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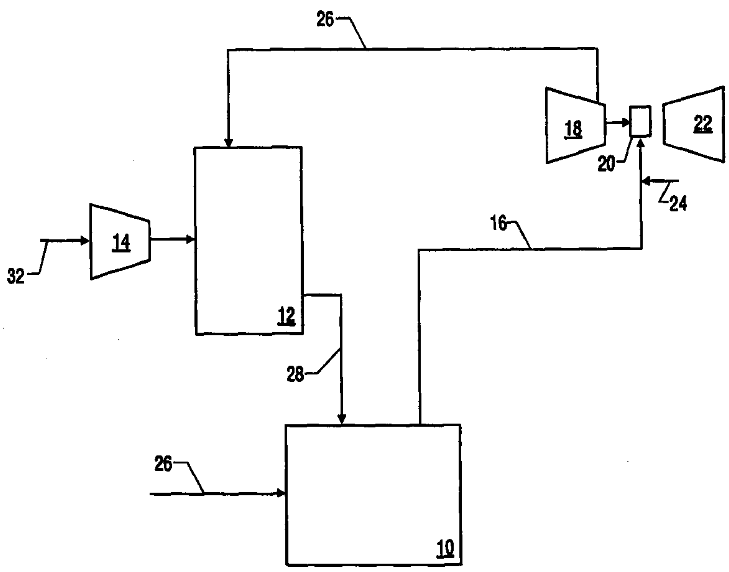
(54) Title: AIR EXTRACTION IN A GASIFICATION PROCESS



(57) Abstract

The invention is a process for generating power from syngas in a combustion turbine that includes an air compressor (18), a combustor (20), and an expansion turbine (22). The invention involves continuously withdrawing a fraction (26) of the compressed air from the air compressor (18) and supplying this compressed air (26) to an air separation unit (12) used in the manufacture of the syngas, wherein the supplied compressed air (26) provides a fraction of the compressed air requirements of an air separation (12) unit used in the manufacture of the syngas. The invention also involves continuously mixing gaseous hydrocarbons (24) with the synthesis gas (16) to produce a fuel gas, controlling the quantity of gaseous hydrocarbons (24) added to the fuel gas to match the air compressor output to the combustor with combustor air requirements, and introducing the fuel gas to the combustor (20). It is usually advantageous to combine the two processes to obtain the maximum power generation from a combustion turbine.

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AIR EXTRACTION IN A GASIFICATION PROCESS

CROSS REFERENCE TO PATENTS

This application claims priority from provisional patent application serial number 60/048,833 filed on June 6, 1997, entitled Air Extraction In A Gasification Unit.

FIELD OF THE INVENTION

The invention relates to the manufacture and combustion of synthesis gas, or syngas, for power generation. In particular, the invention relates to more efficient utilization of a combustion turbine.

BACKGROUND OF THE INVENTION

The gasification and subsequent combustion of certain carbonaceous materials provides a environmentally friendly method of generating power from these otherwise environmentally unfriendly feedstocks. Coal, petroleum based feedstocks including petroleum coke and other carbonaceous materials, waste hydrocarbons, residual oils and byproducts from heavy crude oil are commonly used for gasification reactions that produce mixtures of hydrogen gas and carbon monoxide gas, commonly referred to as "synthesis gas" or simply "syngas." Syngas usually contains many contaminants, such as ammonia and hydrogen sulfide. These contaminants are removed prior to combusting the gas. Syngas can therefore be used as a clean fuel to generate power.

The process of gasifying carbonaceous material requires high pressure air. The more efficient gasification reactors operate at pressures in excess of 10 atmospheres, often in excess of 80 atmospheres pressure. The carbonaceous material is gasified in a partial oxidation reactor by reacting with limited quantities of oxygen containing gas. The most efficient gasification processes use substantially pure, greater than 95 mole percent, oxygen. To obtain this oxygen, an air separation plant is supplied with compressed air. The product of the air separation plant are two streams, one of substantially pure oxygen and the other principally nitrogen. The oxygen is at a lower pressure than the air stream that was sent to the air separation unit, and the oxygen often needs to be compressed again prior to introduction to the reactor. These gasification reactors require large quantities of compressed air, and economics of the process hinge on efficient utilization any byproducts.

The partial oxidation reaction that is used to gasify carbonaceous material is exothermic, and the heat generated in the gasification reactor is advantageously utilized to make power. But the syngas is a partially oxidized product when compared to hydrocarbons. And the subsequent burning of the syngas therefore requires less oxygen than a similar quantity of hydrocarbons.

A gasification/power generation unit usually comprises an air separation unit, a gasifier, and a combustion turbine. The air separation unit provides oxygen to the gasifier. The gasifier converts oxygen and hydrocarbon into clean burning gaseous fuel, i.e. syngas. The combustion turbine uses the fuel from the gasifier to generate power.

Combustion turbines are commercially available in discreet sizes. Therefore, on projects where the amount of power desired is fixed or where the amount of feed to the gasifier is fixed, the combustion turbine is sometimes too large for the desired application which hurts the economics of the project. Typical systems are described in, for example, US Patent Nos. 4,017,272; 5,081,845; 5,295,350; 5,394,686; 5,410,869; 5,421,166; 5,501,078; 5,609,041 which are incorporated herein by reference.

What is needed is a process to make more efficient utilization of the combustion turbine, regardless of whether the supply of syngas is fixed or whether the amount of power desired is fixed.

SUMMARY OF THE INVENTION

The invention is a process for generating power from syngas in a combustion turbine that includes an air compressor, a combustor, and an expansion turbine. The invention involves continuously withdrawing a fraction of the compressed air from the air compressor and supplying this compressed air to an air separation unit used in the manufacture of the syngas, wherein the supplied compressed air provides a fraction of the compressed air requirements of an air separation unit used in the manufacture of the syngas. The invention also involves continuously mixing gaseous hydrocarbons with the synthesis gas to produce a fuel gas, controlling the quantity of gaseous hydrocarbons added to the fuel gas to match the air compressor output with combustor air requirements, and introducing the fuel gas to the combustor. The two processes are advantageously used in combination.

DETAILED DESCRIPTION OF THE INVENTION

As used herein, the term "combustion turbine" is an apparatus that includes an air compressor, a combustor, and a turbine expander. Air is compressed to supply the oxygen required for combustion. The compressed air is then fed into the combustor with a fuel gas. The products of combustion travel through an expander to generate power.

As used herein, the term "synthesis gas" or "syngas" refers to gases comprising hydrogen gas, carbon monoxide gas, or mixtures thereof. The ratio of hydrogen to carbon monoxide may, but need not necessarily, be about one to one. There is often some inerts in the syngas, particularly nitrogen.

The invention is a process to generate power with syngas. Syngas can be manufactured by any partial oxidation method. Typically, the syngas is manufactured in a partial oxidation, or gasification, reactor wherein carbonaceous fuels are reacted with oxygen to create hydrogen and carbon monoxide. The gasification processes are known to the art. See, for example, U.S. Patent 4,099,382 and U.S. Patent 4,178,758, the disclosures of which are incorporated herein by reference. Preferably, the gasification process utilizes substantially pure oxygen, that is, a gas with above about 95 mole percent oxygen.

Combustion turbines are integral units that consist of a combustor, an expansion turbine, and an air compressor. These units are designed for conventional fuel, such as natural gas. The principal component of natural gas is methane. One methane molecule combines with two oxygen molecules, which are obtained from the air compressor, in a combustion process. On the other hand, two syngas molecules, be they hydrogen gas, carbon monoxide, or both, react with only one oxygen molecule in a combustion process. Therefore, the combustion of a given quantity of syngas requires roughly one fourth of the air required to combust a similar quantity of natural gas.

The air compressor, combustor, and turbine in a combustion turbine are matched for the higher compressed air demands of a fuel such as natural gas. The air compressor portion of the combustion turbine is oversized when synthesis gas from a gasifier is used as the fuel. Because these units are manufactured and sold in discrete sizes, they are also usually oversized for a particular application.

If the amount of power needed from the turbine is fixed, the power output from the combined cycle unit must be reduced. In the present invention, this is accomplished by extracting air from the combustion turbine's air compressor to be used as feed to the air separation unit. This reduces the power output of the combustion turbine and reduces the capital cost of the project by decreasing the air compressor size in the air separation unit.

The invention therefore comprises a process for generating power from syngas in a combustion turbine comprising an air compressor, a combustor, and an expansion turbine. The process comprises continuously withdrawing a fraction of the compressed air from the air compressor, and supplying this compressed air to air an separation unit used in the manufacture of the synthesis gas, wherein the supplied compressed air provides a fraction of the compressed air requirements of the air separation unit. The air separation unit supplies oxygen that is used in the manufacture of the synthesis gas. At least about 20 percent, preferably at least about 40 percent, and more preferably at least about 50 percent of the air compressor output supplied by the combustion turbine is sent to the air separation unit. This compressed air then is converted to a portion of the oxygen-containing gas that is fed to the gasification reactor.

The amount of compressed air from the combustion turbine diverted to the air separation unit can advantageously regulated with, for instance, a variable position control valve. In the event the gasification reactor is running at a reduced output, the amount of oxygen required by the gasification reactor will decrease. If supplemental fuel such as natural gas is added to keep the turbine operating, the combustion turbine oxygen requirements may well increase. A variable position valve can advantageously be used to divert compressed air to the power generation system where the air is most needed, be it the combustor or the air separation unit.

Another aspect of this invention is to add supplemental fuel to increase the heating value of the resulting fuel gas, to obtain smoother running turbine output, or to more closely utilize the full capacity of the combustion turbine. The invention therefore also comprises a process for generating power with syngas in a combustion turbine comprising an air compressor, a combustor, and an expansion turbine. The invention involves monitoring the syngas flow to detect increases or decreases in the rate of syngas, continuously mixing gaseous hydrocarbons with the synthesis gas to produce a fuel gas, controlling the quantity of gaseous hydrocarbons added to the fuel gas to match the air compressor output with combustor air requirements or to match absolute combustor capacity, and introducing the fuel gas to the combustor.

The process of monitoring the syngas flow to detect increases or decreases in the rate of syngas simply is useful to vary the amount of gaseous hydrocarbons added. If the quantity of gaseous hydrocarbons added is essentially fixed, there is no need to monitor the syngas rate.

This process more fully utilizes the combustion turbine capacity. By matching air compressor output to combustor air requirements, it is meant that the air compressor output to the combustor provides between about 90% and 130%, preferably between about 96% and 104%, of the air required for complete combustion of the fuel gas introduced to the combustor. By complete combustion of the fuel gas, it is meant that at least 95 weight percent of the combustable components, i.e., carbon monoxide, hydrogen, and hydrocarbons, in the fuel gas are oxidized to carbon dioxide and water.

The syngas is continuously mixed with gaseous hydrocarbons. Gases can be mixed by commingling in the pipe or in the combustor. If the gaseous hydrocarbon is a finely dispersed droplets of liquid, then the droplets may be suspended in the syngas or in a separate stream of gas which can then be commingled with the syngas.

The gaseous hydrocarbons comprise one or more of natural gas, gaseous light hydrocarbons, or liquid fuel droplets finely dispersed in gas. Gaseous light hydrocarbons include natural gas liquids such as ethane, propane, butanes, pentanes, hexanes, or mixtures thereof.

It is often advantageous to operate the combustion turbine at the capacity of the combustor. There will often be excess compressed air capacity if the fuel is a mixture of natural gas and syngas, and the combustor capacity may be limited by the gaseous throughput capacity of the combustor. However, if the supplemental fuel is gaseous light hydrocarbons or finely dispersed liquid hydrocarbons, then the combustor capacity may be limited by the compressed air supply. Finally, the combustor capacity may be limited by the power generating capacity of the combustion turbine.

By adding supplemental fuel to the combustor, the output of the combustion turbine can be stabilized. This in turn allows the combustion turbine to supply compressed gas to the air separation unit when the gasifier is inoperative. The supplemental fuel can allow the turbine to run during periods when syngas production is severely limited or interrupted.

To allow for uninterrupted turbine operation during upsets in the gasification process, it is preferred that at least 25 percent of the heating value of the fuel gas originate from the supplemental gaseous hydrocarbons during normal operations.

The gaseous hydrocarbons and the syngas are advantageously mixed prior to introduction to the combustor, to insure the fuel gas is well mixed. It is advantageous to have a variable position control valve, or other flow controller, on the gaseous hydrocarbon inlet line, so that the amount of gaseous hydrocarbons introduced to the fuel gas can be varied to meet power requirements, or to smooth out variations in the syngas production rate to keep the combustion turbine operating at a desired capacity, or to match the combustion turbine air compressor output to the combustor with the oxygen requirements of the fuel gas. At times when syngas production is high, the amount of gaseous hydrocarbons added to the fuel may be reduced. However, it is advantageous to always add some gaseous hydrocarbons to the fuel gas.

It is also advantageous to have sufficient supplemental gaseous hydrocarbon fuel capacity so that if the gasification process is interrupted, then the amount of gaseous hydrocarbons being introduced is sufficient to keep the turbine operational. As the gasifer comes back into operation, the amount of gaseous hydrocarbons can be reduced to effect a smooth transition back to a mixed fuel gas without interrupting the operation of the combustion turbine.

It is also advantageous to have a means of detecting or calculating the fraction of the fuel gas that is supplemental gaseous hydrocarbons. The heating value of the fuel gas, and subsequently the amount of air required to achieve complete combustion, will depend on this fraction. It is therefore advantageous to have a means of controlling the valve that allows diversion of compressed air from the combustion turbine to the air separation unit be affected by the amount of gaseous hydrocarbons in the fuel gas. If the fuel gas has an increased fraction of gaseous hydrocarbons, the amount of compressed air diverted to the air separation unit may have to be reduced to supply sufficient air to the combustor.

The preferred gaseous hydrocarbon is natural gas. Pipeline quality natural gas is a gas comprising usually at least about 95 mole percent methane. The natural gas used in the present invention need not be pipeline quality, and may contain substantial quantities of inerts such as carbon dioxide and nitrogen. The natural gas preferably comprises at least about 50, more preferably at least about 75, mole percent methane. In applications wherein the gaseous hydrocarbons comprise natural gas, it is preferred that at least about 25 percent, more preferably at least about 40 percent, and most preferably at least about 50 percent by volume of the fuel gas comprises natural gas.

In many applications, it is advantageous to both remove a portion of the compressed air from the combustion turbine for use in the air separation unit, and to add supplemental gaseous hydrocarbons to the fuel gas. This allows more effective use of the combustion turbine capacity, and utilizes the excess capacity of the combustion turbine air compressor, and allows for uninterrupted operation of the combustion turbine during upsets in the gasification process. When both aspects of the invention are being used simultaneously, it is preferred that the gaseous hydrocarbons comprise at least about 20, more preferably at least about 30 percent of the heating value of the fuel gas, and it is also preferred that at least about 15, more preferably at least about 30 percent of the air compressor output supplied by the combustion turbine is bypassed to the air separation unit.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 is a schematic of a embodiment of the invention, comprising a gasifier (10), an air separation unit (12) that supplies oxygen to the gasifier (10) through the conducting means (28), an air compressor (14) that takes low pressure or atmospheric pressure air from conducting means (32) and supplies at least a portion of the compressed air required by the air separation unit (12), a combustion turbine comprising a combustion turbine air compressor (18), a combustor (20), and an expansion turbine (22). Syngas is conveyed to the combustor (20) through the conducting means (16), and supplemental gaseous hydrocarbon fuel is conveyed to the combustor (20) through the conducting means (24). The syngas and supplemental gaseous hydrocarbon fuel are advantageously mixed before reaching the combustor (20). Excess compressed air from the combustion turbine air compressor (18) is conveyed to the air separation unit (12) through the conducting means (24).

CLAIMS:

1. A process for generating power with syngas in a combustion turbine comprising an air compressor, a combustor, and an expansion turbine, said process comprising

a. continuously mixing gaseous hydrocarbons with the synthesis gas to produce a fuel gas,

b. controlling the quantity of gaseous hydrocarbons added to the fuel gas to match the air compressor output with combustor air requirements or to meet the desired combustor capacity, and

c. introducing the fuel gas to the combustor.

2. The process of claim 1 wherein the gaseous hydrocarbons comprise one or more of natural gas, gasified light hydrocarbons, or liquid fuel droplets finely dispersed in gas.

3. The process of claim 1 further comprising controlling the rate of introduction of fuel gas such that the air compressor output supplies between about 90% and 130% of the air required for complete combustion of the fuel gas.

4. The process of claim 2 wherein gaseous hydrocarbons comprises at least about 25 percent of the heating value of the fuel gas.

5. The process of claim 1 wherein the gaseous hydrocarbons comprise natural gas.

6. The process of claim 5 wherein natural gas comprises at least about 25 percent by volume of the fuel gas.

7. The process of claim 5 wherein natural gas comprises at least about 40 percent by volume of the fuel gas.

8. The process of claim 5 wherein natural gas comprises at least about 50 percent by volume of the fuel gas.

9. A process for generating power from syngas in a combustion turbine comprising an air compressor, a combustor, and an expansion turbine, said process comprising

continuously withdrawing a fraction of the compressed air from the air compressor, and supplying this compressed air to an air separation unit used in the manufacture of the synthesis gas, wherein the supplied compressed air provides a fraction of the compressed air requirements of the air separation unit.

10. The process of claim 9 wherein at least about 20 percent of the air compressor output is bypassed to the air separation unit.

11. The process of claim 9 wherein at least about 40 percent of the air compressor output is bypassed to the air separation unit.

12. The process of claim 9 wherein at least about 50 percent of the air compressor output is bypassed to the air separation unit.

13. The process of claim 9 further comprising

a. continuously mixing gaseous hydrocarbons with the synthesis gas to produce a fuel gas,

b. controlling the quantity of gaseous hydrocarbons added to the fuel gas to match the air compressor output to the combustor with combustor air requirements or to meet the desired combustor capacity, and

c. introducing the fuel gas to the combustor.

14. The processes of claim 13 wherein gaseous hydrocarbons comprise at least about 20 percent of the heating value of the fuel gas, and wherein at least about 15 percent of the air compressor output is bypassed to the air separation unit.

15. The processes of claim 13 wherein gaseous hydrocarbons comprise at least about 30 percent of the heating value of the fuel gas, and wherein at least about 30 percent of the air compressor output is bypassed to the air separation unit.

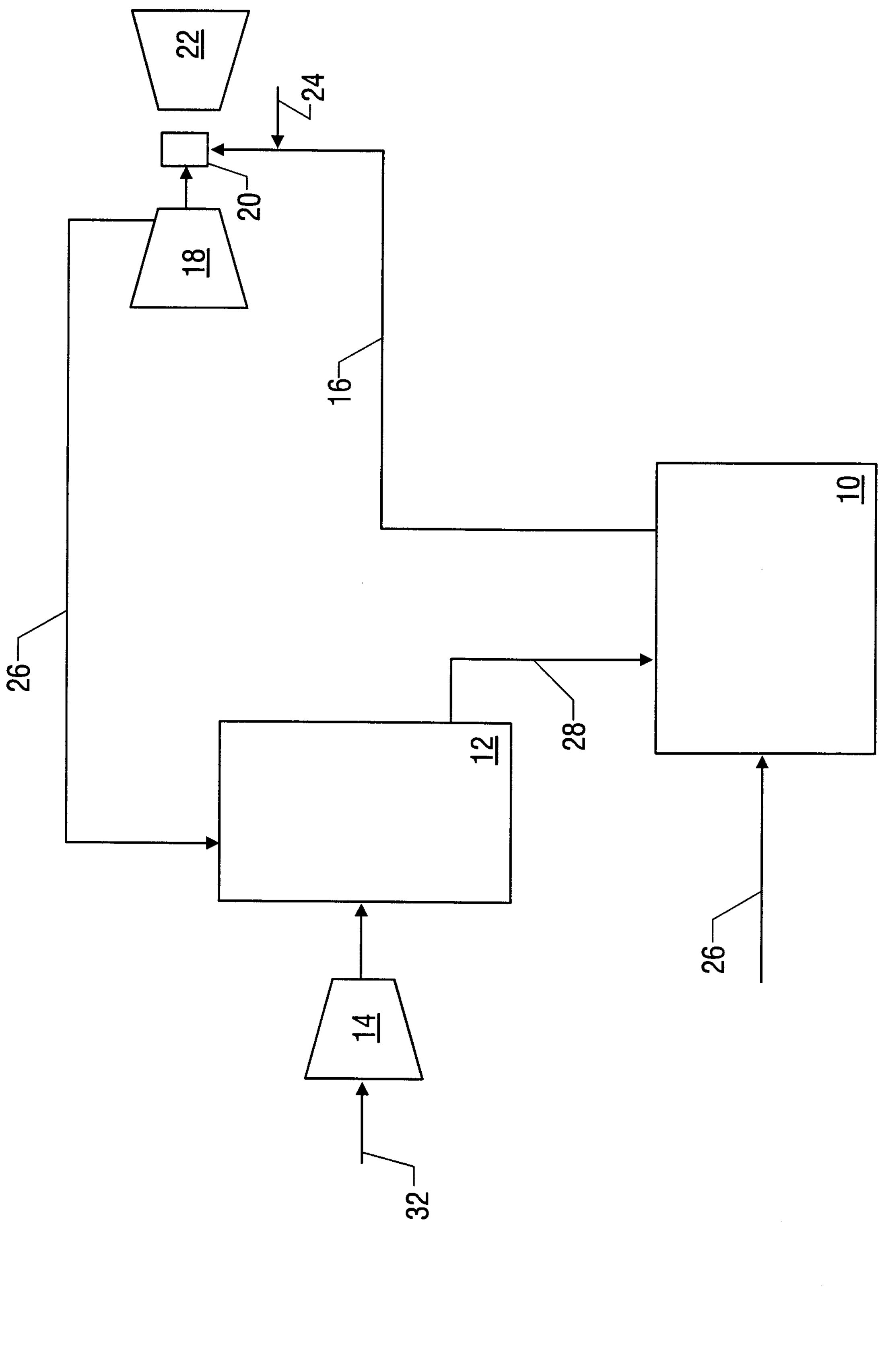

FIG. 1

INTERNATIONAL SEARCH REPORT

Interna al Application No
PCT/US 98/12061

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F25J3/04 F01K23/06 F02C3/28

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 6 F25J F01K F02C

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 501 078 A (PAOLINO GERALD A) 26 March 1996 cited in the application see the whole document ---	1,2,5,9, 13
A	EP 0 580 910 A (TEXACO DEVELOPMENT CORP) 2 February 1994 see column 9, line 50 - line 54; claims; figures see column 10, line 1 - line 4 ---	1,2,5,9, 13
A	WO 94 16210 A (COMBUSTION ENG) 21 July 1994 see page 21, line 18 - line 21 ---	1,2,5,9, 13
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[X] Further documents are listed in the continuation of box C.

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15 September 1998	25/09/1998

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 5 394 686 A (LAFFERTY JR WILLIAM L ET AL) 7 March 1995 cited in the application see the whole document ---	1,2,5,9, 13
P,A	US 5 666 800 A (SCHARPF ERIC WILLIAM ET AL) 16 September 1997 see column 3, line 25 - line 32; claims; figures see column 3, line 51 - column 4, line 4 see column 4, line 64 - column 5, line 2 see column 5, line 29 - line 37 see column 5, line 53 - line 59 -----	1,2,5,9, 13

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Interna al Application No
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