



(19) **United States**  
(12) **Patent Application Publication**  
**Spitzauer et al.**

(10) **Pub. No.: US 2009/0267349 A1**  
(43) **Pub. Date: Oct. 29, 2009**

(54) **PRODUCTION PROCESSES, SYSTEMS, METHODS, AND APPARATUSES**

**Publication Classification**

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(51) **Int. Cl.**  
*F01D 15/10* (2006.01)  
*C10L 1/10* (2006.01)  
*F28D 15/00* (2006.01)  
*B01J 19/00* (2006.01)  
(52) **U.S. Cl.** ..... **290/52**; 44/300; 44/313; 422/129; 422/224; 422/225; 422/198; 422/187; 165/104.11

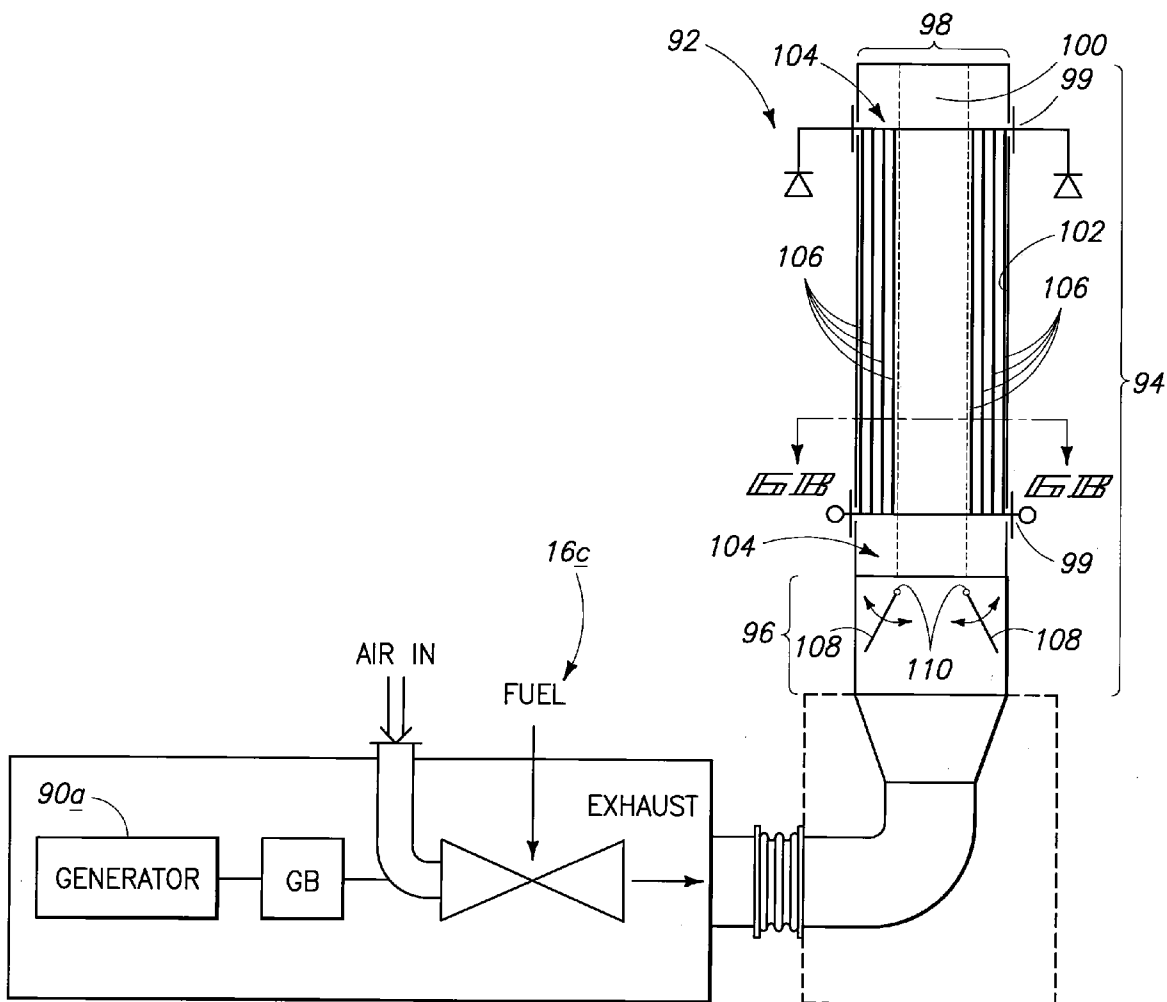
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(57) **ABSTRACT**

The present disclosure provides production processes that can include exposing a carbon-based material to liquid media to form hydrocarbon fuel. Waste to fuel conversion processes as well as waste material processing reactors are provided that can be configured to convert waste to fuel. Heat exchangers, power generation processes and combustion turbine exhaust apparatus are also provided. Fuel generation processes and generation systems are provided. Reaction media conduit systems as well as processes for servicing reactant media pumps coupled to both inlet and outlet conduits containing reactant media, are also provided.

(21) Appl. No.: **12/108,438**

(22) Filed: **Apr. 23, 2008**



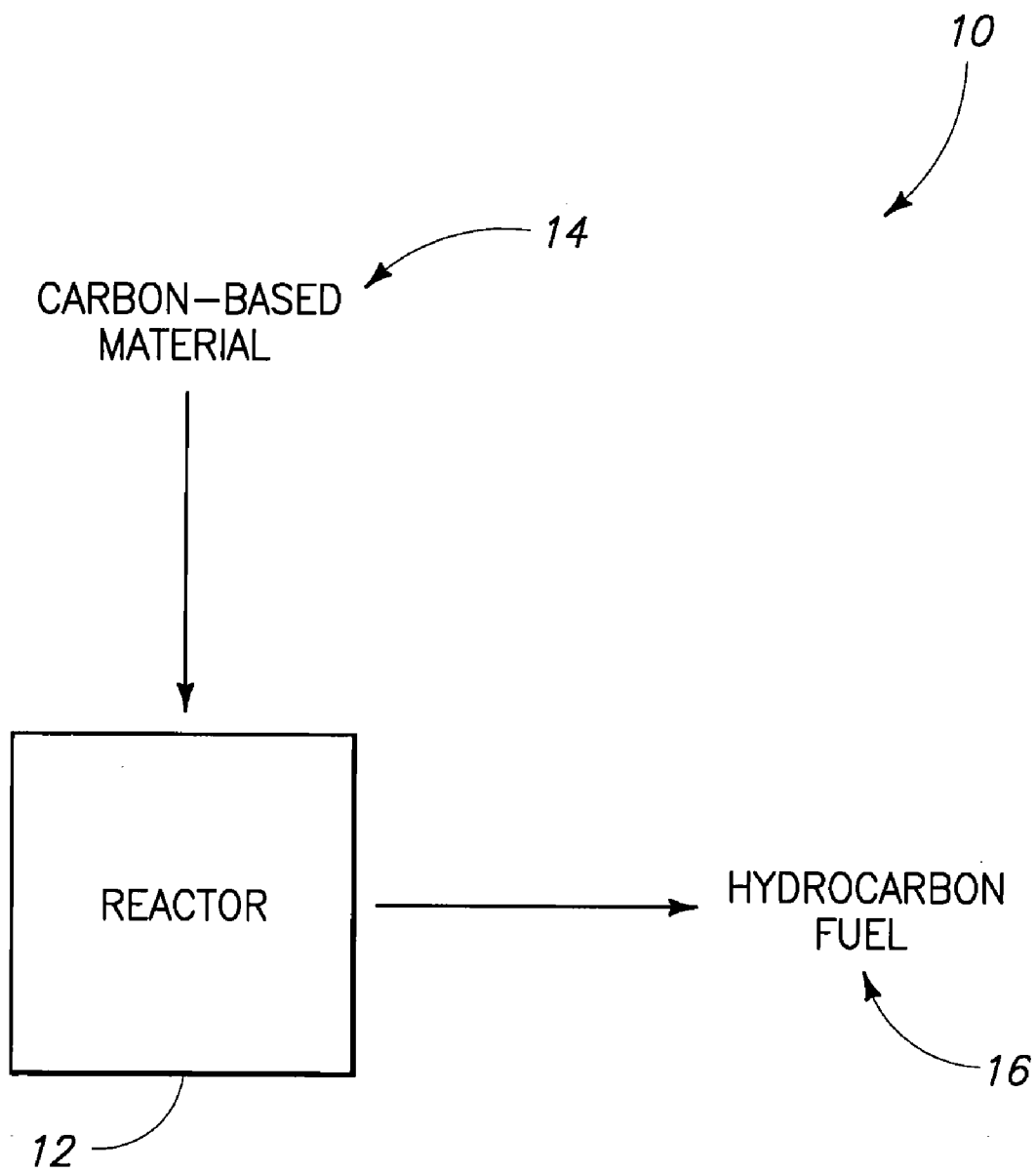
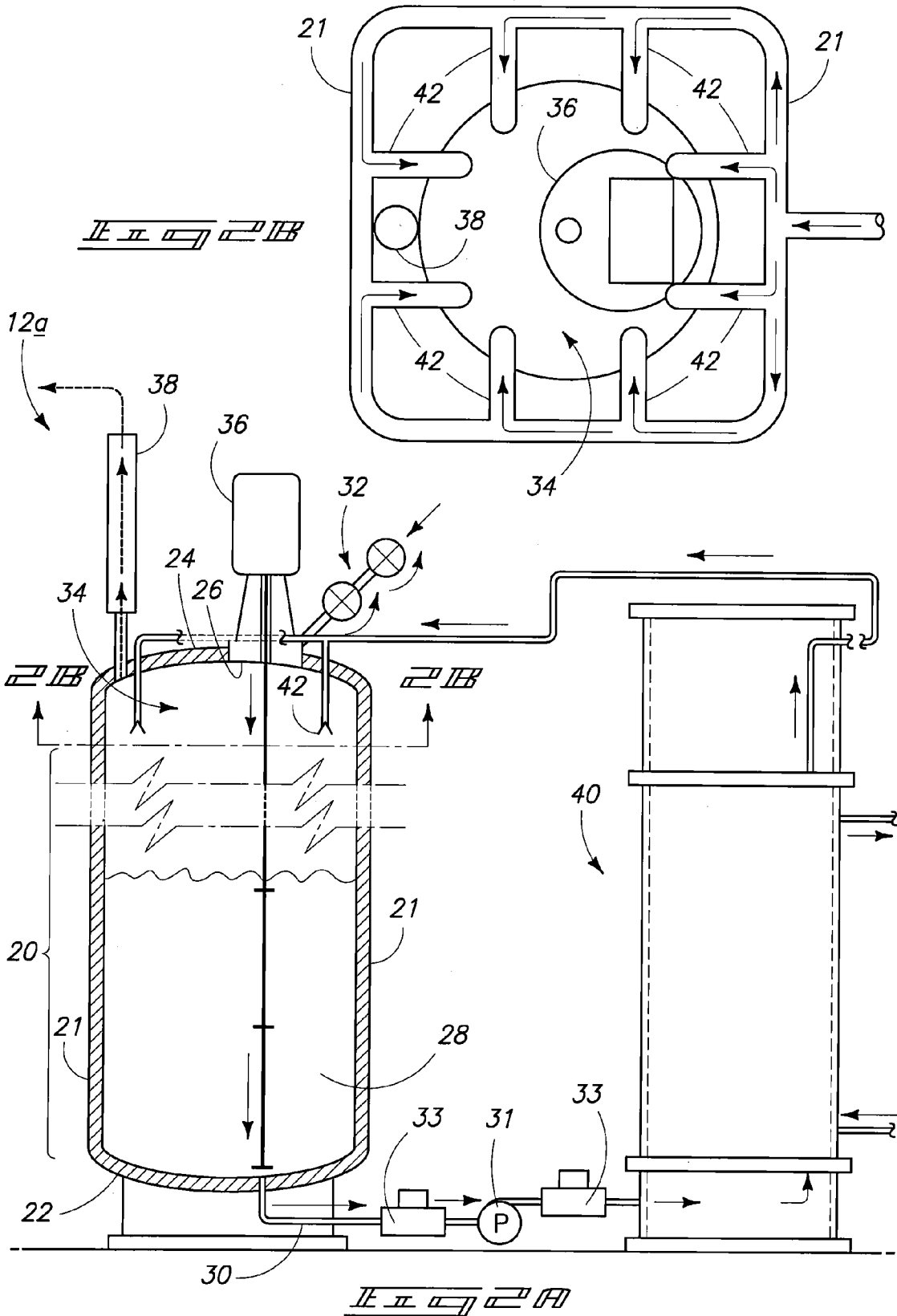
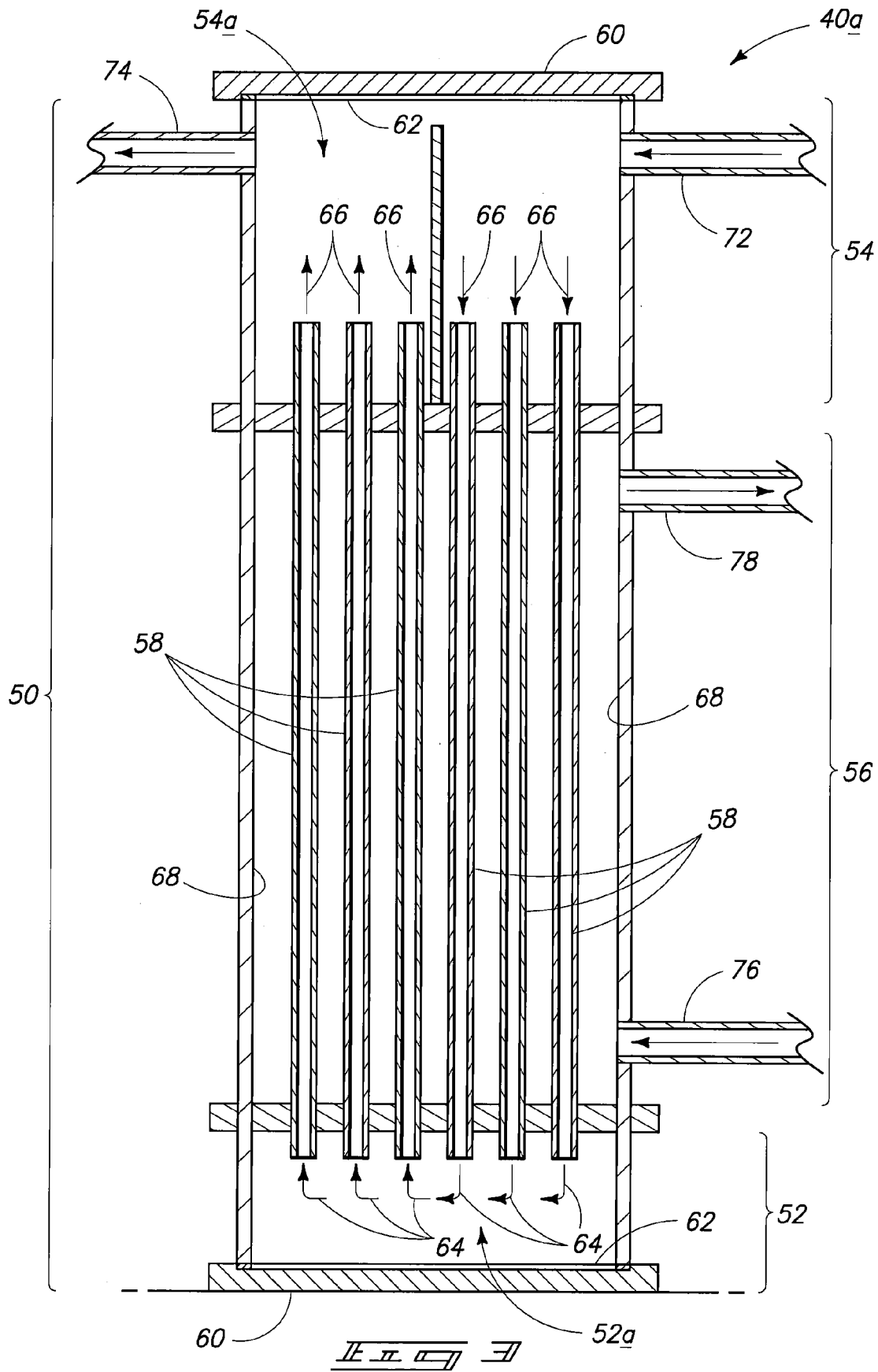


FIG. 1





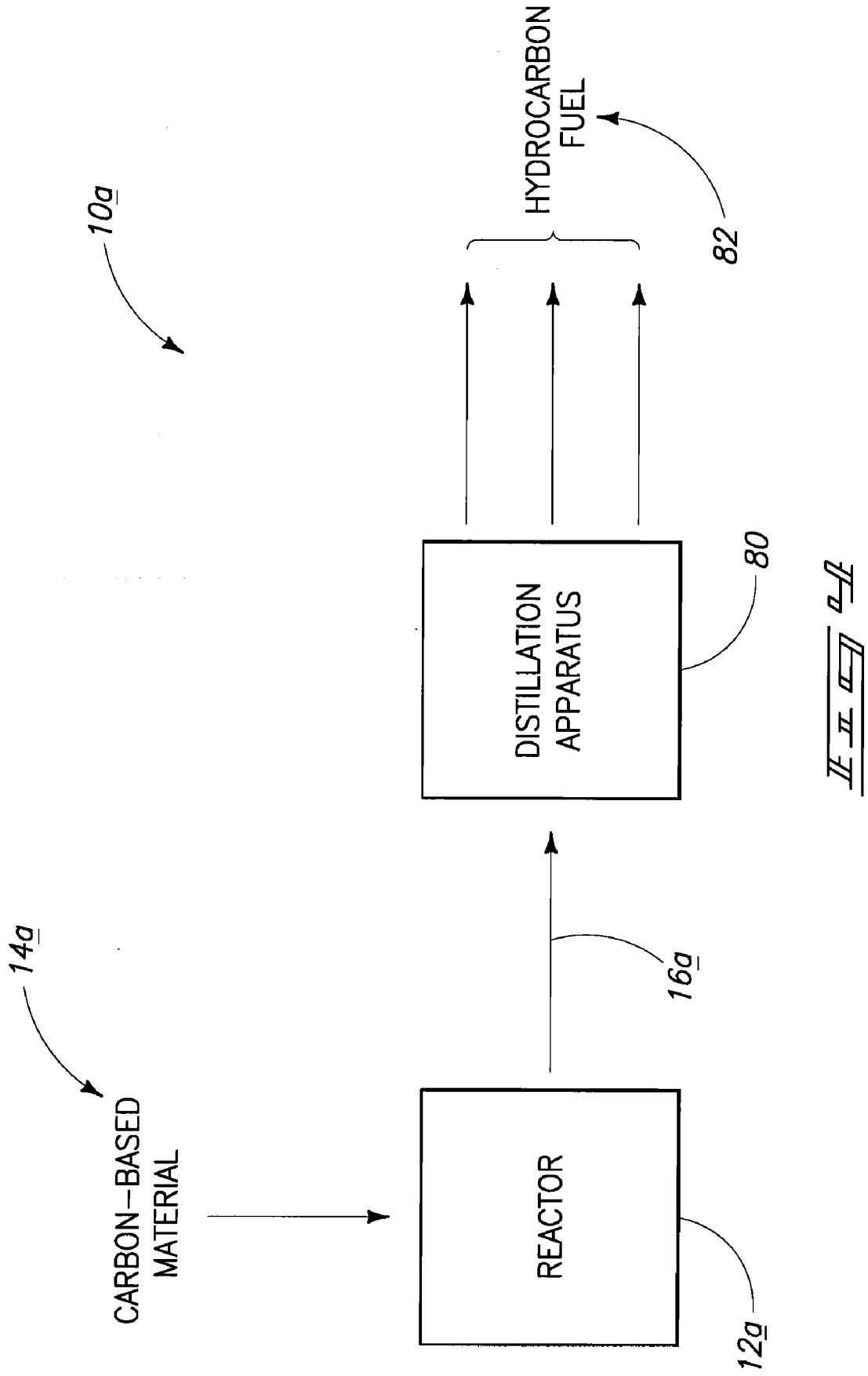
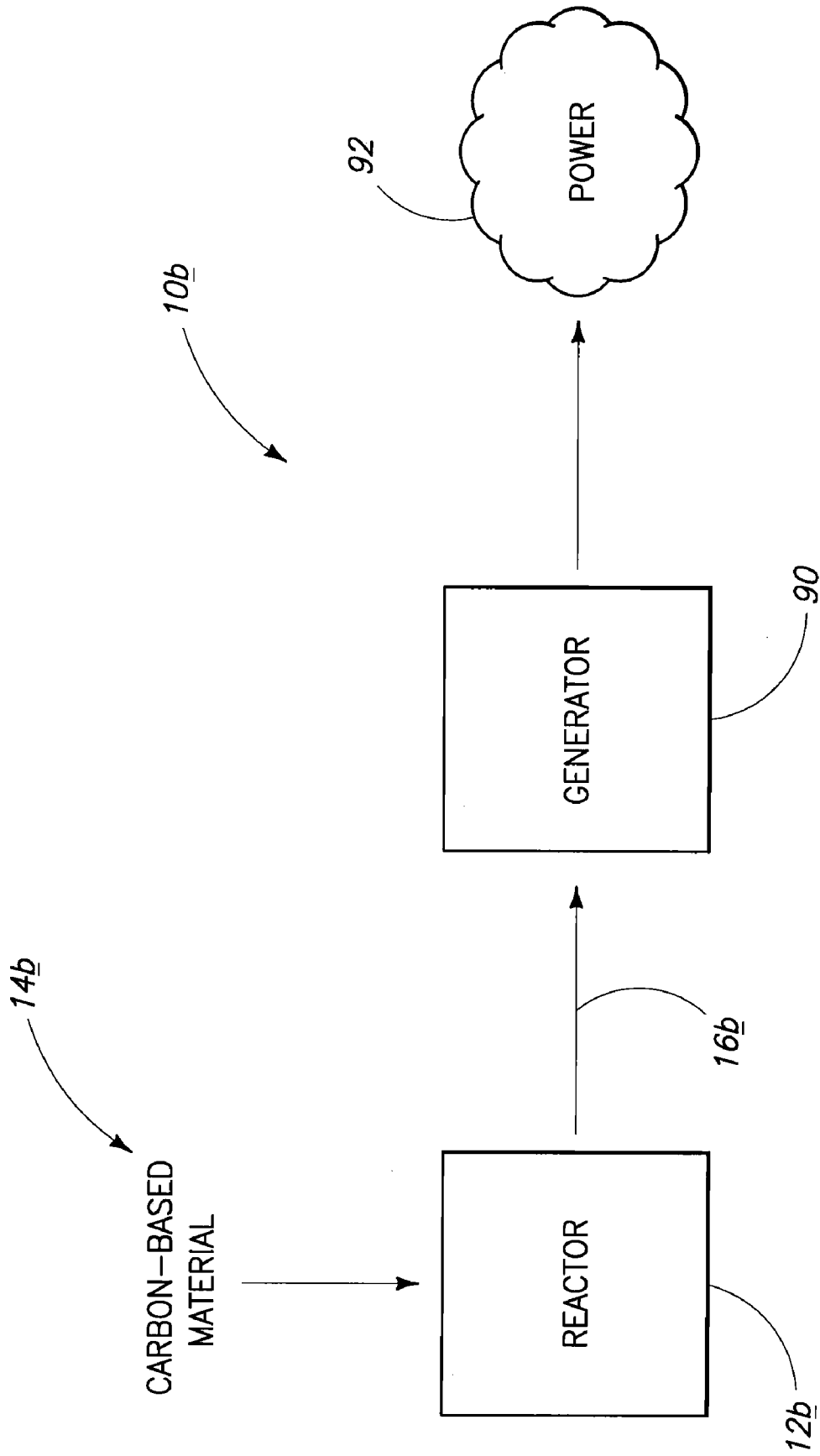


FIG. 4



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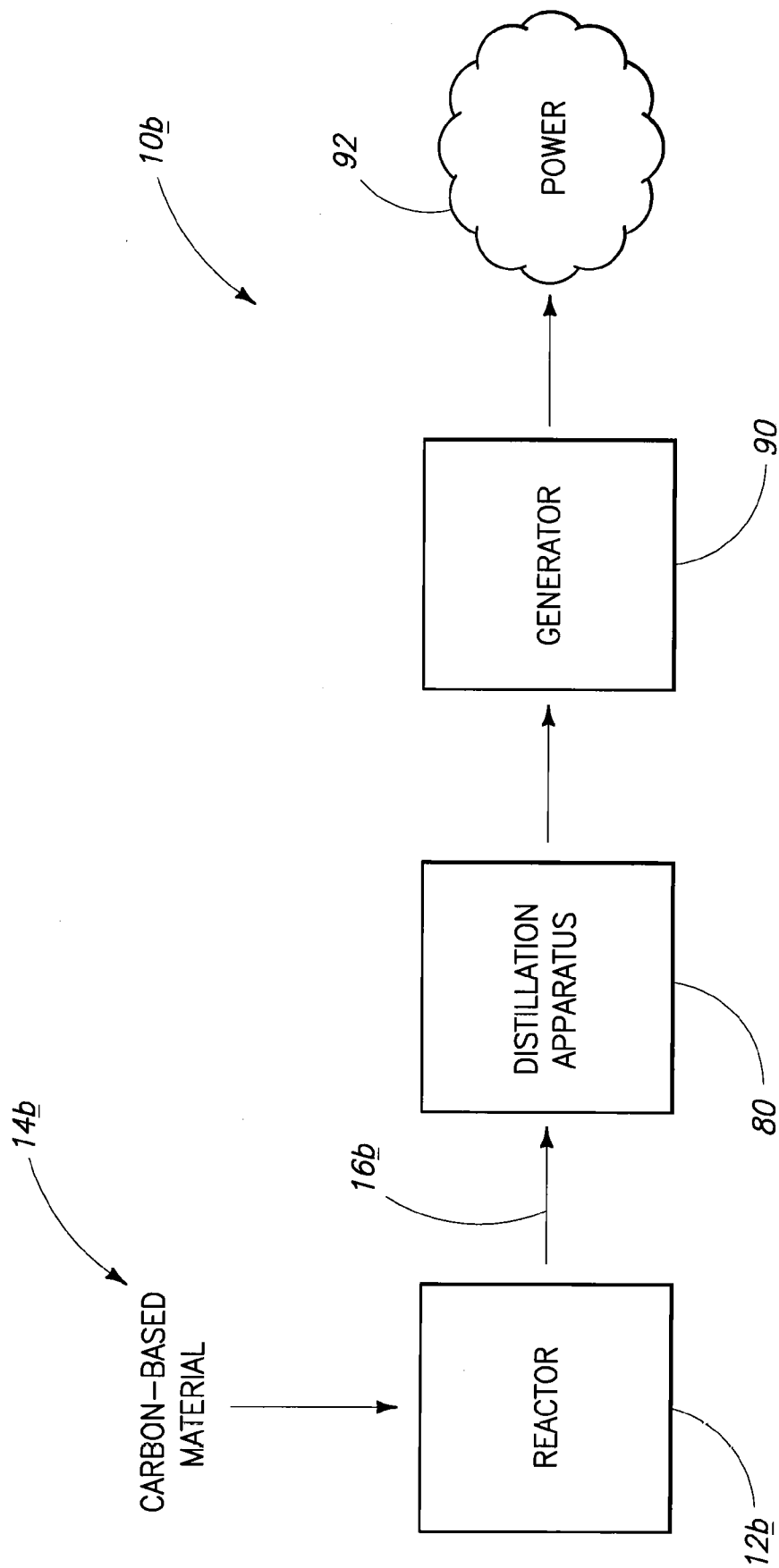
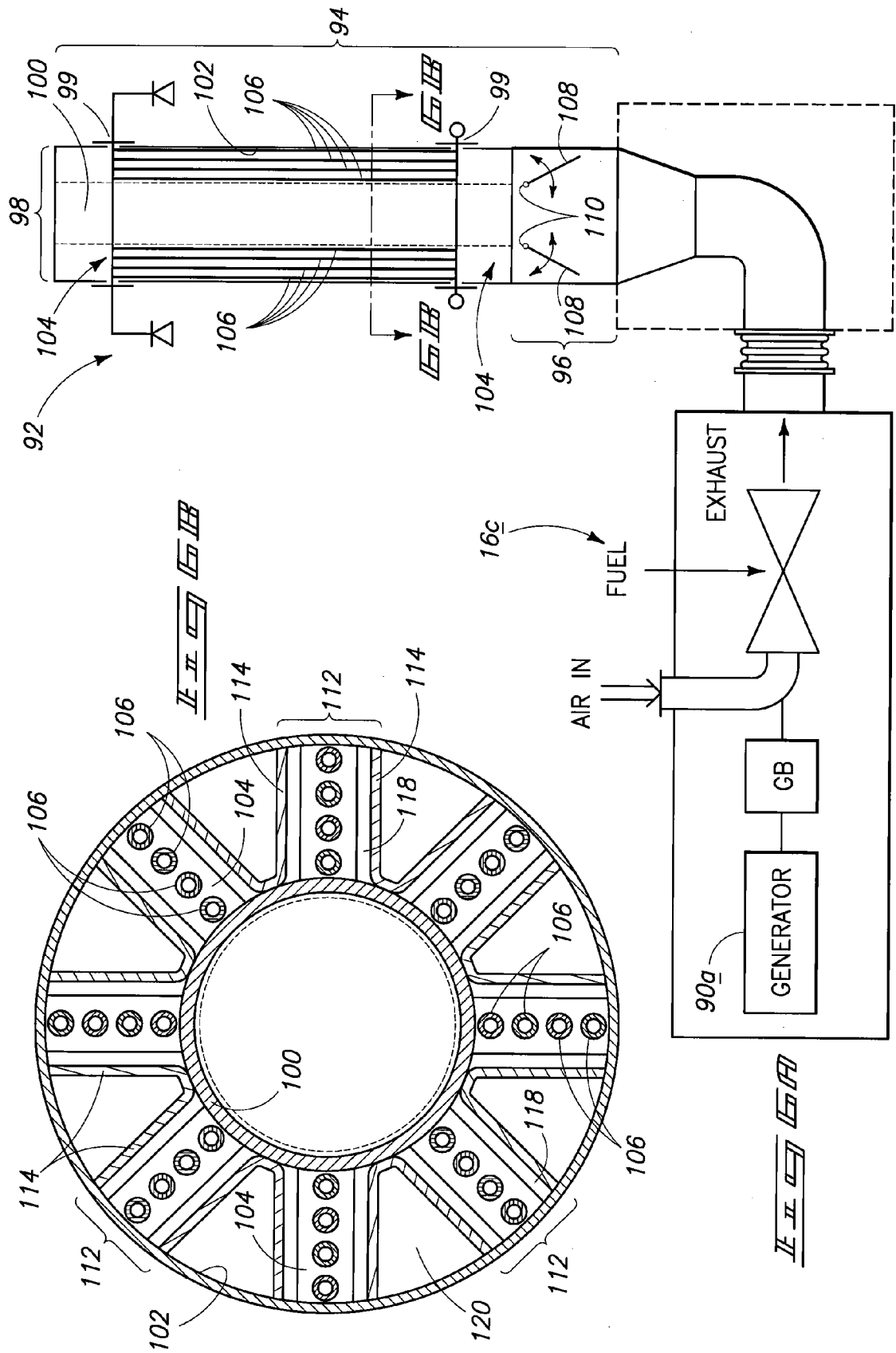
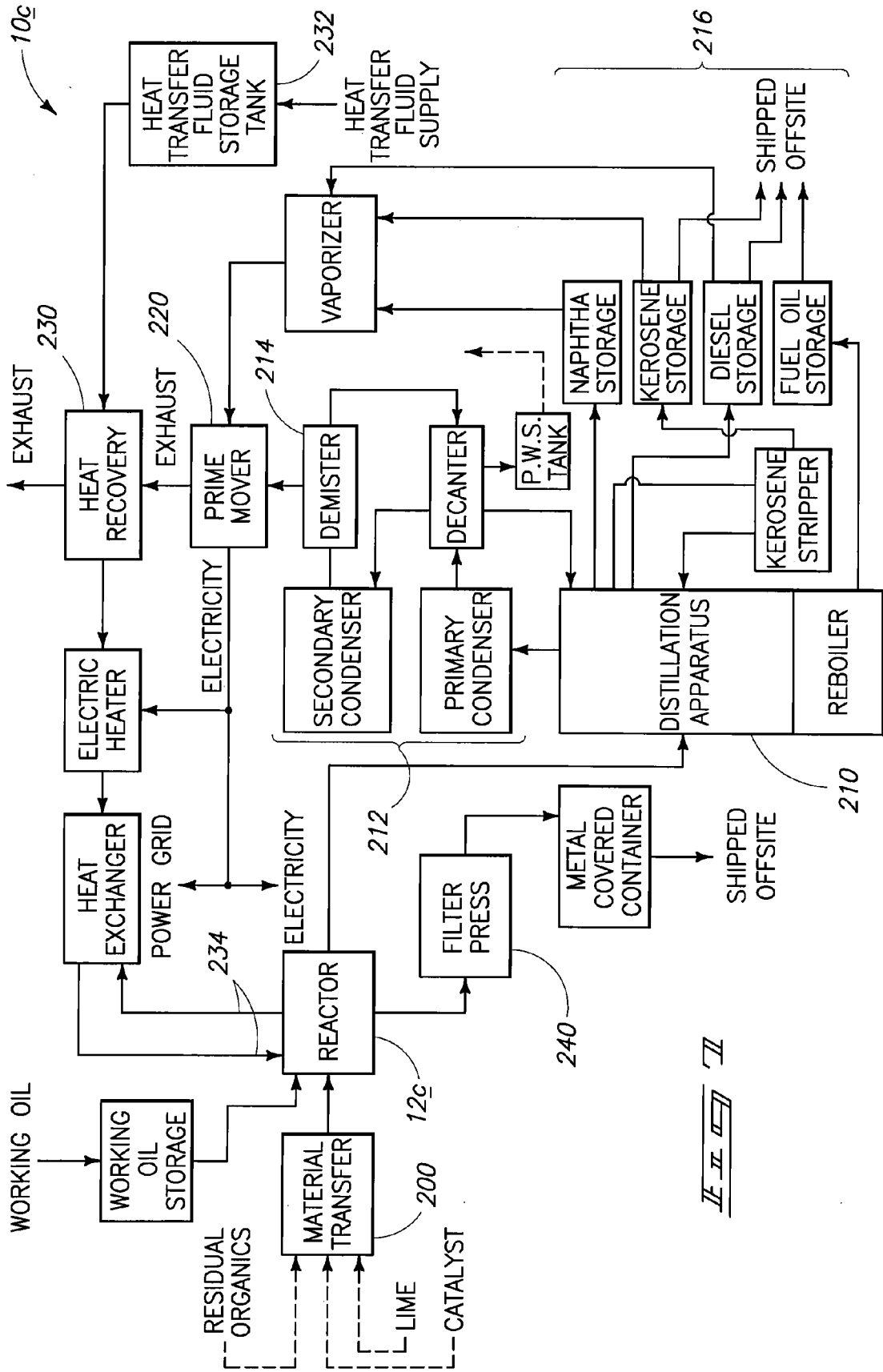


FIG. 5B







## PRODUCTION PROCESSES, SYSTEMS, METHODS, AND APPARATUSES

### TECHNICAL FIELD

**[0001]** The present disclosure relates to production processes and more specifically to fuel production processes.

### BACKGROUND

**[0002]** Each day the need for economically reasonable fuel sources becomes increasingly important. Similarly the need to dispose of waste in an economical yet environmentally friendly method is also highly desirable. The present disclosure provides processes for the conversion of carbon-based material such as waste material into fuel, fuel that may be used to power turbines and/or vehicles.

### SUMMARY OF THE DISCLOSURE

**[0003]** The present disclosure provides production processes that can include exposing a carbon-based material to liquid media to form hydrocarbon fuel.

**[0004]** Waste to fuel conversion processes are also provided that can include providing a low-moisture carbon-based waste material, and exposing the waste material to a liquid reaction media under a substantially oxygen-free atmosphere within a reactor. The processes can further provide for recovering gaseous hydrocarbon fuel from the reactor.

**[0005]** Waste to fuel processes can also include exposing a solid carbon-based material to a liquid reaction media to form a hydrocarbon fuel mixture. The fuel mixture can include non-condensable hydrocarbon fuel and condensable hydrocarbon fuel. Processes can proceed by separating the non-condensable hydrocarbon fuel from the condensable hydrocarbon fuel.

**[0006]** Waste material processing reactors are provided that can be configured to convert waste to fuel. The reactors can include a substantially columnar vessel extending along the vessel walls from a base portion to a top portion. An opening can be provided within the top portion of the vessel and the opening can be configured to receive carbon-based waste material. A liquid media conduit can be provided that extends from the base portion to the top portion of the vessel with the conduit being configured to circulate liquid media from within the base portion of the reactor to the top portion of the reactor.

**[0007]** Power generation processes are provided that can include exposing solid carbon-based material to a liquid reaction media to form non-condensable hydrocarbon fuel. The processes can continue by providing the non-condensable hydrocarbon fuel to a combustion turbine to generate power.

**[0008]** Combustion turbine exhaust apparatus are also provided that can include a substantially columnar housing extending along a plane from an inlet portion to outlet portion. The apparatus can also include a substantially columnar exhaust chute within the housing and extending parallel along the plane with the exhaust chute recessed from the walls of the housing. The exhaust chute and housing can define a space between the chute and housing within the apparatus. A plurality of heating fluid conduits can be provided within the space and extending along the plane.

**[0009]** Fuel generation processes are provided that can include exposing a solid carbon-based material to a liquid reaction media to form a mixture of hydrocarbon fuel and separating the fuel into at least two portions, a first portion and

a second portion. The process can also include providing the first portion to a combustion turbine to generate power, and storing the second portion for use as fuel.

**[0010]** Fuel generation systems are provided that can include a reactor configured to house a liquid reaction media and receive solid carbon-based material. Systems can also include a distillation apparatus coupled to the reactor and configured to receive gaseous hydrocarbon fuel from the reactor. In accordance with example embodiments, the system can include a combustion turbine coupled to the distillation apparatus and configured to receive distillate portions from the distillation apparatus.

**[0011]** Reaction media conduit systems are also provided that can include conduits coupled to a reaction media pump with a portion of the conduit proximate the pump comprising a jacket defining a volume configured to receive a refrigerant material.

**[0012]** Processes for servicing reactant media pumps coupled to both inlet and outlet conduits containing reactant media are also provided with the process, including at least partially solidifying portions of the reactant media proximate to the pump and within each of the inlet and outlet conduits and uncoupling at least a portion of the pump from either of the conduits while maintaining a majority of the reactant media within the conduits.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0013]** Embodiments of the disclosure are described below with reference to the following accompanying drawings.

**[0014]** FIG. 1 is a system according to an embodiment of the disclosure.

**[0015]** FIG. 2A is a portion of the system of FIG. 1 according to an embodiment of the disclosure.

**[0016]** FIG. 2B is a cross section of a portion of the system of FIG. 1 according to an embodiment of the disclosure.

**[0017]** FIG. 3 is a cross section of a portion of the system of FIG. 1 according to an embodiment of the disclosure.

**[0018]** FIG. 4 is a system according to an embodiment of the disclosure.

**[0019]** FIG. 5 is a system according to an embodiment of the disclosure.

**[0020]** FIG. 6A is a portion of the system of FIG. 5 according to an embodiment of the disclosure.

**[0021]** FIG. 6B is a cross section of a portion of the system of FIG. 5 according to an embodiment of the disclosure.

**[0022]** FIG. 7 is a system according to an embodiment of the disclosure.

### DESCRIPTION

**[0023]** This disclosure is submitted in furtherance of the constitutional purposes of the U.S. Patent Laws "to promote the progress of science and useful arts" (Article 1, Section 8).

**[0024]** Processes and systems according to the present disclosure are described with reference to FIGS. 1-7. Referring first to FIG. 1, a system 10 is disclosed that includes a reactor 12 configured to receive carbon-based material 14 and form hydrocarbon fuel 16. According to an example implementation, reactor 12 can house a liquid media. An example liquid media comprises a petroleum-based material, and such petroleum-based material may have a boiling point of at least about 290° C. One example petroleum-based material is that provided by 76 Lubricants® (a division of ConocoPhillips, 600 N. Dairy Ashford, Houston, Tex. 77079-1175; 1-800-762-

0942). Example materials from 76 Lubricants® used as liquid media can be the 76 Turbine Oil 100-460.

**[0025]** According to example implementations, this liquid media can also comprise a zeolite catalyst as well as have a boiling point of at least 290° C. This liquid media can be referred to as catalytic liquid media and/or catalytic cracking fluid, for example. According to example implementations, the catalyst utilized can be GPI Cat received from Tricat Industries Inc., Schilling Circle, Hunt Valley, Md. 21031 (Tel: (410)785-7900; Fax: (410) 785-7901). The liquid reaction media can also comprise a lime material such as a hydrated lime. Example hydrated limes include Type S dolomitic hydrated lime (Ca(OH)<sub>2</sub>\*Mg(OH)<sub>2</sub>). Such hydrated lime materials can be acquired from the Chemical Lime Company at 3724 Hulen Street, Ft. Worth, Tex. 76107. This company can be reached at, for example, (817) 732-8164. The liquid reaction media in combination with either one or both of the lime and catalyst can be referred to as catalytic cracking fluid.

**[0026]** To this liquid media can be added a carbon-based material. Example carbon-based materials can comprise cellulose as well as hydrogen materials. Example carbon-based materials comprise fluff as well. Fabric, thread, plastic and wood can be used as carbon-based materials.

**[0027]** Materials 14 can include but are not limited to: industrial waste residue from commercial cleaners; solvents; lignite; bitumen; early stages of coal; sawdust; natural and synthetic fabrics; natural and synthetic fibers; acid alkyl sludges; acid tars; acidic pickling solutions acidifying agent; acids not otherwise specified; activated carbon from chlorine production; adhesives and sealants sludges containing halogenated solvents; adhesives and sealants sludges free of halogenated solvents; agrochemical wastes; alkaline solutions; alkalis not otherwise specified; ammonia; animal rendering; aqueous liquid waste from gas treatment and other aqueous liquid wastes; aqueous liquid waste from oil regeneration; aqueous solvent mixes containing halogens; aqueous solvent mixes free of halogens; aqueous washing liquids; aqueous washing liquids and mother liquors; bilge oils from inland navigation; bilge oils from jetty sewers; bilge oils from other navigation; bleach solutions and bleach fixer solutions; boiler dust; brake fluids; calcium arsenate; calcium hydroxide-chelating agent; chlorinated emulsions; chlorinated engine, gear and lubricating oils; chlorine dioxide activator; chlorofluorocarbons, cyanide-free wastes containing chromium; cyanidic (alkaline) wastes containing heavy metals other than chromium; cyanidic (alkaline) wastes which do not contain heavy metals; degreasing wastes containing solvents without a liquid phase; desalter sludges or emulsions; discarded chemicals; electrolyte from batteries and accumulators; fixer solutions; flue gas dust; fly ash; fly ash and other flue gas treatment wastes; gibberlic acid; grease and oil mixture from oil/waste water separation; halogenated filter cakes; spent absorbents; halogenated solvents and solvent mixes; halogenated still bottoms and reaction residues; halogenated wastes from dressing and finishing; hydrochloric acid; hydrofluoric acid; ink sludges containing halogenated solvents; ink sludges free of halogenated solvents; insulation materials containing asbestos; liquid wastes and sludges from metal treatment and coating of metals (e.g. galvanic processes, zinc coating processes, pickling processes, etching, phosphatizing, alkaline de-greasing); machining sludges; metal hydroxide sludges and other sludges from metal insolubilization treatment; metallic salts; nitric acid and nitrous acid; non-chlorinated emulsions, oil fly ash; oil spills; oil/water separator

sludges; oil/water separator solids; oily sludges; organic halogenated solvents, washing liquids and mother liquors filter cake from gas treatment; gaseous substances and preparations which are flammable in air at normal pressure; hydraulic oils containing only mineral oil; hydraulic oils containing PCBs or PCTs; insulating or heat transmission oils and other liquids containing PCBs or PCTs; interceptor sludges; lead batteries; liquid municipal waste; liquid restaurant and food factory waste; liquid substances and preparations having a flash point below 21° C. (including extremely flammable liquids); organochlorinated wood preservatives; organometallic wood preservatives; other chlorinated hydraulic oils (not emulsions); phosphoric and phosphorous acid; photo chemicals; pulp & paper sludge; salts and solutions containing cyanides; saturated or spent ion exchange resins; skimmings; sludges and solids from tempering processes; sludges containing halogenated solvents; sludges containing mercury; sludges containing other solvents; sludges from gas treatment; sludges from paint or varnish removal containing halogenated solvents; sludges from paint or varnish removal free of halogenated solvents; sludges from zinc hydrometallurgy (including jarosite, goethite); sludges or solid wastes containing halogenated solvents; sludges or solid wastes containing solvents; soda; solid municipal waste; solid restaurant and food factory waste; solid substances and preparations which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition; solid waste from gas treatment; solutions and sludges from regeneration of ion exchangers; solvent based developer solutions; solvent mixes or organic liquids free of halogenated solvents; solvents; solvents and solvent mixes free of halogenated solvents; spent activated carbon; spent activated carbon from flue gas treatment; spent filter clays; spent waxes and fats; steam degreasing wastes; styrofoam packing; styrofoam peanuts; substances and preparations capable by any means, after disposal, of yielding another substance, e.g. a leachate, which possesses any of the characteristics listed above; substances and preparations which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy; substances and preparations which release toxic or very toxic gases in contact with water, air or an acid; substances and preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities; sulphuric acid; sulphuric acid and sulphurous acid; synthetic insulating and heat transmission oils and other liquids; synthetic machining oils; tank bottom sludges; tars and other carbon-containing wastes from anode manufacture; tires; vitrified wastes and wastes from vitrification; waste acidic solutions; waste adhesives and sealants containing halogenated solvents; waste adhesives and sealants free of halogenated solvents; waste containing silver from on-site treatment of photographic waste; waste from agricultural, horticultural, hunting, fishing and aquaculture primary production, food preparation and processing; waste from electrolytic refining; waste from marine transport tank cleaning, containing chemicals; waste from marine transport tank cleaning, containing oil; waste from natal care, diagnosis, treatment or prevention of disease in humans; waste from natural gas purification; waste from railway and road transport tank cleaning, containing chemicals; waste from railway and road transport tank cleaning, containing oil; waste from research, diagnosis, treatment or prevention of disease involving animals; waste from solvent and coolant recovery

(still bottoms); waste from storage tank cleaning, containing chemicals; waste from storage tank cleaning, containing oil; waste from the pyrolytic treatment of coal; waste from transport and storage tank cleaning; waste hydraulic oils and brake fluids; waste ink containing halogenated solvents; waste ink free of halogenated solvents; waste insulating and heat transmission oils and other liquids; waste machining emulsions containing halogens; waste machining emulsions free of halogens; waste machining oils containing halogens (not emulsioned); waste machining oils free of halogens (not emulsioned); material finishing wastes such as waste paints and varnish containing halogenated solvents, waste paints and varnish free of halogenated solvents; and wastes and sludges from non-ferrous hydrometallurgical processes.

**[0028]** Wastes such as the following can be utilized carbon-based materials: wastes from human or animal health care and/or related research (excluding kitchen and restaurant wastes which do not arise from immediate health care); wastes from incineration or pyrolysis of municipal and similar commercial, industrial and institutional wastes; wastes from metal decreasing and machinery maintenance; wastes from oil regeneration; wastes from organic chemical processes; wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal; wastes from power station and other combustion plants; wastes from shaping (including forging, welding, pressing, drawing, turning, cutting and filing); wastes from shaping and surface treatment of metals and plastics; wastes from specific physical/chemical treatments of industrial wastes (e.g. dechromation, decyanidation, neutralization); wastes from textile industry such as cleaning and degreasing of natural products; wastes from the leather industry; wastes from the manufacture, formulation, supply and use of coatings (paints, varnishes and vitreous enamels), adhesive, sealants and printing inks; wastes from waste treatment facilities, off-site waste water treatment plants and the water industry; waste streams such as wastes from waste water treatment plants; wastes from water and steam degreasing processes; and wastes from wood processing and the production of paper, cardboard, pulp, panels and furniture.

**[0029]** Materials **14** can also include but are not limited to: numerous polymeric materials such as; rubber, including that from automobile tires; mixed waste plastics, as small crumbs, or granules; granulate from used tires and granulated textiles from the tires, including the PVC portion; rubber and motor-car tire foam; pvc; styrofoam.

**[0030]** Materials **14** can also include but are not limited to: waste oils, waxes and fats, for example (including hydraulic oils and transformer oils); used mineral oils, including PCB contaminated transformer oils (pyralene); residues of the vacuum distillation in oil refineries; engine grease and other lubricants; vegetable oils; waste oils; waxes and fats of all kinds including the oil of the electrical changing of currency and hydraulic oils; all refinery arrears, bitumen, tars, etc.; paint; and glycerine.

**[0031]** Materials **14** can also include but are not limited to: agricultural materials (including animal waste products, spoiled food, etc.); biomass; wood products such as cardboard; slaughterhouse residues (bones, meat etc); animal waste products and spoiled food sugar plant bagasse; rice plants; shrubs; drugs; wheat; corn; tomatoes; oils and greases; palm waste; lubricants; crop protectant, growth regulator; inorganic pesticides, biocides and wood preserving agents; inorganic wood preservatives.

**[0032]** Materials **14** can also include but are not limited to: hospital waste materials; refinery by-products (bitumen, tars, for example); medical waste, sterilized; drains and dried biological materials; and autoclaved materials.

**[0033]** Materials **14** can also include but are not limited to: biological materials (wood, vegetables, meat wastes, etc.); household waste; lignite; sludge (paper, water treatment, etc); sewer sludge; paper sludge; municipal solid waste; municipal liquid waste; human waste; diapers; clothing; shoes; hair; vegetables; fruits; leather; animal waste; algae; plants; cherry waste; sludge from wineries; nut waste; food processing waste; coffee grounds; chicken manure; cow manure; hog manure; animals; forestry waste; farm waste; clippings; and bee attractant.

**[0034]** Materials **14** can also include but are not limited to: shredder residue; automobile components; wood; cellulose; fluff; electrical waste; electronic waste; and paper.

**[0035]** Materials **14** can also include but are not limited to: household waste materials: chip/snack bags; clothing, textiles, shoes; diapers; foam take-out containers; frozen good bags; juice boxes; lids, caps, tops; mail; magazines; mixed paper & catalogs; milk boxes; milk cartons; plastic bags; plastic bottles; plastic cups & utensils; plastic food boxes; plastic food trays; prescription vials; phone books; pill bottles; paint, inks, adhesives and resins; paper bags; paper or frozen food boxes; paper plates, cups & napkins; construction and demolition waste (including road construction); and books.

**[0036]** Materials **14** can also include but are not limited to: "Corrosive" substances and preparations which may destroy living tissue on contact; substances and preparations which present or may present immediate or delayed risks for one or more sectors of the environment.

**[0037]** Materials **14** can also include but are not limited to: "Explosive" substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene.

**[0038]** Materials **14** can also include but are not limited to: "Flammable" liquid substances and preparations having a flash point equal to or greater than 21° C. and less than or equal to 55° C.

**[0039]** Materials **14** can also include but are not limited to: "Harmful" substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may involve limited health risks.

**[0040]** Materials **14** can also include but are not limited to: "Infectious" substances containing viable micro-organisms or their toxins which are known or reliably believed to cause disease in man or other living organisms.

**[0041]** Materials **14** can also include but are not limited to: "Irritant" non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation.

**[0042]** Materials **14** can also include but are not limited to: "Mutagenic" substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce hereditary genetic defects or increase their incidence.

**[0043]** Materials **14** can also include but are not limited to: "Oxidizing" substances and preparations which exhibit highly exothermic reactions when in contact with other substances, particularly flammable substances.

**[0044]** Materials **14** can also include but are not limited to: "Teratogenic" substances and preparations which, if they are

inhaled or ingested or if they penetrate the skin, may induce non-hereditary congenital malformations or increase their incidence.

**[0045]** Materials **14** can also include but are not limited to: "Toxic" substances and preparations (including very toxic substances and preparations) which, if they are inhaled or ingested or if they penetrate the skin, may involve serious, acute or chronic health risks and even death. Toxic wastes such as the following can be utilized as carbon-based materials: Wastes containing arsenic, asbestos from electrolysis, cyanide and heavy metals such as mercury.

**[0046]** Hydrocarbon fuel **16** can comprise non-condensable gasses. The hydrocarbon fuel **16** can also include kerosene and/or diesel fuel as well as naphtha. Example non-condensable gasses can include C1-C4 hydrocarbons as well as CO and H<sub>2</sub>. The hydrocarbon fuel can also comprise condensable gasses. Together, these gasses can have a carbon chain length range from C1 to about C-25 as well as a boiling point less than 382° C. According to example implementations, the hydrocarbon fuel can be a mixture of components. This mixture can have a boiling point substantially less than the boiling point of the liquid reaction media, or in the alternative, the boiling point of the liquid reaction media can have a boiling point substantially greater than the boiling point of the fuel mixture. Upon exposing the carbon-based material to the liquid reaction media, at least a portion of the fuel mixture can be formed. Fuel **16** can be vaporized upon formation and this vaporized fuel can be provided to a prime mover as described and/or a distillation apparatus as described by example herein. As stated above, the non-condensable fuel portion of the mixture can include C1 to C4 hydrocarbon compounds as well as CO and H<sub>2</sub>. According to example implementations, this fuel mixture can comprise hydrocarbon compounds having greater than five carbon atoms. The carbon-based material can be substantially dry prior to being exposed to the liquid media. According to example implementations, the carbon-based material can have a moisture content less than about 16% (wt./wt.).

**[0047]** Reactor **12** can, according to example implementations, be referred to as a reaction zone, and this reaction zone can house the zeolite catalyst referred to above. According to example implementations, the exposing of the material can include exposing the material to the catalyst in the presence of the liquid media. According to example implementations, the reaction zone can also house the lime and the exposing can further include exposing the material to the catalyst to the lime in the presence of the media. Reactor **12** can be configured to house the liquid reaction media and receive solid carbon-based fuel. According to example implementations, the carbon-based material can be provided to reactor **12** utilizing a conveyor apparatus associated with reactor **12**. The conveyor apparatus can be configured to convey the material to a receiving portion of the reactor.

**[0048]** According to an example implementation, a waste to fuel conversion process can be performed utilizing system **10**. The process can include providing a low moisture carbon-based waste material such as that described herein, and exposing the waste material to a liquid reaction media under a substantially oxygen-free atmosphere within reactor **12**. The process can continue by recovering gaseous hydrocarbon fuel **16** from reactor **12**. As stated above, the waste material can comprise biomass, for example, and the low moisture carbon-based waste material can contain less than 16% (wt./wt.) water. According to example implementations, prior to

the exposing of the carbon-based material to the liquid reaction media can include providing a substantially oxygen-free atmosphere above the liquid reaction media within reactor **12** and providing the waste material through the atmosphere and into the reaction media within reactor **12**. This substantially oxygen-free atmosphere can include an atmosphere such as nitrogen, for example. According to example implementations, the liquid reaction media can be maintained at a temperature of at least about 270° C., or between from about 270° C. to about 582° C. during the exposing. The liquid reaction media can be agitated during the exposing and this agitation can include mechanical agitation, for example.

**[0049]** Referring to FIGS. **2A** and **2B**, reactor **12a** is shown that includes a waste material processing reactor as disclosed as configured to convert waste to fuel. This reactor **12a** can include a substantially columnar vessel **12** that extends along vessel walls **21** from a base portion **22** to a top portion **24**. Reactor **12a** can have an opening **26** within top portion **24** of the vessel. The opening can be configured to receive carbon-based waste material, for example. Liquid media **28** can reside within reactor **12a** and a liquid media conduit **30** can extend from base portion **22** to the top portion **24** of vessel **20**. According to example implementations, this conduit can be configured to circulate liquid media **28** from base portion **22** to top portion **24**, for example.

**[0050]** Materials of construction used for the systems described herein can include but are not limited to carbon steel and/or stainless steel. Implementations can include components constructed of Hastelloy as well. For example, vessel **12** can be constructed of carbon steel material for use in one embodiment. In other embodiments, vessel **12** can be constructed of Hastelloy where particularly acidic compounds such as fluoro and chloro compounds are anticipated as part of the feedstock.

**[0051]** Reactor **12a** can be configured with an atmosphere exchange conveyor **32**. Conveyor **32** can be configured as an inert gas purged air lock that includes tipping valves in combination with rotary valves. Conveyor **32** can be coupled to opening **26** and configured to exchange an oxygen-comprising atmosphere associated with waste material with a substantially oxygen-free atmosphere **34** within reactor **12a**. Reactor **12a** can also include an agitation apparatus **36**. Example agitation apparatuses include mechanical agitation apparatuses such as propeller configured stirring apparatuses. This apparatus can extend to within the vessel and proximate base portion **22** of vessel **20**. Reactor **12a** can also include a hydrocarbon fuel recovery conduit **38**. This conduit can be in fluid communication with the interior of vessel **20**, for example. According to example implementations, conduit **30** can extend along vessel walls **22** on the exterior of the reactor. According to other implementations, conduit **30** can be coupled to a heat exchanger **40**. According to example implementations, conduit **30** can have an internal diameter of at least 2.54 cm.

**[0052]** On either or both sides of pump **31** coupled to conduit **30** can be plug apparatus **33**. Apparatus **33** can be proximate to pump **31**, for example, and can include an exterior portion of conduit **30** as well a jacket defining a volume between the exterior portion of conduit **30** and the jacket. The jacket can define a continuous volume surrounding the entire perimeter of the exterior portion of the conduit. Apparatus **33** can be configured to receive and contain a refrigerant com-

position within the volume defined between the jacket and the exterior portion of conduit 30. An example refrigerant can include liquid nitrogen.

[0053] According to example implementations pump 31, for example, can be serviced by providing refrigerant material to apparatus 33 to at least partially solidifying portions of the reactant media proximate the pump and within each of the inlet and/or outlet conduits. Pump 31 can then be uncoupled from either of the conduits while maintaining a majority of the reactant media within the conduits.

[0054] Referring to cross section 2B, in conjunction with FIG. 2A, a plurality of nozzles can extend to within and be in fluid communication with the interior of vessel 20. According to example implementations, and referring to FIG. 2, these nozzles can be arranged around portion 24 within vessel 20. The nozzles can be configured to provide liquid media 28 to within vessel 20 as received from conduit 30. According to example implementations, the nozzles may form a perimeter around opening 26 in portion 24 of vessel 20. Nozzles 42 can be configured to provide media 28 in substantially the same direction as the travel of waste material upon entry into the vessel. According to example implementations, with reference to the configuration of reactor 12a, this direction can be a substantially downward direction.

[0055] Referring to FIG. 3, an example configuration of heat exchanger 40 is shown as heat exchanger 40a. Heat exchanger 40a includes a vessel 50 extending along a plane from an inlet portion 52 to an outlet portion 54. According to example implementations, the inlet and outlet portions define continuous respective volumes 52a and 54a. Vessel 50 can include a heating media compartment 56 which is defined by vessel 50 and is located along the plane between inlet portion 52 and outlet portion 54. The exchanger also includes a plurality of conduits 58 within vessel 50. The individual conduits 58 can extend from the inlet portion volume 52a through the heating media compartment 56 and to outlet portion volume 54a. The conduits can be configured to maintain a fluid communication between the volumes of the inlet and outlet portions.

[0056] According to example implementations, vessel 50 can be substantially columnar and inlet and outlet portions 52 and 54 can be at opposing ends of the columnar vessel 50. According to example implementations, inlet and outlet portions 52 and 54 can be configured with removable caps 60. Caps 60 can be affixed to vessel 50 utilizing gasket material, for example. Each of caps 60 comprise an interior facing surface 62, and this interior facing surface can define at least a portion of the respective continuous volume 52a and/or 54a. Within heat exchanger 40a, each of the individual conduits 58 define an inlet opening 64 extending to an outlet opening 66. Each of these inlet and outlet openings 64 and 66 of conduits 58 can be associated respectively with each of the inlet and outlet portions 54 and 52 of vessel 50. According to example implementations, openings 64 and 66 can be aligned substantially normal to face 62 of caps 60. Conduits 58 can also be aligned substantially parallel with interior walls 68 of vessel 50. According to an example implementation, the conduits can be aligned substantially normal to the inlet and outlet portions 52 and 54 of vessel 50. Inlet and outlet portion 52 and 54, respectively, of heat exchanger 40A can define respective inlet and outlet ports 72 and 74 respectively. These inlet and outlet ports can be configured to receive and dispense fluid to

be heated. For example, such fluid to be heated can include the liquid reaction media for use in reactor 12 of FIG. 1, for example.

[0057] Under some process conditions, conduits 58 can become restricted or even plugged. One or both of caps 60 can be removed and an apparatus used to expel any or all materials that may be restricting flow through conduits 58.

[0058] According to example implementations, media compartment 56 can define inlet and outlet ports 76 and 78. These inlet and outlet ports can be configured to receive and dispense a heating fluid. Such heating fluid can include but is not limited to Thermanol® VP1 heat transfer fluid by Solutia (Solutia, P.O. Box 66760, St. Louis, Mo. 63166-6760; (314) 674-1000).

[0059] Referring to FIG. 4, system 10a is provided that includes a reactor 12a configured to receive carbon-based material 14a and provide hydrocarbon fuel 16a. System 10a further comprises a distillation apparatus 80 that may be configured to separate portions of hydrocarbon fuel 16a into discrete hydrocarbon fuel portions 82. According to example implementations, solid carbon-based material 14a can be exposed to a liquid reaction media within reactor 12a to form a hydrocarbon fuel mixture 16a. This hydrocarbon fuel mixture 16a can include non-condensable hydrocarbon fuel and condensable hydrocarbon fuel, for example. Distillation apparatus 80 can be configured to separate the non-condensable hydrocarbon fuel from the condensable hydrocarbon fuel and form discrete hydrocarbon fuel portions 82. According to example implementations, the liquid reaction media within reactor 12a can be blanketed with a substantially oxygen-free atmosphere and upon exposing the carbon-based material to the liquid reaction media, the fuel mixture 16a formed can include at least a portion of this oxygen-free atmosphere.

[0060] Utilizing distillation apparatus 80, at least this portion of the oxygen-free atmosphere can be separated from the non-condensable and condensable fuels within discrete hydrocarbon fuel portions 82. According to example implementations, distillation apparatus 80 can be configured to distill fuel mixture 16a. Portions 82 of hydrocarbon fuel can also include naphtha as well as kerosene and diesel fuel portions. Distillation apparatus 80 through fractional distillation and design can be configured to separate these discrete hydrocarbon fuel portions.

[0061] Referring now to FIGS. 5A and 5B, a system 10b is disclosed that includes a reactor 12b coupled to a generator 90 which is utilized to produce power 92. Generator 90 can be considered a prime mover with example prime movers including but not limited to combustion turbines. According to example implementations, carbon-based material 14b can be exposed to a liquid reaction media within reactor 12b to form a hydrocarbon fuel mixture 16a. This hydrocarbon fuel mixture 16a can include non-condensable hydrocarbon fuels, for example. According to example implementations, this hydrocarbon fuel can be provided to generator 90. Example combustion turbines include but are not limited to gas, liquid, and combination gas/liquid fired combustion turbines.

[0062] According to example implementations, the carbon-based material can be provided to the liquid reaction media in the presence of a substantially oxygen-free atmosphere. Fuel mixture 16a can include this substantially oxygen-free atmosphere and prior to providing this fuel mixture 16a to generator 90, at least a portion of or all of this substantially oxygen-

free atmosphere can be removed. Example oxygen-free atmospheres contain nitrogen and/or product vapor such as hydrocarbons, CO, and/or H<sub>2</sub>.

[0063] According to an example implementation, a mixture comprising fuel mixture 16a can include the non-condensable hydrocarbon fuel in the atmosphere. The fuel can be separated from the atmosphere and then this fuel provided to generator 90. An example method for separating the nitrogen-containing atmosphere from the fuel can include distilling the fuel mixture 16a but in doing so, in providing this process, the hydrocarbon fuel can be substantially free of nitrogen and/or water upon being provided to generator 90. According to example implementations, the combustion turbine can be configured to provide at least 2.5 megawatts of electricity in the form of power 92. Prior to providing this fuel mixture 16a, according to other example implementations, non-condensable hydrocarbon fuel within mixture 16a can be separated from condensable hydrocarbon fuel and then non-condensable hydrocarbon fuel provided to generator 90 while providing the condensable hydrocarbon fuel for either storage or another source.

[0064] Referring to FIG. 5B, system 10b includes both a distillation apparatus 80 and a generator 90 configured to receive hydrocarbon fuel from distillation apparatus 80 and generate power 92 therefrom.

[0065] Referring to FIGS. 6A and 6B, a generator 90a is provided having a combustion turbine exhaust apparatus 92. Apparatus 92 can include a substantially columnar housing 94 extending along a plane from an inlet portion 96 to an outlet portion 98. Apparatus 92 can further include a substantially columnar exhaust chute 100 within housing 94 and extending parallel along the same plane as housing 94. Exhaust chute 100 can be recessed from walls 102 of the housing of housing 94, the exhaust chute 100 and housing defining a space 104 between chute 100 and housing 94. Apparatus 92 further comprises a plurality of heating fluid conduits 106 within space 104. Apparatus 92 further comprises dampers 108 associated with inlet portion 96 of housing 94. According to example implementations, dampers 108 can be configured to manipulate the flow of exhaust from the turbine between chute 100 and space 104. Dampers 108 can be hinged at 110 proximate the exhaust apparatus 92.

[0066] Apparatus 92 can include telescoping portions 99. According to example implementations, telescoping portions 99 can be provided along housing 94 between portions 96 and 98 for example.

[0067] Referring to FIG. 6B, one cross-section of apparatus 92 is shown. According to example implementations, the plurality of heating conduits 106 can comprise separate groups of conduits 112. Individual groups of conduits can comprise at least conduits within a channel defined by channel walls 114. These groups can extend between chute 100 and housing 94. Channel walls 114 can extend substantially normal between housing interior surface 102 and chute wall 116. These channel walls and groups can extend a substantial portion parallel along the plane within space 104 between housing wall 102 and chute wall 116. These channels can extend substantially parallel with the walls of the chute and housing. The walls can define a continuous volume 118 extending between inlet portion 96 and outlet portion 98 of the apparatus. Groups 112 can be dispersed around a perimeter of the chute and according to example implementations, the groups can be evenly dispersed around the chute. Baffles

120 can extend between groups 112, thereby forcing the exhaust gasses to pass proximate conduits 106.

[0068] Referring to FIG. 7, fuel generation system 10c is provided that includes a reactor 12c configured to house a liquid reaction media and receive solid carbon-based material via material transfer apparatus 200. System 10c can include a distillation apparatus 210 coupled to the reactor and configured to receive gaseous hydrocarbon fuel from the reactor. System 10c can also include a combustion turbine 220 coupled to the distillation apparatus and configured to receive distillate portions from the distillation apparatus. As an example implementation, material transfer apparatus 200 can be configured as a conveyor apparatus associated with reactor 12c. The conveyor apparatus can be configured to convey material to a receiver portion of reactor 12c. System 10c can also include a heat exchanger 230 coupled to the reactor. Heat exchanger 230 can be configured to heat the liquid reaction media of reactor 12c by providing heat from a heat exchanger fluid such as that stored in heat transfer fluid storage tank 232.

[0069] According to another example implementation, heat exchanger 230 can be coupled to turbine 220, for example, coupled to the exhaust of turbine 220. As an example, the heat exchanger fluid can circulate within the exhaust apparatus of the heat exchanger of the combustion turbine. System 10c can include a media circulating conduit 234 configured to circulate liquid reaction media between the reactor and the heat exchanger 230, for example. These conduits can define an access configured to allow for removal of a portion of the media during circulating. Filter press 240 can be in fluid communication with this access, for example.

[0070] According to example implementations, distillation apparatus 210 can also include condensers 212. These condensers can be configured to receive gaseous compounds from apparatus 210 and the condensers can also be ranged in serial condenser decanter configurations. These condenser-decanters can be configured to receive gaseous compounds from distillation apparatus 210 and return liquid compounds to distillation apparatus 210. According to example implementations, a portion of distillation apparatus 210 can include a demister 214 coupled to one of condensers 212. This demister can be configured to demist gaseous compounds received from the condenser and provide these demisted gaseous compounds directly to combustion turbine 220, for example. In this configuration, condensers 212 can be directly in line between distillation apparatus 210 and combustion turbine 214.

[0071] According to example implementations, distillation apparatus 210 can be configured to separate portions of hydrocarbon fuel 216. These portions 216 can include any one or more of fuel oil, kerosene, diesel, naphtha, and/or non-condensable hydrocarbon fuel such as CO and/or H<sub>2</sub>. In accordance with the utilization of system 10c, a fuel generation process can be utilized that provides for exposing a solid carbon-based material to a liquid reaction media to form a mixture of hydrocarbon fuel 216. The fuel can be separated into at least two portions, with a first portion and a second portion. The first portion can be provided to a combustion turbine to generate power, and the second portion can be used for liquid fuel. The substantially dry carbon-based material can be exposed to an oxygen-free reaction zone housed in liquid reaction media, for example, and the separating can include separating a substantially oxygen-free atmosphere from the fuel before separating the fuel into two portions. The first portion of these fuels can include the non-condensable

hydrocarbons, and the second portion can comprise the condensable hydrocarbons. According to another implementation, the first portion can comprise non-condensable hydrocarbons and kerosene, and the second portion can comprise diesel fuel, for example. This first portion can be provided to the combustion turbine, and prior to providing to the combustion turbine, this portion can be vaporized.

**[0072]** According to example implementations, the liquid media can be heated with a heat transfer fluid, and the providing of the fuel can include generating power as well as an exhaust from the combustion of the turbine wherein the exhaust is used to heat the heat transfer fluid.

**[0073]** In compliance with the statute, embodiments of the invention have been described in language more or less specific as to structural and methodical features. It is to be understood, however, that the entire invention is not limited to the specific features and/or embodiments shown and/or described, since the disclosed embodiments comprise forms of putting the invention into effect. The invention is, therefore, claimed in any of its forms or modifications within the proper scope of the appended claims appropriately interpreted in accordance with the doctrine of equivalents.

1. A production process comprising exposing a carbon-based material to catalytic liquid media to form hydrocarbon fuel.

2. The process of claim 1 wherein the carbon-based material comprises cellulose.

3. The process of claim 1 wherein the liquid media comprises a zeolite catalyst.

4. The process of claim 1 wherein the liquid media comprises hydrated lime.

5. The process of claim 1 wherein the liquid media comprises a petroleum-based material.

6. The process of claim 5 wherein the petroleum-based material has a boiling point of at least 370° C.

7. The process of claim 1 wherein the carbon-based material comprises hydrogen.

8. The process of claim 1 wherein the carbon-based material comprises fluff.

9. The process of claim 1 wherein the hydrocarbon fuel comprises non-condensable gases.

10. The process of claim 1 wherein the hydrocarbon fuel comprises kerosene.

11. The process of claim 1 wherein the hydrocarbon fuel comprises diesel fuel.

12. A waste to fuel conversion process comprising:  
providing a low-moisture carbon-based waste material;  
exposing the waste material to a catalytic liquid reaction media under a substantially oxygen-free atmosphere within a reactor; and  
recovering gaseous hydrocarbon fuel from the reactor.

13. The process of claim 12 wherein the carbon-based waste material contains less than 16% (wt./wt.) water.

14. The process of claim 12 wherein the waste material comprises biomass.

15. The process of claim 12 wherein the exposing comprises providing a substantially oxygen-free atmosphere above the liquid reaction media and providing the waste material through the atmosphere and into the reaction media.

16. The process of claim 15 wherein the liquid reaction media is maintained at a temperature of at least about 310° C. during the exposing.

17. The process of claim 12 wherein the liquid reaction media is agitated during the exposing.

18. The process of claim 17 wherein the agitation comprises mechanical agitation.

19. The process of claim 12 wherein the gaseous hydrocarbon fuel comprises hydrocarbon compounds ranges in carbon chain length from C-1 to C-25.

20. The process of claim 12 wherein the atmosphere comprises N<sub>2</sub>.

21. The process of claim 12 wherein the waste material is provided to the reaction media during the exposing via an inert gas purged air lock.

22. A waste material processing reactor configured to convert waste to fuel, the reactor comprising:

a substantially columnar vessel extending along the vessel walls from a base portion to a top portion;

an opening within the top portion of the vessel, the opening configured to receive carbon-based waste material; and  
a liquid media conduit extending from the base portion to the top portion of the vessel, the conduit configured to circulate liquid media from within the base portion of the reactor to the top portion of the reactor.

23. The reactor of claim 22 wherein the vessel is constructed primarily of carbon steel material.

24. The reactor of claim 22 further comprising an atmosphere exchange conveyor coupled to the opening, the exchange conveyor configured to exchange an oxygen-comprising atmosphere associated with the waste material with a substantially oxygen-free atmosphere within the reactor.

25. The reactor of claim 22 wherein the opening is also configured to receive an agitation apparatus.

26. The reactor of claim 25 wherein the agitation apparatus comprises a mechanical agitation apparatus that extends to within the vessel and proximate the base of the vessel.

27. The reactor of claim 22 further comprising a hydrocarbon fuel recovery conduit coupled to the reactor and in fluid communication with the interior of the vessel.

28. The reactor of claim 22 wherein the liquid media conduit extends along the vessel walls on the exterior of the reactor.

29. The reactor of claim 22 wherein the liquid media conduit is coupled to a heat exchanger.

30. The reactor of claim 22 further comprising a plurality of nozzles arranged around the top portion within the vessel, the nozzles in fluid communication with the liquid media conduit and configured to provide the liquid media to within the vessel.

31. The reactor of claim 30 wherein the nozzles form a perimeter around the opening in the top portion of the vessel and the nozzles are configured to provide the liquid media in substantially the same direction as the travel of waste-material upon entry into the vessel.

32. A waste to fuel process comprising:

exposing a solid carbon-based material to a liquid reaction media to form a hydrocarbon fuel mixture, the fuel mixture comprising non-condensable hydrocarbon fuel and condensable hydrocarbon fuel; and

separating the non-condensable hydrocarbon fuel from the condensable hydrocarbon fuel.

33. The process of claim 32 wherein the liquid reaction media has a boiling point substantially greater than a boiling point of the fuel mixture.

34. The process of claim 32 wherein upon exposing the solid carbon-based material to the liquid reaction media at least a portion of the fuel mixture is formed.



**35.** The process of claim **32** wherein the liquid reaction media is blanketed with a substantially oxygen-free atmosphere, and upon the exposing the fuel mixture comprises at least a portion of the atmosphere.

**36.** The process of claim **35** wherein the portion of the atmosphere is separated from the non-condensable and condensable fuels.

**37.** The process of claim **32** wherein separating comprises distilling the fuel mixture.

**38.** The process of claim **32** wherein the non-condensable fuel comprises C-1 to C-4 hydrocarbon compounds.

**39.** The process of claim **32** wherein the non-condensable fuel comprises CO and H<sub>2</sub>.

**40.** The process of claim **32** wherein the condensable fuel comprises hydrocarbon compounds having greater than 5 carbon atoms.

**41.** A power generation process comprising:

exposing solid carbon-based material to a liquid reaction media to form vaporized hydrocarbon fuel; and providing the vaporized hydrocarbon fuel to a combustion turbine to generate power.

**42.** The process of claim **41** wherein the vaporized hydrocarbon fuel comprises C-1 to C-4 compounds.

**43.** The process of claim **41** wherein the exposing further comprises exposing the material to a substantially oxygen-free atmosphere.

**44.** The process of claim **43** wherein the providing comprises:

generating a mixture comprising the vaporized hydrocarbon fuel and the atmosphere;

separating a substantial amount of the fuel from the atmosphere; and

providing the fuel to the combustion turbine.

**45.** The process of claim **44** wherein separating comprises distilling the mixture.

**46.** The process of claim **41** wherein the vaporized hydrocarbon fuel is substantially free of nitrogen and water upon being provided to the combustion turbine.

**47.** The process of claim **41** wherein the combustion turbine is configured to provide at least 1000 kW of electricity.

**48.** The process of claim **41** wherein the forming the vaporized hydrocarbon fuel furthering comprises separating the non-condensable hydrocarbon fuel from condensable hydrocarbon fuel.

**49.** A combustion turbine exhaust apparatus comprising:

a substantially columnar housing extending along a plane from an inlet portion to outlet portion;

a substantially columnar exhaust chute within the housing and extending parallel along the plane, the exhaust chute recessed from the walls of the housing, the exhaust chute and housing defining a space between the chute and housing; and

a plurality heating fluid conduits within the space and extending along the plane.

**50.** The apparatus of claim **49** wherein dampers are associated with inlet portion of the housing, the dampers configured to manipulate the flow of exhaust from the turbine between the chute and the space.

**51.** The apparatus of claim **50** wherein the dampers are hinged proximate the apparatus.

**52.** The apparatus of claim **49** wherein the plurality of heating fluid conduits comprises separate groups of conduits.

**53.** The apparatus of claim **52** wherein the groups of conduits comprise at least two conduits within a channel extending between the chute and housing within the space.

**54.** The apparatus of claim **53** wherein the channel is defined by channel walls extending substantially normally between the housing and chute.

**55.** The apparatus of claim **53** wherein the channel is defined by channel walls extending within space between the inlet and outlet portions substantially parallel with the walls of the chute and housing.

**56.** The apparatus of claim **53** wherein each of the channels defines a continuous volume extending between the inlet and outlet portions of the apparatus.

**57.** The apparatus of claim **53** wherein the groups are dispersed around the chute.

**58.** The apparatus of claim **53** wherein in one cross section the groups are evenly dispersed around the chute.

**59.** The apparatus of claim **53** wherein baffles extend between the groups with the space.

**60.** A fuel generation process comprising:

exposing a solid carbon-based material to a liquid reaction media to form a mixture of hydrocarbon fuel;

separating the fuel into at least two portions, a first portion and a second portion;

providing the first portion to a combustion turbine to generate power; and

storing the second portion for use as fuel.

**61.** The process of claim **60** wherein the exposing comprises providing a substantially dry carbon-based material to a substantially oxygen-free reaction zone housing the liquid reaction media.

**62.** The process of claim **61** wherein the reaction zone houses a zeolite catalyst, the exposing further comprising exposing the material to the catalyst in the presence of the media.

**63.** The process of claim **61** wherein the reaction zone houses lime, the exposing further comprising exposing the material to the catalyst in the presence of the media.

**64.** The process of claim **60** wherein the first portion comprises non-condensable hydrocarbons and the second portion comprises condensable hydrocarbons.

**65.** The process of claim **60** wherein the first portion comprises non-condensable hydrocarbons and kerosene and the second portion comprises diesel fuel.

**66.** The process of claim **60** wherein the providing the first portion to the combustion turbine comprises vaporizing the first portion.

**67.** The process of claim **60** wherein the liquid reaction media is heated with heat transfer fluid and the providing further comprises generating power as well as an exhaust from the combustion the turbine, wherein the exhaust is used to heat the heat transfer fluid.

**68.** The process of claim **60** wherein the first portion comprises kerosene and the second portion comprises diesel fuel.

**69.** The process of claim **68** wherein separating comprises distilling the mixture to separate the portions.

**70.** A fuel generation system comprising:

a reactor configured to house a liquid reaction media and receive solid carbon based material;

a distillation apparatus coupled to the reactor and configured to receive gaseous hydrocarbon fuel from the reactor; and

- a combustion turbine coupled to the distillation apparatus and configured to receive distillate portions from the distillation apparatus.
- 71.** The system of claim **70** further comprising a conveyor apparatus associated with reactor, the conveyor apparatus configured to convey material to a receiving portion of the apparatus.
- 72.** The system of claim **70** further comprising a heat exchanger coupled to the reactor, the heat exchanger configured to heat the liquid reaction media by providing heat from a heat exchanger fluid.
- 73.** The system of claim **72** wherein the heat exchanger is coupled to the combustion turbine.
- 74.** The system of claim **73** wherein at least a portion of the heat exchanger fluid of the heat exchanger circulates within an exhaust apparatus of the combustion turbine.
- 75.** The system of claim **70** wherein the reactor comprises a media circulating conduit configured to circulate the liquid reaction media.
- 76.** The system of claim **75** wherein conduit comprises a fluid pump, the conduit further configured to have the fluid pump removed from the conduit while maintaining substantially all the fluid within the conduit.
- 77.** The system of claim **75** wherein the conduit defines an access configured to allow for removal of a portion of the media during the circulating.
- 78.** The system of claim **77** further comprising a filter press in fluid communication with the access.
- 79.** The system of claim **70** wherein the distillation apparatus comprises at least one condenser configured to receive gaseous compounds from the apparatus.
- 80.** The system of claim **70** wherein the distillation apparatus comprises a plurality of serial condenser-decantor apparatus, the condenser-decantor apparatus configured to receive gaseous compounds from the distillation apparatus and return liquid compounds to the distillation apparatus.
- 81.** The system of claim **70** wherein the distillation apparatus comprises a condenser coupled to a demister, the demister configured to demist gaseous compounds received from the condenser.
- 82.** The system of claim **81** wherein the distillation apparatus is coupled to a combustion turbine.
- 83.** The system of claim **82** wherein a condenser is inline between the distillation apparatus and combustion turbine.
- 84.** The system of claim **70** wherein the distillation apparatus is configured to separate portions of condensable hydrocarbon fuel.
- 85.** The system of claim **84** wherein the portions comprise kerosene and/or diesel fuel.
- 86.** A reaction media conduit coupled to a reaction media pump, a portion of the conduit proximate the pump comprising a jacket defining a volume configured to receive a refrigerant material.
- 87.** The conduit of claim **86** wherein the conduit and pumps are configured to transfer the reaction media, the reaction media comprising an industrial grade high molecular weight oil.
- 88.** The conduit of claim **86** wherein the conduit has an internal diameter of at least 2.54 cm.
- 89.** The conduit of claim **86** wherein the conduit and pump are configured to transfer reaction media from an industrial grade reactor.
- 90.** The conduit of claim **86** wherein the conduit and pump are configured to transfer reaction media to an industrial grade heat exchanger.
- 91.** The conduit of claim **86** wherein the conduit extends from entrance and exit portions of the pump and the jacket is proximate either the exit or entrance portions of the pump.
- 92.** The conduit of claim **86** wherein conduit extends from entrance and exit portions of the pump and these portions both comprise jackets.
- 93.** The conduit of claim **86** wherein the jacket defines a continuous volume surrounding the entire perimeter of the portion of the conduit.
- 94.** The conduit of claim **86** wherein the refrigerant material comprises liquid nitrogen.
- 95.** A process for servicing reactant media pumps coupled to both inlet and outlet conduits containing reactant media, the process comprising:  
at least partially solidifying portions of the reactant media proximate to the pump and within each of the inlet and outlet conduits; and  
uncoupling at least a portion of the pump from either of the conduits while maintaining a majority of the reactant media within the conduits.
- 96.** The process of claim **95** wherein the inlet conduit is coupled to an industrial grade reactor.
- 97.** The process of claim **95** wherein the outlet conduit is coupled to an industrial grade heat exchanger.
- 98.** The process of claim **95** wherein the partially solidifying comprises providing a refrigerant proximate the inlet and outlet conduits.
- 99.** The process of claim **95** wherein the reactant media comprises industrial grade oil.

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