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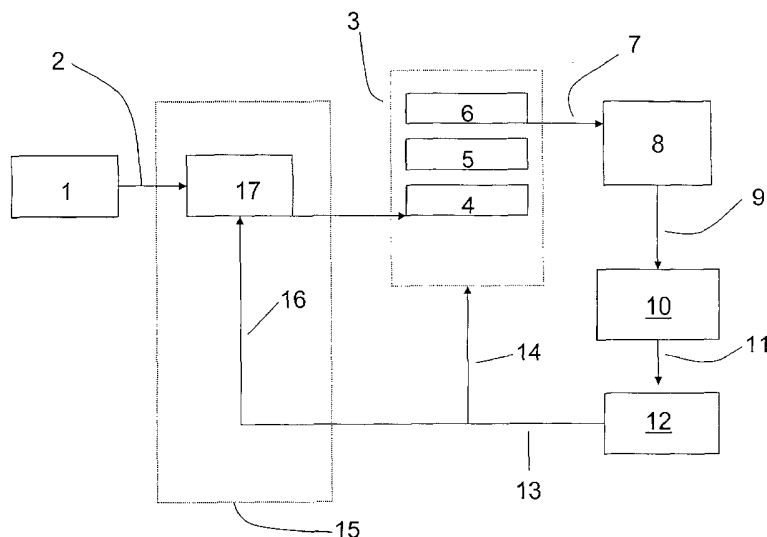
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(54) Title: UTILISATION OF WASTE GAS STREAMS



(57) Abstract: In a waste gas abatement system for abating gas from a semiconductor processing apparatus (1), the waste gas abatement system comprises one or more treatment devices (3, 8, 10) for treating waste gas, and the abatement system further comprises a fuel cell (12). At least one treatment device (3, 8, 10) is arranged to generate a fuel for the fuel cell (12) and the fuel cell (12) is connected to an electrically powered device of the waste gas abatement system or of the semiconductor processing apparatus (1) so as to be able to power wholly or in part said electrically powered device. The abatement system allows waste gases from semiconductor processing to be used to improve the efficiency of a semiconductor processing step and/or of the abatement system itself by generating energy for use therein.

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**UTILISATION OF WASTE GAS STREAMS**

This invention relates to new methods of treating waste gas streams and, more particularly, to one in which hydrogen present in such waste gas streams is purified for re-use.

Hydrogen gas is increasingly employed in the processing of silicon semiconductor and compound semiconductor devices including the manufacture of light emitting diodes (LEDs).

Because of its extreme flammability there is an increasing demand to treat the waste hydrogen as an alternative to discharging it at rooftop level. It is known that simply burning hydrogen is a common alternative to high level atmospheric discharge. However, specific issues arise, in particular that standard burners need to possess adequate air added at all times to ensure complete combustion; in addition, large quantities of heat are generated which need to be managed through considerable additional engineering of plant and increased costs. Furthermore, concerns about "flashback" of hydrogen and oxidant mixtures also need to be managed.

Many semiconductor processes utilise large flows of hydrogen containing various toxic and sometimes pyrophoric gases that require to be treated before being released to the atmosphere. Examples of such processes are gallium nitride deposition, polycrystalline silicon deposition, epitaxial silicon deposition, and indium phosphide deposition. The exhaust gases from those processes may comprise a mixture of gases, for example including hydrogen in combination with one or more of ammonia, nitrogen, phosphine, arsine, and silanes, including disilanes and halosilanes, sometimes together with solid particulate material such as unused organogallium, organoindium or other organometallic compounds.

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Ordinarily, the exhaust from such processes may be treated by incineration followed by wet scrubbing. With that technique, the whole waste stream, including both any toxic components and the hydrogen, is burned. That generates a considerable amount of waste heat, typically 20kW from the incinerator, plus an additional 20kW for each 100 l/min of hydrogen present. The hot waste gases from incineration pass into a wet scrubber for removal of solid and soluble gaseous by-products. The total heat load is absorbed by the re-circulating liquor of the wet scrubber. To maintain the scrubber at an appropriate operating temperature, cooling is required. The exhaust gases from a number of semiconductor tools may be combined for treatment in the incinerator. An alternative technique is to use a local wet scrubber to remove the impurities and then to dilute the hydrogen to below the lower explosive limit (4% by volume) before release.

With increasing flow rates, the dilution method is becoming impractical. There is therefore a need for a method of abatement of such waste streams which obviates the need for very high dilution rates and which can offer a reduced cooling burden over existing techniques. Further there is a need for a more effective way of managing hydrogen gas in terms of its recovery and/or the recovery of a good proportion of the latent energy of the hydrogen.

The invention provides a waste gas abatement system for abating gas from a semiconductor processing apparatus, the waste gas abatement system comprising one or more treatment devices for treating waste gas, wherein the abatement system further comprises a fuel cell, at least one said treatment device is arranged to generate a fuel for said fuel cell and said fuel cell is connected to an electrically powered device of the waste gas abatement system or of the semiconductor

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processing apparatus so as to be able to power wholly or in part said electrically powered device.

The waste gas abatement system of the invention enables a proportion of the waste gas to be re-utilised in a manner  
5 which can reduce the overall external energy input required to operate the abatement system.

The abatement system itself may comprise one or more electrically powered devices, the fuel cell being arranged to power wholly or in part at least one of said electrically  
10 powered devices of the abatement system. Alternatively or in addition, one or more electrically powered devices may form part of the semiconductor processing apparatus, the fuel cell being arranged to power wholly or in part at least one of said electrically powered devices. In that connection,  
15 "semiconductor processing apparatus" is intended to include those components that form part of such an apparatus but may be physically located outside of any processing tool. Such components may include, for example, vacuum pumps which in some circumstances may be structurally distinct from the  
20 processing tool but in communication therewith so as to effect a pressure reduction therein.

Advantageously, said at least one fuel-generating treatment device for generating a fuel for the fuel cell comprises a reactor in which the waste gas is to be decomposed  
25 into a gas mixture containing said fuel. Decomposition of the waste gas is to be understood herein as extending to decomposition of a proportion of the waste gas, for example, where the waste gas contains a mixture of gases, decomposition of a component of the waste gas.

30 Advantageously, the abatement system comprises separator means downstream of said reactor for separation of the fuel

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from other components of said gas mixture. Preferably, the fuel is hydrogen.

Fuel cell technology utilises hydrogen or a hydrogen-rich gas stream and converts it into electrical energy. There may  
5 be used as the fuel cell any suitable fuel cell. Suitable types of fuel cell that are commercially available include alkaline fuel cells, proton exchange membrane fuel cells, molten carbonate fuel cells, phosphoric acid fuel cells, and solid oxide fuel cells. Selection of an appropriate fuel cell  
10 will depend upon the nature of the fuel feed to be used and also upon the other components of the abatement system. In general, low temperature fuel cells are prone to CO poisoning and are therefore less suitable for use with waste streams that will contain material amounts of CO. Alkaline fuel cells  
15 are sensitive to CO<sub>2</sub>. Phosphoric acid fuel cells are sensitive to sulphur contamination. Alkaline fuel cells and proton exchange membrane fuel cells require relatively high purity hydrogen feeds, and will therefore often be appropriate only when the system includes a hydrogen separator and optionally a  
20 hydrogen purifier. The higher the operating temperature, the longer the warm-up time before the cells can generate a significant supply of electrical energy, so the most chemically robust cell may not be the best choice. In practice, a fuel cell will often be formed of a multiplicity  
25 of associated individual cell units, and references herein to a "fuel cell" are to be understood as including such a multiplicity of individual cell units.

The hydrogen compartment may be arranged with a continuous bleed to prevent a build-up of nitrogen and/or  
30 other gases. The bleed may be further treated to reduce the hydrogen content still further, or released. A bleed may in particular be unnecessary when there is a hydrogen separation

step prior to the fuel cell providing a substantially pure hydrogen fuel stream. The fuel cell typically generates 40% of the thermodynamic energy available from the source fuel as electricity, with the balance being dissipated as heat. The electrical energy thus generated can serve to provide power to one or more electrically powered devices of the abatement system and/or of a semiconductor processing apparatus. For example, it can serve to power a thermal reactor of the abatement system, in which case the abatement system may be self contained and only require an external source of energy for start-up or when not abating process gas.

Thus, the abatement system can advantageously selectively be powered in part or wholly by the fuel cell. Preferably, the abatement system comprises at least one thermal reactor that is powered wholly or in part by said fuel cell or cells. With a reactor designed to have a comparatively large thermal mass, the change-over from one energy source to another has little impact on the overall performance of the system. Any excess electrical energy can be simply dumped to a resistive load bank. This could be outside the building and air cooled, thus putting no additional load on the process cooling water circuit.

Where an external source of energy is required for the abatement system that external source is advantageously electricity or hydrogen. For long periods of continuous operation with comparatively few, short periods of downtime, supplementing the available hydrogen with an external source of hydrogen would be preferable. For more intermittent operation, supplementing the electrical supply would be more efficient.

In a further embodiment of the invention, the abatement module may be integrated with a vacuum pumping system for the

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semiconductor process tool. Alternatively, the vacuum pump may be integrated with the semiconductor process tool.

Alternatively, the vacuum pump may stand alone, physically separate from the process tool and the abatement system.

5 However, in such a case it is considered that the pump still forms part of the semiconductor processing apparatus.

Excess electrical energy derived from the abatement process could be used to provide some or all of the power to operate the vacuum pumping system. Thus, the abatement  
10 system may comprise at least one pump that is powered wholly or in part by said fuel cell or cell.

Advantageously, the abatement system comprises a control device for monitoring the electrical current generated by the fuel cell and determining in dependence thereon an additional  
15 power requirement to be derived from an external power source.

The abatement system may comprise two or more fuel cells arranged to receive said fuel.

In an especially preferred embodiment of the invention, the abatement system is arranged to recover hydrogen from an  
20 ammonia-containing waste gas, and comprises a thermal reactor for decomposing ammonia into hydrogen and nitrogen, optionally with a hydrogen separator arranged to receive the decomposed gaseous decomposition product and separate hydrogen therefrom.

Ammonia is a major constituent of many semiconductor  
25 processes and is often used concurrently with, or sequenced with, hydrogen. Ammonia is a pungent gas with a TLV of 25ppm. However, when burned, great care is needed to prevent the formation of  $\text{NO}_x$ , whilst known wet scrubbing processes may well eventually de-gas the ammonia and/or result in high  
30 nitrate discharge rates in to ground water.

It is known that a hot, packed bed containing a suitable catalyst can decompose ammonia in to its constituents gas,

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nitrogen and hydrogen, to produce one part nitrogen and three parts hydrogen (by volume). This is an endothermic process and the gases and the catalyst need to be heated in accordance with the disclosure of our British Patent Application No.

5 2 353 034 A. Other ingredients can be added to the hot bed to remove other gases or vapours which may co-discharge from the reactor.

In accordance with that especially preferred embodiment of the invention, hydrogen for use in the fuel cell is  
10 hydrogen which is wholly or partly derived from ammonia cracked into its component parts - hydrogen and nitrogen - over a suitable catalyst and optionally thereafter purified. Preferably, the ammonia is a waste stream containing ammonia as a component gas.

15 Thus, the abatement system of the invention advantageously comprises an ammonia-cracking device having a hot, packed catalyst bed.

Where the abatement system comprises a hydrogen separator, the hydrogen separator may be a pressure swing  
20 adsorption system. The pressure swing adsorbents used in the pressure swing adsorption system will generally be effective in separating the hydrogen from nitrogen in particular. They are therefore effective in separating hydrogen gas itself from a gas mixture or in separating the hydrogen gas constituent of  
25 ammonia (including any hydrogen gas itself which is present) from the gas mixture. Preferably, the hydrogen produced from the pressure swing adsorption system using known adsorbents can be in excess of 99%, often in excess of 99.9% pure. Hydrogen of this purity can be passed through a palladium  
30 purifier to produce hydrogen gas of required purity of, or in excess of, 99.999%. Thus, the abatement system may comprise a purifier, for example, a palladium purifier, for purifying

hydrogen gas separated by said hydrogen separator prior to use of said hydrogen gas in said fuel cell. In practice, however, the use of a purifier for further purification is unlikely to be efficient in terms of cost and/or energy efficiency.

5 The invention further provides a method of utilising a waste gas, comprising treating the waste gas to obtain a fuel, feeding the fuel to a fuel cell and utilising energy generated by the fuel cell in the treatment of the gas stream. An abatement system according to any one of the preceding claims,  
10 which is arranged to receive waste gas from a semiconductor processing step.

Advantageously, the energy generated by the fuel cell is supplemented by energy from an external source.

Advantageously, the energy generated by the fuel cell is  
15 continuously supplemented by an external source.

Advantageously, the energy generated by the fuel cell is intermittently supplemented by an external source.

Advantageously, the level of supplementary energy provided by an external source can vary and can be determined in  
20 dependence upon the energy delivered by the fuel cell.

Advantageously, the fuel is fed to a plurality of fuel cells.

Two illustrative embodiments of the invention will now be described with reference to the accompanying drawings, in  
25 which:

Fig. 1 is a schematic representation of a first semiprocessor reactor and abatement system according to the invention;

Fig.2 is a schematic representation of a second semiprocessor reactor and abatement system according to the invention.

30 Referring to Fig. 1, there is shown in schematic form a chamber for epitaxial deposition of gallium nitride, together with an associated abatement system. The epitaxy chamber 1

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has an outlet for exhaust gases, which communicates via line 2 with thermal reactor 3 (optionally via a pump system, described in more detail below). The thermal reactor 3 comprises three electrically heated granular beds of reactants such as described in British Patent Application No. 2 353 034 A. The waste stream enters the reactor, being preheated over the first layer 4 of the bed. Trimethylgallium undergoes a base catalysed thermal decomposition on the second layer 5 of the bed. The third layer 6 comprises a catalyst for decomposing the ammonia. Effluent gas from the reactor 3 thus includes N<sub>2</sub>, H<sub>2</sub> and traces of CH<sub>4</sub>. This stream is fed via line 7 through a filter 8 (which is optional but preferred in the embodiment of Fig. 1) to guard against the transmission of particles from the reactor, before passing via line 9 to a pressure swing adsorption system 10 in which hydrogen is separated from nitrogen and other gases present. The separated hydrogen, which is about 99% pure is then fed via line 11 to fuel cell 12. An electric current generated by fuel cell 12 is taken by current carrier means 13 and 14 to thermal reactor 3 to be used in heat generation therein. As well, or instead, current may be supplied via carrier means 13 to a pumping system 15 including current carrier means 16 and pump 17, the pump being arranged to withdraw gases from chamber 1. the current carrier means 13, 14, 16 include one or more inverters to convert the fuel cell outputs into a synchronous AC suitable for use in the reactor 3 or pump 17.

The embodiment shown in the drawing is suitable for treatment of exhaust gases from gallium nitride deposition, and allows for use of the generated electrical current in heating the thermal reactor 3 and/or operating the pump 17.

Analogous apparatus may be used in processing waste gases from a variety of semiconductor processes, some of which are

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included by way of illustration in the Examples below. In each case, the hydrogen generated is fed to the fuel cell, whilst any secondary streams emitted at the fuel cell or separated in any interim separation or purification step will be subjected to further treatment or, in the case of nitrogen or other gas streams meeting environmentally acceptable quality levels, released to the atmosphere.

The following Examples illustrate the invention:

#### 10 Example 1

Gallium nitride is deposited in a reactor and the exhaust gases are treated in an abatement system according to Fig. 1 including filter 8 (although a filter is not essential), but omitting pressure swing adsorption system (PSA) 10. The exhaust gas from the reactor 1 contains about 80 l/min  $\text{NH}_3$ , 80 l/min  $\text{H}_2$ , 50 l/min  $\text{N}_2$  and 2g/hr  $\text{Ga}(\text{CH}_3)_3$ . After treatment in the ammonia cracker 3, the gas stream contains about 200 l/min  $\text{H}_2$ , 90 l/min  $\text{N}_2$ , and 0.02 l/min  $\text{CH}_4$ , corresponding to impurities of approx 100ppm  $\text{CH}_4$  and with about 500ppm  $\text{NH}_3$ . The treated gas stream is fed to the fuel cell 12 without further treatment to separate the hydrogen from the nitrogen. Waste products emitted at the fuel cell are nitrogen, methane, oxygen and water. If the PSA 10 is present, most of the nitrogen and methane can be removed upstream of the fuel cell. Base catalysed decomposition of the small quantities of trimethyl gallium will occur in the second layer 5 of the bed of the thermal reactor 3.

#### Example 2

30 Polycrystalline silicon deposition is carried out in a reactor, and the exhaust gases are treated in an abatement system analogous to that of Fig. 1 except that the ammonia

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cracker 3 is replaced by a thermal reactor for decomposition of  $\text{SiH}_2\text{Cl}_2$ , and as filter 8 a filtration system for removal of solid silicon particulates. The PSA is also omitted. The exhaust gas from the reactor 1 contains about 200 l/min  $\text{H}_2$ , 50 l/min  $\text{N}_2$ , 1 to 2 l/min  $\text{SiH}_2\text{Cl}_2$ . After treatment in the thermal reactor and filtering in the filtration system, the gas stream contains about 200 l/min  $\text{H}_2$ , 50 l/min  $\text{N}_2$ , and <1 ppm  $\text{SiH}_2\text{Cl}_2$ . The treated gas stream is fed to the fuel cell without further treatment to separate the hydrogen from the nitrogen. Waste products emitted at the fuel cell are nitrogen, oxygen and water. If the PSA 10 is present, most of the nitrogen can be removed upstream of the fuel cell.

### Example 3

Epitaxial deposition of silicon is carried out in a reactor, and the exhaust gases are treated in an abatement system analogous to that of Fig. 1 except that the ammonia cracker is replaced by a thermal reactor for decomposition of  $\text{SiH}_4$ , which includes as filter 8 a filtration system for removal of solid silicon particulates. The exhaust gas from the reactor contains about 200 l/min  $\text{H}_2$ , 50 l/min  $\text{N}_2$ , and 1 to 2 l/min  $\text{SiH}_4$ . After treatment in the thermal reactor and filtering in the filtration system, the gas stream contains about 200 l/min  $\text{H}_2$ , 50 l/min  $\text{N}_2$ , and <1 ppm  $\text{SiH}_4$ . The treated gas stream is fed to the fuel cell without further treatment to separate the hydrogen from the nitrogen. Waste products emitted at the fuel cell are nitrogen, oxygen and water. If the PSA 10 is present, most of the nitrogen can be removed upstream of the fuel cell.

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## Example 4

Deposition of indium phosphide is carried out in a reactor, and the exhaust gases are treated in an abatement system analogous to that of Fig. 1 except that the ammonia cracker is replaced by a thermal cracker for decomposition of phosphine, arsine, trimethyl indium, and trimethyl gallium filter 8 is replaced by a condenser system for removal of by condensation of arsenic, phosphorus, indium phosphide and other by-products at its outlet. The exhaust gas from the reactor contains about 50 l/min  $H_2$ , and 50 l/min  $N_2$ . In the thermal cracker,  $PH_3$  and  $AsH_3$ , are converted to hydrogen and phosphorus or arsenic, respectively, whilst  $Ga(CH_3)_3$  and  $In(CH_3)_3$  are converted to methane and solid gallium and indium compounds. The solid gallium and indium by-products condense on surfaces of the thermal reactor 3 or are carried along and trapped in the condenser system. In the condenser, phosphorus and arsenic are condensed and removed from the gas stream. From the condenser, the gas is transported to the fuel cell without further treatment to separate the hydrogen from the rest of the gaseous stream. Waste products emitted at the fuel cell are nitrogen, methane, oxygen and water. If the PSA is present, most of the nitrogen and methane can be removed upstream of the fuel cell.

25

## Example 5

Gallium nitride is deposited epitaxially in a reactor with recycle line constructed generally as shown in Fig. 1, except that the filter 8 is omitted. Waste gas from the reactor contains 20 l/min hydrogen, 20 l/min nitrogen and 5 l/min ammonia. On exit from the thermal reactor 3, the gaseous feed contains about 27.5 l/min hydrogen and 22.5 l/min

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nitrogen. The unconcentrated hydrogen feed is then supplied to the fuel cell 12, which based on a conversion efficiency of 40% generates about 2.2 KW. Where the thermal reactor 3 has an operating power requirement of 1.5KW, the fuel cell may  
5 therefore be capable of providing continuous operating power to the reactor at least during operation of the apparatus.

## Claims

1. A waste gas abatement system for abating gas from a semiconductor processing apparatus, the waste gas abatement system comprising one or more treatment devices for treating waste gas, wherein the abatement system further comprises a fuel cell, at least one said treatment device is arranged to generate a fuel for said fuel cell and said fuel cell is connected to an electrically powered device of the waste gas abatement system or of the semiconductor processing apparatus so as to be able to power wholly or in part said electrically powered device.
2. An abatement system according to claim 1 comprising one or more electrically powered devices, wherein the fuel cell is arranged to power wholly or in part at least one of said electrically powered devices.
3. An abatement system according to claim 1 or claim 2, in which said at least one fuel-generating treatment device comprises a reactor in which the waste gas is to be decomposed into a gas mixture containing said fuel.
4. An abatement system according to claim 3, which comprises separator means downstream of said reactor for separation of the fuel from other components of said gas mixture.
5. An abatement system according to any one of the preceding claims, in which the fuel is hydrogen.
6. An abatement system according to any one of the preceding claims, in which the system is arranged to recover hydrogen from an ammonia-containing waste gas, and comprises an ammonia cracking device for decomposing ammonia into hydrogen and nitrogen and a hydrogen separator arranged to receive the decomposed gaseous decomposition product and separate hydrogen therefrom.

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7. An abatement system according to claim 6, in which the hydrogen separator is a pressure swing adsorption system.

8. An abatement system according to claim 6 or claim 7, which comprises a purifier for purifying hydrogen gas separated by  
5 said hydrogen separator prior to use of said hydrogen gas in said fuel cell.

9. An abatement system according to any one of the preceding claims, which comprises two or more fuel cells arranged to receive said fuel.

10 10. An abatement system according to any one of the preceding claims, wherein the one or more electrically powered devices comprises at least one pump that is powered wholly or in part by said fuel cell or cells.

11. An abatement system according to any one of the preceding  
15 claims, wherein the one or more electrically powered devices comprises at least one heating device that is powered wholly or in part by said fuel cell or cells.

12. An abatement system according to any one of the preceding claims, which can selectively be powered in part or wholly by  
20 an external power source.

13. An abatement system according to any one of the preceding claims, which comprises a control device for monitoring the electrical current generated by the fuel cell and determining in dependence thereon an additional power requirement to be  
25 devised from an external power source.

14. An abatement system according to any one of the preceding claims, which is arranged to receive waste gas from a semiconductor processing step.

15. A method of utilising a waste gas, comprising treating the  
30 waste gas to obtain a fuel, feeding the fuel to a fuel cell and utilising energy generated by the fuel cell in the treatment of the gas stream.

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16. A method according to claim 15, in which the energy generated by the fuel cell is supplemented by energy from an external source.

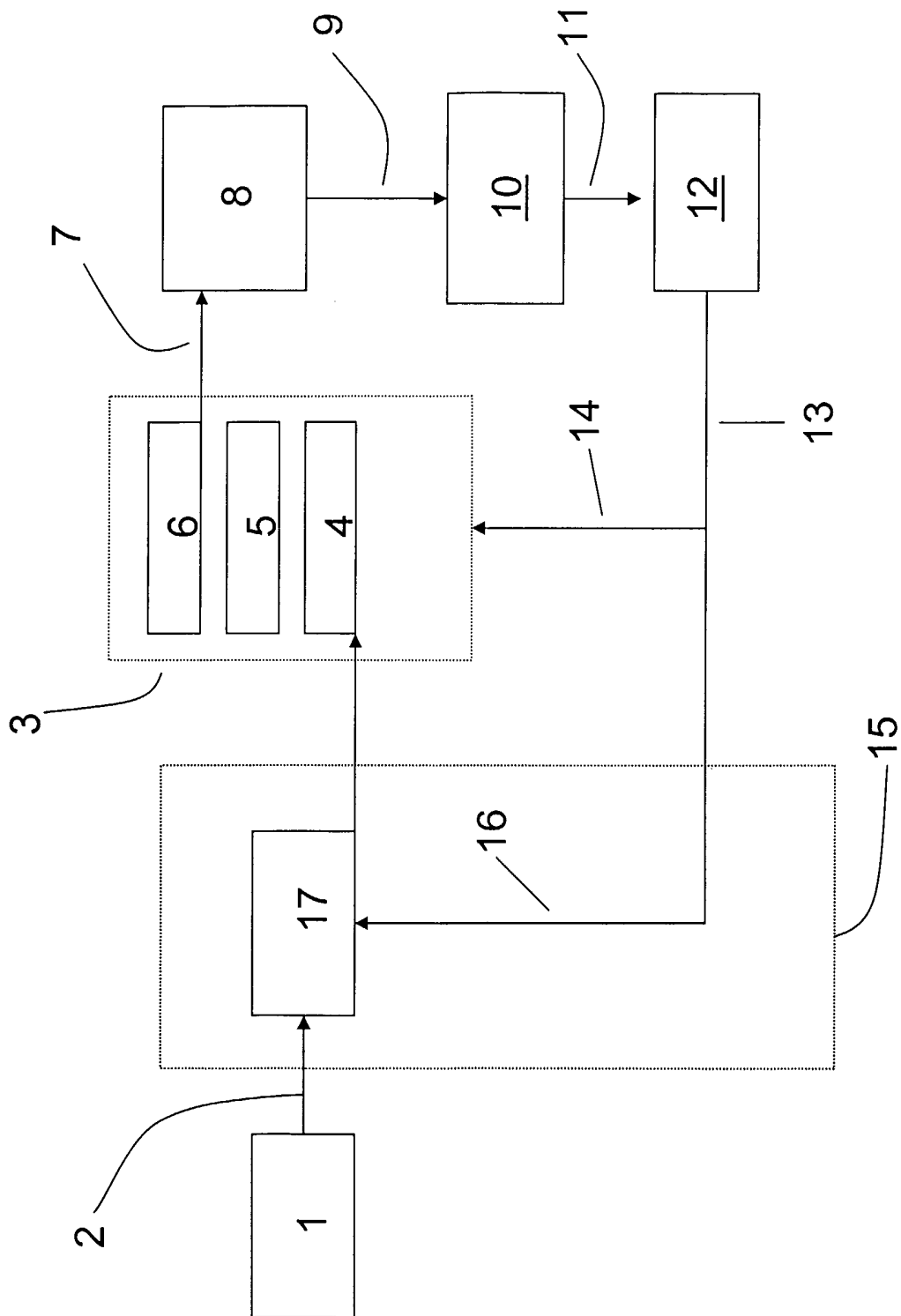
5 17. A method according to claim 16, in which the energy generated by the fuel cell is continuously supplemented by an external source.

18. A method according to claim 16, in which the energy generated by the fuel cell is intermittently supplemented by an external source.

10 19. A method according to anyone of claims 16 to 18, in which the level of supplementary energy provided by an external source can vary and can be determined in dependence upon the energy delivered by the fuel cell.

15 20. A method according to any one of claims 15 to 19, in which the fuel is fed to a plurality of fuel cells.

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INTERNATIONAL SEARCH REPORT

International Application No  
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A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 B01D53/86

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 B01D C01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 03, 30 March 2000 (2000-03-30) & JP 11 333247 A (KANKEN TECHNO KK), 7 December 1999 (1999-12-07) abstract	1, 15
A	PATENT ABSTRACTS OF JAPAN vol. 2000, no. 05, 14 September 2000 (2000-09-14) & JP 2000 061255 A (AWAJI TOSHIO), 29 February 2000 (2000-02-29) abstract	1, 15
A	WO 01 87770 A (GRADIENT TECHNOLOGY ;GOETSCH DUANE A (US); SCHMIT STEVE J (US)) 22 November 2001 (2001-11-22) claim 8	15
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Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

\* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
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- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

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- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*&\* document member of the same patent family

Date of the actual completion of the international search

14 November 2003

Date of mailing of the international search report

26/11/2003

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# INTERNATIONAL SEARCH REPORT

Internati	plication No
PCT/GB 03/03696	

**C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT**

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>PATENT ABSTRACTS OF JAPAN                      vol. 010, no. 373 (C-391),                      12 December 1986 (1986-12-12)                      &amp; JP 61 168518 A (MITSUI TOATSU CHEM INC),                      30 July 1986 (1986-07-30)                      abstract</p> <p style="text-align: center;">-----</p>	

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International Application No  
PCT/GB 03/03696

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JP 2000061255	A	29-02-2000	NONE
WO 0187770	A	22-11-2001	AU 6306901 A 26-11-2001 EP 1286914 A1 05-03-2003 WO 0187770 A1 22-11-2001 US 2002028171 A1 07-03-2002
JP 61168518 5	A		NONE