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GB 2431511 A

(58) Field of Search:
Other: **No search performed: Section 17(5)(b)**

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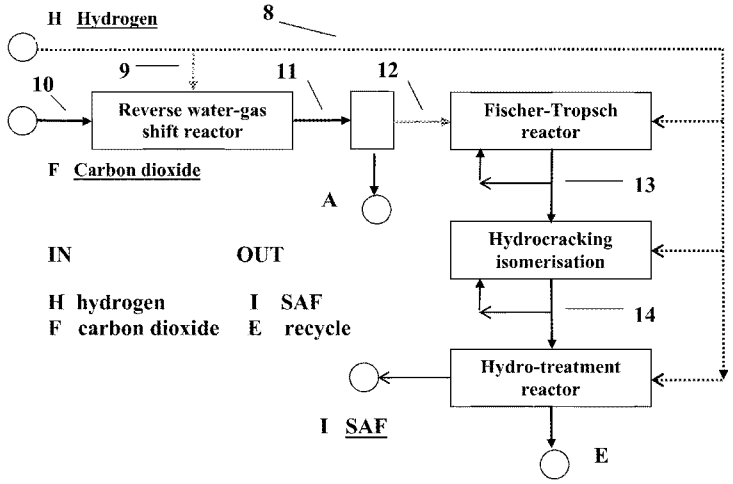
(54) Title of the Invention: **Sustainable aviation fuels by synthesis gas fuel cells**
Abstract Title: **Apparatus for producing hydrocarbon aviation fuels**

(57) The apparatus for producing hydrocarbon fuels uses an apparatus to provide the hydrogen and carbon oxides feedstocks. The apparatus comprises two integrated parts: a set of equipment and vessels which produce hydrogen, carbon dioxide and electricity; and a set of equipment and vessels which uses the carbon dioxide and hydrogen as feedstock, to produce a mixture of hydrocarbons which corresponds to those found in fuels used in aviation for supplying power to jet engines in aircraft. A reaction vessel is used for a Fischer-Tropsch reaction. A hydro-cracking vessel is used to reduce the length of the molecules by reacting with hydrogen over a catalyst. Also claimed is an apparatus for producing sustainable aviation fuels in which any shortfall in energy requirement is met by supplying electricity from renewable sources to the electrolyser.

FIGURE 2



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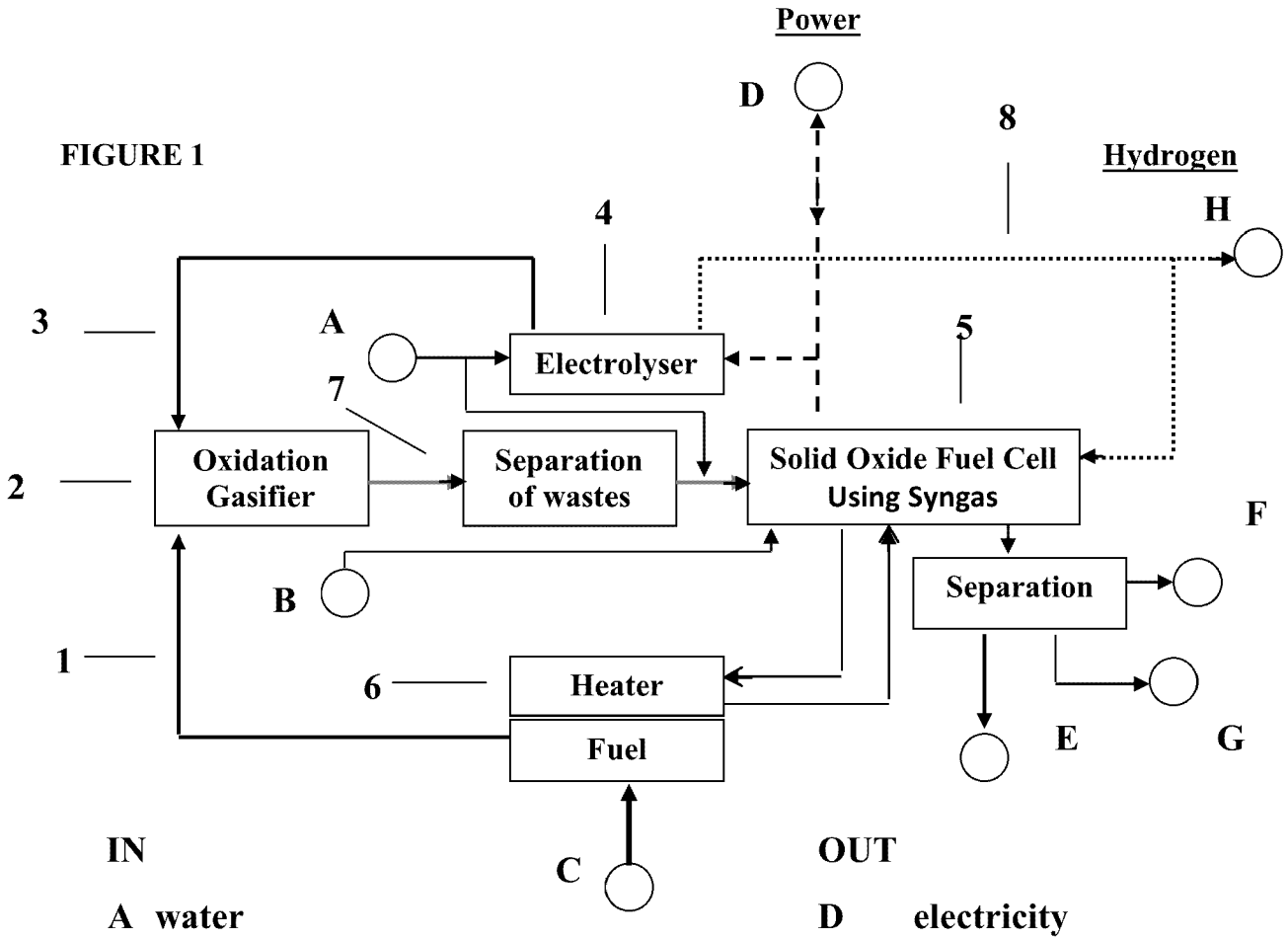
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIGURE 1



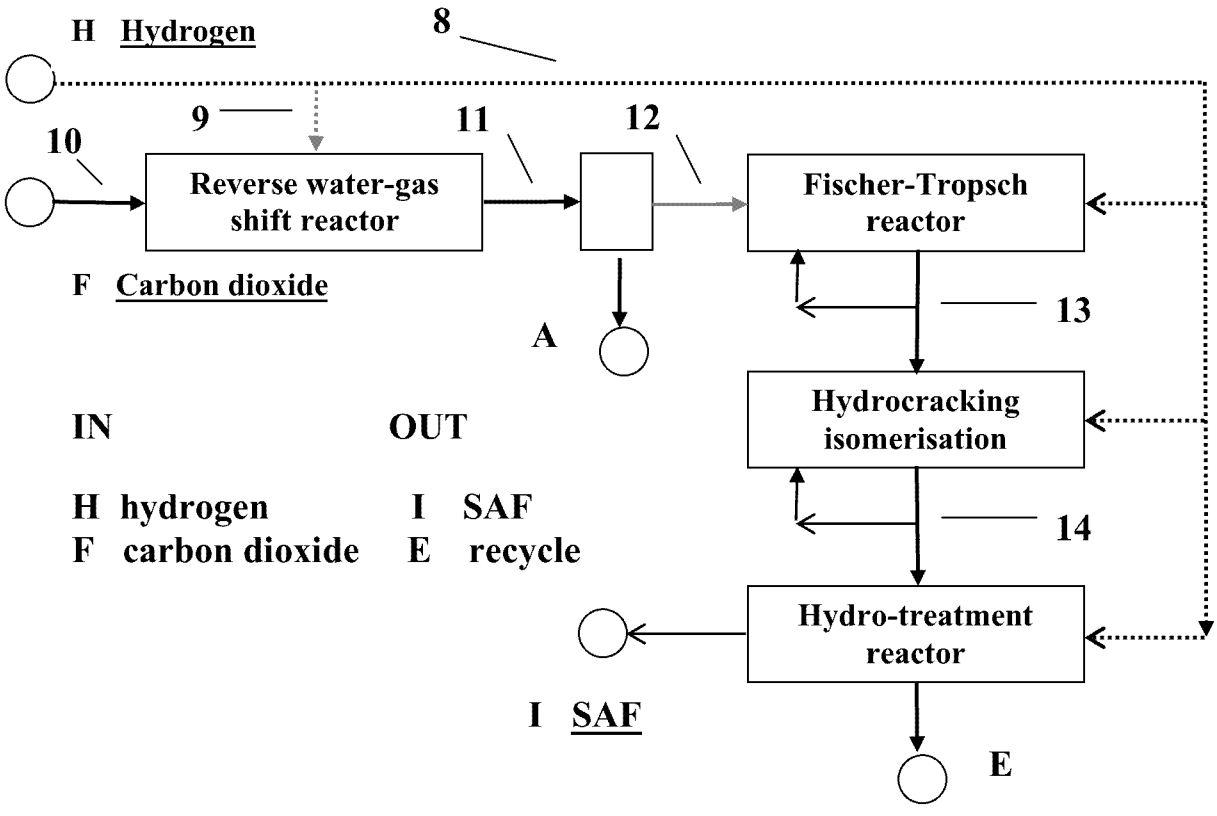
IN

A water
B water/air
C fuel
D electricity to meet any deficit

OUT

D electricity
E recycle syngas
F carbon dioxide
G inert gases
H hydrogen
A water

FIGURE 2



IN

H hydrogen
F carbon dioxide

OUT

I SAF
E recycle

Description: Sustainable Aviation Fuels by synthesis gas fuel cells

Introduction

This proposal relates to a manufacturing system for the production of liquid fuels which may qualify as Sustainable Aviation Fuels (SAFs), and which uses hydrocarbon materials which may include mixtures containing biomass, municipal solid wastes or waste oils as a feedstock.

A commonly known process for making such fuels uses carbon dioxide and hydrogen, via a series of chemical reactions, including those known as "Fischer-Tropsch". This process creates mixtures of long-chain paraffinic molecules similar to those found in fossil-derived fuels currently used extensively in aviation to power passenger jet aircraft. The benefit of these synthesised fuels is the potential to decarbonise air travel without the need for major changes to airframe platforms.

The qualification of aviation fuels as "sustainable" is in the gift of the ASTM (American Society for the Testing of Materials). A key condition is the sustainable way that the hydrogen is provided and the energy used in the process is derived. Hydrogen produced from the electrolysis of water using electricity generated by, for example, wind turbines or other "renewable" techniques, would qualify.

This proposal is based on the use of a patented process as described in GB2431511. This uses hydrocarbon materials to generate power, electrolytic hydrogen and a highly-concentrated stream of carbon dioxide. This is done by using a configuration of apparatus including a gasifier, a solid oxide fuel cell stack and a water electrolyser. Whereas the main purpose is to generate power, the invention does provide the feedstocks (carbon oxides and hydrogen) which are suitable for the production of liquid fuels consisting of the long chain paraffinic compounds and which are potentially acceptable as Sustainable Aviation Fuels (SAFs).

This proposal relates to a process, apparatus or system in which the embodiment described in GB2431511 is integrated with the systems which produce the paraffinic compounds for use in Sustainable Aviation Fuels. In so doing any surplus energy generated in some parts may be usefully consumed in others. Similarly wastes and effluents can be recycled internally to improve the overall yield.

Process flow-scheme

The attached graphical representation shows a schematic flow-scheme of an apparatus or process proposed. It includes two parts, firstly the embodiment described in GB2431511 (FIGURE 1) and secondly the process for manufacturing the higher paraffins which are the major components of the SAF (FIGURE 2). The hydrocarbon fuel (C), which can be any oil or waste or coal or gaseous hydrocarbon fuel or mixture of wastes such as Municipal Solid Waste, is conditioned (6) and fed to the oxidation gasifier (2) where it reacts in an oxygen-rich gas stream (3). The flow from the oxidation gasifier (7) is a synthesis gas comprising a

mixture of carbon monoxide, hydrogen, water and carbon dioxide, plus hydrocarbons including various tars and residues. This stream is conditioned and unwanted components such as tars, residues and long-chain hydrocarbons are removed. This is necessary to prevent poisoning or contamination of the fuel cell stack (5), the anode of which it is fed into. Steam may be added to this stream in order to promote the formation of hydrogen either internally within the fuel cell stack, or alternatively in a preliminary reactor. Air is supplied to the cathode side of the fuel cell stack. The electricity generated in the fuel cell stack is supplied to a water electrolyser (4) which produces hydrogen (8) and oxygen (3). A concentrated stream of carbon dioxide remains which may also contain water and unreacted syngas. This stream comprising mainly of carbon dioxide (10) is fed to a reactor where the reverse of the water-gas shift reaction takes place over a catalyst. The reaction is influenced by the equilibrium which exists between the partial pressures of the reactants and products. The supply of hydrogen to the reactor (9) ensures the balance shifts towards the production of a syngas of predominantly water, hydrogen and carbon monoxide (11). Water is removed in a dryer and the dried syngas enters the reactor containing tubes of catalyst in which the Fischer-Tropsch reaction takes place to form paraffinic molecules. Unreacted syngas is recycled and the paraffinic components (13) flow to a hydrocracking reactor which is supplied with more of the hydrogen produced in the electrolyser (8). Unreacted components are separated and recycled and the modified paraffins (14) flow into a hydro-treatment reactor to create the mix of components suitable for use as aviation fuel. The unreacted components are recycled.

Claims:

Claim 1

Apparatus for producing hydrocarbon fuels which uses the apparatus described in patent GB2431511 to provide the hydrogen and the carbon oxides feedstocks.

Claim 2

Apparatus for producing hydrocarbon fuels comprising two integrated parts as follows:

i) A set of equipment and vessels as described in patent GB2431511 which produces hydrogen, carbon dioxide and electricity. This is shown in FIGURE 1 in the drawing. The hydrogen is produced by the electrolysis of water or steam (4). The carbon dioxide may contain water and unused syngas including carbon monoxide and hydrogen (F). A method of removing water and unused syngas is provided.

ii) A set of equipment and vessels as shown in FIGURE 2 in the drawing which uses the carbon dioxide and hydrogen produced in the apparatus described in FIGURE 1 as feedstock. It produces a mixture of hydrocarbons which corresponds to those found in fuels used in aviation for supplying the power to jet engines in aircraft.

The set of equipment and vessels described in FIGURE 2 includes:

a) a reaction vessel in which the carbon dioxide is reacted with hydrogen to form carbon monoxide and water over a catalyst (the reverse water-gas shift reactor).
b) a condenser which enables water to be removed.
c) a reaction vessel in which the Fischer-Tropsch reaction takes place between the carbon monoxide (12) and hydrogen supplied from the electrolyser (8).
d) a means of conditioning and separating the gases which exit the vessel (13) so that the unreacted components can be recycled into it.
e) a hydro-cracking vessel in which the molecules are reduced in length by reacting with hydrogen over a catalyst.

f) a means of conditioning and separating the gases which exit the vessel (14) so that the unreacted components can be recycled into it.

g) a hydro-treatment reactor in which the molecular structure can be further modified to more closely match those of the desired composition.

h) a means of separating the gases which exit the hydro-treatment reactor vessel so that the unreacted components (E) can be recycled into the oxidation gasifier (2) or another vessel as appropriate.

Claim 3

Apparatus for producing Sustainable Aviation Fuels in which any shortfall in energy requirement is met by supplying electricity from renewable sources (D) to the electrolyser (4).

Intellectual Property Office

Application No:	GB2303771.6	**Examiner:**	Katie Harbach
Claims searched:	1 and 2	**Date of search:**	13 September 2023

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 & 2	GB2431511 A (HANCOCK) See whole document.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

The following online and other databases have been used in the preparation of this search report

International Classification:

Subclass	Subgroup	Valid From
H01M	0008/0612	01/01/2016
C01B	0003/36	01/01/2006
C10G	0002/00	01/01/2006
C10J	0003/00	01/01/2006