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Attorney Docket No. 96484
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The below identified patent application is available for licensing. Requests for information should be addressed to:

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Attorney Docket No. 96484
Customer No. 23523

SELF CONTAINED FUEL SYSTEM FOR SOLID OXIDE FUEL CELL

TO ALL WHOM IT MAY CONCERN

BE IT KNOWN THAT (1) LOUIS G. CARREIRO, (2) A. ALAN BURKE and (3) STEVEN P. TUCKER, employees of the United States Government, citizens of the United States of America, and residents respectively of (1) WESTPORT, County of BRISTOL, Commonwealth of MASSACHUSETTS, (2) MIDDLETOWN, County of NEWPORT, State of RHODE ISLAND and (3) PORTSMOUTH, County of NEWPORT, State of RHODE ISLAND, have invented certain new and useful improvements entitled as set forth above of which the following is a specification:

JEAN-PAUL A. NASSER, Esq.
Reg. No. 53372

Attorney Docket No. 96484

SELF CONTAINED FUEL SYSTEM FOR SOLID OXIDE FUEL CELL

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefore.

CROSS REFERENCE TO OTHER RELATED APPLICATIONS

Not applicable.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to fuel cells, and more specifically to a novel fuel system designed for use with a solid oxide fuel cell for powering unmanned underwater vehicles.

(2) Description of the Prior Art

The most logical choice of an energy source for an unmanned underwater vehicle would appear to be a battery, since it can be operated in the absence of air. However, most batteries lack sufficient energy density to carry out the long missions associated with unmanned undersea vehicles, and the few batteries that might find application, for example lithium thionyl chloride, are prohibitively expensive. There continues to be a need for energy sources with a high energy density that can power unmanned undersea vehicles. These energy sources need to have long endurance, quiet operation, be relatively inexpensive, environmentally friendly, safe to operate, reusable, capable of a long shelf life and not prone to spontaneous chemical or electrochemical discharge.

In an effort to develop power sources for unmanned undersea vehicles with increased energy density, research has been directed towards semi fuel cells and fuel cells as one of several high energy density power sources being considered. For larger scale unmanned underwater vehicles, and longer duration missions, proton exchange membrane fuel cells and solid oxide fuel cells are being used because they can be completely re-fueled from both a fuel and oxidizer standpoint.

A key requirement for an unmanned underwater vehicle powered by a solid oxide fuel cell and maneuvering in shallow water in a surveillance mode is that its presence goes undetected. Stealthy operation of the unmanned underwater vehicle will depend, in part, on the reduction or elimination of any "signature" caused by the evolution of the product gas carbon dioxide, CO_2. Carbon dioxide, produced from the use of hydrocarbons in a solid oxide fuel cell must be contained and stored onboard the unmanned underwater vehicle. Since proton exchange fuel cells require pure hydrogen, H_2, for their operation, and release only water, H_2O, as a product, carbon dioxide is not an issue. However, proton exchange membrane fuel cells cannot run on hydrocarbon fuels because their platinum-metal catalysts will not tolerate any carbon monoxide, CO, that forms inside the fuel cell. For this reason, what is needed is a solid oxide fuel cell fuel system that offers an innovative solution to address carbon dioxide evolution.

SUMMARY OF THE INVENTION

It is a general purpose and object of the present invention to provide a power source for an unmanned undersea vehicle with increased energy density that employs a self-contained fuel system to address carbon dioxide evolution.

It is a further object to have a solid oxide fuel cell as the power source in the self-contained fuel system.

This object is accomplished by employing a chemical composite that when combined with water creates a fuel for the solid oxide fuel cell and a water soluble byproduct that can then be combined with the carbon dioxide gas generated by the fuel cell to create a storable solid precipitate.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention and many of the attendant advantages thereto will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIG. 1 is an illustration of the components of the self-contained fuel system of the present invention;

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 there is illustrated a unique fuel system 10 that is intended for use with a high-temperature fuel cell such as a solid oxide fuel cell 12. A solid chemical composite consisting of calcium carbide, CaC_2, and calcium oxide, CaO is reacted with water, H_2O, in a reaction chamber 14 connected to the solid oxide fuel cell 12, to generate acetylene gas, C_2H_2, and the byproduct calcium hydroxide, $Ca(OH)_2$. The chemical reactions are illustrated in equation (1):

$$CaC_2 + CaO + 3H_2O \Rightarrow C_2H_2 + 2Ca(OH)_2 \quad (1)$$

The byproduct calcium hydroxide, $Ca(OH)_2$ is directed to a precipitation chamber 16 connected to the reaction chamber 14 and solid oxide fuel cell 12. The acetylene gas, C_2H_2, is then either reformed to synthesis gases (CO and H_2) in a reformer, or is fed directly into the solid oxide fuel cell 12 where it can undergo electrochemical oxidization at the anode to produce water, H_2O, and carbon dioxide, CO_2, according to equation (2):

$$C_2H_2 + 5O^{2-} \Rightarrow 2CO_2 + H_2O + 10e^- \quad (2)$$

The CO_2 effluent is then directed via a hose 18 or some other device to the precipitation chamber 16 where it is reacted with $Ca(OH)_2$ to precipitate calcium carbonate, $CaCO_3$, which can then be stored in solid form. The chemical reactions are illustrated in equation (3):

$$Ca(OH)_2 + CO_2 \Rightarrow CaCO_3 + H_2O \quad (3)$$

The liquid oxidant, hydrogen peroxide, H_2O_2, can be used as the oxygen, O_2, source in equation (2) for the solid oxide fuel cell. The hydrogen peroxide, H_2O_2, is decomposed over the appropriate catalyst in a decomposition chamber 20 connected to the reaction chamber 14 and the solid oxide fuel cell 12, to produce water and oxygen according to the reaction illustrated in equation (4):

$$2H_2O_2 \Rightarrow 2H_2O + O_2 \quad (4)$$

The water, H_2O, formed by this reaction can be used in equation (1) to convert the composite consisting of calcium carbide, CaC_2, and calcium oxide, CaO, to acetylene, C_2H_2, and calcium hydroxide, $Ca(OH)_2$, hence eliminating the need for carrying an additional source of water, H_2O.

The advantage of the present invention over the prior art is that it is a self contained, zero-effluent fuel system with two distinct features: (1) it generates its own hydrocarbon fuel, acetylene, C_2H_2, and (2) it produces calcium hydroxide, $Ca(OH)_2$, which reacts with carbon dioxide gas, CO_2, to form a storable solid, calcium carbonate, $CaCO_3$. Since there is zero effluent, i.e. no carbon dioxide gas, CO_2, evolution to the underwater environment, buoyancy of the unmanned undersea vehicle is not affected. In addition, the fuel composite of calcium carbide, CaC_2, and calcium oxide, CaO is stored in solid form until it is converted to fuel upon demand.

In light of the above, it is therefore understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

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SELF CONTAINED FUEL SYSTEM FOR SOLID OXIDE FUEL CELL

ABSTRACT OF THE DISCLOSURE

A power source for an unmanned undersea vehicle with increased energy density is described that employs a self-contained fuel system to address carbon dioxide evolution. A solid oxide fuel cell serves as the power source in the self-contained fuel system. In combination with the solid oxide fuel cell, the system comprises a chemical composite that is combined with water to create both a hydrocarbon fuel for the solid oxide fuel cell and a water-soluble byproduct. The byproduct is then combined with the carbon dioxide gas generated by the fuel cell to create a storable solid precipitate.

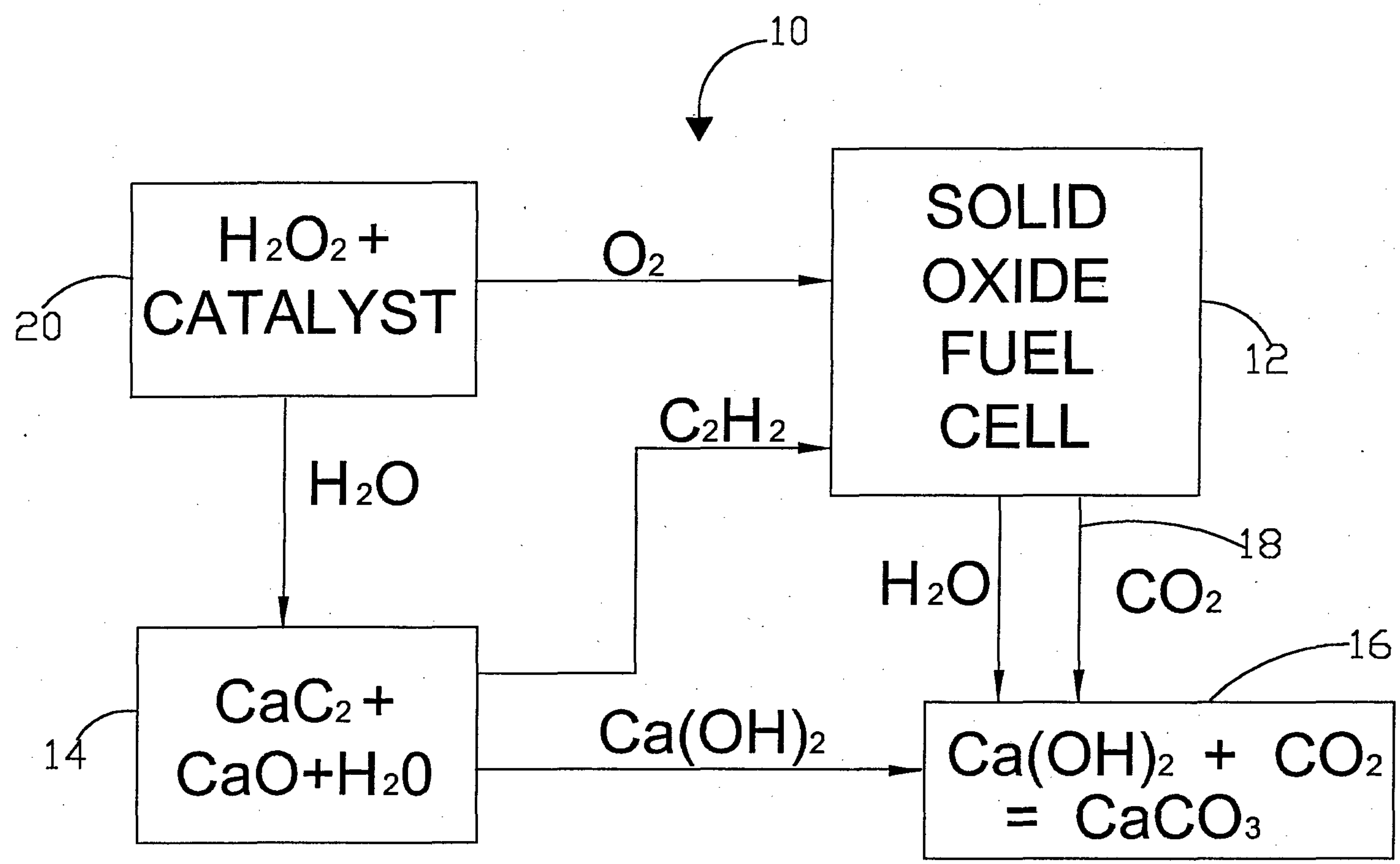
10
H2O2 +
CATALYST
20
O2
SOLID
OXIDE
FUEL
CELL
12
H2O
C2H2
H2O
CO2
18
16
CaC2 +
CaO+H20
14
Ca(OH)2
Ca(OH)2 + CO2
= CaCO3

FIG. 1