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DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
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KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME,
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OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
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(54) Title: ALGAE-DERIVED FUEL/WATER EMULSION

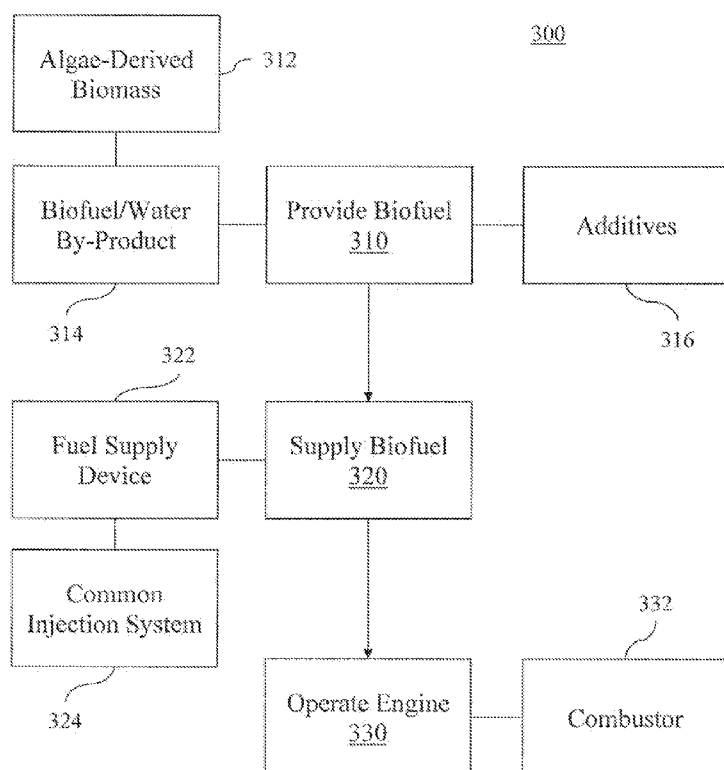


Fig. 3

(57) Abstract: A method including providing a wet algae material having been subjected to a refinement process without a water separation phase; supplying the wet algae material including a water fraction and an algae-grown biofuel to a turbine engine; and operating the turbine engine with the wet algae material where a retained portion of the water fraction is retained in the wet biofuel during a manufacturing process not including a dehydration step and includes an amount sufficient to reduce generation of a quantity of nitrogen oxides, and where the turbine engine can further include a combustor capable of combusting the wet biofuel.



(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

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— *with international search report (Art. 21(3))*

ALGAE-DERIVED FUEL/WATER EMULSION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application Serial No. 61/786,083, entitled "Algae-Derived Fuel/Water Emulsion," filed March 14, 2013, which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention generally relates to algae-derived biofuel, and more particularly, but not exclusively, to algae-derived fuel/water emulsions.

BACKGROUND

[0003] Present approaches to algae-derived biofuel suffer from a variety of drawbacks, limitations, disadvantages and problems including those respecting processing time, cost, energy and others. There is a need for the unique and inventive algae-derived fuel/water emulsion apparatuses, systems and methods disclosed herein.

SUMMARY

[0004] One embodiment of the present invention is a unique algae-derived fuel/water emulsion. Other embodiments include apparatuses, systems, devices, hardware, methods, and combinations for algae-derived fuel/water emulsions. Further embodiments, forms, features, aspects, benefits, and advantages of the present application shall become apparent from the description and figures provided herewith.

BRIEF DESCRIPTION OF THE FIGURES

[0005] Fig. 1 is a schematic diagram of a gas turbine system including an embodiment of the present application.

[0006] Fig. 2 is a schematic diagram of a portion of a gas turbine system including an embodiment of the present application.

[0007] Fig. 3 is a flow diagram of one embodiment of the present application.

DETAILED DESCRIPTION

[0008] For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Any alterations and further modifications in the described embodiments, and any further applications of the principles of the invention as described herein are contemplated as would normally occur to one skilled in the art to which the invention relates.

[0009] With reference to Fig. 1, a gas turbine engine 100 is shown including a compressor 110, a combustor 120, a turbine 130, and a fuel source 150. Gas turbine engine 100 can provide energy as part of an electrical generator set in some forms, and/or in other forms may provide power to an aircraft or marine application. As used herein, the term “aircraft” includes, but is not limited to, helicopters, airplanes, unmanned space vehicles, fixed wing vehicles, variable wing vehicles, rotary wing vehicles, hover crafts, and other airborne and/or extraterrestrial vehicles. Further, the present inventions are contemplated for utilization in other applications that may not be coupled with an aircraft such as, for example, industrial applications, power generation, pumping sets, naval propulsion weapons systems, security systems, perimeter defense/security systems, and the like known to one of ordinary skill in the art.

[0010] For gas turbine engine 100 as shown in Fig. 1, an airflow 140 enters compressor 110 whereupon it is compressed and passed to combustor 120 to be mixed with fuel from fuel source 150 and burned. The products of combustion produced from a combustion event exit combustor 120 and are passed to turbine 130 before exiting gas turbine engine 100. Though gas turbine engine 100 is shown as a single-spool, axial flow engine, other engine types and configurations are also possible. In one non-limiting example, compressor 110 can include a high pressure and low pressure compressor, and in some forms may include a mixed axial/centrifugal flow compressor sections. Gas turbine engine 100 can be an adaptive cycle or variable cycle engine. Furthermore, in some embodiments, gas turbine engine 100 can take the form of a turbofan, turboprop, turbojet, or turboshaft engine suitable for use as a power plant at a variety of operating conditions.

Other variations and combinations of gas turbine engine 100 are also contemplated herein.

[0011] Gas turbine engine 100 operates by receiving working fluid through an inlet 160 of gas turbine engine 100 and discharging working fluid through an outlet 165, which typically includes combustion exhaust. Airflow 140 entering inlet 160 of gas turbine engine 100 flows through compressor 110, combustor 120, and turbine 130 before exiting at outlet 165 of gas turbine engine 100. Upon traversing gas turbine engine 100, airflow 140 is expanded through turbine 130 thereby creating mechanical work to drive compressor 110, an output shaft connected to a rotating machine, and/or to provide thrust for an aircraft, to set forth just a few non-limiting examples.

[0012] Turning now to Fig. 2, one form of a combustor 220 is shown. Combustor 220 of the illustrated embodiment is sometimes referred to as an annular combustor. In other embodiments, however, combustor 220 can take different forms such as a can/tubular combustor or a can-annular combustor. Furthermore, combustor 220 can be a straight-through flow combustor, as illustrated, or a reverse flow combustor. Combustor 220 includes a casing 222, a liner 224, and a fuel nozzle 255, but in other embodiments can include fewer or additional components. Casing 222 provides a region within which combustion occurs after air is mixed with fuel provided by fuel nozzle 255. Liner 224 includes an inner combustor liner wall 224a and an outer combustor liner wall 224b that together at least partially define a combustion zone 260. Compressed air from a compressor (not shown) is mixed with fuel from fuel nozzle 255 and burned between inner combustor liner wall 224a and outer combustor liner wall 224b in combustion zone 260.

[0013] Fuel nozzle 255 can take a variety of forms other than that depicted in the illustrative embodiment. In some forms fuel nozzle 255 can include internal air and fuel passages, air swirlers, and fuel filmers, among others. Fuel nozzle 255 can take the form of an air blast atomizer, among other types. A fuel source 250 supplies fuel to fuel nozzle 255. The fuel is supplied for combustion and can be mixed with air prior to combustion. Fuel and air mixing configurations can vary as understood by one skilled in

the art. The high pressure air from the compressor is heated by the combustion taking place in the combustor at a constant pressure and then fed to the turbine to produce the mechanical rotation energy of the turbine.

[0014] Fuel source 250 in Fig. 2 includes a biofuel containing a portion of water. In a specific embodiment, the water/fuel mixture can be an emulsion. In another embodiment, a wet hydrocarbon biofuel from fuel source 250 can be supplied to the combustor through fuel nozzle 255. A water component can thereby be injected into the combustor through the same supply system as the fuel to provide a low flame temperature combustion reaction including fuel and water. Because water is already mixed with the biofuel emulsion, additional water injected into the combustor is not required. This eliminates the need to have separate water injection hardware or a water source for applications needing water addition for the combustion process. In one embodiment, a common injection system can provide improved fuel and water mixing in the combustion system.

[0015] In an embodiment of the present application, the portion of water in the wet hydrocarbon biofuel is retained from the water by-product of the biofuel production process. Manufacturing processes for producing biofuel from an algae-derived biomass can include water from sources such as an algae pool and as a product of a transesterification of algae oil, to name a few. At least a portion of the water by-product is not separated out from the biofuel product which, in some embodiments, can be unrefined or partially refined biofuel. In other embodiments, the manufacturing process can be without a separation of water and fuel step or with a reduced dewatering step.

[0016] In Fig. 3, a process 300 is shown for operating a gas turbine engine. Operation 310 provides a biofuel to the gas turbine engine. The biofuel of operation 310 can include a biofuel produced from an algae-derived biomass 312 in a process which produces a biofuel and water component mixture 314. In one embodiment for this process, at least a portion of the water component from a biofuel manufacturing process is retained in an emulsion with the biofuel. In another embodiment, operation 310 provides a wet biofuel which includes a water/fuel emulsion formed by a water phase

retained during a manufacturing process and an algae-grown biofuel. In yet another embodiment, operation 310 can include a biofuel manufacturing process without a water/fuel separation step thereby retaining at least a portion of the water phase. In other embodiments, the wet biofuel can also include additives 316 such as, but not limited to, an antifreeze, a surfactant, an emulsifier, an ion exchange material, and combinations of these.

[0017] The wet biofuel provided in operation 310 is supplied in operation 320 to the gas turbine engine with a fuel supply device 322. In one embodiment, fuel supply device 322 can include a common injection system 324 as the biofuel and the water are in emulsion. Following the supplying of wet biofuel in operation 320 is operation 330 where the gas turbine engine is operated when fueled by the wet biofuel. In one embodiment, the gas turbine engine is operated when the supplied wet biofuel participates in a combustion reaction in a combustor region of the gas turbine engine. As air, usually compressed by a compressor, is supplied to the combustor region, oxygen in the air aids in fueling the combustion reaction of the wet biofuel. In various embodiments, the wet biofuel is supplied to the combustor portion of the gas turbine engine to maintain a combustion state adequate to operate the gas turbine engine.

[0018] Biofuel can be considered a drop-in fuel allowing gas turbine engine equipment to remain relatively the same as for conventional fuel burning equipment. In other embodiments of the present application, a wet biofuel can introduce water to the combustion reaction. Water in a combustion reaction can contribute to thermal management of the gas turbine engine. In one embodiment, the retained portion of the water includes an amount sufficient to produce a combustion reaction which reduces generation of nitrogen oxides. Water in the combustion can produce a low flame temperature which can reduce the generation of nitrogen oxides. In another embodiment, the retained portion of the water includes an amount sufficient to produce a combustion reaction which reduces an operating temperature of the gas turbine engine. The operating temperature can be, for example, a turbine inlet temperature which can be reduced in response to the heat absorption of the water in the wet biofuel.

[0019] One aspect of the present application includes a method which provides a wet algae material having been subjected to a refinement process without a water separation phase; supplies the wet algae material including a water fraction and an algae-grown biofuel to a turbine engine; and operates the turbine engine with the wet algae material where operating the turbine engine can further include combusting the wet biofuel in a combustor of the turbine engine. Further aspects can include providing the wet algae material by processing an algae-derived biomass to retain a retained portion of the water fraction; processing the algae-derived biomass by producing a water/fuel emulsion from the retained portion of the water fraction and the wet algae material. Another feature of this aspect can include reducing a generation of a quantity of nitrogen oxides in a combustion process with a determined amount of the retained portion of the water fraction and reducing an operating temperature in a combustion process with a determined amount of the retained portion of the water fraction.

[0020] Another aspect of the present application is a system including a turbine engine capable of operating with a wet hydrocarbon fuel; a source of the wet hydrocarbon fuel having been subjected to a hydro-cracking process in the absence of a water separation stage and having a water component; and a supply device structured to deliver the wet hydrocarbon fuel from the source to the turbine engine where the wet hydrocarbon fuel having the water component is a water/fuel emulsion; an unrefined algae-grown hydrocarbon fuel; an algae-grown biofuel; and/or further includes an additive from a group consisting of an antifreeze, a surfactant, an emulsifier, an ion exchange resin, and combinations thereof.

[0021] Further features of this aspect can include the wet hydrocarbon fuel having at least a portion of water component retained in the wet hydrocarbon fuel during a manufacturing process where the manufacturing process does not include a separation of water and fuel step or a dehydration step, where the portion of water component includes an amount sufficient to reduce generation of a quantity of nitrogen oxides produced by the turbine engine or an amount sufficient to reduce an operating temperature of the turbine engine. Still further features can include the turbine engine having a combustor capable of combusting the wet hydrocarbon fuel and the supply device having a supply

line and a common injection device for the wet hydrocarbon fuel having the water component.

[0022] Yet another aspect of the present application is a method including providing a wet biofuel including an algae-grown biofuel and at least a portion of a water phase; supplying the wet biofuel with a source supply device structured to deliver the wet biofuel to a turbine engine; and operating the turbine engine with the wet biofuel where providing the wet biofuel further includes retaining the portion of the water phase in the wet biofuel during a manufacturing process without a dewatering step, where providing the wet biofuel further includes reducing a generation of a quantity of nitrogen oxides when operating the turbine engine with a determined amount of the portion of the water phase, and where the turbine engine can further include a combustor capable of combusting the wet biofuel.

[0023] While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiments have been shown and described and that all changes and modifications that come within the spirit of the inventions are desired to be protected. It should be understood that while the use of words such as preferable, preferably, preferred or more preferred utilized in the description above indicate that the feature so described may be more desirable, it nonetheless may not be necessary and embodiments lacking the same may be contemplated as within the scope of the invention, the scope being defined by the claims that follow. In reading the claims, it is intended that when words such as “a,” “an,” “at least one,” or “at least one portion” are used there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. When the language “at least a portion” and/or “a portion” is used the item can include a portion and/or the entire item unless specifically stated to the contrary.

WHAT IS CLAIMED IS:

1. A method comprising:

providing a wet algae material having been subjected to a refinement process with an incomplete water separation phase;

supplying the wet algae material including a water fraction and an algae-grown biofuel to a turbine engine; and

operating the turbine engine with the wet algae material.
2. The method of claim 1, wherein operating the turbine engine further includes combusting the wet algae material in a combustor of the turbine engine.
3. The method of claim 1, wherein providing the wet algae material further includes processing an algae-derived biomass to retain a retained portion of the water fraction.
4. The method of claim 3, wherein said processing the algae-derived biomass further includes producing a water/fuel emulsion of the retained portion of the water fraction and the wet algae material.
5. The method of claim 3, wherein said processing the algae-derived biomass further include reducing a generation of a quantity of nitrogen oxides in a combustion process with a determined amount of the retained portion of the water fraction.

6. The method of claim 3, wherein said processing the algae-derived biomass further include reducing an operating temperature in a combustion process with a determined amount of the retained portion of the water fraction.

7. A system comprising:

a turbine engine capable of operating with a wet hydrocarbon fuel;
a source of the wet hydrocarbon fuel having been subjected to a hydro-cracking process and having an at least partially complete water separation stage that leave a water component; and

a supply device structured to deliver the wet hydrocarbon fuel from the source to the turbine engine.

8. The system of claim 7, wherein the wet hydrocarbon fuel having the water component is a water/fuel emulsion.

9. The system of claim 7, wherein the wet hydrocarbon fuel is an unrefined algae-grown hydrocarbon fuel.

10. The system of claim 7, wherein the wet hydrocarbon fuel further includes an additive from a group consisting of an antifreeze, a surfactant, an emulsifier, an ion exchange resin, and combinations thereof.

11. The system of claim 7, wherein the wet hydrocarbon fuel is an algae-grown biofuel.

12. The system of claim 7, wherein the wet hydrocarbon fuel further includes at least a portion of water component retained in the wet hydrocarbon fuel during a manufacturing process.

13. The system of claim 12, wherein the manufacturing process operates without a separation of water and fuel step.

14. The system of claim 12, wherein the manufacturing process does not include a dehydration step.

15. The system of claim 12, wherein the portion of water component includes an amount sufficient to reduce generation of a quantity of nitrogen oxides produced by the turbine engine.

16. The system of claim 12, wherein the portion of water component includes an amount sufficient to reduce an operating temperature of the turbine engine.

17. The system of claim 12, wherein the turbine engine further includes a combustor capable of combusting the wet hydrocarbon fuel.

18. The system of claim 12, wherein the supply device further includes a supply line and a common injection device for the wet hydrocarbon fuel having the water component.

19. A method comprising:

providing a wet biofuel including an algae-grown biofuel and at least a portion of a water phase;

supplying the wet biofuel with a source supply device structured to deliver the wet biofuel to a turbine engine; and

operating the turbine engine with the wet biofuel wherein said providing the wet biofuel further includes retaining the portion of the water phase in the wet biofuel during a manufacturing process with an incomplete dewatering step, and wherein said providing the wet biofuel further includes reducing a generation of a quantity of nitrogen oxides in said operating the turbine engine with a determined amount of the portion of the water phase.

20. The method of claim 19, wherein the turbine engine further includes a combustor capable of combusting the wet biofuel.

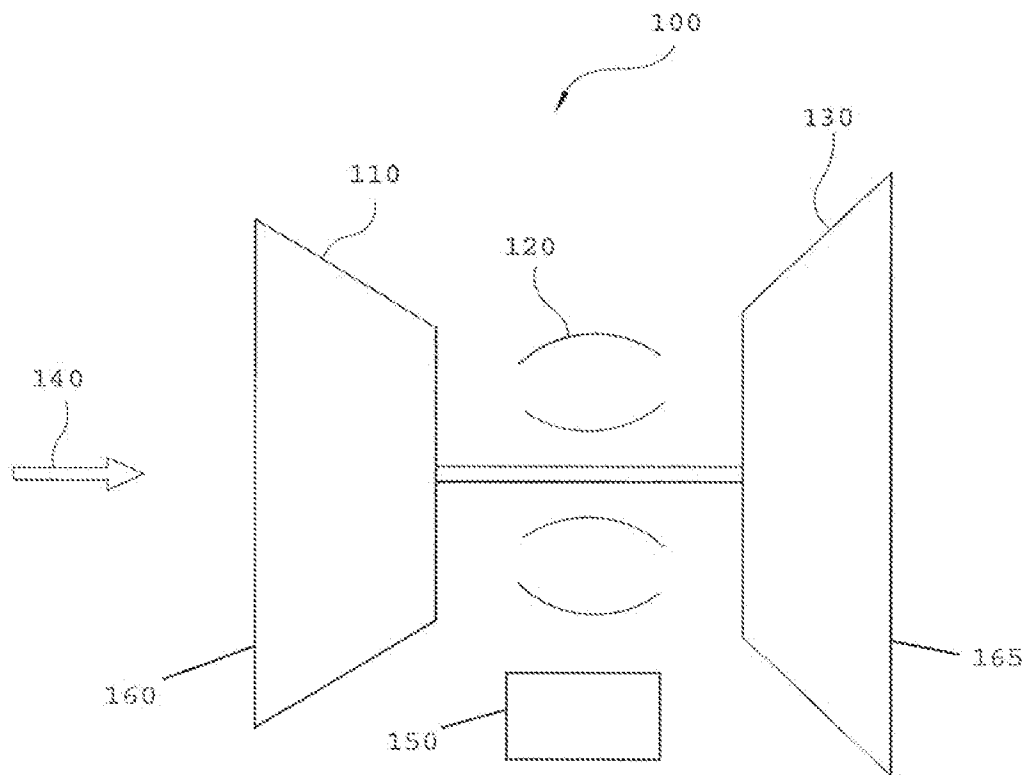


Fig. 1

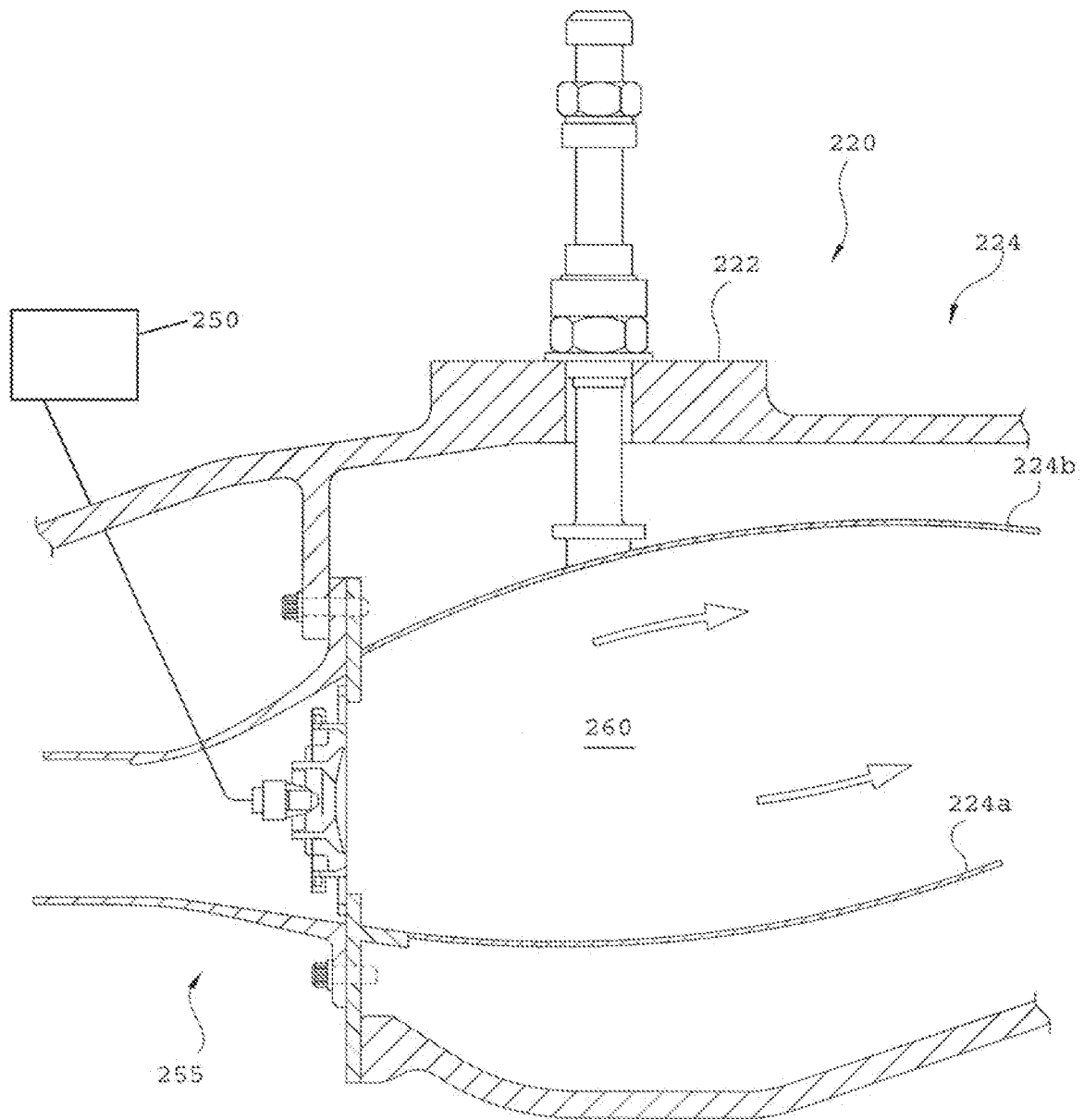
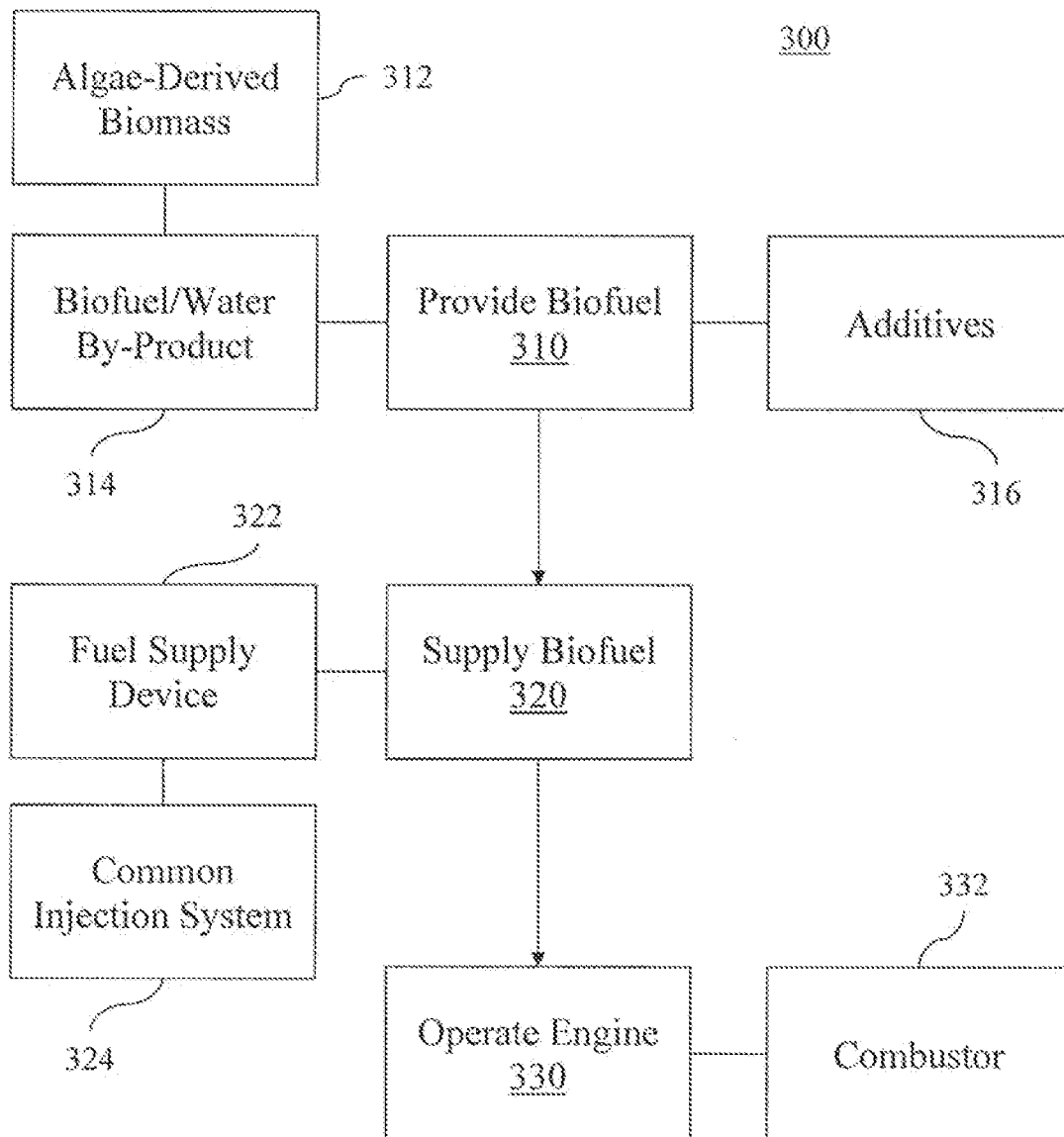


Fig. 2

**Fig. 3**

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/076524

A. CLASSIFICATION OF SUBJECT MATTER
INV. C10L1/32
ADD.

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)
C10L

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 practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010/269514 A1 (FULLTON III ROBERT [US]) 28 October 2010 (2010-10-28)	1-3
Y	paragraph [0008] - paragraph [0012]; claims 1,4, 11,17; figures 3,4 paragraph [0042] - paragraph [0053] -----	4-6,9, 11,19,20
Y	WO 92/19701 A1 (NALCO FUEL TECH [US]) 12 November 1992 (1992-11-12) page 4; claims 1-4; figure 33 -----	4-6,19, 20
Y	WO 93/07238 A1 (NALCO FUEL TECH [US]) 15 April 1993 (1993-04-15) page 13, line 11 - line 19; claims 1,2 -----	4-6,19, 20
Y	US 2011/167713 A1 (QUIGNARD ALAIN [FR] ET AL) 14 July 2011 (2011-07-14) paragraph [0155] - paragraph [0166]; claim 1; example 2; table 8 -----	9,11



Further documents are listed in the continuation of Box C.



See patent family 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 application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

6 March 2014

Date of mailing of the international search report

17/06/2014

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/076524

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of Item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-6, 9, 11, 19, 20

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6, 9, 11, 19, 20

method or system comprising providing wet algae derived material after refinement process with incomplete water separation including a water fraction to a turbine engine and operating the turbine engine with this wet algae derived material

2. claims: 7, 8, 10, 12-18

method or system comprising turbine engine capable of operating with a wet hydrocarbon fuel, a source of wet hydrocarbon fuel that has been subjected to hydrocracking with at least partial complete water separation that leaves water in the fuel and a supply device to deliver the wet hydrocarbon fuel to the turbine engine.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2013/076524

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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