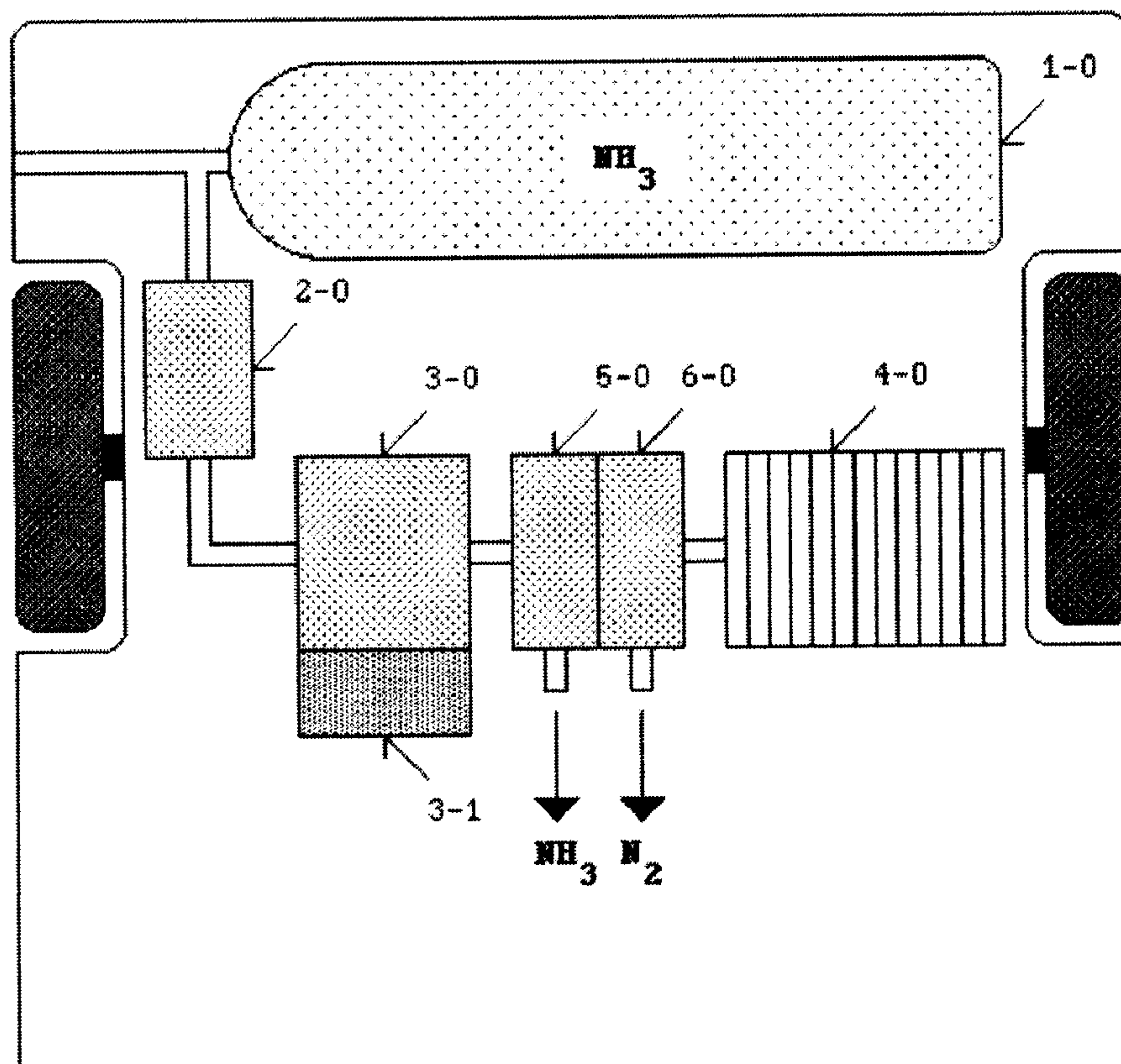




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(54) Titre : VEHICULE A PILES A COMBUSTIBLE MUNI D'UNE UNITE DE CRAQUAGE D'AMMONIAC PAR RAYONNEMENT ULTRAVIOLET
(54) Title: FUEL-CELL VEHICLE WITH ULTRAVIOLET AMMONIA CRACKER



(57) Abrégé/Abstract:

• A fuel-cell vehicle comprises an ammonia tank, a gas regulator, an ultraviolet ammonia cracker, and a fuel-cell stack. The ammonia tank stores anhydrous ammonia fuel in liquid form under pressure. The gas regulator vapourises liquid ammonia in the

(57) **Abrégé(suite)/Abstract(continued):**

ammonia tank into gaseous ammonia (NH₃). The ultraviolet ammonia cracker produces gaseous hydrogen (H₂). The ultraviolet ammonia cracker comprises an ultraviolet light source for generating electromagnetic radiation in the ultraviolet (UV) region of the spectrum. The fuel-cell stack generates electrical power from an electrochemical reaction between gaseous hydrogen (H₂) and gaseous oxygen (O₂) in order to drive a plurality of electric motors for vehicle propulsion. The ultraviolet light source is capable of dissociating gaseous ammonia (NH₃) into gaseous nitrogen (N₂) and gaseous hydrogen (H₂) according to formula: $2 \text{NH}_3 \rightarrow \text{N}_2 + 3 \text{H}_2$. This invention relates to fuel-cell vehicles, and the principal use of the invention is for ground transportation.

Abstract

- A fuel-cell vehicle comprises an ammonia tank, a gas regulator, an ultraviolet ammonia cracker, and a fuel-cell stack. The ammonia tank stores anhydrous ammonia fuel in liquid form under pressure. The gas regulator vapourises liquid ammonia in the ammonia tank into gaseous ammonia (NH_3). The ultraviolet ammonia cracker produces gaseous hydrogen (H_2). The ultraviolet ammonia cracker comprises an ultraviolet light source for generating electromagnetic radiation in the ultraviolet (UV) region of the spectrum. The fuel-cell stack generates electrical power from an electrochemical reaction between gaseous hydrogen (H_2) and gaseous oxygen (O_2) in order to drive a plurality of electric motors for vehicle propulsion. The ultraviolet light source is capable of dissociating gaseous ammonia (NH_3) into gaseous nitrogen (N_2) and gaseous hydrogen (H_2) according to formula: $2 \text{NH}_3 \rightarrow \text{N}_2 + 3 \text{H}_2$. This invention relates to fuel-cell vehicles, and the principal use of the invention is for ground transportation.

Description**Title**

- **Fuel-Cell Vehicle with Ultraviolet Ammonia Cracker**

Technical Field

- This invention relates to fuel-cell vehicles, more particularly to a fuel-cell vehicle with an ultraviolet ammonia cracker.

Background Art

- There are many instances where it would be desirable to be able to provide a fuel-cell vehicle with an on-board fuel processor.
- Compared to other candidate fuels for fuel-cell vehicles, such as pure hydrogen (H_2) and methanol (CH_3OH), ammonia (NH_3) has advantages in energy density (high) and fire safety (non-flammable), among others. In addition, an ammonia fuel-cell system has superior environmental performance to a methanol fuel cell system because the exhaust contains not CO_2 (greenhouse gas) or CO (toxic gas) but N_2 (inert gas). Moreover, ammonia is naturally found (e.g., urine), and is a household cleaning product (e.g., Windex (Trade Mark)). Furthermore, ammonia is a liquid at modest pressures, not unlike propane. Therefore, high hydrogen content is possible in a relatively small volume. As for toxicity, the smell of ammonia will prevent people from drinking it.
- Because ammonia (NH_3) can be decomposed easily to yield hydrogen (H_2), it is a convenient portable source of atomic hydrogen for welding. If an atom or molecule absorbs energy from a beam of light ($E = hv$), it gains far more energy than it ever could by other methods (e.g., from ordinary heating).
- A number of patents disclose fuel-cell vehicles.
- **U.S. Patent 5 629 102** discloses "Electrical automobile having a fuel cell, and method of powering an electrical automobile with a fuel cell system".
- **U.S. Patent 5 690 902** discloses "Hydrogen-powered automobile with in situ hydrogen generation".
- These prior art arrangements do not provide a fuel-cell vehicle with an on-board ultraviolet ammonia cracker.

Description of the Invention

- It is a primary object of the invention to provide a fuel-cell vehicle with an on-board fuel processor.
- It is another object of the invention to provide a fuel-cell vehicle which uses liquid anhydrous ammonia (NH_3) as a fuel.
- It is another object of the invention to provide a fuel-cell vehicle

which uses photodissociation with ultraviolet light to crack ammonia (NH_3).

- A fuel-cell vehicle comprises an ammonia tank, a gas regulator, an ultraviolet ammonia cracker, and a fuel-cell stack. The ammonia tank stores anhydrous ammonia fuel in liquid form under pressure. The gas regulator vapourises liquid ammonia in the ammonia tank into gaseous ammonia (NH_3). The ultraviolet ammonia cracker produces gaseous hydrogen (H_2). The ultraviolet ammonia cracker comprises an ultraviolet light source for generating electromagnetic radiation in the ultraviolet (UV) region of the spectrum. The fuel-cell stack generates electrical power from an electrochemical reaction between gaseous hydrogen (H_2) and gaseous oxygen (O_2) in order to drive a plurality of electric motors for vehicle propulsion. The ultraviolet light source is capable of dissociating gaseous ammonia (NH_3) into gaseous nitrogen (N_2) and gaseous hydrogen (H_2) according to formula: $2 \text{NH}_3 \rightarrow \text{N}_2 + 3 \text{H}_2$.

Brief Description of the Figures in the Drawings

- In drawings which illustrate embodiments of the invention:
 - **Figure 1** is a sectional view of one embodiment of a fuel-cell vehicle with an ultraviolet ammonia cracker according to the invention.

Modes for Carrying Out the Invention

- In one embodiment of the invention shown in **Figure 1**, a fuel-cell vehicle comprises an ammonia tank 1-0, a gas regulator 2-0, an ultraviolet ammonia cracker 3-0, and a fuel-cell stack 4-0.
- The ammonia tank 1-0 stores anhydrous ammonia fuel in liquid form under pressure.
- The gas regulator 2-0 vapourises liquid ammonia in the ammonia tank 1-0 into gaseous ammonia (NH_3).
- The ultraviolet ammonia cracker 3-0 produces an output gas containing gaseous hydrogen (H_2). The ultraviolet ammonia cracker 3-0 comprises an ultraviolet light source 3-1 for generating electromagnetic radiation in the ultraviolet (UV) region of the spectrum.
- The fuel-cell stack 4-0 generates electrical power from an electrochemical reaction between gaseous hydrogen (H_2) from the ultraviolet ammonia cracker 3-0 and gaseous oxygen (O_2) from ambient air in order to drive a plurality of electric motors for vehicle propulsion.
- The ultraviolet light source 3-1 of the ultraviolet ammonia cracker 3-0 is capable of dissociating gaseous ammonia (NH_3) into gaseous nitrogen (N_2) and gaseous hydrogen (H_2) according to formula: $2 \text{NH}_3 \rightarrow \text{N}_2 + 3 \text{H}_2$.
- The fuel-cell vehicle may further comprise an ammonia remover 5-0 for removing residual ammonia (NH_3) from the output gas from the ultraviolet

ammonia cracker 3-0. The ammonia remover 5-0 may comprise a membrane for removing NH_3 molecules.

- The fuel-cell vehicle may further comprise a nitrogen remover 6-0 for removing nitrogen (N_2) from the output gas from the ultraviolet ammonia cracker 3-0. The nitrogen remover 6-0 may comprise a membrane for removing N_2 molecules.
- Preferably, the ultraviolet light source 3-1 of the ultraviolet ammonia cracker 3-0 generates electromagnetic radiation in the vacuum ultraviolet (VUV) region of the spectrum.
- The fuel-cell stack 4-0 may comprise a plurality of alkaline fuel cells (AFC), a plurality of polymer electrolyte membrane fuel cells (PEMFC), a plurality of proton exchange membrane fuel cells (PEMFC), a plurality of direct ammonia fuel cells (DAFC), or a plurality of ammonia-air fuel cells (AAFC).
- The fuel-cell stack 4-0 may comprise a plurality of regenerative fuel cells, or a plurality of reversible fuel cells
- The fuel-cell vehicle may be a hybrid vehicle further comprising, as a secondary energy storage system, an ultracapacitor, a supercapacitor, or a hypercapacitor. The fuel-cell vehicle may be a hybrid vehicle further comprising, as a secondary energy storage system, a chemical battery to store chemical energy, or a flywheel battery to store kinetic energy.

Claims

- The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A fuel-cell vehicle, comprising:

- an ammonia tank for storing anhydrous ammonia fuel in liquid form under pressure;
- a gas regulator for vapourising liquid ammonia in the ammonia tank into gaseous ammonia (NH_3);
- an ultraviolet ammonia cracker for producing an output gas containing gaseous hydrogen (H_2), the ultraviolet ammonia cracker comprising:
 - an ultraviolet light source for generating ionising electromagnetic radiation in the vacuum ultraviolet (VUV) region of the spectrum;
- a fuel-cell stack for generating electrical power from an electrochemical reaction between gaseous hydrogen (H_2) from the ultraviolet ammonia cracker and gaseous oxygen (O_2) from ambient air in order to drive a plurality of electric motors for vehicle propulsion;
- an ammonia remover for removing residual ammonia (NH_3) from the output gas from the ultraviolet ammonia cracker, the ammonia remover comprising:
 - a membrane for removing NH_3 molecules; and
- a nitrogen remover for removing nitrogen (N_2) from the output gas from the ultraviolet ammonia cracker, the nitrogen remover comprising:
 - a membrane for removing N_2 molecules;

the ultraviolet light source of the ultraviolet ammonia cracker being capable of dissociating gaseous ammonia (NH_3) into gaseous nitrogen (N_2) and gaseous hydrogen (H_2) according to formula: $2 \text{NH}_3 \rightarrow \text{N}_2 + 3 \text{H}_2$ without any heating unit or relay control with a thermocouple, the ultraviolet ammonia cracker using an anaerobic process for producing an output gas.

2. The fuel-cell vehicle as defined in claim 1, in which the fuel-cell stack comprises a plurality of alkaline fuel cells (AFC).
3. The fuel-cell vehicle as defined in claim 1, in which the fuel-cell stack comprises a plurality of polymer electrolyte membrane fuel cells or proton exchange membrane fuel cells (PEMFC).
4. The fuel-cell vehicle as defined in claim 1, in which the fuel-cell stack comprises a plurality of direct ammonia fuel cells (DAFC).

5. The fuel-cell vehicle as defined in claim 1, in which the fuel-cell stack comprises a plurality of ammonia-air fuel cells (AAFC).
6. The fuel-cell vehicle as defined in claim 1, in which the fuel-cell stack comprises a plurality of regenerative fuel cells or reversible fuel cells
7. The fuel-cell vehicle as defined in claim 1, in which the fuel-cell vehicle is a hybrid vehicle further comprising:
 - an ultracapacitor or a supercapacitor or a hypercapacitor as a secondary energy storage system.
8. The fuel-cell vehicle as defined in claim 1, in which the fuel-cell vehicle is a hybrid vehicle further comprising:
 - a chemical battery as a secondary energy storage system.
9. The fuel-cell vehicle as defined in claim 1, in which the fuel-cell vehicle is a hybrid vehicle further comprising:
 - a flywheel battery as a secondary energy storage system.

Figure 1

