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F02B 43/10, C01B 3/08

(52) UK CL (Edition L)

F1B B2L1A

(56) Documents cited

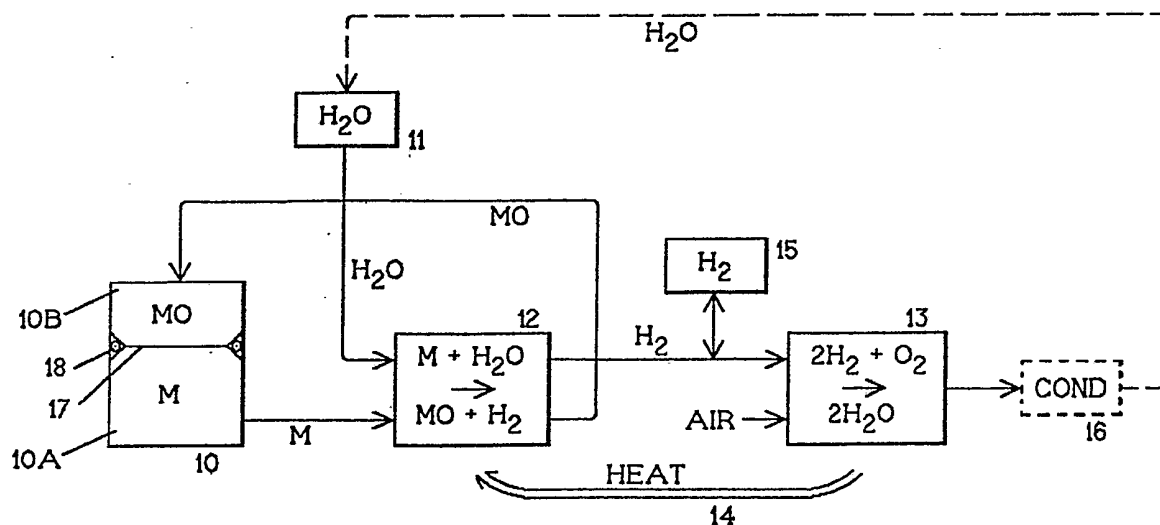
GB 1378820 A EP 0055134 A1 US 4698974 A
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US 3648668 A

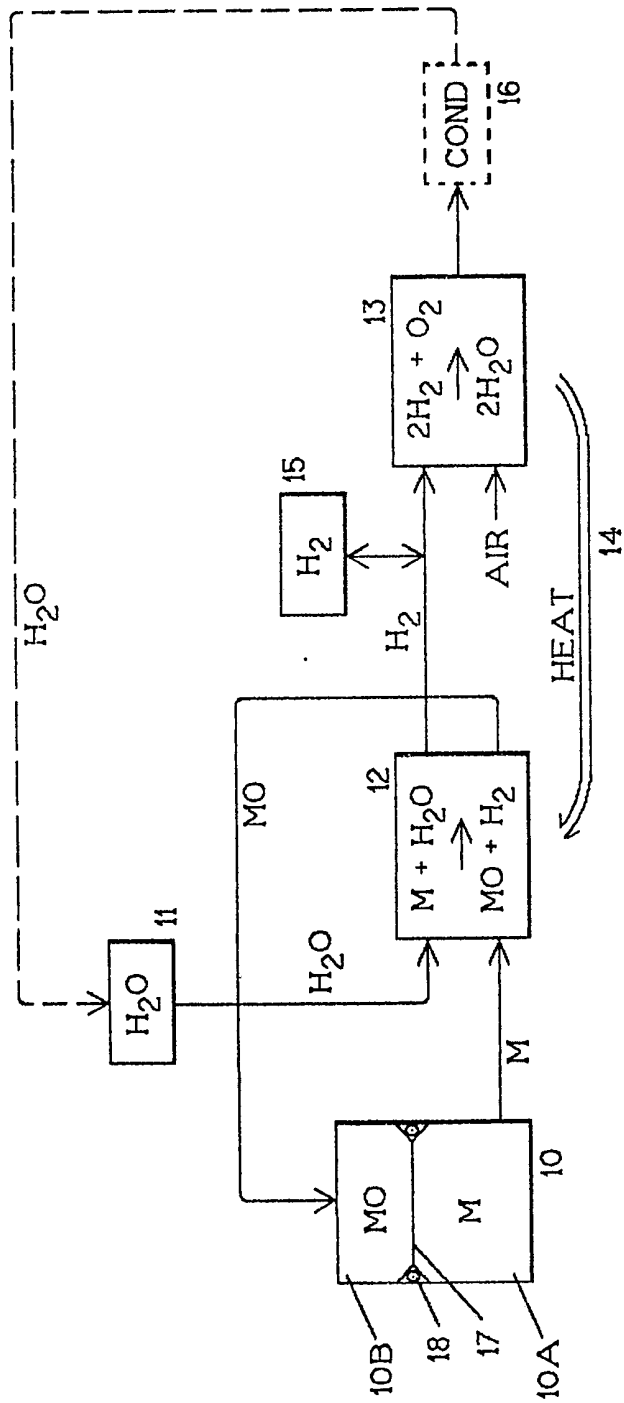
(58) Field of search

UK CL (Edition K) C1A, F1B
INT CL⁵ C01B 3/08, F02B 43/08 43/10

(54) Engine fed by a hydrogen generator

(57) An internal combustion engine 13 uses hydrogen which is generated from powdered or granulated lithium, iron or magnesium which is reacted with water in a hydrogen generator 12. Heat to maintain hydrogen generation is obtainable by directly burning some of the hydrogen generated and/or by using exhaust from the engine and/or a heat transfer fluid. The generator 12 may be a fluidized bed device. The resulting metal oxide MO can be stored in a metal container 10 being separated from the metal M to be reacted by a movable divider 17. The system preferably also includes a small hydrogen store, either compressed gas or a hydride store, for start-up purposes. The exhaust from the engine can be condensed to recover some or more of the water used.





Engine System

The present invention relates to power systems, and is particularly though not exclusively concerned with hydrogen-powered internal combustion engines.

Hydrogen-powered engines are of increasing interest. Compared to petrol-powered engines, they offer greatly reduced pollution. However, they present some major problems, among which are those of generating the hydrogen and of storing it. The generation problem is, in the last resort, a question of the cost of power (typically electrical) and the efficiency with which hydrogen can be generated from it. The storage problem is in some ways more difficult.

There are two obvious ways of storing hydrogen; as a liquid or as compressed gas. Storage as a liquid presents major problems, because of the very low temperatures required and the consequent need for a permanently running refrigeration system. Storage as compressed gas also presents major problems, as the pressures required are very high, leading to problems with both weight and safety.

A third storage method has therefore received attention. This is the use of metal hydrides. A suitable metal in granular form is contained in a suitable container, and hydrogen is pumped in. The hydrogen combines with the metal to form a metal hydride, and a given quantity of hydrogen can therefore be stored at ambient temperatures under pressures much less than required for the same quantity in gaseous form. However, the release of hydrogen from a metal hydride is relatively slow and inefficient, even with the application of heat.

The present invention represents a new approach to powering such engines. In the present invention, hydrogen is used as the fuel for the engine, but is not the primary energy source; instead, a metal is used as the primary power source, being reacted with water in a hydrogen generator to generate the hydrogen. This system combines a high degree of safety with ease of storage. The metal is stored as a solid, in powdered or granulated form; the water is of course stored as liquid.

The metal is preferably chosen such that it has a high specific energy content (i.e. a high energy content per unit mass). It is also preferably chosen to be non-toxic and reasonably cheap, though extreme cheapness is not necessary as the metal will normally be recycled and losses are likely to be very small. The metal should also be selected such that its reactivity is reasonably low at ambient temperatures but high (in reaction with water) at reasonably elevated temperatures.

Low reactivity at ambient temperatures is desirable for safety and to minimize oxidation when stored; the reactivity with water should be high at temperatures which are elevated but not extremely high, to minimize the amount of heating required by the hydrogen generator. It is not necessary to have zero reactivity at ambient temperatures, as the metal can be stored in a sealed container, though provided the reactivity is low, slight imperfections of the sealing will be tolerable. (This is comparable to petrol storage, where the petrol needs to be kept under safe conditions but slight leakage, e.g. by evaporation, is tolerable.)

Examples of suitable metals include lithium, iron, and magnesium. Lithium has low density; iron is cheap; and magnesium has high reactivity. Examples of undesirable metals are sodium and higher alkali metals (which have excessive reactivity with water at ambient temperatures), beryllium (which is toxic), tin and lead (which are unduly heavy and have low reactivity and energy density), and precious metals (which are unduly heavy, have low reactivity, and are excessively costly). A suitable mixture or alloy of metals may be used if desired to obtain a convenient combination of energy content and reactivity.

The water requirement will generally be modest, and can generally be met without difficulty. If desired, the exhaust from the engine can be condensed to recover some or most of the water used.

The metal is used in the form of granules or powder of sufficiently small size that the hydrogen-generating reaction with water proceeds sufficiently rapidly. The heat balance of the reaction will depend on the metal involved, but is likely to be negative. Heat input will therefore be required to maintain the reaction; this heat input can be obtained by directly burning some of the hydrogen generated and/or by using some of the heat produced by the burning of the hydrogen in the engine. This can be achieved by using the exhaust from

the engine and/or by circulating a heat transfer fluid between the engine (which it will cool) and the hydrogen generator. A controlled admixture of atmospheric oxygen may also be used. This will result in the direct oxidation of some of the metal, producing at least some of the heat required to drive the hydrogen generator.

The hydrogen generator may utilize fluidized bed techniques to generate the hydrogen from the metal. The resulting metal oxide will generally also be in granular or powdered form. It may be convenient to store the resulting metal oxide in the metal container - the space available for such storage will increase as the metal is used up. If this is done, a movable divider is preferably used to keep the metal and the metal oxide separated.

The system preferably also includes a small hydrogen store, in the form of either a compressed gas or a hydride store, for start-up purposes.

The drawing is a block diagram of a preferred form of the system. A metal container 10 containing a metal M in suitable physical form and a water container 11 containing water H_2O feed a hydrogen generator 12, which may run at a temperature of around 600 °C. In the generator, the metal and the water react to produce metal oxide MO and hydrogen H_2 . This is passed to an internal combustion motor 13, where it is burnt to produce water and mechanical energy. The maximum temperature produced by burning hydrogen is in the region of 2400 °C, and part of the energy produced by this burning is passed back, as shown at 14, to maintain the temperature of the hydrogen generator.

A small hydrogen store 15 is coupled between the hydrogen generator 12 and the motor 13 to store a start-up quantity of hydrogen, which is sufficient to heat the motor 13 and hydrogen generator 12 to working temperatures on start-up. A condenser 16 may be provided at the exhaust of the motor 13 to recover at least part of the water produced, such water being fed back to the water store 11.

The metal oxide MO from the hydrogen generator 12 may be fed back to the metal store 10, this store being divided into two chambers 10A and 10B as shown by a movable partition 17. This partition may have small guide wheels or rollers 18 as shown.

The couplings of the chamber 10A to the input to the hydrogen generator and of the output of the hydrogen generator to the chamber 10B may consist of conveyors or worm feeds.

Claims

- 1 A heat engine in which hydrogen is used as the fuel for the engine, and a metal is used as the primary power source, being reacted with water in a hydrogen generator to generate the hydrogen.
- 2 A heat engine according to claim 1 wherein the metal is stored as a solid in powdered or granulated form, and the water is stored as liquid.
- 3 A heat engine according to either previous claim wherein the metal has a high specific energy content, has a relatively low reactivity at ambient temperatures but high reactivity (in reaction with water) at reasonably elevated temperatures, and is non-toxic.
- 4 A heat engine according to claim 3 wherein the metal is lithium, iron, or magnesium.
- 5 A heat engine according to any previous claim including means for condensing the exhaust from the engine.
- 6 A heat engine according to any previous claim wherein the metal is in the form of granules or powder.
- 7 A heat engine according to any previous claim including means for heating the hydrogen generator by means of the exhaust from the engine and/or by circulating a heat transfer fluid between the engine and the hydrogen generator.
- 8 A heat engine according to any previous claim wherein the hydrogen generator utilizes fluidized bed techniques to generate the hydrogen from the metal.
- 9 A heat engine according to any previous claim wherein the metal oxide produced by the hydrogen generator is stored in the metal container.
- 10 A heat engine according to claim 9 including a divider in the metal container which separates the metal and the metal oxide therein.

11 A heat engine according to any previous claim including a small hydrogen store, in the form of either a compressed gas or a hydride store, for start-up purposes.

12 A heat engine substantially as herein described with reference to the drawing.

Any novel and inventive feature or combination of features specifically disclosed herein within the meaning of Article 4H of the International Convention (Paris Convention).

Patents Act 1977
Examiner's report to the Comptroller under
Section 17 (The Search Report)

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Relevant Technical fields

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(ii) Int Cl (Edition 5) F02B 43/08, 43/10, C01B 3/08

Search Examiner

R J DENNIS

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search

1 OCTOBER 1992

Documents considered relevant following a search in respect of claims

1 TO 12

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 1378820 (SUZUKI)	1 to 4
X Y	EP 0055134 A1 (CORNISH)	1 and 3 5
X	US 4698974 (GARRETT)	1, 3 and 4
X	US 4643166 (GARRETT)	1, 3 and 4
X	US 4356163 (DAVIDSON)	1
Y	US 3818875 (PHILLIPS)	5
X	US 3648668 (EBERT)	1, 3, 4 and 11

Category	Identity of document and relevant passages	Relevance to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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