(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 January 2012 (26.01.2012)

PCT

(10) International Publication Number
WO 2012/012386 A2

(51) International Patent Classification: *C10G 3/00* (2006.01)

(21) International Application Number: PCT/US2011/044480

(22) International Filing Date: 19 July 2011 (19.07.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12/840,699 21 July 2010 (21.07.2010) US

(71) Applicant *(for all designated States except US)*: **L'AIR LIQUIDE SOCIETE ANONYME POUR L'ETUDE ET L'EXPLOITATION DES PROCEDES GEORGES CLAUDE** [FR/FR]; 75 quai d'Orsay, F-75007 Paris (FR).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: **VAUK, Dennis, A.** [US/US]; 16727 Coyotillo Lane, Houston, TX 77095 (US).

(74) Agents: **HAYNES, Elwood, Leonard** et al.; 2700 Post Oak Boulevard, Suite 1800, Houston, TX 77056 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, 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, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) **Title**: COMBINED FIRST AND SECOND GENERATION BIOFUELS PROCESS

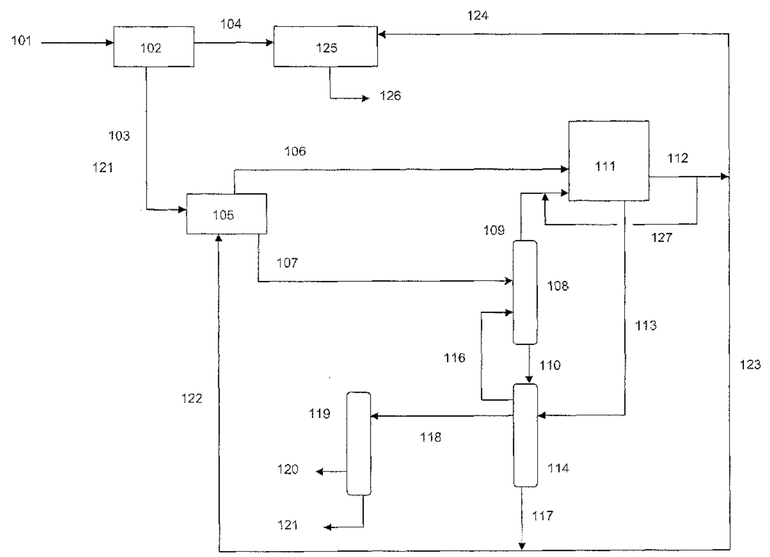

Fig. 1

(57) **Abstract**: A process to integrate a first biofuels process and a second generation cellulosic biofuels process is provided. The pyrolysis means which produces the char stream and a bioliquid stream. The low pressure hydrotreating component, a high pressure hydrotreating component, the low pressure hydrotreating component which produces the hydrocarbon stream, the high pressure hydrotreating component which produces the steam stream and bioliquid stream. A distillation means, which produces a green gasoline stream and a green diesel stream from the bioliquid stream. The second biofuels process may be a first generation bio-ethanol process, which produces a bio-ethanol stream. The hydrogen production unit, which produces the hydrogen stream and the steam stream. The hydrogen production unit may be a steam reformer or partial oxidation unit.

WO 2012/012386 A2

Combined First and Second Generation Biofuels Process

Background

Biofuels are a wide range of fuels which are in some way derived from biomass. The term covers solid biomass, liquid fuels and various biogases. Biofuels are gaining increased public and scientific attention, driven by factors such as oil price spikes, the need for increased energy security, and concern over greenhouse gas emissions from fossil fuels.

Bioethanol is an alcohol made by fermenting the sugar components of plant materials and it is made mostly from sugar and starch crops. With advanced technology being developed, cellulosic biomass, such as trees and grasses, are also used as feedstocks for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is widely used in the USA and in Brazil.

Biodiesel is made from vegetable oils, animal fats or recycled greases. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. Biodiesel is produced from oils or fats using transesterification and is the most common biofuel in Europe.

'First-generation biofuels' are biofuels made from sugar, starch, vegetable oil, or animal fats using conventional technology. Often, first-generation biofuels are produced by fermenting plant-derived sugars to ethanol, using a similar process to that used in beer and wine-making. The basic feedstocks for the production of first generation biofuels are often seeds or grains such as sunflower seeds, which are pressed to yield vegetable oil that can be used in biodiesel, or wheat, which yields starch that is fermented into bioethanol. These feedstocks could instead enter the animal or human food chain, and as the global population has risen their use in producing biofuels has been criticised for diverting food away from the human food chain, leading to food shortages and price rises.

This typically requires the use of 'food' crops such as sugar cane, corn, wheat, and sugar beet. These crops are required for food, so if too much biofuel is made from them, food prices could rise and shortages might be experienced in some countries. Corn, wheat and sugar beet also require high agricultural inputs in the form of fertilizers, which limit the greenhouse gas reductions that can be achieved.

Second generation biofuel technologies have been developed because first generation biofuels manufacture has important limitations. First generation biofuel processes are useful, but limited in most cases: there is a threshold above which they cannot produce enough biofuel without threatening food supplies and biodiversity. Many first generation biofuels are dependent of subsidies and are not cost competitive with existing fossil fuels such as oil, and some of them produce only limited greenhouse gas emissions savings. When taking emissions from production and transport into account, life cycle assessment from first-generation biofuels frequently exceed those of traditional fossil fuels.

Second generation biofuels can help solve these problems and can supply a larger proportion of our fuel supply sustainably, affordably, and with greater environmental benefits.

The goal of second generation biofuel processes is to extend the amount of biofuel that can be produced sustainably by using biomass consisting of the residual non-food parts of current crops, such as stems, leaves and husks that are left behind once the food crop has been extracted, as well as other crops that are not used for food purposes (non food crops), such as switch grass, jatropha and cereals that bear little grain, and also industry waste such as woodchips, skins and pulp from fruit pressing, etc.

The problem that second generation biofuel processes are addressing is to extract useful feedstocks from this woody or fibrous biomass, where the useful sugars are locked in by lignin and cellulose. All plants contain cellulose and lignin. These are complex carbohydrates (molecules based on sugar). Lignocellulosic ethanol is made by freeing the sugar molecules from cellulose using enzymes, steam heating, or other pre-treatments. These sugars can then be fermented to produce ethanol in the same way as first generation bioethanol production. The by-product of this process is lignin. Lignin can be burned as a carbon neutral fuel to produce heat and power for the processing plant and possibly for surrounding homes and businesses.

Summary

In another embodiment, the first biofuels process is a second generation cellulosic biofuels process, which includes, but is not limited to the following. The pyrolysis means which produces the char stream and a bioliquid stream. The low pressure hydrotreating component, a high pressure hydrotreating component, the low pressure hydrotreating component which produces the stabilized hydrocarbon stream, the high pressure hydrotreating component which produces the steam stream and a bioliquid stream. A distillation means, which produces a green gasoline stream and a green diesel stream from the bioliquid stream. The second biofuels process may be a first generation bio-ethanol process, which produces a bio-ethanol stream. The hydrogen production unit, which produces the hydrogen stream and the steam stream. The hydrogen production unit may be a steam reformer or partial oxidation unit.

Brief Description of the Figures

Figure 1 illustrates one embodiment of the present invention..

Figure 2 illustrates details of one embodiment of the hydrogen production unit and the associated waste heat boilers.

Figure 3 illustrates one embodiment of water gas shift section of the present invention.

Figure 4 illustrates another embodiment of the water gas shift section of the present invention.

Figure 5 illustrates another embodiment of the water gas shift section of the present invention.

Figure 6 illustrates another embodiment of the water gas shift section of the present invention.

Description of Preferred Embodiments

Illustrative embodiments of the invention are described below. While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developer's specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

Turning now to figure 1, the invention is a hybrid process for combining first generation biofuels technology with second generation biofuels technology. In particular, this is an integrated process for producing biofuels from a biofuel feedstock from a cellulosic component and a starch component. The cellulosic component **103** and a hydrogen stream **113** generated by a hydrogen production unit **111** are introduced into a first biofuels process. The starch component **104** and a steam stream **124** are introduced into a second biofuels process **125. A** char stream **106** generated by a pyrolysis process **105** of the first biofuels process; and a hydrocarbon stream **109** generated by a low pressure hydrotreating component **108** are introduced into the hydrogen production unit **111**.

In one embodiment, the steam stream **117, 112**, **124** is generated by a high pressure hydrotreating component **114** of the first biofuels process and/or the hydrogen production unit **111**. In another embodiment, the first biofuels process is a second generation cellulosic biofuels process. The second biofuels process may be a first generation bio-ethanol process.

In another embodiment, the first biofuels process is a second generation cellulosic biofuels process, which includes, but is not limited to the following. The pyrolysis means **105** which produces the char stream **106** and a bioliquid stream **107.** The low pressure hydrotreating component **108,** a high pressure hydrotreating component **114**, the low pressure hydrotreating component which produces the hydrocarbon stream **109**, the high pressure hydrotreating component **114** which produces the steam stream **117.** A distillation means **119**, which produces a green gasoline stream **120** and a green diesel stream **121** from the bioliquid stream **107**. The second biofuels process may be a first generation bio-ethanol process, which produces a bio-ethanol stream **126.** The hydrogen production unit **111,** which produces the hydrogen stream **112** and the steam stream **112**. The hydrogen production unit **111** may be a steam reformer

Turning now to figure 2, the hydrogen production unit has a furnace **211**, a process effluent stream **207**, a flue gas stream **202**, a feed stream and a fuel stream **201.** The feed stream is the hydrocarbon stream **109,** the fuel stream **201** is the char stream **106**, and the feed is combined with the steam stream **127**, which is produced from the hydrogen production unit **111,** and fed to the furnace **211**. In another embodiment, the process effluent stream **207** indirectly exchanges heat with a first feed water stream **209** in a first waste heat boiler **208** and the flue gas stream **202** indirectly exchanges heat with a second feedwater stream **205** in a second waste heat boiler **203** to produce the steam stream **112**.

In another embodiment, the process effluent **207** is contacted with a catalyst **302** in a water gas shift reactor **301** to convert carbon monoxide to hydrogen and carbon dioxide, thereby producing a shift effluent **303.** The shift effluent **303** and a first feed water stream **209** may be in indirect heat exchange in a first waste heat boiler **208** to produce the steam stream **112**, thereby producing a cooled shift effluent **304.** The cooled shift effluent **304** may be fed into a pressure swing adsorption (PSA) unit **305** to separate hydrogen from carbon monoxide, un-reacted hydrocarbons and carbon dioxide, thereby producing the hydrogen stream **113** and a PSA tail gas stream **306**. The hydrogen stream **113** may be sent to the high pressure hydrotreating component **114,** The PSA tail gas **306** may be sent to the furnace **211** wherein it is used as fuel for the furnace in combination with the char stream **106**. The high pressure hydrotreating component **114** may be a bioliquid hydrotreater.

In one embodiment, at least a portion of the steam stream **112** is fed to the furnace **211** and at least a portion of the steams stream **112** produced is exported to the second biofuels process **125.** In another embodiment the hydrogen production unit **111** may be a partial oxidation unit.

Turning now to figure 3, the PSA tail gas **306** may comprise carbon monoxide, un-reacted hydrocarbons and carbon dioxide and some portion of hydrogen.

Turning now to figure 4, the char stream **106** and the hydrocarbon stream **109** are introduced as feed. An oxygen stream **402**, generated by air separation in a cryogenic process **401,** is introduced into the partial oxidation unit **111.** The oxygen stream **40**2, the char stream **106**, and the hydrocarbon stream **109** are combined in the partial oxidation unit **111** thereby producing a syngas stream **403**. The syngas stream **403** is cooled in a first heat exchanger **404** thereby creating a cooled syngas stream **405**. The cooled syngas stream **405** is combined with a water stream or a steam stream **406**, thereby producing a wet syngas stream **407**. The wet syngas stream **407** is introduced into a water gas shift reactor 408 wherein a water gas shift reaction is promoted by contact with a catalyst **409**, thereby producing a shifted syngas stream **410**. The shifted gas stream **410** and a feed water stream **412** exchange heat in an indirect contact waste heat boiler **411** to produce a steam stream **413**, thereby producing a cooled shifted syngas stream **414.** The cooled shifted syngas stream **414** is further cooled in an air cooler **415,** thereby producing a further cooled shifted syngas stream **416**. The further cooled shifted syngas stream **416** is introduced into a first absorbtion unit **417** where a hydrogen stream **418** is separated from a first off-gas stream **419**.

In another embodiment, the syngas stream **403** comprises hydrogen, carbon monoxide and carbon dioxide. In another embodiment, the catalyst **409** promotes the conversion of carbon monoxide to hydrogen to produce a shifted syngas **410** with at least 90% of the carbon monoxide converted to hydrogen. The first adsorption unit **417** may be of a pressure swing adsorption (PSA) unit producing hydrogen with a purity of greater than 99.5%. The hydrogen stream **418** may be sent to the bioliquid hydrotreater.

Turning now to figure 5, the first off-gas stream **418,** comprises a PSA tail gas consisting of carbon monoxide, carbon dioxide, unreacted hydrocarbon, nitrogen and argon impurities of the oxygen stream. At least part of the first off-gas stream **419** is compressed in a compressor **501** thereby producing a compressed off-gas stream **502**, and a remainder stream **508**. The compressed off-gas stream **502** is recycled to the first adsorption unit **417** for further recovery of hydrogen or sent to a second adsorption unit **504** for further recovery of hydrogen, and thereby producing a second off-gas stream **506**, and a second hydrogen stream **505**. The remainder stream **508** and the second off-gas stream **506** are combined to form a combined off-gas stream **506**. The combined off-gas stream **506** is sent to the the bioliquid hydrotreater **114** to be used as fuel in furnaces within the bioliquid hydrotreater and / or the fractionation section. The second adsorption unit **504** may be a PSA.

Turning now to figure 6, the first adsorption unit **417** comprises an absorber **601** for the removal of carbon dioxide and further purification of hydrogen. The carbon dioxide is removed in the absorber **601**, by contacting the cooled shifted syngas stream **416** with an activated MDEA stream **602**, or similar solvent stream, thereby producing a purified hydrogen stream **603** from the overhead of the absorber **601** and a rich solvent stream **604** from the bottom of the absorber **601**. The rich solvent stream **604** is sent to a regenerator **605** where a steam stream **606** is used to regenerate the solvent stream **604** thereby producing a regenerated solvent stream **613** which is returned to the absorber **601.** The purified hydrogen stream **603** is heated in a heat exchanger **607**, thereby producing a heated purified hydrogen stream **608**, which is sent to a methanation reactor **609** where it is contacted with a catalyst **610** to promote the reaction of remaining carbon monoxide and carbon dioxide to produce a methane stream **612** and a further purified hydrogen stream **611.** The further purified hydrogen stream **611** has a purity of greater than 97%, and the further purified hydrogen stream **611** is sent to the the high pressure hydrotreating component **114.**

The biofuels production process **100**, includes providing a biofuel feedstock **101**, comprising a cellulosic component **103** and a starch component **104**, separating the cellulosic component **103** from the starch component **104**, introducing the cellulosic component **103** to a pyrolysis process **105**, thereby producing at least a char stream **106** and a bio-oil stream **107**, introducing the bio-oil stream **106** and a purge hydrogen stream **116** into a low pressure hydrotreating process **108**, thereby producing a first intermediate liquid stream **110** , and a hydrocarbon stream **109**, introducing the first intermediate liquid stream **110** and a hydrogen stream **113** into a high pressure hydrotreating process **114**, thereby producing a second intermediate liquid stream **118**, the purge hydrogen stream **116**, and the steam stream **117**, introducing the second intermediate liquid stream **118** to a distillation column **119**, thereby producing a product green gasoline stream **120** and a product green diesel stream **121**, introducing the char stream **106**, the hydrocarbon stream **109**, into a hydrogen production unit **111**, thereby producing the hydrogen stream **113**, and a second steam stream **112,** combining the steam stream **117** and the second steam stream to form combined steam stream **124,** introducing the starch component **104**, and the combined steam stream **124** into an ethanol plant **125**, thereby producing a bio-ethanol stream **126**.

The system for producing biofuels, includes a feedstock separation means **102**, a pyrolysis means **105**, a low pressure hydrotreating means **108**, a high pressure hydrotreating means **114**, a distillation column **119**, a hydrogen production means **111**, an ethanol plant **125**; a means for providing a biofuel feedstock **101**, comprising a cellulosic component **103** and a starch component **104**, a means for introducing the cellulosic component **103** to the pyrolysis means **105**, thereby producing at least a char stream **106** and a bio-oil stream **107**, a means for introducing the bio-oil stream **107** and a means for providing a purge hydrogen stream **116** into the low pressure hydrotreating means **108**, thereby producing a first intermediate liquid stream **110**, and a hydrocarbon-containing stream **109**, a means for introducing the first intermediate liquid stream **110** and a means for introducing a hydrogen stream **113** into the high pressure hydrotreating process **114**, thereby producing a second intermediate liquid stream **118**, the purge hydrogen stream **116**, and the steam stream **117**, a means for introducing the second intermediate liquid stream **118** to the distillation column **119**, thereby producing a product green gasoline stream **120** and a product green diesel stream **121**, a means for introducing the char stream **106**, a means for introducing the hydrocarbon-containing stream **109**, into the hydrogen production means **111**, thereby producing the hydrogen stream **113** and a second steam stream **112**, a means for combining the steam stream **117** and the second steam stream **112,** and a means for introducing the starch component **104**, and a means for introducing a combined steam stream **124** into the ethanol plant.

What is claimed is:

Claim 1: An integrated process for producing biofuels from a biofuel feedstock, comprising a cellulosic component and a starch component, the process comprising:

- introducing the cellulosic component and a hydrogen stream generated by a hydrogen production unit, into a first biofuels process,
- introducing the starch component and a steam stream into a second biofuels process,
- introducing a char stream generated by a pyrolysis process of the first biofuels process; and a hydrocarbon stream generated by a low pressure hydrotreating component into the hydrogen production unit,

Claim 2: The process of claim 1, wherein said steam stream is generated by a high pressure hydrotreating component of the first biofuels process and/or the hydrogen production unit.

Claim 3: The process of claim 1, wherein the first biofuels process is a second generation cellulosic biofuels process.

Claim 4: The process of claim 1, wherein the second biofuels process is a first generation bio-ethanol process.

Claim 5. The process of claim 1, wherein:

- the first biofuels process is a second generation cellulosic biofuels process comprising:
  - the pyrolysis means, the pyrolysis means producing the char stream and a bioliquid stream,

   - the low pressure hydrotreating component, a high pressure hydrotreating component, the low pressure hydrotreating component producing the hydrocarbon stream, the high pressure hydrotreating component producing the steam stream, and
   - a distillation means, producing a green gasoline stream and a green diesel stream from the bioliquid stream,
- the second biofuels process is a first generation bio-ethanol process, producing a bio-ethanol stream, and
- the hydrogen production unit, produces the hydrogen stream and the steam stream.

Claim 6: The process of claim 1, where the hydrogen production unit is a steam reformer

Claim 7; The process of claim 5 wherein the hydrogen production unit has a furnace, a process effluent stream, a flue gas stream, a feed stream and a fuel stream, wherein the feed stream is the hydrocarbon stream, the fuel stream is the char stream, and the feed is combined with the steam stream, produced from the hydrogen production unit, and fed to the furnace.

Claim 8: The process of claim 7 where the process effluent stream indirectly exchanges heat with a first feed water stream in a first waste heat boiler and the flue gas stream indirectly exchanges heat with a second feedwater stream in a second waste heat boiler to produce the steam stream.

Claim 9: The process of claim 7 further comprising:

- contacting the process effluent with a catalyst in a water gas shift reactor to convert carbon monoxide to hydrogen and carbon dioxide, thereby producing a shift effluent,

- indirectly exchanging heat between the shift effluent and a first feed water stream in a first waste heat boiler to produce the steam stream, thereby producing a cooled shift effluent,
- feeding the cooled shift effluent into a pressure swing adsorption (PSA) unit to separate hydrogen from carbon monoxide, un-reacted hydrocarbons and carbon dioxide, thereby producing the hydrogen stream and a PSA tail gas stream,
- sending the hydrogen stream to the high pressure hydrotreating component, and
- sending the PSA tail gas to the furnace wherein it is used as fuel for the furnace in combination with the char stream.

Claim 10: The process of claim 9, wherein the high pressure hydrotreating component is a bioliquid hydrotreater.

Claim 11: The process of claim 9, wherein the PSA tail gas comprises carbon monoxide, un-reacted hydrocarbons and carbon dioxide and some portion of hydrogen.

Claim 12: the process of claim 9 where at least a portion of the steam stream is fed to the furnace and at least a portion of the steams stream produced is exported to the second biofuels process.

Claim 13: The process of claim 5 where the hydrogen production unit consists of a partial oxidation unit.

Claim 14: The process of claim 13 wherein the partial oxidation unit further comprises:

- introducing the char stream and the hydrocarbon stream as feed,
- generating an oxygen stream by air separation in a cryogenic process and introducing the oxygen stream into the partial oxidation unit,

- combining the oxygen stream, the char stream, and the hydrocarbon stream in the partial oxidation unit thereby producing a syngas stream,
- cooling the syngas stream in a first heat exchanger thereby creating a cooled syngas stream,
- combining the cooled syngas stream with a water stream or a steam stream, thereby producing a wet syngas stream,
- introducing the wet syngas stream into a water gas shift reactor wherein a water gas shift reaction is promoted by contact with a catalyst, thereby producing a shifted syngas stream,
- indirectly exchanging heat between the shifted gas stream and a feed water stream in a waste heat boiler to produce a steam stream, thereby producing a cooled shifted syngas stream,
- further cooling the cooled shifted syngas stream in an air cooler, thereby producing a further cooled shifted syngas stream, and
- sending said further cooled shifted syngas stream to a first absorbtion unit where a hydrogen stream is separated from a first off-gas stream.

Claim 15. The process of claim 14, wherein the syngas stream comprises hydrogen, carbon monoxide and carbon dioxide.

Claim 16: The process of claim 14, wherein the catalyst promotes the conversion of carbon monoxide to hydrogen to produce a shifted syngas with at least 90% of the carbon monoxide converted to hydrogen.

Claim 17: The process of claim 14 where the first adsorption unit consists of a pressure swing adsorption (PSA) unit producing hydrogen with a purity of greater than 99.5%.

Claim 18: The process of claim 14, wherein the hydrogen stream is sent to the bioliquid hydrotreater.

Claim 19: The process of claim 14, wherein the first off-gas stream, comprising a PSA tail gas consisting of carbon monoxide, carbon dioxide, unreacted hydrocarbon, nitrogen and argon impurities of the oxygen stream, comprising:

- compressing at least part of the first off-gas stream in a compressor thereby producing a compressed off-gas stream, and a remainder stream and
- recycling the compressed off-gas stream to the first adsorption unit for further recovery of hydrogen or
- sending the compressed off-gas stream to a second adsorption unit for further recovery of hydrogen, and thereby producing a second off-gas stream, and a second hydrogen stream,
- combining the remainder stream and the second off-gas stream to form a combined off-gas stream, and
- sending the combined off-gas stream to the the bioliquid hydrotreater to be used as fuel in furnaces within the bioliquid hydrotreater and / or the fractionation section.

Claim 20: The process of claim 14 wherein the second adsorption unit is a PSA.

Claim 21: The process of claim 14 wherein the first adsorption unit comprises an absorber for the removal of carbon dioxide and further purification of hydrogen comprising:

- removing carbon dioxide in the absorber, by contacting the cooled shifted syngas stream with an activated MDEA stream, or similar solvent stream, thereby producing a purified hydrogen stream from the overhead of the absorber and a rich solvent stream from the bottom of the absorber,
- sending the rich solvent stream to a regenerator where a steam stream is used to regenerate the solvent stream thereby producing a regenerated solvent stream which is returned to the absorber,

- heating the purified hydrogen stream in a heat exchanger, thereby producing a heated purified hydrogen stream, which is sent to a methanation reactor where it is contacted with a catalyst to promote the reaction of remaining carbon monoxide and carbon dioxide to produce a methane stream and a further purified hydrogen stream, wherein the further purified hydrogen stream has a purity of greater than 97%, and the further purified hydrogen stream is sent to the high pressure hydrotreating component.

Claim 22: A biofuels production process, comprising:

- providing a biofuel feedstock, comprising a cellulosic component and a starch component,
- separating the cellulosic component from the starch component,
- introducing the cellulosic component to a pyrolysis process, thereby producing at least a char stream and a bio-oil stream,
- introducing the bio-oil stream and a purge hydrogen stream into a low pressure hydrotreating process, thereby producing a first intermediate liquid stream, and a hydrocarbon stream,
- introducing the first intermediate liquid stream and a hydrogen stream into a high pressure hydrotreating process, thereby producing a second intermediate liquid stream, the purge hydrogen stream, and the steam stream,
- introducing the second intermediate liquid stream to a distillation column, thereby producing a product green gasoline stream and a product green diesel stream,
- introducing the char stream, the hydrocarbon stream, into a hydrogen production unit, thereby producing the hydrogen stream, and a second steam stream,
- combining the steam stream and the second steam stream to form combined steam stream,

- introducing the starch component, and the combined steam stream into an ethanol plant, thereby producing a bio-ethanol stream.

Claim 23: A system for producing biofuels, comprising:

- A feedstock separation means,
- a pyrolysis means,
- a low pressure hydrotreating means,
- a high pressure hydrotreating means,
- a distillation column,
- a hydrogen production means,
- an ethanol plant;
- a means for providing a biofuel feedstock, comprising a cellulosic component and a starch component,
- a means for introducing the cellulosic component to the pyrolysis means, thereby producing at least a char stream and a bio-oil stream,
- a means for introducing the bio-oil stream and a means for providing a purge hydrogen stream into the low pressure hydrotreating means, thereby producing a first intermediate liquid stream, and a hydrocarbon-containing stream,
- a means for introducing the first intermediate liquid stream and a means for introducing a hydrogen stream into the high pressure hydrotreating process, thereby producing a second intermediate liquid stream, the purge hydrogen stream, and the steam stream,
- a means for introducing the second intermediate liquid stream to the distillation column, thereby producing a product green gasoline stream and a product green diesel stream,
- a means for introducing the char stream, a means for introducing the hydrocarbon-containing stream, into the hydrogen production means, thereby producing the hydrogen stream and a second steam stream,

- A means for combining the steam stream and the second steam stream, and
- a means for introducing the starch component, and a means for introducing a combined steam stream into the ethanol plant.

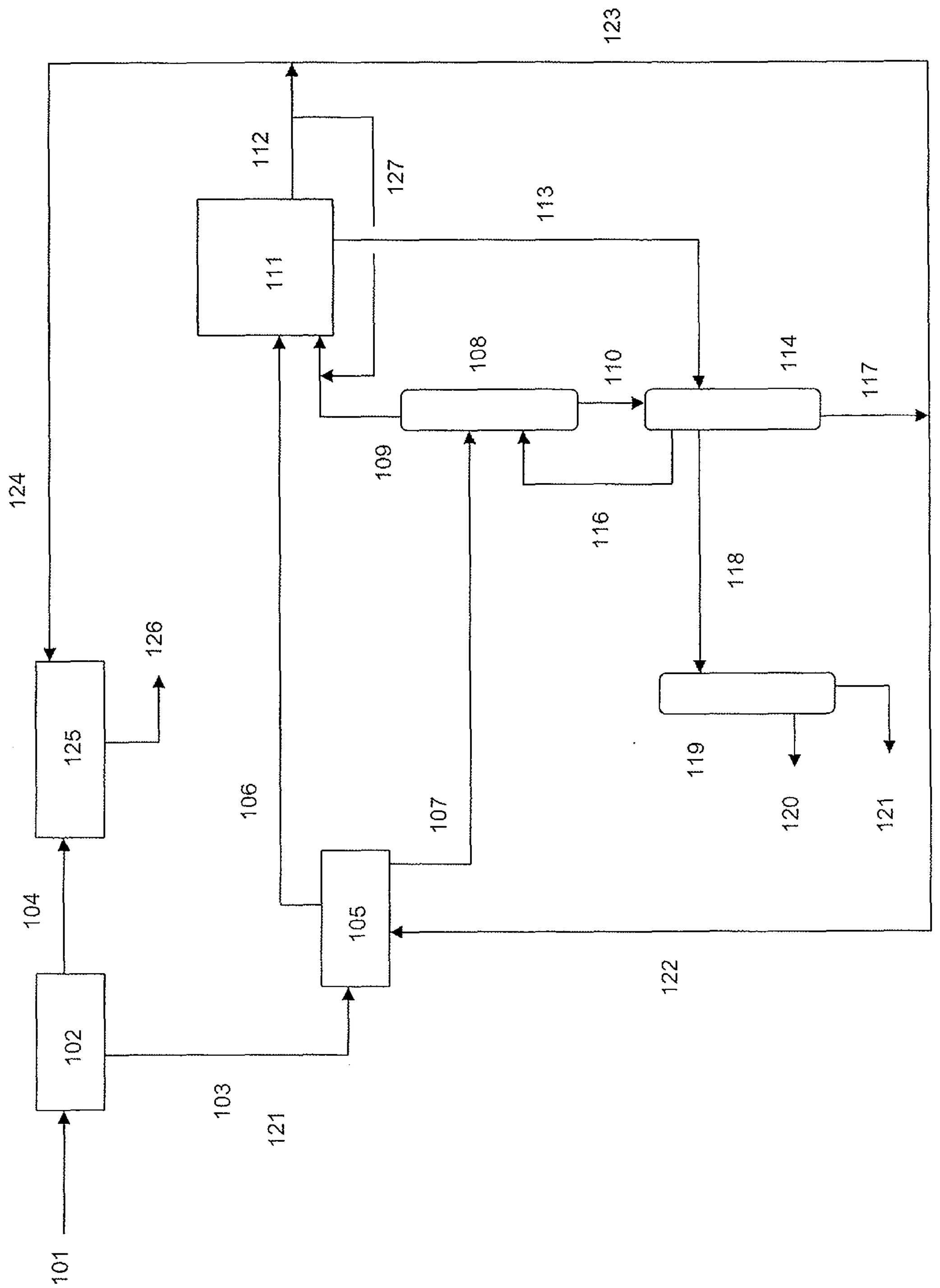
123
112
127
113
111
108
110
114
117
109
124
116
118
126
125
119
106
107
120
121
104
105
122
102
103
121
101

Fig. 1

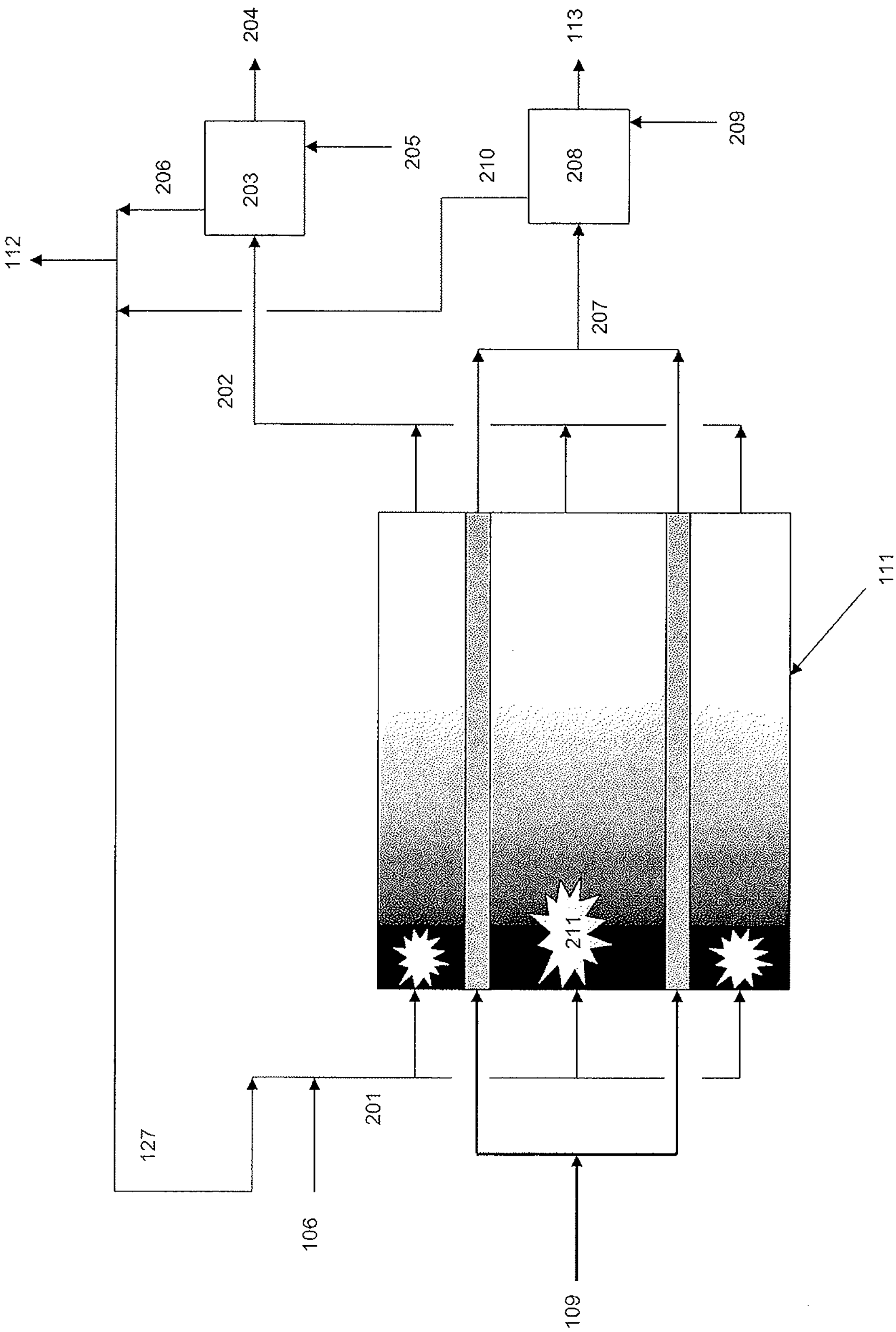
204
113
209
205
206
203
210
208
112
207
202
111
211
201
127
106
109

Fig. 2

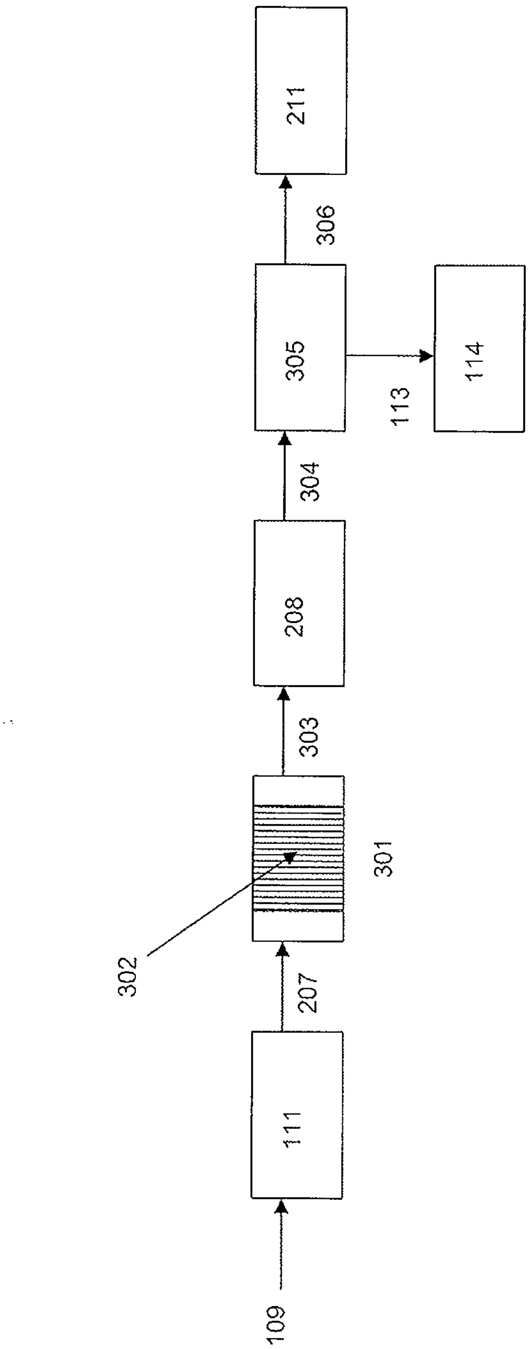

Fig. 3

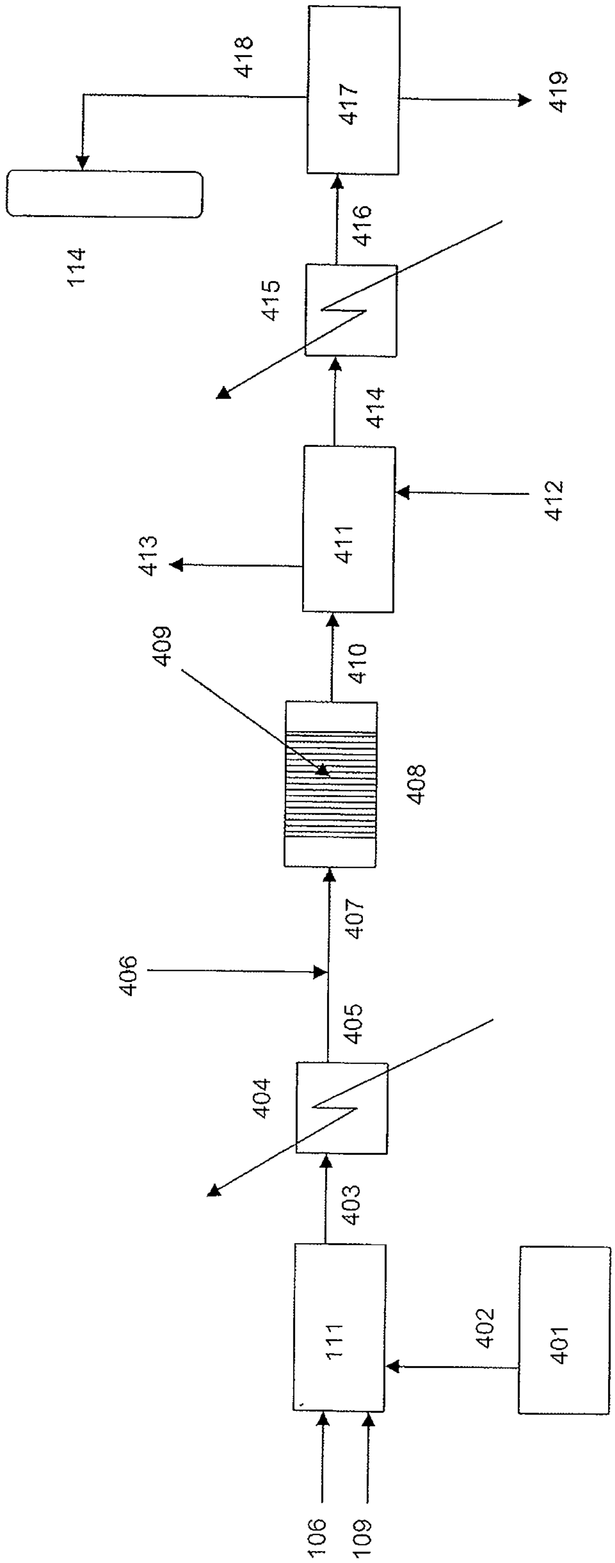
417
418
419
114
416
415
414
411
412
413
409
410
408
407
406
405
404
403
111
402
401
106
109

Fig. 4

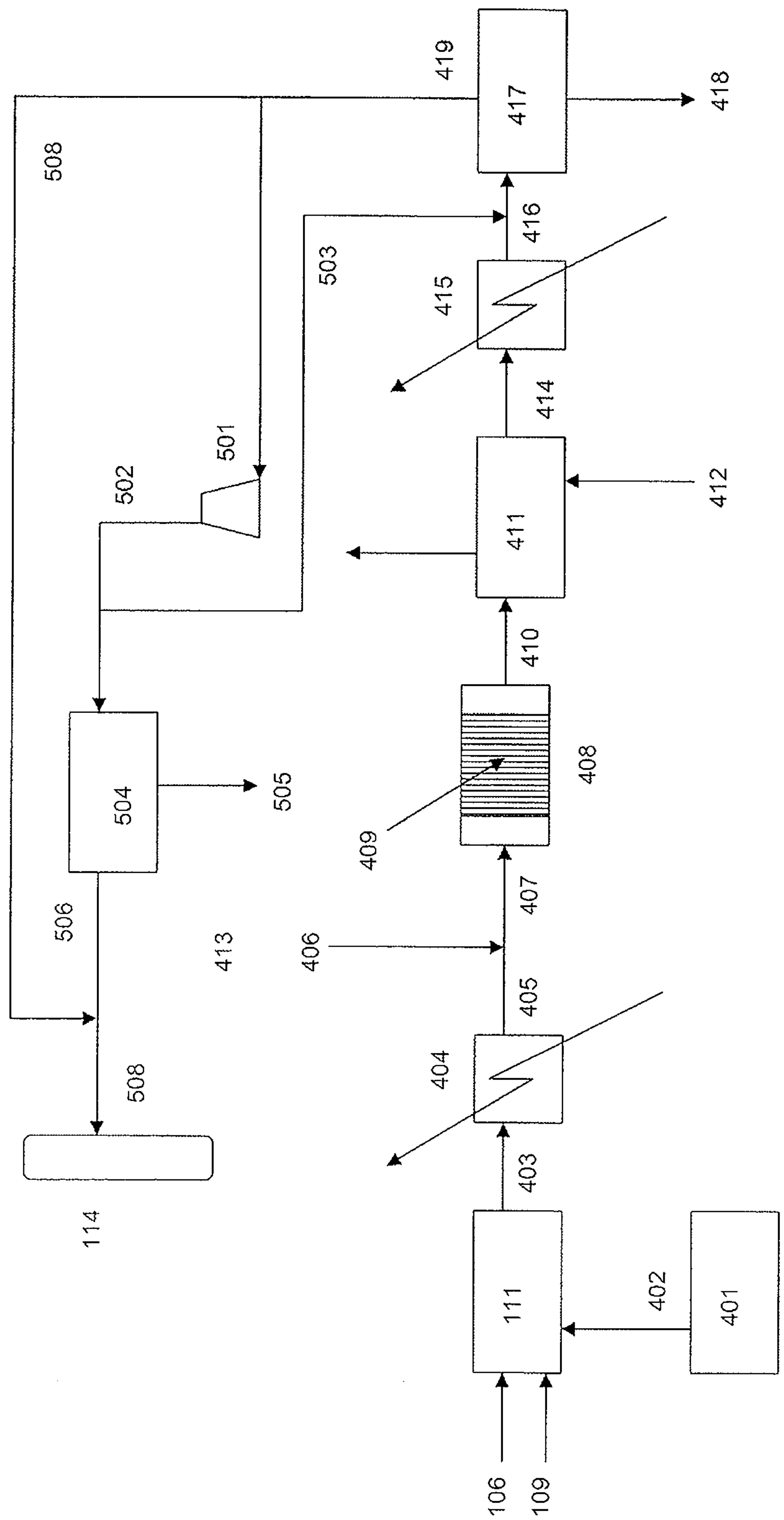
417
419
418
508
416
503
415
414
501
502
411
412
410
408
409
504
505
506
413
406
407
405
404
403
508
114
111
402
401
106
109

Fig. 5

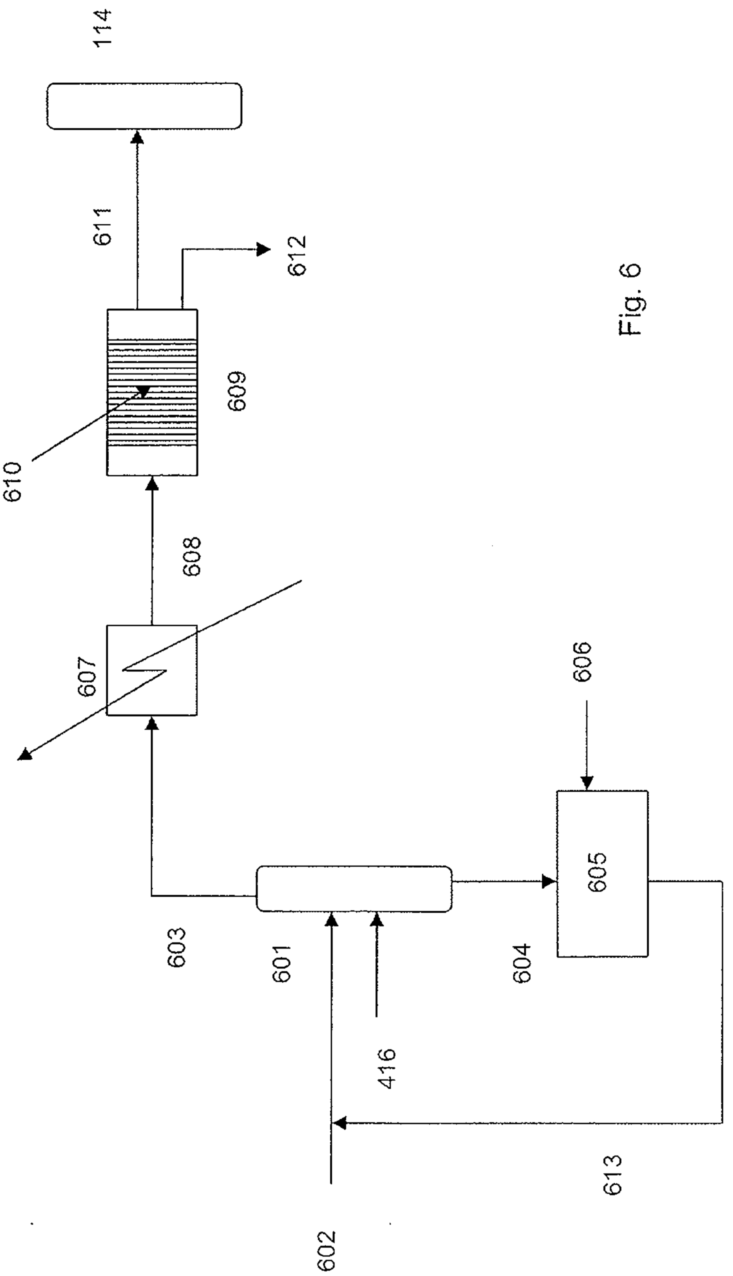

Fig. 6