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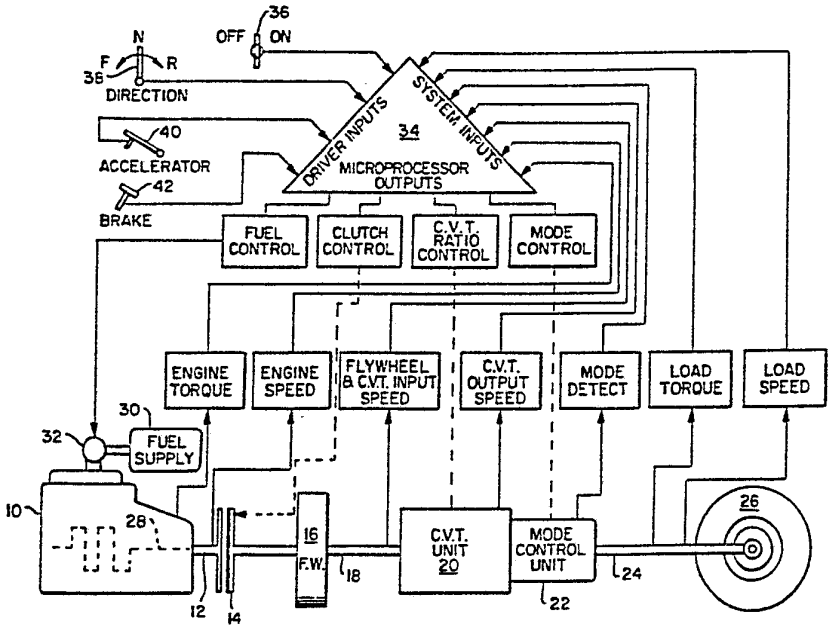
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(57) Abstract

A method for propelling a wheel driven vehicle having a drive line with a prime mover or engine (10), an energy storage device or flywheel (16), a clutch (14) between the engine and the flywheel, and a continuously variable transmission unit (20) in which fuel consuming operation of the engine is restricted to not less than a predetermined minimum thermal efficiency when needed to develop power for the system. Developed power in excess of that required to propel the vehicle when so developed is stored as kinetic energy by increased flywheel speed resulting from the excess power. Operation of the engine to develop power above the predeterminedminimum thermal efficiency may be on an idealized line of operation or may proceed to maximum power in conventional fashion.

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TITLE OF THE INVENTION

METHOD OF VEHICLE PROPULSION

BACKGROUND OF THE INVENTION

This invention relates to vehicular propulsion and more particularly, it concerns a method for propelling a wheel driven vehicle in which the operation of a prime mover or engine is coordinated with kinetic energy storage in a manner to maximize efficiency of the overall propulsion system.

Hybrid power plants or drive line systems for inertial loads like those incurred in the operation of automobiles and other wheeled vehicles are well known. Generally, hybrid systems include a prime mover such as an internal combustion engine or other device for converting potential energy contained in a combustible fuel to mechanical power capable of being transmitted to the drive wheels of a vehicle, for example, a kinetic energy storage device such as a flywheel, and a mechanical power transmission capable of power transfer between either of the engine or flywheel and the inertial load represented by the drive wheels of vehicle. The energy storage device or flywheel is used to store for subsequent conversion to usable power, either or both excess energy developed by optimized operation of the prime mover or the kinetic energy of vehicular deceleration.

The many diverse hybrid systems described in prior patents and other literature may be characterized generally as being in one of two classes at least in terms of intended

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mode of operation. In a first class, a relatively high technology flywheel or a large capacity energy storage device provides the primary source of mechanical power used to satisfy power demand by the load or at the driving wheels of a vehicle, for example, with engine or prime mover developed power and energy of vehicle deceleration being used primarily to charge the flywheel as needed to supply the demand for power. In theory, hybrid systems within this first class can result in a substantial savings of fuel needed for vehicle propulsion due to (a) operation of the fuel consuming prime mover or engine only at optimum specific fuel consumption, (b) engine or prime mover shut-down when the kinetic energy stored is adequate to propel the vehicle and above that necessary to restart the engine or prime mover, and (c) the storage and use of braking energy resulting from deceleration of the vehicular mass and which otherwise would be wasted as heat energy. A major deterrent to the use of such systems, on the other hand, are the many problems incident to the incorporation of a high technology flywheel in the drive line system. High speed flywheels contribute losses to the transmission of kinetic energy to and from the flywheel due to required gearing and clutches and the like. Also, such flywheels require elaborate evacuated housings for the avoidance of windage losses. Thus, high technology flywheel systems and similar large capacity energy storage devices are vulnerable to efficiency losses in themselves which offset in substantial measure the efficiency gained by optimized operation of the engine or prime mover.

In the second class of hybrid systems, the prime mover or engine is relied on primarily to supply the power demand of the vehicular load with excess energy resulting either from operation of the prime mover or vehicle deceleration being stored in a relatively low capacity storage device such as an automotive crank shaft flywheel enlarged for increased capacity and operated at speeds on the order

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of or slightly in excess of conventional internal combustion engine crank shaft speeds. Hybrid systems of this second class have the advantage of being easily accommodated by the geometry of existing drive lines and also may use state-of-the-art technology relative to continuously variable transmissions needed to optimize both classes of hybrid systems. This latter class of hybrid systems is exemplified by U.K. Patent Application No. GB 2031822A published April 30, 1980 (corresponds to U.S. Patent Application Serial No. 023,398, filed March 23, 1979) and also described in an article entitled: "The Vadetec Inertial Drive Line" by S. Shih, E. G. Trackman and Y. Kemper, Society of Automotive Engineers, No. 800101, February 1980.

Computer simulations of automotive vehicles equipped with the designated second class of hybrid systems have shown results comparable to the first mentioned class of hybrid systems and by which the fuel consumption is significantly reduced as compared with conventional automotive drive lines. Yet, the only modification of a conventional automotive drive line needed for the second class of hybrid systems other than the substitution of a continuously variable transmission (CVT) for the usual multi-speed transmission and the provision of an on-board microprocessor for automated control, is the use of a clutch between the engine crank shaft and the flywheel and an increase in the thickness of the flywheel.

The operational mode for the second class of hybrid system, other than under vehicle speeds where engine crank shaft and the vehicle drive wheels are in direct driving relationship, has involved optimized operation of the engine to supply power called for at the drive wheels, irrespective of how low that power may be. The kinetic energy of vehicle deceleration is stored in the flywheel and the engine turned off whenever the energy thus stored in the flywheel is adequate to satisfy the drive wheel load as well as to restart the engine.



SUMMARY OF THE PRESENT INVENTION

In accordance with the present invention, a hybrid system represented by a fuel consuming prime mover having a power output connected to a vehicular load in series through a clutch, a flywheel and a variable speed transmission is operated in a manner to avoid low thermal efficiencies in the fuel consuming prime mover without adding efficiency losses to the remainder of the system very simply by operating the prime mover, when operation thereof is required, at no less than a minimum level of developed power which will provide a relatively narrow range of good thermal efficiencies, storing prime mover developed power, which is in excess of that needed to propel the vehicle, in the flywheel during such operation of the engine and controlling the power delivered to the vehicular load by varying the speed ratio of the transmission. The prime mover is decoupled from the flywheel and shut off to terminate fuel consumption when the flywheel reaches a predetermined level of speed. The stored kinetic energy is then transmitted as power to the load by controlled operation of the variable speed transmission.

A primary object of the present invention is, therefore, to provide an improved method for propelling a wheel driven vehicle using a hybrid system of the identified second class by operating the fuel consuming prime mover of the system only as needed and when needed, only in excess of output power levels providing a narrowed range of good thermal efficiencies. Other objects and further scope of

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applicability of the present invention will become apparent from the detailed description to follow taken in conjunction with the accompanying drawings in which like parts are designated by like reference numerals.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic diagram illustrating the components of a hybrid system used in the practice of the present invention;

Fig. 2 is a graph representing an engine performance map;

Fig. 3 is a graph like Fig. 2 but depicting engine operation in accordance with the present invention; and

Fig. 4 is a graph showing a curve resulting from plotting values of BSFC against developed horse power at minimum constant engine speed.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In Fig. 1 of the drawings, a hybrid power system or drive line is shown to include a fuel consuming prime mover or engine 10 having a power output shaft 12 adapted to be releasably coupled by a clutch 14 to a flywheel 16 and the input shaft 18 of a variable speed transmission, preferably a continuously variable transmission (CVT) unit 20. The output of the CVT unit is through a mode control unit to a final drive shaft 24 coupled for power transfer to a load represented by a drive wheel 26 of a land vehicle.

The prime mover or engine 10 may be any one of several types of engines which operate to convert the potential energy in a combustible fuel to a mechanical power output in the shaft 12 and is schematically depicted in Fig. 1 as a piston engine having a crank shaft 28 of which the shaft 12 is a direct extension, a fuel supply 30 and a metering device 32, preferably a fuel injector, by which a controlled supply of fuel may be fed from the supply 30 to the engine 10. The clutch 14, CVT unit 20 and mode control unit are fully described in the aforementioned published U.K. patent application No. 2031822 and need not be described in further detail for a complete understanding of the present invention. It should be understood, however, that the CVT unit is capable of transmitting power from the input shaft 18 to the output shaft in a range of continuously variable speed ratios. Also the mode control unit may be considered as gearing by which the system may be shifted between "forward", "neutral", and "reverse" modes of operation

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as well as to provide multiple fixed speed ratio outputs from the CVT unit 20. As illustrated, the clutch 14 is a friction clutch and is capable of actuation between full engagement and non-engagement.

The flywheel 16 is a low technology flywheel and will vary in size depending on the size of the engine 10 as well as the size of the vehicle or other load to be driven by the system. The flywheel functions both as a crank shaft flywheel for the engine and as an energy storage device and may in practice be of a size on the order of magnitude the same as a conventional crank shaft flywheel that would be used with the engine 10.

In Fig. 1, the direct connection of the flywheel to the input shaft 18 of the CVT unit is predicated primarily on the capability of the CVT unit 20 to attain an output/input speed ratio of 0/1 or infinity. While such ratios are entirely consistant with CVT state-of-the-art, it is contemplated that a conventional friction clutch (not shown) may be used between the flywheel and the shaft 18 to allow use of a CVT unit with a finite range of speed ratios or one in which the range does not extend to an output/input ratio of 0/1.

System control is provided by a microprocessor or computer 34 which like the system disclosed in the aforementioned published British patent application, includes a plurality of system monitoring inputs, a series of driver inputs and a series of outputs or control functions. Monitored system functions include engine torque, engine speed, flywheel and CVT input speed, CVT output speed, mode control state, load torque and load speed. Driver inputs may include a main control 36, a direction control member 38, a power control such as an accelerator 40, and a brake pedal 42. Outputs from the microprocessor 34 include a fuel control for adjusting the fuel injector 32 from a position of complete shut-off of fuel supply to the engine 10, a clutch control

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by which the clutch 14 may be adjusted between conditions of full disengagement through partial engagement to full engagement, a CVT ratio control and a mode control for the unit 22.

Basic operation of the drive line or power system illustrated in Fig. 1 in terms of power transfer between the engine 10 or the flywheel 16 and the drive wheel 26, whether such power transfer is positive as when the wheel 26 is a driven load or negative as when vehicle deceleration operates to transmit energy from the wheel 26 back through the drive line in a reverse direction, is dependent primarily on the condition of the clutch 16 and the speed ratio of the CVT unit 20. Because the energy storing flywheel 16 is also the crank shaft flywheel of the engine 10, it will be appreciated that power developing operation of the engine 10 can occur only when the clutch 14 is engaged. When so engaged, the flywheel is rotated directly with the engine crank shaft and the transfer of power at the CVT input shaft 18 to the wheel 26 is dependent on adjustment solely of the CVT unit 20 and mode control unit 22. Correspondingly, fuel consuming operation of the engine 10 is terminated or shut off at all times when the clutch 14 is disengaged.

From the foregoing it will be appreciated that the engine 10 may be started initially by turning on the main control 36 to energize an electric starter motor (not shown) drivably coupled with the flywheel 16. At this time, the flywheel is decoupled from the wheel 26 either by adjustment of the CVT unit to a zero output ratio or by decoupling a clutch (not shown) between the flywheel and the input of the CVT unit 20. With the mode control unit 22 adjusted to operate the drive line in a forward vehicle propelling direction, power developed by the engine 10 will be transmitted to the wheel 26 with appropriate control of the CVT unit 20 and of the fuel injector 32 in a manner to be described in more detail below.

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An understanding of the manner in which the fuel injector 32 is adjusted to control power developing operation of the engine 10, when needed, as well as speed ratio adjustment of the CVT unit 20 will be facilitated by reference first to Fig. 2 of the drawings. In the engine efficiency map of Fig. 2, varying levels of constant thermal efficiency, represented by lines of constant brake specific fuel consumption (BSFC) each labeled with numerical values of Lb/H.P./Hr units, are shown for varying values of engine torque (M-Kg) and engine speed (R.P.M.). Optimized power developed by the engine is represented in Fig. 2 by a curve T_i. In other words, ideal operation of the engine 10 from the standpoint of gaining the least expensive developed power from the engine itself would require regulation of the fuel injector 32 to provide values of torque and engine speed on the curve T_i. From the numerical values assigned to curves representing BSFC in Fig. 2, it will be observed that fuel consumption decreases at a relatively slow rate above a line at which the BSFC is approximately .60 Lb/H.P./Hr. The specific fuel consumption below the same line, however, increases rapidly in exponential fashion.

Because any value of power delivered to the wheel 26 which would cause the wheel to accelerate or increase in speed will, for a constant speed ratio at the CVT unit 20, result in increased speed of the engine power shaft 12, power developing operation of the engine to conform accurately with any operating line or curve in Fig. 2 will require continuous or infinitely variable speed ratios in the drive line between the engine and the wheel 26. This requirement may be understood by considering the curve or line segment $P_o - P_a$ of the curve T_i which represents engine operation at essentially constant minimum speed. In the illustrated embodiment, it is assumed that 1,000 R.P.M. is the minimum speed at which the engine 10 will remain in an operating state. An idle setting of the fuel injector 32, therefore,

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may be assumed when engine operation is at a point P_0, which point corresponds to zero torque and zero developed power. Engine operation on the line segment up to the point P_a will result in increasing developed power to provide 10 M-Kg of torque or approximately 14 H.P. with very little increase in engine speed as the result of increasing the fuel supplied to the engine. Engine speed is maintained without substantial increases in this state of engine operation by increasing the load to which the power shaft 12 is connected. Variation of the load to maintain the speed of the engine 10 in this way is accomplished by varying the speed ratio of the CVT unit 20 to maintain engine speed relatively constant irrespective of the speed at which the wheel 26 is driven.

A corollary to operation of the engine 10 at varying power levels without corresponding changes in the speed at which the engine is operated and which is important to a full understanding of the present invention, is that when power developed by the engine is more than that required at the wheel 26, regardless of wheel speed (assuming that the ratio range of the unit 20 is not exceeded), the speed of the engine and of the engine power shaft 12 will increase at a rate determined by the power excess. Moreover, any such increasing of engine speed due to engine developed power exceeding that used at the wheel 26, will result in an acceleration of or an increase in the rotational speed of the flywheel 16. In this way, power developed by the engine 10, which is in excess of that needed for vehicle propulsion, may be stored as kinetic energy in the flywheel 16.

In Fig. 3, the efficiency map of Fig. 2 is partially reproduced to illustrate the method of operating the drive line or power system of Fig. 1 in accordance with the present invention. Thus, the ideal engine operating curve T_i is again shown for the same values of engine torque and speed, as are the points P_a and P_{max} representing illustrative values of developed power. Additionally in Fig. 3, however,

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a point of minimum acceptable developed power P_{min} is shown at the intersection of the curve T_i and a line T_c of constant torque which, in the illustrated embodiment, is selected to coincide approximately with the line representing a BSFC of .60 Lb/H.P./Hr.

In the context of Fig. 3, therefore, the engine 10 is either shut off to a non-fuel-consuming mode or operated in a power developing mode and when operated in the latter mode, only at or above a selected minimum percentage of thermal efficiency, for example, a BSFC of .60 Lb/H.P./Hr, or only in a manner to develop a minimum constant torque represented by the line T_c. When so operating in the power developing mode, the power requirement at the wheel 26, as determined by driving conditions and driver actuation of the accelerator pedal 40, can and often will be less than the minimum power P_{min} at which the engine 10 is permitted power developing operation. In that case, the speed ratio of the CVT unit 20 and the fuel injector 32 will be controlled by the microprocessor 34 to maintain engine operation at the minimum acceptable thermal efficiency with the result that developed power in excess of that required at the wheel 26 will cause the engine 10 to increase in speed. The increased engine speed, in turn, will increase the speed of the flywheel 16 so that the developed power in excess of power asked for at the wheel 26, will be stored as kinetic energy in the flywheel 16.

Power developing operation of the engine 10 may continue at constant torque or on the line T_c in Fig. 3 and, in the absence of increased demand for power at the wheel 26, will result in engine and flywheel speed increasing to a preprogrammed shut-off speed, for example, 3,000 R.P.M. Unless more demand for power is made during operation of the engine on the line T_c between the point P_{min} and the shut-off speed, the engine operating mode will be terminated, the clutch 14 disengaged and the speed ratio of the CVT unit 20

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adjusted to transmit kinetic energy stored in the flywheel 16 as power to the drive wheel 26. As the flywheel speed slows to a minimum engine starting speed of 1,000 R.P.M., for example, the engine 10 is restarted by engagement of the clutch 14 and the fuel injector 32 adjusted to develop power no less than a value represented by the point P_{min} in Fig. 3.

In Fig. 4, the curve S_{min} is the result of plotting values of thermal efficiencies in terms of BSFC against engine horse power where engine speed is maintained at the constant minimum speed or 1,000 R.P.M., for example. In this figure, the point P_{min}, representing the minimum power at which the engine 10 is permitted power developing operation, lies at the intersection of a line F_c of constant BSFC (.60 Lb/H.P./Hr) and the curve S_{min}. It will be appreciated from Fig. 4 that by restricting engine operation in the power developing mode to a relatively small percentage of the horse power available at the illustrated speed, the major portion of relatively low thermal efficiencies at that speed are avoided.

The previous discussion of system operation to practice the invention is directed primarily to operation of the engine at the minimum accepted thermal efficiency which is represented either by the line T_c in Fig. 3 or the line F_c in Fig. 4. It is contemplated that in practice, the precise value of minimum thermal efficiency for a given engine in a given vehicle will be calculated for accommodation of relatively low power operation of the engine 10 such as that likely to be incurred under city driving conditions where the vehicle driver is guided in his judgment more by traffic conditions than by conditions requiring high engine performance. When the power called for at the wheel 26 is more than that represented by operation of the engine 10 at the minimum percentage of thermal efficiency previously described, then the engine is preferably operated on the ideal power line or that represented by the curve T_i in

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Fig. 3. If at the instant of power demand engine speed is between 1,000 and 3,000 R.P.M., for example, at 2,500 R.P.M., engine operation on the curve T_i is initiated by terminating power developing operation of the engine 10, disengaging the clutch 14 and drawing kinetic energy from the flywheel 16 for initial acceleration by appropriate adjustment of the CVT unit 20. When the flywheel slows to approximately 1,000 R.P.M., the engine 10 is restarted and the fuel injector 32 adjusted to provide a minimum power of P_{min}. Thereafter, the fuel injector 32 and CVT unit 20 are controlled to maintain engine operation on the ideal curve T_i.

The aforementioned transition from operation on the line T_c at minimal accepted thermal efficiencies to the ideal power line T_i is preferred where no significantly increased demand for power at the wheel 26 is made by extreme movement of the accelerator pedal 40. It is contemplated that the microprocessor 34 will be programmed to account for such rapid increases in the demand for power by a restarting of the engine 10, again with appropriate adjustment of the fuel injector 32 and CVT unit 20, at whatever speed the flywheel may be rotating. Under these conditions and in the context of Fig. 3, engine operation will follow a curve from the line T_c steeply inclined up to and along or beyond the ideal curve T_i potentially to an absolute maximum power developing capacity of the engine 10. In a situation where the driver chooses engine performance rather than economy of operation, therefore, system operation may correspond to conventional operation of an automotive engine. In this latter respect, it should be noted also that because the flywheel 16 may approximate the size of a conventional crank shaft flywheel, speed response of the engine 10 to full depression of the accelerator pedal 40 does not differ significantly from a conventional automotive engine.

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In addition, the flywheel 16 is used to store the kinetic energy of vehicle deceleration. To achieve this use of the flywheel 16, whenever the load at the wheel 22 nulls or becomes negative as commanded by either the accelerator 40 or brake 42, the clutch 14 is disengaged. If the brake 42 is depressed, the energy of vehicular momentum is absorbed in the flywheel with appropriate downshifting of the CVT unit 20 to increase flywheel speed. Upon a subsequent command for acceleration, the energy previously stored in the flywheel 16 will be fed as power to the wheel 26 until the speed of the flywheel 16 is reduced to the minimal starting speed in the absence of a sudden demand for more power as described. At that time, the clutch 14 will be re-engaged and the engine 10 started using the residual energy stored in the flywheel 16.

It is apparent, therefore, that the method of the present invention avoids low thermal efficiencies or high rates of fuel consumption during the operation of the engine 10 as a result of the capacity of the flywheel to store energy developed by the engine when developed engine power exceeds power needed at the wheel 26. Also, it will be apparent and is contemplated that modifications and/or changes may be made in the described embodiment without departure from the invention. Accordingly, it is expressly intended that the foregoing description is illustrative of a preferred embodiment only, not limiting, and that the true spirit and scope of the present invention be determined by reference to the appended claims.

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CLAIMS

1. The method of propelling a wheel driven vehicle having a drive line including a fuel consuming prime mover operative at variable percentages of thermal efficiencies to develop power, an energy storage device adapted to be coupled in energy transfer relationship with said prime mover at all times during power developing operation of said prime mover and decoupled therefrom when said prime mover is inoperative and not consuming fuel and a variable speed ratio transmission for transferring power between said energy storage device and the vehicle drive wheels, said method comprising the steps of:

operating said prime mover only at thermal efficiencies above predetermined minimum percentage of thermal efficiency when operation of said prime mover is required to propel the vehicle;

increasing the energy in said storage device with power developed by such operation of said prime mover when the power developed at said minimum percentage of thermal efficiency is in excess of that power needed to drive the vehicle, thereby to store such excess power as kinetic energy in said storage device;

terminating fuel consuming operation of said prime mover when the power as kinetic energy stored in said storage device exceeds the power needed to propel the vehicle; or

decoupling said storage device from said prime mover and varying the ratio of said transmission to transfer kinetic energy from said storage device as power to propel the vehicle; and

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recoupling said storage device and the prime mover to restart power developing operation of said prime mover at said predetermined minimum percentage of thermal efficiency when the energy stored in said storage device reaches a predetermined lower limit.

2. The method recited in claim 1, wherein the energy storage device is a flywheel adapted to be coupled in direct driving relation with the power output of said prime mover, said method comprising the further steps of:

regulating the supply of fuel to said prime mover to develop power at thermal efficiencies above said predetermined minimum percentage;

adjusting the speed ratio of said transmission to transfer prime mover developed power through the flywheel to the vehicle drive wheel; and

increasing the operating speed of the prime mover and the flywheel to convert prime mover developed power in excess of that needed to propel the vehicle as kinetic energy resulting in increased speeds of said flywheel.

3. The method recited in claim 2, including the step of terminating operation of the prime mover when the speed of said flywheel is in excess of the prime mover power output speed at which the level of power needed for propulsion is developed most efficiently by the prime mover, and restarting the engine to develop power at optimum thermal efficiencies.

4. The method of propelling a wheel driven vehicle having a drive line including a fuel consuming engine operative at variable percentages of thermal efficiencies to develop power at varying torque and speed in an output shaft, a flywheel adapted to be coupled directly with said output shaft at all times during power developing operation of said prime mover and decoupled therefrom when said prime mover is inoperative and not consuming fuel, and a continuously variable speed ratio transmission for transferring power between said flywheel and the vehicle drive wheels, said method comprising the steps of:

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operating said prime mover at a predetermined minimal percentage of thermal efficiency to develop power at said output shaft when operation of said prime mover is required to propel the vehicle;

transmitting power from said output shaft as needed to propel the vehicle;

storing power developed by said prime mover as kinetic energy in said flywheel during operation at said predetermined minimum percentage of thermal efficiency when power so developed is in excess of power transmitted to propel the vehicle; and

operating said engine at thermal efficiencies above said predetermined minimum to develop only that power needed to propel the vehicle.

5. The method recited in claim 4, comprising the steps of terminating operation of said engine and decoupling said flywheel from said output shaft when vehicle propelling power is negative and when said flywheel reaches a predetermined speed representative of energy adequate to propel the vehicle.

6. The method recited in claim 5, comprising the step of restarting operation of the engine when the speed of said flywheel reaches a predetermined minimum speed representative of energy required to restart the engine.

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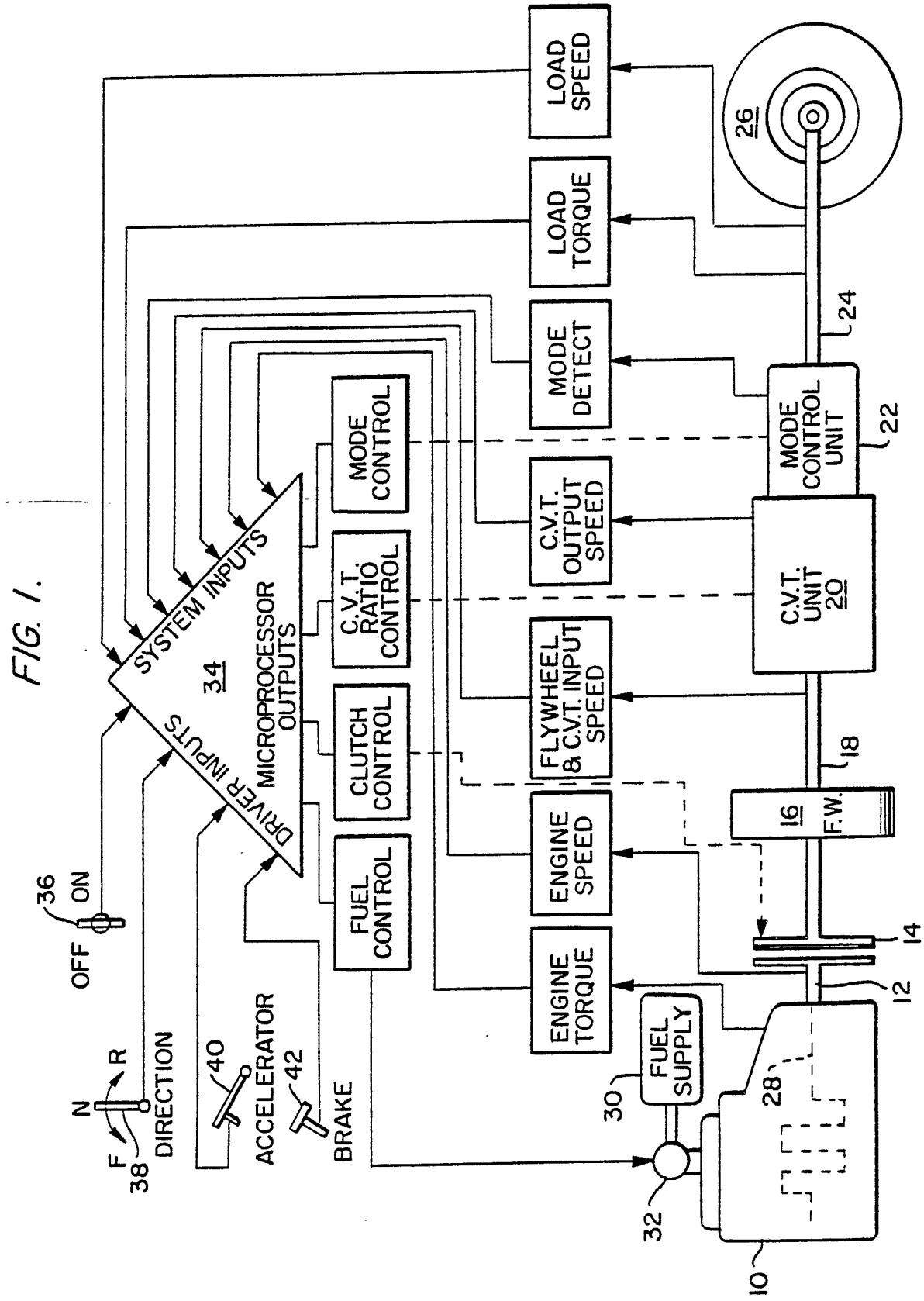


FIG. 1.

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FIG. 2.

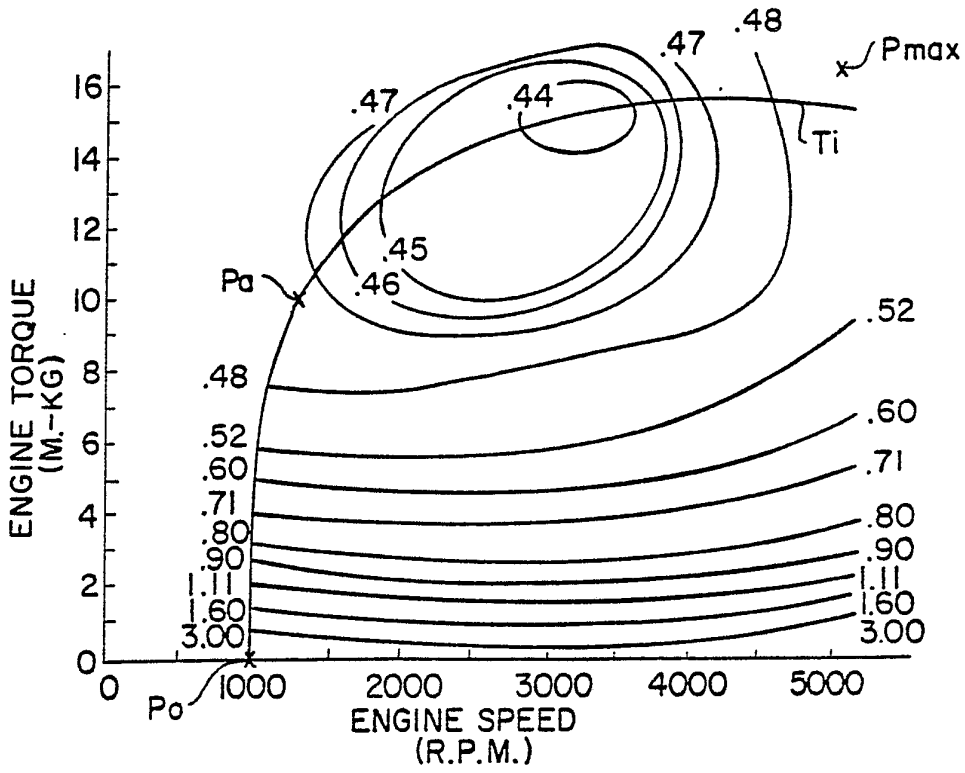


FIG. 3.

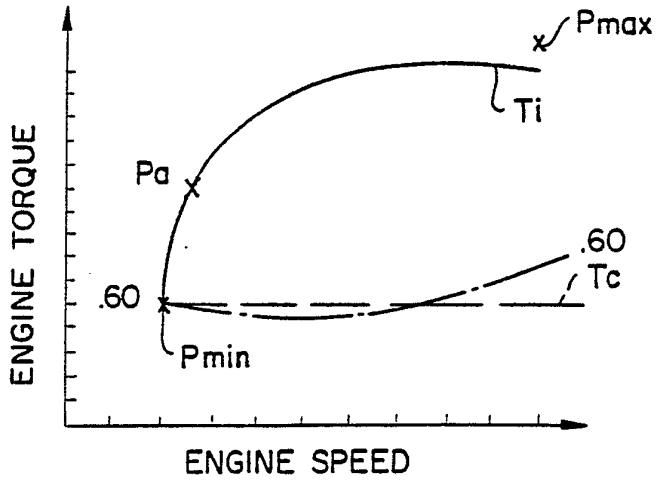
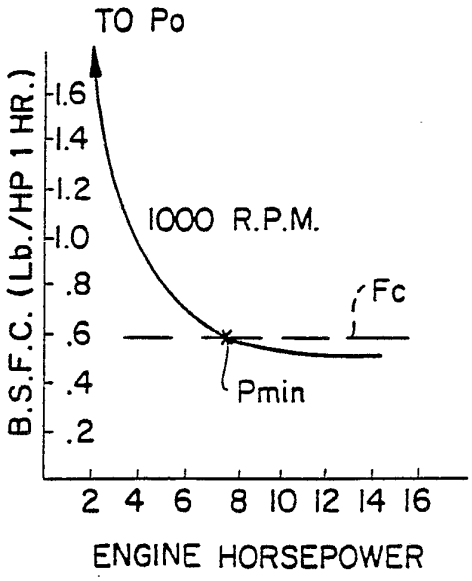


FIG. 4.



SUBSTITUTE SHEET

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INTERNATIONAL SEARCH REPORT

International Application No PCT/US80/01471

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

INT. CL.[3] B60K 9/04, B60K 41/28
US CL. 180/165

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
US	180/165,54R 192/.044 74/751

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

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]
A	US, A, 3,870,116 Published 11 March 1975, Seliber	1-6
A	US, A, 3,771,311 Published 13 November 1973, Herbst	1-6
A	US, A, 3,923,115 Published 02 December 1975, Helling	1-6
	US, A, 4,187,741 Published 12 February 1980, Nyman	1-6
	US, A, 4,126,200 Published 21 November 1978, Miller	1-6
	US, A, 3,749,194 Published 31 July 1973, Bardwick	1-6
	GB, A, 2,031,822 Published 30 April 1980, Kemper	1-6

* Special categories of cited documents: [15]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
11 August 1981	21 AUG 1981
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	David M. Mitchell

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