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Hotto

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(54) **SYSTEM AND METHOD FOR EXTRACTING PROPULSION ENERGY FROM MOTOR VEHICLE EXHAUST**

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This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

(63) Continuation of application No. 12/423,763, filed on Apr. 14, 2009, now Pat. No. 8,286,742, which is a continuation of application No. 10/994,957, filed on Nov. 22, 2004, now Pat. No. 7,520,350.

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B60K 6/32 (2007.10)
B60K 13/04 (2006.01)

(52) **U.S. Cl.**
USPC **180/65.31**; 180/309; 903/944; 60/272

(58) **Field of Classification Search**
USPC 180/65.21, 65.31, 309; 903/908, 903/944; 60/272, 278, 279; 123/3
See application file for complete search history.

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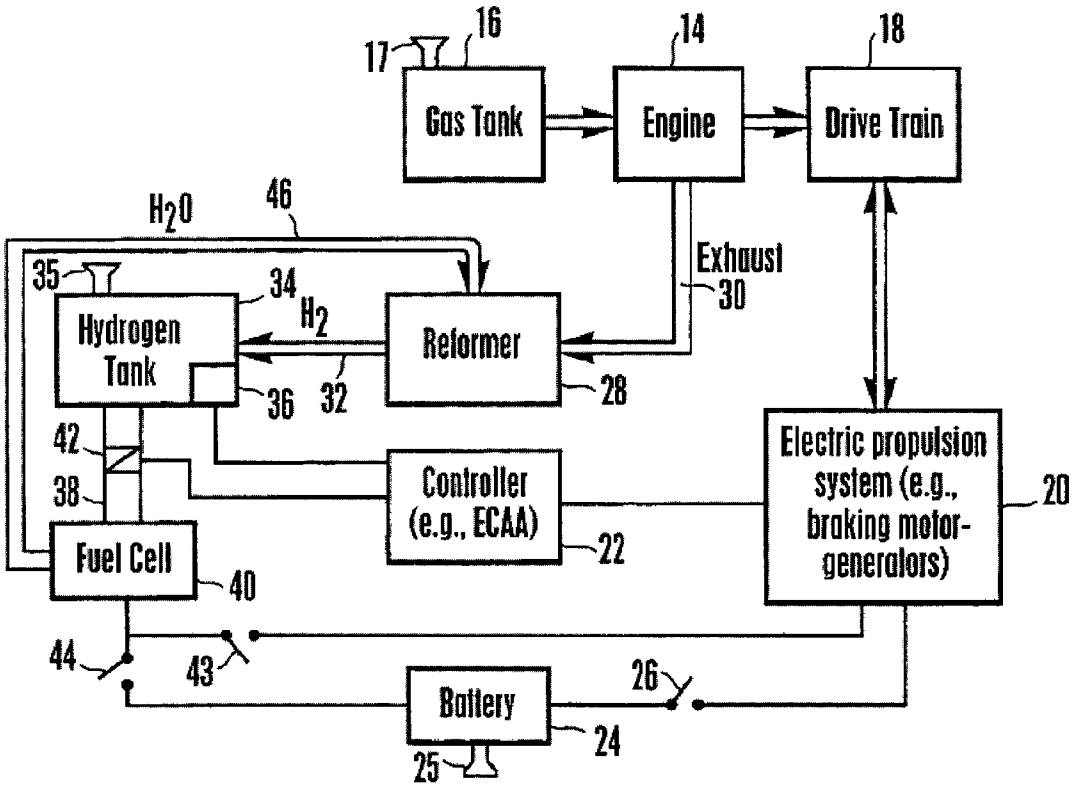
Primary Examiner — John Walters

(57) **ABSTRACT**

Engine exhaust is sent to a reformer, which produces hydrogen from fuel remaining in the exhaust. The hydrogen may be stored in a hydrogen tank, and may be used by a fuel cell to produce electricity to recharge a vehicle battery and/or to supply propulsion current to an electric propulsion system.

15 Claims, 2 Drawing Sheets



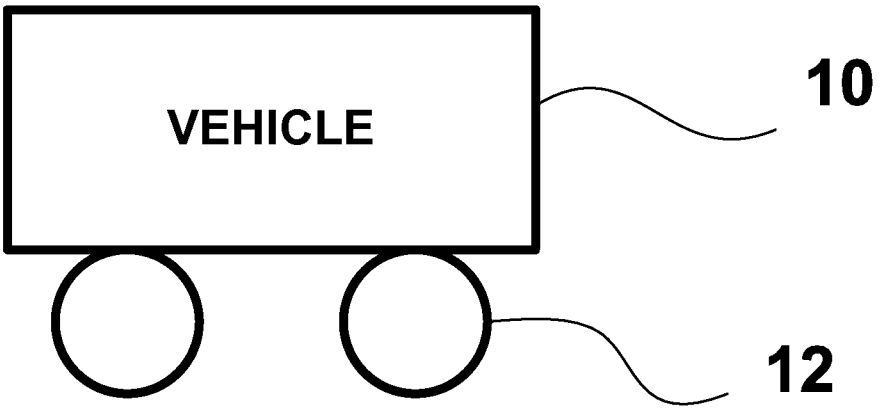


FIG. 1

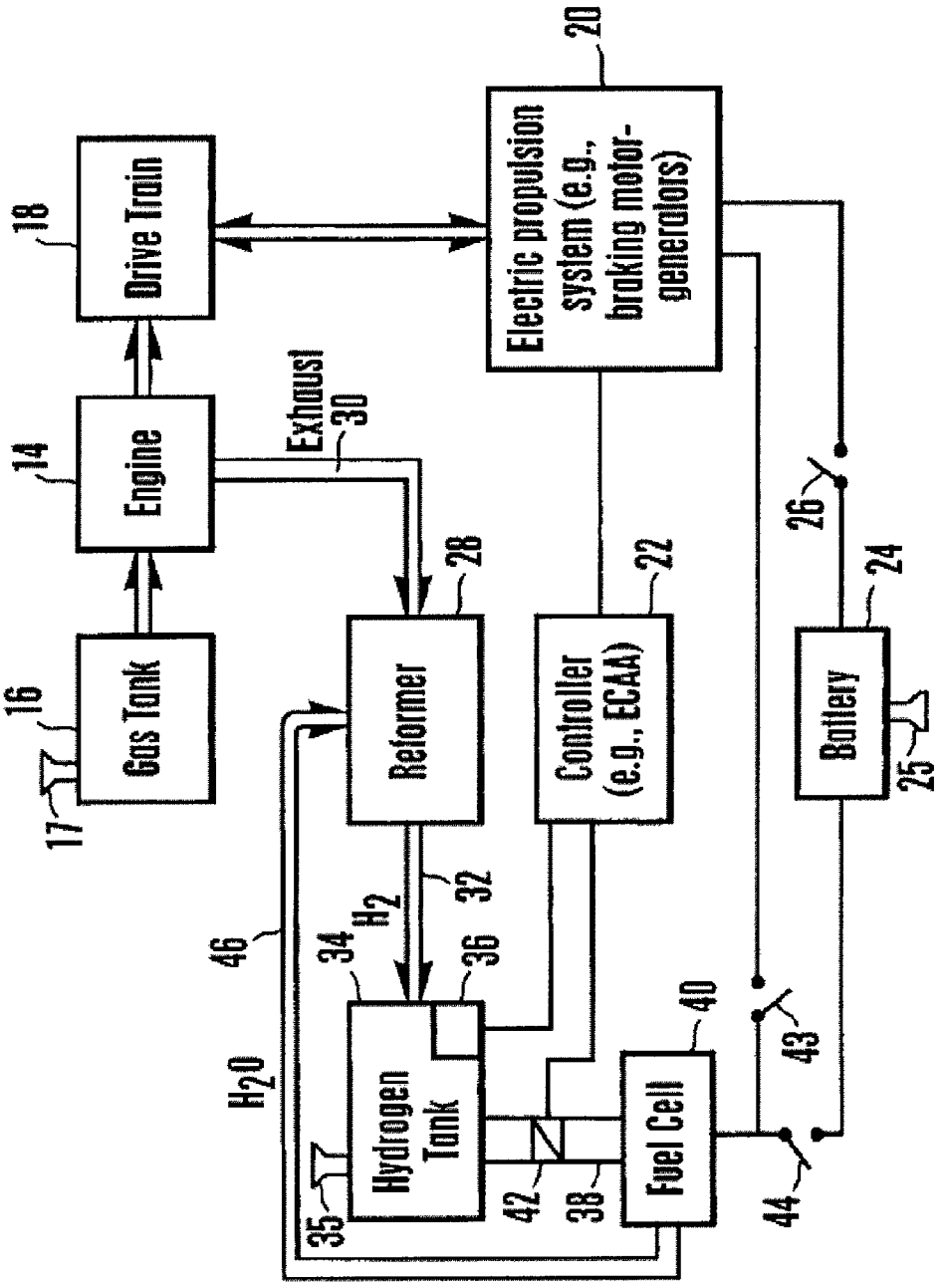


Figure 2
System

SYSTEM AND METHOD FOR EXTRACTING PROPULSION ENERGY FROM MOTOR VEHICLE EXHAUST

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of and claims priority to U.S. Utility patent application Ser. No. 12/423,763, filed Apr. 14, 2009, now U.S. Pat. No. 8,286,742, which is a continuation of U.S. Utility patent application Ser. No. 10/994,957, entitled SYSTEM AND METHOD FOR EXTRACTING PROPULSION ENERGY FROM MOTOR VEHICLE EXHAUST, filed on Nov. 22, 2004, now U.S. Pat. No. 7,520,350, the contents of which are incorporated by reference herein in their entirety for all purposes.

FIELD OF THE INVENTION

The present invention relates generally to motor vehicles.

BACKGROUND

The importance of energy conservation goes without saying. Not only must fossil fuels be conserved for future use, but limiting the amount of fossil fuels that must be burned appears to be highly beneficial for the environment. However, many proposals for improving vehicle energy consumption efficiency cannot be realistically implemented any time soon. Hence, the present invention.

SUMMARY

The present invention is directed generally to systems and methods for enhancing fuel utilization in an engine. In one aspect the present invention is related to a system for enhancing fuel utilization in an internal combustion engine, comprising a pipe coupled to the engine to receive engine exhaust gases and a reformer connected to the pipe, the reformer configured to produce hydrogen from hydrocarbons in the exhaust gases.

In another aspect, the present invention is related to a method for enhancing fuel utilization in an internal combustion engine, comprising generating exhaust gases from combustion in the engine, coupling the exhaust gases from the engine to a reformer configured to produce hydrogen from the exhaust gases and transferring the hydrogen to a hydrogen storage tank or a fuel cell.

In another aspect, the present invention is related to a method of enhancing combustion engine operation, comprising receiving, at a reformer having an input coupled to an exhaust output of the engine, exhaust gases produces by the engine, generating in the reformer, from hydrocarbons in the exhaust gases, hydrogen and transferring the hydrogen to a hydrogen storage tank or a fuel cell.

Additional aspects of the present invention are further described below with respect to the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The following is a brief description of the drawings wherein:

FIG. **1** is a schematic representation of a motor vehicle; and

FIG. **2** is a block diagram of an embodiment of the present invention, with double lines illustrating mechanical couplings and single lines indicating electrical connections.

DETAILED DESCRIPTION

FIG. **1** shows a motor vehicle **10** that may use the present propulsion system to cause one or more wheels **12** to rotate and move the vehicle **10**. The vehicle **10** may be an automobile, truck, motorcycle, or other wheeled vehicle. The present principles also apply to non-wheeled vehicles including boats, aircraft, or other vehicles that use an internal combustion engine.

FIG. **2** shows that the present propulsion system includes an internal combustion engine **14** that can be a four stroke (e.g., gasoline) engine or two stroke (e.g., diesel) engine. The engine **14** receives hydrocarbon fuel from a gas tank **16** (that can be filled at a service station with gas through a filler pipe **17**), and the engine outputs torque to a drive train **18** that can include a combination of components known in the art, e.g., crankshafts, transmissions, axles, and so on.

Additionally, the propulsion system can include an electrical propulsion system **20** such as braking motor-generators, sometimes referred to as "regenerators", in accordance with hybrid vehicle principles known in the art. Briefly, braking motor-generators work in response to signals that can be sent from a controller **22**, such as might be implemented in an engine control module (ECM). When a brake pedal is depressed by a driver, the ECM activates the braking motor generators (by, e.g., supplying field current to them), which act as electro-magnetic brakes in cooperation with complementary structure on the wheels or axle or other part of the drive train **18** to slow the vehicle down. In this mode, the braking motor-generators act as generators, outputting electricity to a vehicle battery **24** through a main battery switch **26** that is controlled by the controller **22** to shut the switch. If desired, the battery **24** also can be recharged at a service station through a recharging line **25**. On the other hand, the controller **22**, which also controls the engine **14**, can cause the engine **14** to stop and/or to be disengaged from the drive train **18** to conserve fuel, and instead cause the battery **24** to supply propulsion power through the switch **26** to the braking motor-generators, which act as motors to cause the complementary structure in the drive train **18** to turn.

The controller **22** may be implemented by any suitable processing apparatus, including a digital signal processor (DSP) or computer microprocessor, to execute the logic set forth further below. The logic below may be implemented by plural controllers.

Thus far, a so-called "hybrid" vehicle has been described. In accordance with the present invention, however, in addition to the power sources discussed above, the exhaust from the engine **14** is supplied to a reformer **28** through an exhaust pipe **30**. According to reformer principles known in the art, the reformer **28** produces hydrogen from the exhaust gases, e.g., from unburnt fuel that remains in the engine exhaust. As critically recognized herein, the exhaust from the engine is hot, facilitating performance of the reformer **28**.

Hydrogen from the reformer **28** is directed through a hydrogen line **32** to a hydrogen tank **34** for storage. If desired, in addition to receiving hydrogen from the reformer **28**, the hydrogen tank **34** can be filled at a service station with hydrogen through a filler pipe **35**. The hydrogen tank **34** may include a detector **36** that generates an electrical signal representative of the amount of hydrogen in the tank, and this signal may be sent to the controller **22**. Hydrogen from the tank **34** can be supplied through a fuel cell line **38** to a fuel cell **40**, which uses the hydrogen to generate electricity in accordance with fuel cell principles known in the art. A valve **42** such as a solenoid valve may be controlled by the controller **22** in accordance with logic below to selectively block or

unblock the fuel cell line **38**. Water can be returned from the fuel cell **40** if desired to the reformer **28** through a water line **46**.

Further, the present invention recognizes that the exhaust gas that remains after being stripped of hydrogen in the reformer **28** possesses newly exposed carbon bonds, and consequently may be recycled back to the engine **14** from the reformer **28** for further combustion.

As shown in FIG. **2**, the fuel cell **40** can output propulsion current to the electric propulsion system **20** through a fuel cell switch **43**, which is controlled by the controller **22**. Also, if desired the fuel cell **40** can output recharging current to the battery **44** through a recharging switch **44**, which is controlled by the controller **22** to recharge the battery **24**. In some implementations the fuel cell **40** can output current directly to the electrical propulsion system **20** as shown as well as to the battery **24**, or it may output current only to the electrical propulsion system **20**, or it may output only recharging current to the battery **24**.

The switches discussed above may be electro-mechanical or electrical, e.g., they may be implemented by field effect transistors (FET).

With the above system architecture in mind, the controller **22** can cause the drive train to be powered by the engine **14**, with the reformer **28** producing hydrogen for storage in the hydrogen tank **34** and with the switches **26**, **43**, **44** open and valve **42** shut. If the controller **22** determines that the state of charge of the battery **24** and operational mode (including demanded speed, etc.) of the vehicle **10** warrant it, the controller **22** can decouple the engine **14** from the drive train **18** and close the battery switch **26** cause the battery **24** to supply propulsion current to the electric propulsion system **20**.

Yet again, regardless of whether the battery **24** can be used in the particular implementation to propel the vehicle, the controller **22** can, when conditions warrant and the amount of hydrogen in the hydrogen tank **34** indicates a sufficient amount of hydrogen, cause the valve **42** to open. This ports hydrogen to the fuel cell **40**, which outputs electricity. The controller **22** may cause the recharging switch **44** to close to recharge the battery **24** from the fuel cell **40**, and/or it may case the fuel cell switch **43** to close to send propulsion current to the electric propulsion system **20** (in which case the engine **14** would be decoupled from the drive train **18**).

While the particular SYSTEM AND METHOD FOR EXTRACTING PROPULSION ENERGY FROM MOTOR VEHICLE EXHAUST as herein shown and described in detail is fully capable of attaining the above-described objects of the invention, it is to be understood that it is the presently preferred embodiment of the present invention and is thus representative of the subject matter which is broadly contemplated by the present invention, that the scope of the present invention fully encompasses other embodiments which may become obvious to those skilled in the art, and that the scope of the present invention is accordingly to be limited by nothing other than the appended claims, in which reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather "one or more". It is not necessary for a device or method to address each and every problem sought to be solved by the present invention, for it to be encompassed by the present claims. Furthermore, no element, component, or method step in the present disclosure is intended to be dedicated to the public regardless of whether the element, component, or method step is explicitly recited in the claims. Absent express definitions herein, claim terms are to be given all ordinary and accustomed meanings that are not irreconcilable with the present specification and file history.

The foregoing description, for purposes of explanation, used specific nomenclature to provide a thorough understanding of the invention. However, it will be apparent to one skilled in the art that specific details are not required in order to practice the invention. Thus, the foregoing descriptions of specific embodiments of the invention are presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed; obviously, many modifications and variations are possible in view of the above teachings. The embodiments were chosen and described in order to best explain the principles of the invention and its practical applications, they thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is intended that the following claims and their equivalents define the scope of the invention.

What is claimed is:

1. A method for enhancing fuel utilization in an internal combustion engine, comprising:
- generating exhaust gases from combustion in the engine;
- stripping hydrogen from the exhaust gases using a reformer;
- transferring the hydrogen-stripped exhaust gases to the engine; and
- using the hydrogen-stripped exhaust gases for further combustion.

2. The method of claim **1**, further comprising the steps of;
- transferring the hydrogen stripped from the exhaust gases to a fuel cell; and
- generating electrical energy from said hydrogen.

3. The method of claim **2**, further comprising the step of:
- providing the generated electrical energy to one or more electrical systems.

4. The method of claim **2**, further comprising the step of:
- using a drive mechanism to generate mechanical power from electrical power provided by the fuel cell.

5. The method of claim **2**, further comprising the steps of:
- using a controller and an associated switching apparatus to selectively switch between one of the following:
- (a) using a first drive mechanism to generate mechanical power from engine combustion;
- (b) using a second drive mechanism to generate mechanical power from electrical power provided by the fuel cell; or
- (c) using a first drive mechanism to generate mechanical power from engine combustion and using a second drive mechanism to generate mechanical power from electrical power provided by the fuel cell.

6. The method of claim **1**, further comprising the step of:
- applying at least a portion of the exhaust gases to said reformer so as to heat the reformer.

7. The method of claim **1**, further comprising the step of:
- using a drive mechanism to generate mechanical power from engine combustion.

8. A method for enhancing fuel utilization in an internal combustion engine, comprising:
- generating exhaust gases from combustion in the engine;
- stripping hydrogen from the exhaust gases using a reformer;
- transferring the hydrogen to a hydrogen storage tank;
- transferring the hydrogen-stripped exhaust gases to the engine; and
- using the hydrogen-stripped exhaust gases for further combustion.

9. The method of claim 8, further comprising the steps of;
transferring hydrogen from the hydrogen storage tank to a fuel cell; and
generating electrical energy from said hydrogen.

10. The method of claim 9, further comprising the step of:
providing the generated electrical energy to one or more electrical systems.

11. The method of claim 9, further comprising the step of:
using a drive mechanism to generate mechanical power from electrical power provided by the fuel cell.

12. The method of claim 9, further comprising the steps of:
using a controller and an associated switching apparatus to selectively switch between one of the following:
(a) using a first drive mechanism to generate mechanical power from engine combustion;
(b) using a second drive mechanism to generate mechanical power from electrical power provided by the fuel cell; or
(c) using a first drive mechanism to generate mechanical power from engine combustion and using a second drive mechanism to generate mechanical power from electrical power provided by the fuel cell.

13. The method of claim 12, further comprising the step of:
applying at least a portion of the exhaust gases to said reformer so as to heat the reformer.

14. The method of claim 8, further comprising the step of:
applying at least a portion of the exhaust gases to said reformer so as to heat the reformer.

15. The method of claim 8, further comprising the step of:
using a drive mechanism to generate mechanical power from engine combustion.

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