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12/972,988 20 December 2010 (20.12.2010) 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) Inventors; and

(75) Inventors/Applicants (for US only): **MUALIM, Hengky** [IN/US]; 12418 Meadowglen Drive, Stafford, Texas 77477 (US). **LEE, Ralls** [US/US]; 1305 Darden Lane, Seabrook, Texas 77586 (US). **GROVER, Bhadra S.** [US/US]; 6526 Wesford Tr., Sugar Land, Texas 77479 (US).(74) Agents: **HAYNES, Elwood L.** et al.; Air Liquide USA LLC, 2700 Post Oak Blvd., Suite 1800, Houston, Texas 77056 (US).

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(54) Title: ETHYLENE RECOVERY FROM OFF-GAS

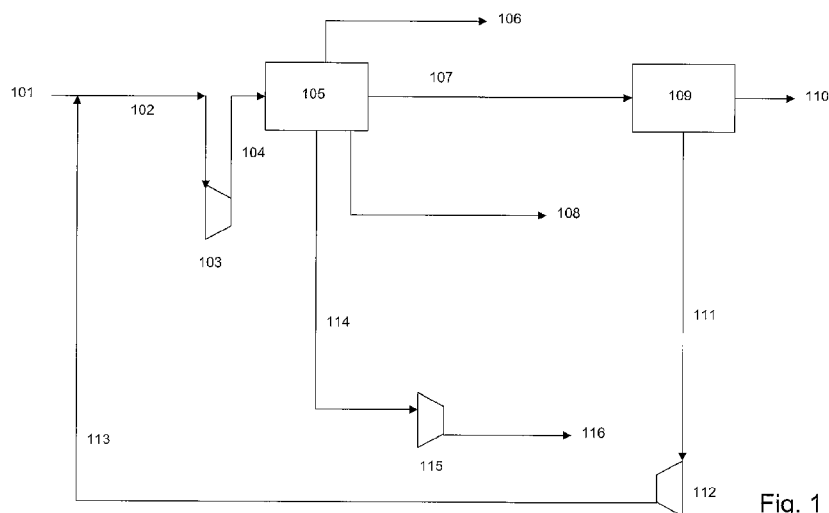


Fig. 1

(57) **Abstract:** A method for the recovery of ethylene from an off-gas is provided. This method includes providing an ethylene containing feed gas stream, introducing the ethylene containing gas stream into a first cryogenic separation device, thereby producing a first condensed stream and a first ethylene poor stream, and introducing the ethylene poor stream into a first feed compressor, thereby producing a pressurized first ethylene poor stream. This is repeated three times, resulting in a pressurized third ethylene poor stream, which is introduced into a pressure swing adsorber, thereby producing a high purity hydrogen stream and a PSA tail gas stream. The PSA tail gas stream is into a PSA tail gas compressor, thereby producing a pressurized PSA tail gas stream, which is then combined with an ethylene containing gas stream to produce the ethylene containing feed gas stream. The first condensed stream, the second condensed stream and the third condensed stream are combined to produce a combined condensed stream, which is introduced into an ethylene separation column thereby producing an ethylene rich stream and a methane rich stream. The methane rich stream is introduced into a methane compressor thereby producing a methane fuel stream.



ETHYLENE RECOVERY FROM OFF-GAS

Background

Ethylene is recovered from light gas mixtures such as cracked gas from hydrocarbon crackers which contain various concentrations of hydrogen, methane, ethane, ethylene, propane, propylene, and minor amounts of higher hydrocarbons, nitrogen, and other trace components. The recovery of ethylene from crude light hydrocarbon gas mixtures is an economically important but highly energy intensive process. A method of separating ethylene which is simple, durable and cost-effective is desirable

Summary

A method for the recovery of ethylene from an off-gas is provided. This method includes providing an ethylene containing feed gas stream, introducing the ethylene containing gas stream into a first cryogenic separation device, thereby producing a first condensed stream and a first ethylene poor stream, and introducing the ethylene poor stream into a first feed compressor, thereby producing a pressurized first ethylene poor stream. This is repeated three times, resulting in a pressurized third ethylene poor stream, which is introduced into a pressure swing adsorber, thereby producing a high purity hydrogen stream and a PSA tail gas stream. The PSA tail gas stream is into a PSA tail gas compressor, thereby producing a pressurized PSA tail gas stream, which is then combined with an ethylene containing gas stream to produce the ethylene containing feed gas stream. The first condensed stream, the second condensed stream and the third condensed stream are combined to produce a combined condensed stream, which is introduced into an ethylene separation column thereby producing an ethylene rich stream and a methane rich stream. The

methane rich stream is introduced into a methane compressor thereby producing a methane fuel stream.

Brief Description of the Figures

Figure 1 illustrates an embodiment of the present invention.

- 5 Figure 2 illustrates another embodiment of the present invention.

Description of Preferred Embodiments

10 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
15 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
20 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.

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As the off gas is chilled in the cold box, methane and ethylene condense and drop out as liquid stream. The stream is chilled in several stages to economize on the compression power of Feed Compressor.

The condensed stream is sent to an ethylene separator column, where ethylene is concentrated at the bottom and methane rich stream is removed at the top. The column is driven by providing heat in a reboiler from a suitable stream within the process. An ethylene rich stream may contain 50-99% ethylene, balance being mainly methane. This stream may be recycled to ethylene plant for further purification or further purified in a separate system.

Turning now to fig. 1, a method for the recovery of ethylene from an off-gas is provided. This method includes providing an ethylene containing feed gas stream **102**, and introducing the ethylene containing feed gas stream **102** into feed compressor **103**, thereby producing a pressurized ethylene containing feed stream **104**. Then pressurized ethylene containing feed stream **104** is introduced into a cryogenic separation device **105**, thereby producing an ethylene rich stream **108**, a high pressure methane rich stream **106**, a low pressure methane rich stream **114**, and an ethylene poor stream **107**.

The ethylene poor stream **107** is introduced into a pressure swing adsorber **109**, thereby producing a high purity hydrogen stream **110** and a PSA tail gas stream **111**. The PSA tail gas stream **111** is introduced into a PSA tail gas compressor **112**, thereby producing a pressurized PSA tail gas stream **113**, which is then combined with an ethylene containing gas stream **101** to produce the ethylene containing feed gas stream **102**. The low pressure methane rich stream **114** is introduced into a methane compressor **115** thereby producing a methane fuel stream **116**.

The ethylene containing gas stream **101** may have less than 10% ethylene. The ethylene containing gas stream **101** may have less than 5% ethylene. The ethylene containing gas stream **101** may have less than 60%

methane. The ethylene containing gas stream **101** may have less than 50% hydrogen. The ethylene containing gas stream **101** may have a composition of about 40% hydrogen, about 58% methane, and about 2% ethylene. The high purity hydrogen stream **110** may have a pressure of about 300 psig. The
5 methane fuel stream **116** may have a pressure of about 75 psig.

Turning now to fig. 2, a method for the recovery of ethylene from an off-gas is provided. This method includes providing an ethylene containing feed gas stream **203**, and introducing the ethylene containing gas stream **201** into a
10 first cryogenic separation device **204**, thereby producing a first condensed stream **206** and a first ethylene poor stream **205**. The ethylene poor stream **205** is introduced into a first feed compressor **207**, thereby producing a pressurized first ethylene poor stream **208**. The pressurized first ethylene poor stream **208** is introduced into a second cryogenic separation device **209**, thereby producing a
15 second condensed stream **211** and a second ethylene poor stream **210**.

The second ethylene poor stream **210** is introduced into a second feed compressor **212**, thereby producing a pressurized second ethylene poor stream **213**. The pressurized second ethylene poor stream **213** is introduced into a third
20 cryogenic separation device **214**, thereby producing a third condensed stream **216** and a third ethylene poor stream **215**. The third ethylene poor stream **215** is introduced into a third feed compressor **217**, thereby producing a pressurized third ethylene poor stream **218**. The pressurized third ethylene poor stream **218** is introduced into a pressure swing adsorber **219**, thereby producing a high
25 purity hydrogen stream **220** and a PSA tail gas stream **221**.

The PSA tail gas stream **221** is introduced into a PSA tail gas compressor **222**, thereby producing a pressurized PSA tail gas stream **223**, which is then combined with an ethylene containing gas stream **201** to produce the ethylene

containing feed gas stream **203**. The first condensed stream **206**, the second condensed stream **211** and the third condensed stream **216** are combined to produce a combined condensed stream **224**. The combined condensed stream **224** is introduced into an ethylene separation column **225** thereby producing an
5 ethylene rich stream **226** and a methane rich stream **227**. The methane rich stream **227** is introduced into a methane compressor **228** thereby producing a methane fuel stream **229**.

The ethylene containing gas stream **201** may have less than 10%
10 ethylene. The ethylene containing gas stream **201** may have less than 5% ethylene. The ethylene containing gas stream **201** may have less than 60% methane. The ethylene containing gas stream **201** may have less than 50% hydrogen. The ethylene containing gas stream **201** may have a composition of about 40% hydrogen, about 58% methane, and about 2% ethylene. The high
15 purity hydrogen stream **220** may have a pressure of about 300 psig. The methane fuel stream **229** may have a pressure of about 75 psig.

What is claimed is:

Claim 1: A method for the recovery of ethylene from an off-gas, comprising;

- 5 a) providing an ethylene containing feed gas stream,
- b) introducing the ethylene containing feed gas stream into a feed compressor, thereby producing a pressurized ethylene containing feed stream,
- c) introducing said pressurized ethylene containing gas feed stream into a
10 cryogenic separation device, thereby producing an ethylene rich stream, a high pressure methane rich stream, a low pressure methane rich stream, and an ethylene poor stream,
- d) introducing said ethylene poor stream into a pressure swing adsorber, thereby producing a high purity hydrogen stream and a PSA tail gas
15 stream,
- e) introducing said PSA tail gas stream into a PSA tail gas compressor, thereby producing a pressurized PSA tail gas stream, which is then combined with an ethylene containing gas stream to produce said ethylene containing feed gas stream,
- 20 f) introducing said low pressure methane rich stream to a methane compressor thereby producing a methane fuel stream.

Claim 2: The method of claim 1, wherein said ethylene containing gas stream has less than 10% ethylene.

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Claim 3: The method of claim 2, wherein said ethylene containing gas stream has less than 5% ethylene

Claim 4: The method of claim 2, wherein said ethylene containing gas stream has less than 60% methane.

Claim 5: The method of claim 2, wherein said ethylene containing gas stream
5 has less than 50% hydrogen.

Claim 6: The method of claim 1, wherein said ethylene containing gas stream has a composition of about 40% hydrogen, about 58% methane, and about 2% ethylene.
10

Claim 7: The method of claim 1, wherein said high purity hydrogen stream has a pressure of about 300 psig.

Claim 8: The method of claim 1, wherein said methane fuel stream has a
15 pressure of about 75 psig.

Claim 9: A method for the recovery of ethylene from an off-gas, comprising;
a) providing an ethylene containing feed gas stream ,
b) introducing said ethylene containing gas stream into a first cryogenic
20 separation device, thereby producing a first condensed stream and a first ethylene poor stream,
c) introducing said ethylene poor stream into a first feed compressor, thereby producing a pressurized first ethylene poor stream,
d) introducing said pressurized first ethylene poor stream into a second
25 cryogenic separation device, thereby producing a second condensed stream and a second ethylene poor stream,
e) introducing said second ethylene poor stream into a second feed compressor, thereby producing a pressurized second ethylene poor stream,

- 5 f) introducing said pressurized second ethylene poor stream into a third cryogenic separation device, thereby producing a third condensed stream and a third ethylene poor stream,
- g) introducing said third ethylene poor stream into a third feed compressor, thereby producing a pressurized third ethylene poor stream,
- h) introducing said pressurized third ethylene poor stream into a pressure swing adsorber, thereby producing a high purity hydrogen stream (120) and a PSA tail gas stream,
- 10 i) introducing said PSA tail gas stream into a PSA tail gas compressor, thereby producing a pressurized PSA tail gas stream, which is then combined with an ethylene containing gas stream to produce said ethylene containing feed gas stream,
- j) combining said first condensed stream, said second condensed stream and said third condensed stream to produce a combined condensed stream,
- 15 k) introducing said combined condensed stream into an ethylene separation column thereby producing an ethylene rich stream and a methane rich stream, and
- l) introducing said methane rich stream to a methane compressor thereby producing a methane fuel stream.
- 20

Claim 10: The method of claim 9, wherein said ethylene containing gas stream (101) has less than 10% ethylene.

25 Claim 11: The method of claim 10, wherein said ethylene containing gas stream has less than 5% ethylene

Claim 12: The method of claim 10, wherein said ethylene containing gas stream has less than 60% methane.

Claim 13: The method of claim 10, wherein said ethylene containing gas stream has less than 50% hydrogen.

- 5 Claim 14: The method of claim 9, wherein said ethylene containing gas stream has a composition of about 40% hydrogen, about 58% methane, and about 2% ethylene.

- 10 Claim 15: The method of claim 9, wherein said high purity hydrogen stream has a pressure of about 300 psig.

Claim 16: The method of claim 9, wherein said methane fuel stream has a pressure of about 75 psig.

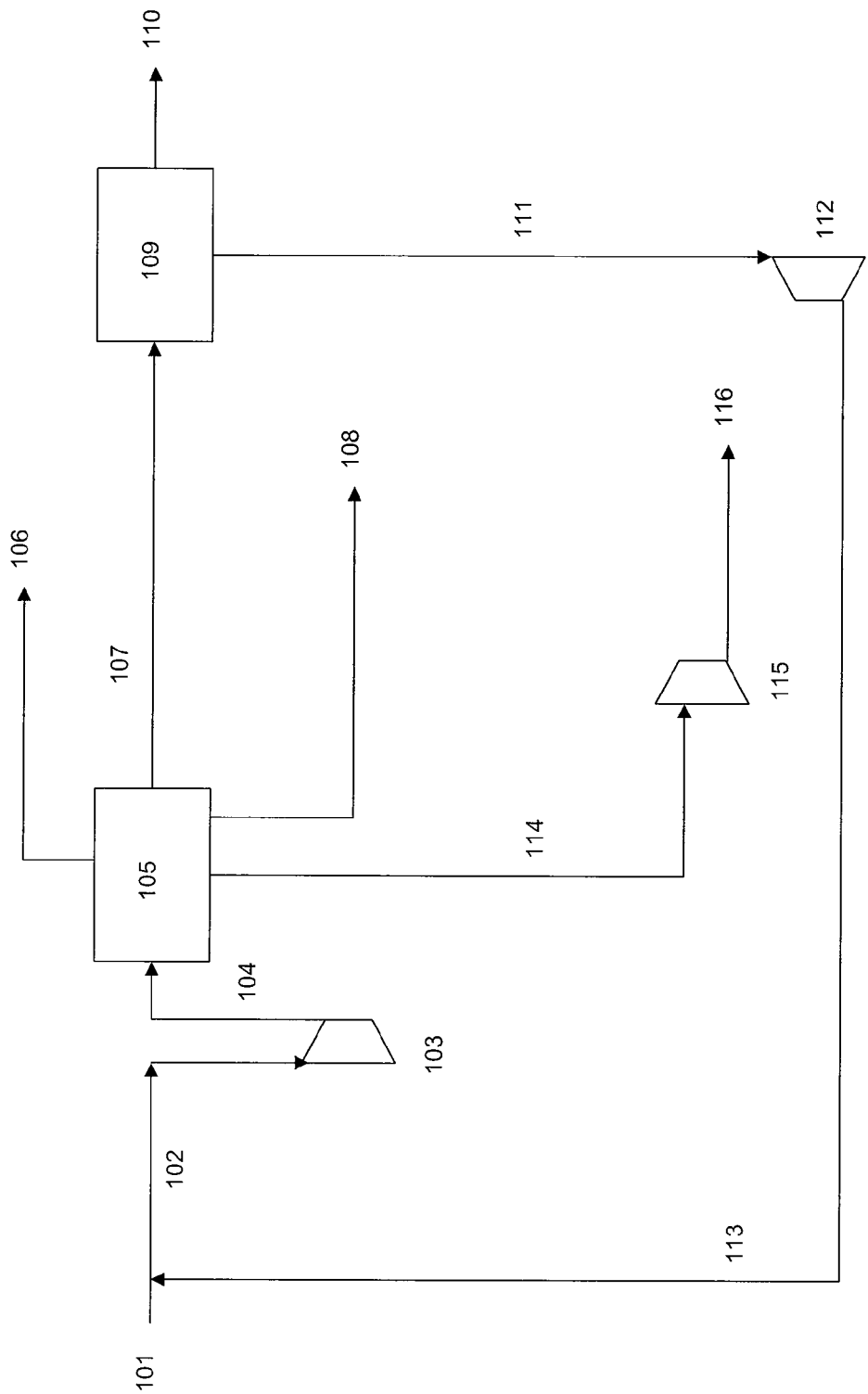


Fig. 1

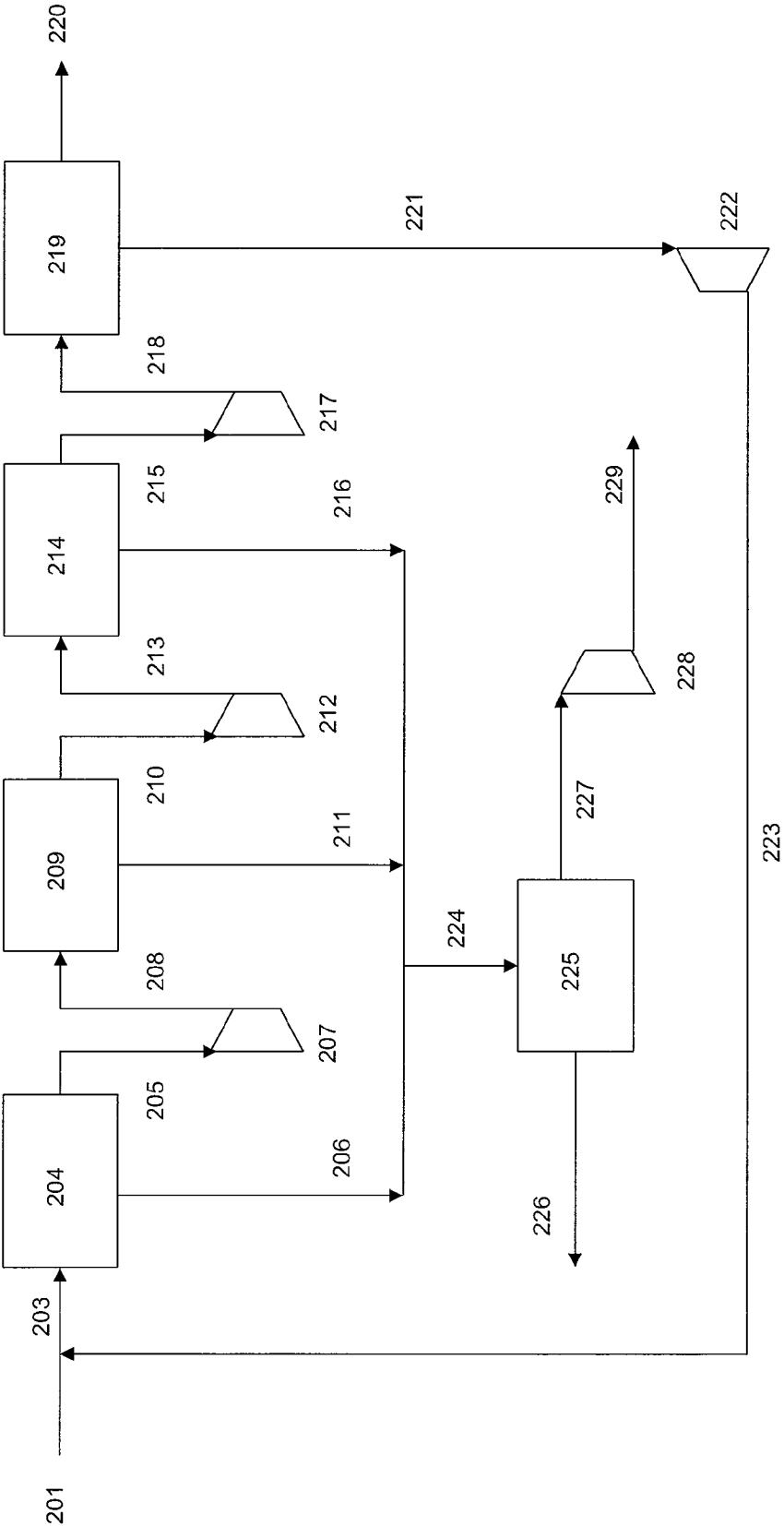


Fig. 2