata			
DD	5931271	8/1999	Haka			

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	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	510582	10/1992	European Patent Office				
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DD	2517110	10/1975	German				
DD	8201170	4/1982	PCT/SE81/00280				
DD	55110328	8/1980	Japan			part	

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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.

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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
DD	5951188	9/1999	Soejima			
DD	5984432	11/1999	Otomo et al			
DD	5979158	11/1999	Kaiser			
DD	5983740	11/1999	Salecker et al			
DD	6006149	12/1999	Salecker et al			
DD	6003626	12/1999	Ibaraki et al			
DD	6009365	12/1999	Takahara et al			
DD	4126200	11/1978	Miller et al			
DD	4090577	5/1978	Moore			
DD	5323688	6/1994	Walker			
DD	5384521	1/1995	Coe			
DD	5623194	4/1997	Boll			

FOREIGN PATENT DOCUMENTS

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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	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

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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
DV	4416360	11/1983	Fiala			
DV	4591016	5/1986	Matthews			
DV	4592454	6/1986	Michel			
DV	4674280	6/1987	Stuhr			
DV	4753078	6/1988	Gardner			
DV	5000003	3/1991	Wicks			
DV	5141173	8/1992	Lay			
DV	5242335	9/1993	Kutter			
DV	5264764	11/1993	Kuang			
DV	5915488	6/1999	Fliege			
DV	5947855	9/1999	Weiss			
DV	5971088	10/1999	Smith			

FOREIGN PATENT DOCUMENTS

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION

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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)

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	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			

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	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)

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JUL 07 2006
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12 of 12

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

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GROUP 3600

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
						NOT SUBMITTED	
	~~50099456~~	~~1/1977~~	~~Japan~~				

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	DATE CONSIDERED 11/29/04

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JUL 0 7 2006
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.: 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.

July 6, 2006
Dated:

Respectfully submitted,

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown RI 02835
401-423-3190

OIPE IAP100
JUL 0 7 2006
PATENT & TRADEMARK OFFICE

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

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.

March 27, 2006
Dated:

Respectfully submitted,

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

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 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	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

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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
	5253929	10/1993	Ohori			
	5326158	7/1994	Ohori			
	5476151	12/1995	Tsuchida et al			
	5569995	10/1996	Kusaka et al			
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	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			
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FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO
	0136055	03.04.85	European Patent Office				

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Miller et al, "Starter-Alternator for Hybrid Electric Vehicle.." (1996)

Johnston et al, "The Design and Development of the [UC Davis].." (No date)

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"PRIUS New Car Features", (Toyota manual) (1998)

TRW Systems Group, "Analysis and Advanced Design Study..." (1971)

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	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	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

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	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	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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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	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.

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
	5412293	5/1995	Minesawa et al			
	5883484	3/1999	Akao			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	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)

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.

OIPE IAP100
JUL 07 2006
PATENT & TRADEMARK OFFICE

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

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 <u>coefficient</u>, 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 $T_L = Tm - M \cdot rw \cdot \alpha$ 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 $M \cdot r \cdot \alpha$ to reach the running load, but calculating $M \cdot r \cdot \alpha$ 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 the 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
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

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	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

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

	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

DATE CONSIDERED 3/16/05

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JUL 0 7 2006
PATENT & TRADEMARK OFFICE

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,

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown, RI 02835
401-423-3190

Dated: 6/30/05

OIPE JC135
JUL 0 1 2005
PATENT & TRADEMARK OFFICE

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OIPE IAP100
JUL 0 7 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 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	NO
DD	2419832	3/1978	France			X	
DD	3124201	10/1989	Japan			X	
DD	51 103220	2/1975	Japan			X	
DD	H5 64531	9/1984	Japan			X	
DD	S 48 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
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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	S5030223	7/1973	Japan			X	
DD	WO8201170	4/1982	PCT				
DD	0510582	12/1995	EPO				
DD	4297330	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

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.

.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	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 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

OIPE JC135 JUL 0 7 2005 PATENT & TRADEMARK OFFICE

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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
	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	WO9924280	11/1997	PCT			X	
DD	EP0743211	5/1996	EP				
DD	EP0839683	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.

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JUL 07 2006
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: 3619
Filed: April 2, 2001 : Att. Dkt.: PAICE201
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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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	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~~ 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

DATE CONSIDERED 11/19/07

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.

OIPE
JUL 0 7 2006
IAP100
PATENT & TRADEMARK OFFICE

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	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.

JC498 U.S. PTO
10/382577
03/07/03

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

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
DD	A	US-6,315,068	11-2001	Hoshiya et al.	180/65.2
DD	B	US-6,330,498	12-2001	Tamagawa et al.	701/22
DD	C	US-6,359,404	03-2002	Sugiyama et al.	318/432
DD	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

OIPE IAP100
JUL 07 2006
PATENT & TRADEMARK OFFICE

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

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

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401-423-3190

INFORMATION DISCLOSURE CITATION IN AN APPLICATION	DOCKET NUMBER PAICE201	APPLICATION NUMBER ~~09/822,866~~ 10/382577	1
	APPLICANT Severinsky et al		
	FILING DATE 4/2/01	GROUP ART UNIT 3616	

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	6382283	6/1988	Japan				
DD	06144020	11/1992	Japan				
DD	06080048	11/1992	Japan				
DD	55069724	11/1978	Japan				
DD	04274926	2/1991	Japan				

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.

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JUL 0 7 2006
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PATENT & TRADEMARK OFFICE

HE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Patent Application of
Severinsky et al
Serial No.: N/A
Filed: Herewith

Examiner: N/A
Group Art Unit: N/A
Att. Dkt.: PAICE201.DIV

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,

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Jamestown, RI 02835
401-423-3190

3/5/03
Dated

OIPE IAP100
JUL 0 7 2006
PATENT & TRADEMARK OFFICE

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: N/A
Group Art Unit: N/A
Att. Dkt.: PAICE201

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

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OIPE
JUL 07 2006
IAP100
PATENT & TRADEMARK OFFICE

JC498 U.S. PTO
10/382577
03/07/03

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

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	

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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

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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	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

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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

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	8/72	Yardney			
	3837419	9/74	Nakamura			
	3874472	4/75	Deane			
	4042056	8/77	Horwinski			
DD	4562894	1/86	Yang			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

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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

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	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
DP	4 6 1 1 4 6 6	9/86	Keedy			
	4 8 1 5 3 3 4	3/89 ~~8/89~~	Lexen			
	3 6 2 3 5 6 8	11/71	Mori			
	3 4 5 4 1 2 2	7/69 ~~8/69~~	Grady, Jr.			
	3 2 1 1 2 4 9	10/65	Papst			
	2 6 6 6 4 9 2	1/54	Nims et al			
	3 5 0 2 1 6 5	3/70	Matsukata			
	1 8 2 4 0 1 4	9/31	Froelich			
	3 8 8 8 3 2 5	6/75 ~~10/75~~	Reinbeck			
	4 5 7 8 9 5 5	4/86	Medina			
	4 7 6 5 6 5 6	8/88	Weaver			
	4 4 3 9 9 8 9	4/84	Yamakawa			
DP	5 3 0 1 7 6 4	4/94	Gardner			

FOREIGN PATENT DOCUMENTS

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U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	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			
DD	5558588	9/96	Schmidt			

FOREIGN PATENT DOCUMENTS

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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~~08077	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

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INFORMATION DISCLOSURE CITATION IN AN APPLICATION

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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~~ Jeannere† et al			
DD	5492189	2/96	Kreigler et al			

FOREIGN PATENT DOCUMENTS

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OTHER DOCUMENTS (Including Author, Title, Date, Pertinent Pages, Etc)

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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
DD	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.			
DD	4444285	4/84	Stewart et al			

FOREIGN PATENT DOCUMENTS

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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

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U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
	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			
	5566774	10/96	Yoshida			

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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

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U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DD	5562565	10/96	Moroto et al			
	5513719	5 ~~6~~/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 ~~4~~/94	Sugiyama et al			

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U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DV	5345761	9 ~~6~~/94	King et al			
	5337848	8/94	Bader			
	5327992	7 ~~4~~/94	Boll			
	5589743	12/96	King			
	5345154	9/94	King			
	4862009	8/89	King			
	5372213	12/94	Hasebe et al			
	5495912	3 ~~5~~/96	Gray, Jr., et al			
	5588498	12/96	Kitada			
	5492189	2/96	Kriegler			
	5193634	3/93	Masut			
	5125469	6/92	Scott			
DD	4511012	4/85	Rauneker			

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U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE
DN	4631456	12/86	Dreacher 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			
	5934395	8/99	Koide et al	180	65.2	
	5969624	10/99	Sakai et al	340	636	
	5986376	11/99	Werson			
	6018198	1/00	Tsuzuki et al	322	16	
DD	6054844	4/00	Frank			

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U.S. PATENT DOCUMENTS

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DD	6059059	5/00 ~~9/94~~	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~~	~~Heidl et al~~			DUPLICATE
	~~5495906~~	~~3/96~~	~~Furutani~~			//
	~~6018694~~	~~1/00~~	~~Egami et al~~			//
DD	6209672	4/01	Severinsky			

FOREIGN PATENT DOCUMENTS

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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.

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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.

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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

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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.

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(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

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(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 ____________________

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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 ____________

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☐ 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 ____________________

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This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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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

EXAMINER	
DUNN, DAVID R	
ART UNIT	PAPER NUMBER
3616	

DATE MAILED: 07/11/2006

Michael de Angeli
60 Intrepid Lane
Jamestown, RI 02835

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 /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.

OIPE 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
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 /David Dunn/	DATE CONSIDERED 07/07/2006

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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
DD	4646896	3/1987	Hammond et al			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	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

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MAR 2 8 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

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	NO
DD	7 2 6 8 9 2 2	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 /David Dunn/

DATE CONSIDERED 07/07/2006

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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	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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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 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	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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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
DD	9 1 3 8 4 6	3/1909	Pieper			

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION	
						YES	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

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 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	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.

1/19/06

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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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

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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						

INTERNATIONAL CLASSIFICATION				
B	6	0	K	6/04
				/
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				/
				/

(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
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	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. 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		10/29/05	DD
Updated		7/7/06	DD

INTERFERENCE SEARCHED

Class	Subclass	Date	Examiner
180	65.2	3/11/05	DD
	65.4		
Updated		10/29/05	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

U.S. Patent and Trademark Office

Part of Paper No. 20041130

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

07/18/2006 HDEMESS2 00000098 040401 10382577

01 FC:1501 1400.00 DA
02 FC:8001 30.00 DA

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.

Michael de Angeli (Depositor's name)
(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
Date July 18, 2006
Typed or printed name Michael de Angeli
Registration No. 27,869

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

OF COMMERCE

OIPE
JUL 1 8 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

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:

☐ ACH/EFT

☐ Credit Card

☒ Deposit Account # 04-0401

☐ Treasury Check

Patent/TM/App/Serial # 10,382,577

Program Area Publishing

Date Processed 08-31-06

ATTENTION ATTENTION ATTENTION

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

UNITED STATES PATENT AND TRADEMARK OFFICE

United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

MONTHLY STATEMENT OF DEPOSIT ACCOUNT

To replenish your deposit account, detach and return top portion with your check. Make checks payable to "Director of the USPTO."

MICHAEL DE ANGELI, P.C.
MR. MICHAEL DE ANGELI
60 INTREPID LANE
JAMESTOWN RI 02835

FINA

Account No.	040401
Date	7-31-06
Page	1

PLEASE SEND REMITTANCES TO:
U.S. Patent and Trademark Office
P.O. Box 371279
Pittsburgh, PA 15251-7279

Call the Deposit Account Branch at 571-272-6500 for assistance.

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
7	31	06	26	SERVICE CHARGE		9202	25.00	951.00

X/

V - we need
to send them
money...
just charged a $1000 filing
fee -

AN AMOUNT SUFFICIENT TO COVER ALL SERVICES REQUESTED MUST ALWAYS BE ON DEPOSIT	OPENING BALANCE	TOTAL CHARGES	TOTAL CREDITS	CLOSING BALANCE
	3031.00	2080.00	0.00	951.00

Att: Refund Branch
Page 2
August 18, 2006

1465.00

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 22 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

06
2/18

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			

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	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
DD	Nagasaka et al, "Development of the Hybrid/Battery ECU...", SAE paper 981122, 1998, pp. 19-27

EXAMINER

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

6 of 12

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			
DD	5406126	~~8/1995~~ 4/1995	Hadley et al			
DD	5669842	9/1997	Schmidt			
DD	5771478	6/1998	Tsukamoto			
DD	5833570	11/1998	Tabata			
DD	5951614	9/1999	Tabata			
DD	5875691	3/1999	Hata			
DD	5931271	8/1999	Haka			

OG 5/80

FOREIGN PATENT DOCUMENTS

	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

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.

x

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

Dg
2/10

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~~ 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			

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 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.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			

DG
2/50

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO
DD	48646226	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
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.

OPAP
IAP8
NOV 18 2011
PATENT & TRADEMARK OFFICE

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,

Michael de Angeli
Reg. No. 27,869
60 Intrepid Lane
Jamestown RI 02835
401-423-3190

Dated: 11/14/11

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