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(54) **METHOD FOR TREATING A MULTI-PHASE HYDROCARBON STREAM AND AN APPARATUS THEREFOR**

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(57) **ABSTRACT**

A multi-phase hydrocarbon stream (**145**) is treated to provide a treated liquid hydrocarbon stream (**165**), such as a liquefied natural gas (LNG) stream. The multi-phase hydrocarbon stream (**145**) is passed to a first gas/liquid separator (**150**), wherein it is separated at a first pressure to provide a first separator hydrocarbon vapour stream (**205**) and a first separator bottoms stream (**155**). The first separator bottoms stream (**155**) is then separated in a second gas/liquid separator (**160**) at a second pressure that is lower than the first pressure, to provide a second separator hydrocarbon vapour stream (**175**) and a treated liquid hydrocarbon stream (**165**). The second separator hydrocarbon vapour stream (**175**) is compressed in an overhead stream compressor (**180**) to provide a stripping vapour stream (**185**) which is passed to the first gas/liquid separator (**150**).

Fig.1

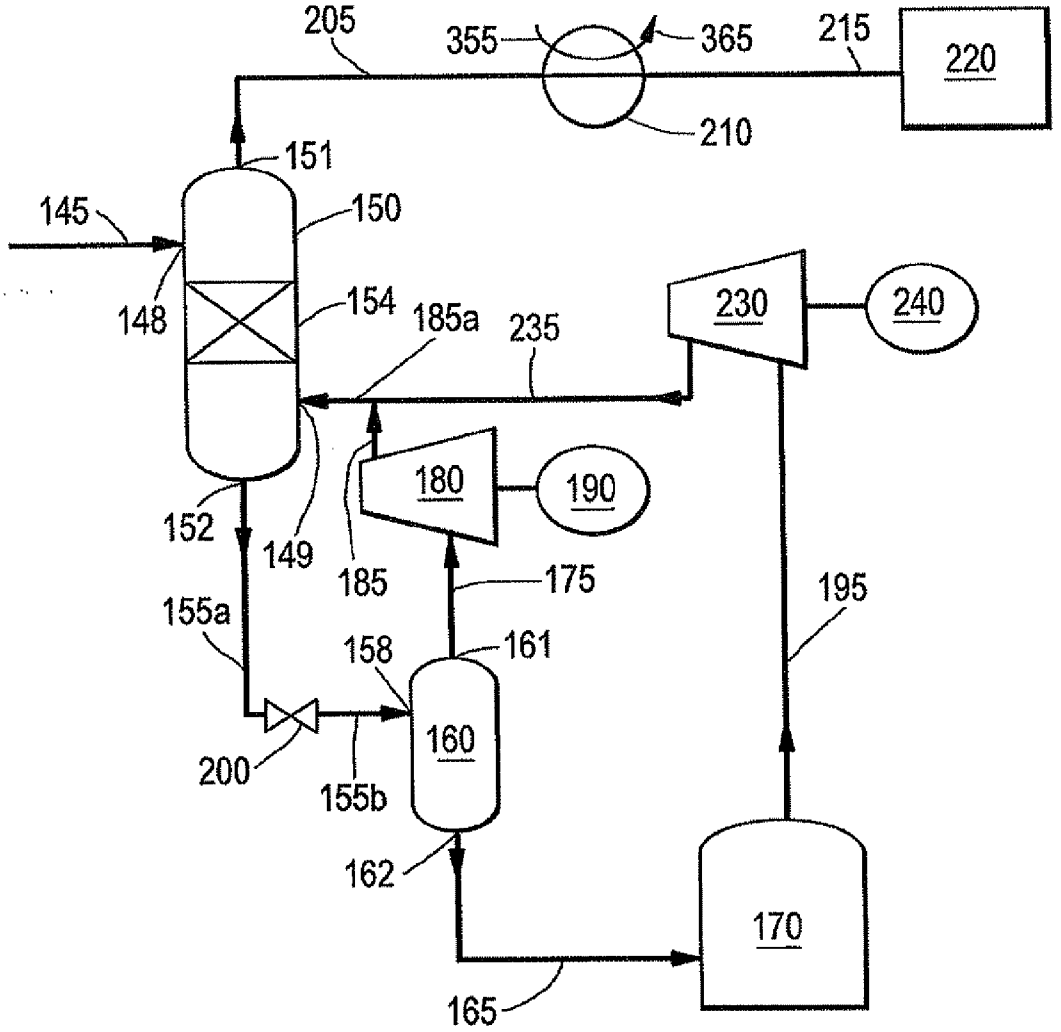
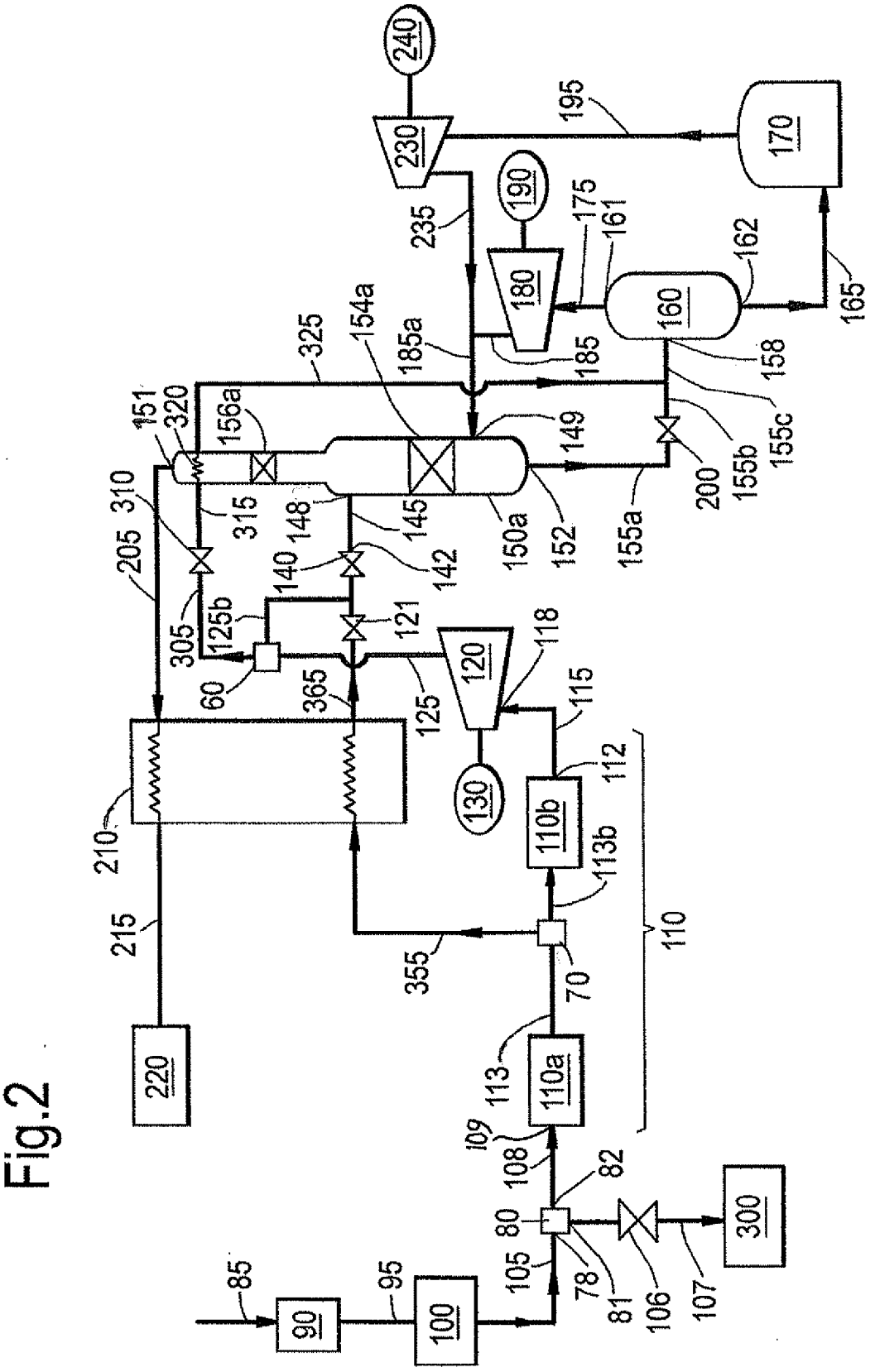

205
355
365
215
220
210
151
145
150
148
154
185a
235
230
240
180
190
152
149
185
175
195
155a
158
161
160
200
155b
162
170
165

Fig.2


240
230
195
170
190
235
175
161
162
180
160
165
325
154a
185a
185
158
151
320
156a
149
155c
155b
200
310
315
148
145
150a
152
155a
205
140
142
305
125b
121
120
118
60
365
125
115
130
112
110b
113b
210
215
355
70
110
220
113
110a
109
108
82
80
300
85
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100
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81
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107

METHOD FOR TREATING A MULTI-PHASE HYDROCARBON STREAM AND AN APPARATUS THEREFOR

[0001] The present invention relates to a method and apparatus for treating a multi-phase hydrocarbon stream.

[0002] The method and apparatus provide a treated liquid hydrocarbon stream. A low pressure fuel gas stream may additionally be provided.

[0003] A common source for a multi-phase hydrocarbon stream is a natural gas stream or a multi-phase stream produced from natural gas e.g. by forming a multi-phase stream comprising a vapour phase and a liquid phase by way of cooling and/or changing the pressure of the natural gas. The methods described herein may thus be employed to provide a treated liquid hydrocarbon stream in the form of a liquefied natural gas (LNG) stream.

[0004] Natural gas is a useful fuel source, as well as being a source of various hydrocarbon compounds. It is often desirable to liquefy natural gas in a liquefied natural gas (LNG) plant at or near the source of a natural gas stream for a number of reasons. As an example, natural gas can be stored and transported over long distances more readily as a liquid than in gaseous form because it occupies a smaller volume and does not need to be stored at high pressure.

[0005] Usually, natural gas, comprising predominantly methane, enters an LNG plant at elevated pressures and is pre-treated to produce a purified feed stream suitable for liquefaction at cryogenic temperatures. The purified gas is processed through a plurality of cooling stages using heat exchangers to progressively reduce its temperature until liquefaction is achieved. The liquid natural gas is then further cooled and expanded to final atmospheric pressure suitable for storage and transportation. The flashed vapour from each expansion can be used as a source of fuel gas.

[0006] Some hydrocarbon streams, such as natural gas, may contain significant quantities of nitrogen such that if special measures are not taken to remove at least a part of the nitrogen from the hydrocarbon stream, the fuel gas and any liquefied hydrocarbon stream produced may contain undesirably high nitrogen levels. Many LNG specifications require less than 1 mol % nitrogen in the final product.

[0007] US 2008/0066493 discloses a method of treating liquefied natural gas to provide a liquid natural gas stream having a reduced content of components having low boiling points, such as nitrogen (N_2). The method comprises expanding liquefied natural gas to provide an expanded multi-phase fluid and introducing the multi-phase fluid into a column below a gas-liquid contacting section to obtain a bottoms liquid stream having a reduced content of components having low boiling points and an overhead gaseous stream enriched in components having low boiling points, such as nitrogen. The bottoms liquid stream is passed to a flash vessel. The overhead gaseous stream enriched in components having low boiling points is heated in a heat exchanger and then compressed to fuel gas pressure to obtain fuel gas. A recycle stream is separated from the fuel gas, at least partly condensed in a heat exchanger against the overhead gaseous stream enriched in components having low boiling points and introduced to the column above the gas-liquid contacting section as a reflux stream. In a number of embodiments of US 2008/0066493, also the second gaseous stream (from the flash vessel) is heated in the heat exchanger, compressed to fuel gas pressure, and added to the recycle stream.

[0008] At least part of the cold present in the overhead gaseous stream is thus used to recondense a recycle stream to produce reflux, which cold cannot be used to cool another process stream elsewhere in the process.

[0009] In a first aspect, the present invention provides a method of treating a multi-phase hydrocarbon stream to provide a treated liquid hydrocarbon stream, comprising at least the steps of:

[0010] producing a multi-phase hydrocarbon stream from natural gas, said multi-phase hydrocarbon stream comprising a vapour phase and a liquid phase;

[0011] passing the multi-phase hydrocarbon stream to a first gas/liquid separator;

[0012] separating the multi-phase hydrocarbon stream in the first gas/liquid separator at a first pressure to provide a first separator hydrocarbon vapour stream, comprising hydrocarbons and nitrogen, and a first separator bottoms stream;

[0013] separating the first separator bottoms stream in a second gas/liquid separator at a second pressure to provide a second separator hydrocarbon vapour stream and a treated liquid hydrocarbon stream in the form of LNG, wherein the second pressure is lower than the first pressure;

[0014] compressing the second separator hydrocarbon vapour stream in an overhead stream compressor to provide a stripping vapour stream; and

[0015] passing the stripping vapour stream to the first gas/liquid separator at a level gravitationally lower than the level at which the multi-phase hydrocarbon stream is passed to the first gas/liquid separator.

[0016] In a further aspect, the present invention provides an apparatus for treating a multi-phase hydrocarbon stream comprising a liquid phase and a vapour phase to provide a treated liquid hydrocarbon stream in the form of LNG, comprising at least:

[0017] means for producing a multi-phase hydrocarbon stream from natural gas, said means comprising at least one of a liquefaction unit and one or more hydrocarbon stream expansion devices;

[0018] a first gas/liquid separator arranged to receive the multi-phase hydrocarbon stream and separate it into a first separator hydrocarbon vapour stream, comprising hydrocarbons and nitrogen, and a first separator bottoms stream, said first gas/liquid separator having a first inlet for feeding the multi-phase hydrocarbon stream into the first gas/liquid separator, a first outlet for discharging the first separator hydrocarbon vapour stream from the first gas/liquid separator, a second outlet for discharging the first separator bottoms stream from the first gas/liquid separator and a second inlet, located at a level gravitationally lower than said first inlet, for feeding a stripping vapour stream into the first gas/liquid separator;

[0019] a second gas/liquid separator arranged to receive the first separator bottoms stream and separate it into a second separator hydrocarbon vapour stream and a treated liquid hydrocarbon stream in the form of LNG, said second gas/liquid separator having a first inlet in fluid communication with the second outlet of the first gas/liquid separator, for feeding the first separator bottoms stream into the second gas/liquid separator, a first outlet for discharging the second separator hydrocarbon vapour stream from the second gas/

liquid separator and a second outlet for discharging the treated liquid hydrocarbon stream from the second gas/liquid separator;

[0020] a bottoms stream expansion device arranged between the second outlet of the first gas/liquid separator and the first inlet of the second gas/liquid separator, to reduce the pressure of the first separator bottoms stream; and

[0021] an overhead stream compressor to compress the second separator hydrocarbon vapour stream to provide the stripping vapour stream, said overhead stream compressor having an inlet in fluid communication with the first outlet of the second gas/liquid separator to receive the second separator hydrocarbon vapour stream, and an outlet in fluid communication with the second inlet of the first gas/liquid separator for discharging the stripping vapour stream.

[0022] Embodiments of the present invention will now be described by way of example only and with reference to the accompanying non-limited drawings in which:

[0023] FIG. **1** is a diagrammatic scheme of a method of and apparatus for treating a multi-phase hydrocarbon stream according to one embodiment; and

[0024] FIG. **2** is a diagrammatic scheme of a method of and apparatus for liquefying a hydrocarbon feed stream incorporating the multi-phase hydrocarbon stream treating method and apparatus.

[0025] For the purpose of this description, a single reference number will be assigned to a line as well as a stream carried in that line.

[0026] The methods and apparatuses disclosed herein propose an improvement in component separation of a multi-phase stream in two subsequent steps in two gas/liquid separators operating at different pressures. The second separator hydrocarbon vapour stream from the second gas/liquid separator is compressed in an overhead stream compressor and returned to the first gas/liquid separator as a stripping vapor stream.

[0027] The present invention may advantageously provide a method and apparatus for treating a multi-phase hydrocarbon stream to provide a treated liquid hydrocarbon stream that does not require the cold in the overhead gaseous stream to be used to produce a reflux stream.

[0028] The method and apparatus of the present invention advantageously utilize a stripping vapor in the first gas/liquid separator that is provided by the compression of the vapour stream from the second gas/liquid separator, to enhance component separation. Producing the stripping vapour from the second gaseous stream allows the second gaseous stream to be utilized to assist the component separation without the need to recondense it or part of it.

[0029] Hence, the cold in the first separator hydrocarbon vapour stream, which in US 2008/0066493 was necessary to produce reflux to achieve a desired efficiency in the separation of the components, has now been freed up to be used in any way. Of course, the invention does not exclude the option that a reflux stream may still be produced (using cold from the first separator hydrocarbon vapour and/or from an external refrigerant) and employed to further enhance the component separation, this is now entirely optional. A group of embodiments of the invention does not require a reflux stream such as that used in US 2008/0066493.

[0030] The one or more hydrocarbon stream expansion devices and the first and second gas/liquid separators may form part of an LNG end flash system. Likewise, the reducing of the pressure of the at least partially liquefied hydrocarbon stream to provide the multi-phase hydrocarbon stream and the subsequent separation in the first and second gas/liquid separators may form part of an LNG end flash process.

[0031] Accordingly, the producing of the multi-phase hydrocarbon stream from the natural gas may comprise the following steps:

[0032] providing a hydrocarbon supply stream from a natural gas stream at elevated pressure;

[0033] extracting a continuing hydrocarbon stream from the hydrocarbon supply stream;

[0034] passing the continuing stream to a cooling and liquefaction unit wherein it is cooled an at least partially liquefied to provide an at least partially liquefied hydrocarbon stream;

[0035] passing the at least partially liquefied hydrocarbon stream to an inlet of at least one hydrocarbon stream expansion device and therein reducing the pressure of the at least partially liquefied hydrocarbon stream to provide the multi-phase hydrocarbon stream.

[0036] The multi-phase stream may comprise a vapour phase and a liquid phase. The treated liquid hydrocarbon stream produced in accordance with the present invention, in particular when provided in the form of LNG, may have a specification suitable for it to be vaporized and used as network gas.

[0037] Without wishing to be bound by the following explanation by analogy, the Applicant suggests that the overhead stream compressor provides heat of compression to the second separator hydrocarbon vapour stream and thus functions as a special reboiler, providing a stripping vapour stream at a higher pressure and temperature than the second separator hydrocarbon vapour stream for the first gas/liquid separator. This stripping vapor stream enhances the separation of the lower boiling point components, such as nitrogen, from the expanded hydrocarbon stream in the first gas/liquid separator. The lower boiling point components are ejected to the first separator hydrocarbon vapor stream.

[0038] If the first separator hydrocarbon vapour stream is not pure nitrogen, but it also comprises an inventory of hydrocarbons, it is possible to use this stream as fuel gas. Thus, the method may further comprise:

[0039] deriving a low pressure (LP) fuel gas stream from the first separator hydrocarbon vapour stream; and

[0040] passing the low pressure fuel gas stream to a combustion device at a fuel gas pressure not higher than the pressure of the first separator hydrocarbon vapour stream. The first pressure of the first gas/liquid separator may be at or above the fuel gas pressure. Advantageously, the first separator hydrocarbon vapour stream nor the low pressure fuel gas stream is compressed before use in the combustion device.

[0041] In US 2008/0066493, N_2 and other vapourous constituents that are separated in the column, are compressed and ejected to the high pressure fuel gas stream. Table 1 of US 2008/0066493 discloses an example in which a natural gas feed stream having a nitrogen content of 3.05 mol % is treated to provide a liquefied natural gas stream having a nitrogen content of 0.65 mol % and a fuel gas having a nitrogen content of 24 mol %. However, high nitrogen content fuel gas streams can produce significant problems when used to fuel gas turbines, which are commonly used to drive compressors or electrical generators within a liquefaction facility. For example, many aeroderivative gas turbines cannot currently tolerate nitrogen contents above 15 mol % in their fuel gas.

[0042] Therefore, in preferred embodiments of the present methods and apparatuses, the first separator hydrocarbon vapour stream is employed as low pressure fuel gas stream. Fuel gas with large amounts of nitrogen can still be used as low pressure fuel gas to fuel for instance a furnace, a boiler, and/or a dual fuel diesel engine.

[0043] As used herein, the term "low pressure" in the low pressure fuel gas stream is relative to the "high pressure" fuel gas stream required to fuel a gas turbine. For the purpose of the present specification, a low pressure fuel gas may be at a pressure in a range of from 2 to 15 bara, more specifically in a range of from 2 to 10 bara. A high pressure (HP) fuel may be at a pressure of higher than 15 bara, generally in a range of 15 to 40 bara, more specifically in a range of from 20 to 30 bara.

[0044] The first gas/liquid separator may advantageously be operated at a suitable fuel gas pressure or above, such that the first separator hydrocarbon vapour stream may advantageously be provided at high enough pressure requiring no, or no extensive, compression before use. It is thus preferred to select the first pressure of the first gas/liquid separator such that the first separator hydrocarbon vapour stream is provided at or above the desired fuel gas pressure.

[0045] Especially when used as low pressure fuel, the first separator hydrocarbon vapour stream of the present invention may comprise N_2 in a wide range, for instance in a range of from 30 mol % to 95 mol % N_2, more preferably in the range of from 60 mol % to 95 mol %.

[0046] Thus, the present invention may advantageously be employed to provide a low pressure fuel gas stream, suitable for use in a combustion device such as a furnace or incinerator, or for instance in a dual fuel diesel engine that may be employed for electric power generator. The low pressure fuel gas stream may be derived from the first separator hydrocarbon vapour stream by warming. The first separator hydrocarbon vapour stream can be sent to any suitable heat exchange device in which it can be used to cool a process stream. Advantageously, the process stream may be provided in the form of a part of the natural gas to cool this part of the natural gas.

[0047] In order to provide a high pressure (HP) fuel gas stream suitable for use as a fuel for a gas turbine, the treating method and apparatus disclosed herein may be incorporated into a method of liquefying a hydrocarbon feed stream and an apparatus therefor. High pressure fuel gas may be extracted from the hydrocarbon feed stream prior to liquefaction. This is advantageous because the hydrocarbon feed stream may have a low nitrogen content compared to the low pressure fuel gas stream derived from the first separator hydrocarbon vapour stream. In addition, the hydrocarbon feed stream is a high pressure stream, such that further pressurization of a portion of this stream for use as a fuel gas stream is not required. Thus, there is no requirement for a high pressure fuel gas compressor. If necessary, where the hydrocarbon feed stream is at too high a pressure, the pressure of the extracted fuel gas may optionally be reduced in pressure before use as fuel.

[0048] In addition, the method disclosed herein is advantageous because it avoids using a gaseous stream produced by the expansion of the liquefied hydrocarbon stream as the high pressure fuel gas stream. Such gaseous streams produced by gas/liquid separation steps, such as end flash processes, would have a higher content of lower boiling components, such as nitrogen, compared to the liquid product produced by the separator.

[0049] Referring to the drawings, FIG. **1** shows a method of and apparatus **1** for treating a multi-phase hydrocarbon stream **145** according to a first embodiment. The multi-phase hydrocarbon stream **145** is derived from natural gas. The multi-phase hydrocarbon stream **145** comprises vapour and liquid phases. One example of how the multi-phase hydrocarbon stream **145** may be provided is discussed in greater detail below with reference to FIG. **2**.

[0050] The multi-phase hydrocarbon stream **145** is passed to a first inlet **148** of a first gas/liquid separator **150**. The first gas/liquid separator **150** provides a first separator hydrocarbon vapour stream **205** as an overhead stream at a first outlet **151** and a first separator bottoms stream **155***a*, which is a liquid stream, at a second outlet **152** at or near the bottom of the first gas/liquid separator **150**. The first gas/liquid separator **150** may be in the form of a separation column such as a fractionation or distillation column. The first gas/liquid separator **150** is preferably provided in the form of a nitrogen separation column. The first separator hydrocarbon vapour stream **205** typically comprises hydrocarbons, typically predominantly methane, and nitrogen.

[0051] The separation is carried out at a first pressure, which is preferably in the range of from 2 to 15 bara, more preferably of from 2 to 10 bara in order to an achieve even lower content of nitrogen in the liquid hydrocarbon stream and still be useable as low pressure fuel gas stream.

[0052] In order to enhance the separation within the first gas/liquid separator **150**, a stripping vapour stream **185***a* is provided at a second inlet **149**. The second inlet **149** typically comprises a vapour inlet device known to the skilled person. The second inlet **149** is preferably at a level gravitationally lower than the first inlet **148** in order to provide efficient stripping of the lighter components of the hydrocarbon mixture, such as nitrogen, from the liquid phase of the multi-phase hydrocarbon stream to the vapour phase. The first inlet **148** may typically comprise an inlet distributor known to the skilled person.

[0053] In a preferred embodiment, the first gas/liquid separator **150** comprises a contacting zone preferably comprising contact enhancing means **154** such as trays or packing, to enhance separation. The contact enhancing means **154** is preferably placed gravitationally between the first and second inlets **148**, **149**.

[0054] The contact enhancing means may comprise a plurality of trays stacked one above the other can be arranged to force the liquid phase to flow horizontally along each tray before falling to the next tray, with the vapour phase bubbling through holes in the trays. This increases the amount of contact area between the liquid and vapour phases. Alternatively, the contact enhancing means may comprise packing. A contacting zone of packing operates in a similar manner to the trays with the packing, which can be either structured or random, increasing the contact area between the liquid and vapour phases.

[0055] The first separator hydrocarbon vapour stream **205** may comprise hydrocarbons and an inventory of greater than or equal to 30 mol % N_2. It is preferred that the first separator hydrocarbon vapour stream **205** has a pressure of less than or equal to 10 bara.

[0056] A low pressure fuel gas stream **215** may be derived from the first separator hydrocarbon vapour stream **205**. For instance, the first separator hydrocarbon vapour stream **205** may be passed to a fuel gas heat exchanger **210**, where it is warmed against a warming stream **355** to provide the low

pressure fuel gas stream **215**, for instance at a pressure of about 5 or 6 bara. At the same time, the warming stream is cooled and turned into a cooled warming stream **365**.

[0057] The fuel gas heat exchanger **210** may be a heater, such as an ambient heater in which case the warming stream **355** may be provided in the form of ambient air or ambient water, to provide the cooled warming stream **365** in the form of cooled air or cooled water stream. The cooled warming stream **365** may be employed as an intermediate stream to chill another stream. However, in preferred embodiments, the warming stream **355** is provided in the form of a process stream that needs to be cooled, thus additionally providing a cooled process stream. In this way, the cold energy from the first separator hydrocarbon vapour stream **205** can be efficiently used to provide cooling to a process stream in the apparatus **1**, such as a hydrocarbon or refrigerant stream. An example of this is provided in relation to the embodiment of FIG. **2**.

[0058] The low pressure fuel gas stream **215** may comprise greater than or equal to 30 mol % N_2. The low pressure fuel gas stream **215** can then be passed to a low pressure fuel gas network. FIG. **1** shows the low pressure fuel gas stream **215** being passed directly to one or more low pressure fuel gas consumers **220**, for example a combustion device, such as a furnace, boiler, or dual fuel diesel engine. Such combustion devices can typically tolerate high levels of nitrogen in the low pressure fuel gas, as known to the skilled person.

[0059] The first separator bottoms stream **155***a* from the first gas/liquid separator **150** may be passed to the first inlet **158** of a second gas/liquid separator **160**. The second gas/liquid separator **160** operates at a second pressure, which is lower that the first pressure used to provide separation in the first gas/liquid separator **150**. The second pressure is preferably less than 4 bara, still more preferably less than 2 bara. The second pressure may suitably be at or near atmospheric pressure. For the purpose of the present disclosure, at or near atmospheric pressure is preferably interpreted as a pressure of between 1 and 1.3 bara.

[0060] If the pressure drop between the first and second gas/liquid separators **150**, **160** is insufficient to provide an appropriate second pressure, the first separator bottoms stream **155***a* can be passed through a bottoms stream expansion device **200**, which provides an (expanded) first separator bottoms stream **155***b* to the first inlet **158** of a second gas/liquid separator **160** at the second pressure.

[0061] The second gas/liquid separator **160** provides a second separator hydrocarbon vapour stream **175** as an overhead stream at a first outlet **161** and a treated liquid hydrocarbon stream **165** at a second outlet **162**. The second gas/liquid separator **160** may be a suitable flash vessel.

[0062] The treated liquid hydrocarbon stream **165**, which may be a LNG stream when the multi-phase hydrocarbon stream **145** is derived from natural gas, can be provided at or near atmospheric pressure. The treated liquid hydrocarbon stream **165** may be passed to a storage tank **170**, such as a cryogenic storage tank.

[0063] The second separator hydrocarbon vapour stream **175** is passed to an overhead stream compressor **180**, where it is compressed to provide a stripping vapour stream **185**. The overhead stream compressor **180** may be mechanically driven by an overhead stream compressor driver **190**, such as a gas turbine, a steam turbine, and/or an electric motor. The stripping vapour stream **185** may optionally be combined with a supplementary stripping vapour stream **235** to form a combined stripping vapour stream **185***a*, before it is passed to the second inlet **149** of the first gas/liquid separator **150** to enhance the separation therein. The stripping vapour stream **185** is provided at a third pressure which should be typically equal to or slightly higher than the first pressure, for example the first pressure plus any pressure loss between the discharge of the overhead stream compressor **180** and the second inlet **149** of the first gas/liquid separator **150**. For instance, the third pressure may be in the range of from 0 to 2 bara higher than the first pressure.

[0064] The supplementary stripping vapour stream **235** may comprise boil off gas from a cryogenic storage tank. In case of cryogenic storage of the treated liquid hydrocarbon, a degree of vaporisation of the treated liquid hydrocarbon can be expected from the storage tank **170** due to imperfect thermal insulation and temperature fluctuations. The resulting boil off vapour can be removed from the storage tank **170** as boil off gas (BOG) stream **195**. The boil off gas stream **195** can be passed to boil off gas compressor **230**, where it is compressed to provide compressed a compressed boil off gas stream **235** for use as supplementary stripping vapour stream. The boil off gas compressor **230** can be driven by a boil off gas compressor driver **240**, such as a gas or steam turbine and/or electric motor.

[0065] In an alternative embodiment not shown in FIG. **1**, the supplemental stripping vapour stream **235** may be passed directly to a further, separate inlet of the first gas/liquid separator **150**. The ultimate choice for where the supplemental stripping vapour **235** is supplied to the first gas/liquid separator may be driven by the composition and temperature of the supplemental stripping vapour stream **235**, such as the compressed boil off gas stream.

[0066] In a preferred embodiment, the method disclosed herein can be utilised as part of a liquefaction process for a hydrocarbon feed stream in which case the multi-phase hydrocarbon stream to be treated may be formed by cooling and/or changing the pressure of a hydrocarbon feed stream. The hydrocarbon feed stream may be any suitable gas stream to be cooled and liquefied, but is usually a natural gas stream obtained from natural gas or petroleum reservoirs. As an alternative the hydrocarbon feed stream may also be obtained from another source, also including a synthetic source such as a Fischer-Tropsch process.

[0067] Usually a natural gas stream is a hydrocarbon composition comprised substantially of methane. Preferably the hydrocarbon feed stream comprises at least 50 mol % methane, more preferably at least 80 mol % methane.

[0068] Hydrocarbon compositions such as natural gas may also contain non-hydrocarbons such as H_2O, N_2, CO_2, Hg, H_2S and other sulphur compounds, and the like. If desired, the natural gas may be pre-treated before cooling and any liquefying. This pre-treatment may comprise reduction and/or removal of undesired components such as CO_2 and H_2S or other steps such as early cooling, pre-pressurizing or the like. As these steps are well known to the person skilled in the art, their mechanisms are not further discussed here.

[0069] Thus, the term "hydrocarbon feed stream" may also include a composition prior to any treatment, such treatment including cleaning, dehydration and/or scrubbing, as well as any composition having been partly, substantially or wholly treated for the reduction and/or removal of one or more compounds or substances, including but not limited to sulphur, sulphur compounds, carbon dioxide, water, Hg, and one or more C_2+ hydrocarbons.

[0070] Depending on the source, natural gas may contain varying amounts of hydrocarbons heavier than methane such as in particular ethane, propane and butanes, and possibly lesser amounts of pentanes and aromatic hydrocarbons. The composition varies depending upon the type and location of the gas.

[0071] Conventionally, the hydrocarbons heavier than methane are removed to various extents from the hydrocarbon feed stream prior to liquefaction for several reasons, such as having different freezing or liquefaction temperatures that may cause them to block parts of a methane liquefaction plant or to provide a desired specification for the liquefied product. C_2+ hydrocarbons can be separated from, or their content reduced in a hydrocarbon feed stream by a demethaniser, which will provide an overhead hydrocarbon stream which is methane-rich and a bottoms methane-lean stream comprising the C_2+ hydrocarbons. The bottoms methane-lean stream can then be passed to further separators to provide Liquefied Petroleum Gas (LPG) and condensate streams.

[0072] After separation, the hydrocarbon stream so produced can be further cooled, preferably liquefied. The cooling could be provided by a number of methods known in the art. The hydrocarbon stream is passed against one or more refrigerant streams in one or more refrigerant circuits. Such a refrigerant circuit can comprise one or more refrigerant compressors to compress an at least partly evaporated refrigerant stream to provide a compressed refrigerant stream. The compressed refrigerant stream can then be cooled in a cooler, such as an air or water cooler, to provide the refrigerant stream. The refrigerant compressors can be driven by one or more gas and/or steam turbines and/or electric motors.

[0073] The cooling of the hydrocarbon stream can be carried out in one or more stages. Initial cooling, also called pre-cooling or auxiliary cooling, can be carried out using a pre-cooling refrigerant, such as a mixed refrigerant, of a pre-cooling refrigerant circuit, in one or more pre-cooling heat exchangers, to provide a pre-cooled hydrocarbon stream. The pre-cooled hydrocarbon stream is preferably partially liquefied, such as at a temperature below 0° C.

[0074] Preferably, such pre-cooling heat exchangers could comprise a pre-cooling stage, with any subsequent cooling being carried out in one or more main heat exchangers to liquefy a fraction of the hydrocarbon stream in one or more main and/or sub-cooling cooling stages.

[0075] In this way, two or more cooling stages may be involved, each stage having one or more steps, parts etc. For example, each cooling stage may comprise one to five heat exchangers. The or a fraction of a hydrocarbon stream and/or the refrigerant may not pass through all, and/or all the same, heat exchangers of a cooling stage.

[0076] In one embodiment, the hydrocarbon may be cooled and liquefied in a method comprising two or three cooling stages. A pre-cooling stage is preferably intended to reduce the temperature of a hydrocarbon feed stream to below 0° C., usually in the range −20° C. to −70° C.

[0077] A main cooling stage is preferably separate from the pre-cooling stage. That is, the main cooling stage comprises one or more separate main heat exchangers. A main cooling stage is preferably intended to reduce the temperature of a hydrocarbon stream, usually at least a fraction of a hydrocarbon stream cooled by a pre-cooling stage, to below −100° C.

[0078] Heat exchangers for use as the two or more pre-cooling or any main heat exchangers are well known in the art. The pre-cooling heat exchangers are preferably shell and tube heat exchangers.

[0079] At least one of any of the main heat exchangers is preferably a spool-wound cryogenic heat exchanger known in the art. Optionally, a heat exchanger could comprise one or more cooling sections within its shell, and each cooling section could be considered as a cooling stage or as a separate 'heat exchanger' to the other cooling locations.

[0080] In another embodiment, one or both of the pre-cooling refrigerant stream and any main refrigerant stream can be passed through one or more heat exchangers, preferably two or more of the pre-cooling and main heat exchangers described hereinabove, to provide cooled refrigerant streams.

[0081] If the refrigerant is a mixed refrigerant in a mixed refrigerant circuit, such as the pre-cooling refrigerant circuit or any main refrigerant circuit, it may be formed from a mixture of two or more components selected from the group comprising: nitrogen, methane, ethane, ethylene, propane, propylene, butanes, pentanes, etc. One or more other refrigerants may be used, in separate or overlapping refrigerant circuits or other cooling circuits.

[0082] The pre-cooling refrigerant circuit may comprise a mixed pre-cooling refrigerant. The main refrigerant circuit may comprise a mixed main refrigerant. A mixed refrigerant or a mixed refrigerant stream as referred to herein comprises at least 5 mol % of two different components. More preferably, the mixed refrigerant comprises two or more of the group comprising: nitrogen, methane, ethane, ethylene, propane, propylene, butanes and pentanes.

[0083] A common composition for a pre-cooling mixed refrigerant can be:

Methane (C1)	0-20 mol %
Ethane (C2)	5-80 mol %
Propane (C3)	5-80 mol %
Butanes (C4)	0-15 mol %
The total composition comprises	100 mol %.

[0084] A common composition for a main cooling mixed refrigerant can be:

Nitrogen	0-10 mol %
Methane (C1)	30-70 mol %
Ethane (C2)	30-70 mol %
Propane (C3)	0-30 mol %
Butanes (C4)	0-15 mol %
The total composition comprises	100 mol %.

[0085] In another embodiment, the pre-cooled hydrocarbon stream, such as a pre-cooled natural gas stream can be further cooled to provide an at least partially, preferably fully, liquefied hydrocarbon stream, such as an LNG stream. The further cooling may be carried out in the main cooling stage. Preferably, the treated liquid hydrocarbon stream provided in the method and apparatus described herein can be stored in one or more storage tanks. The fully liquefied hydrocarbon stream is preferably sub-cooled. The further cooling, e.g. in

the main cooling stage or in a separate sub-cooling stage, may thus comprise sub-cooling of the liquefied hydrocarbon stream.

[0086] After liquefaction, the at least partially, preferably fully, liquefied hydrocarbon stream can be expanded to provide the multi-phase hydrocarbon stream which can be further processed according to the method and apparatus described herein.

[0087] FIG. **2** shows a second embodiment of an apparatus in which a pressurized hydrocarbon feed stream **85** is treated, cooled, at least partially liquefied and expanded, to provide the multi-phase hydrocarbon stream **145** used in the treatment method disclosed herein. Described in more detail, the multi-phase hydrocarbon stream **145** may be provided by the steps of:

[0088] providing an at least partially, preferably fully, liquefied hydrocarbon stream **115**; and

[0089] expanding the at least partially, preferably fully, liquefied hydrocarbon stream **115** in one or more hydrocarbon stream expansion devices **120**,**140**, to provide the multi-phase hydrocarbon stream **145** in the form of an expanded hydrocarbon stream.

[0090] The at least partially, preferably fully, liquefied hydrocarbon stream **115** may be provided by the steps of:

[0091] providing a hydrocarbon supply stream **105**;

[0092] splitting the hydrocarbon supply stream **105** into a high pressure fuel gas stream **107** and a continuing hydrocarbon stream **108**;

[0093] at least partially, preferably fully, liquefying the continuing hydrocarbon stream **108** by cooling at least part of the continuing stream **108** in one or more heat exchangers **110***a*,**110***b*, to provide the at least partially, preferably fully, liquefied hydrocarbon stream **115**.

[0094] The high pressure fuel gas stream **107** may have one or both of a nitrogen content of lower than 15 mol % and a pressure of higher than 15 bara. The high pressure fuel gas stream **107** may suitably be passed to one or more high pressure fuel gas consumers **300**, such as gas turbines.

[0095] A supply stream separation device **80** may be provided to separate the hydrocarbon supply stream **105** into the continuing hydrocarbon stream **108** and the high pressure fuel gas stream **107**. The supply stream separation device **80** may suitably have an inlet **78** for the hydrocarbon supply stream **105**, a first outlet **81** for the high pressure fuel gas stream **107** and a second outlet **82** for the continuing hydrocarbon stream **108**.

[0096] In certain embodiments, the at least partially, preferably fully, liquefying step may comprise:

[0097] pre-cooling at least part of the continuing hydrocarbon stream **108** in one or more pre-cooling heat exchangers **110***a* against a pre-cooling refrigerant in a pre-cooling refrigerant circuit to provide a pre-cooled hydrocarbon stream **113**; and

[0098] at least partially, preferably fully, liquefying at least part **113***b* of the pre-cooled hydrocarbon stream **113** in one or more main cooling heat exchangers **110***b*, against a main cooling refrigerant being cycled in in a main cooling refrigerant circuit, to provide the at least partially, preferably fully, liquefied hydrocarbon stream **115**. These embodiments may further comprise the steps of:

[0099] passing a part **113***b* of the pre-cooled hydrocarbon stream **113** to a fuel gas heat exchanger **210** as the warming stream **355**;

[0100] cooling said part **113***b* of pre-cooled hydrocarbon stream in the fuel gas heat exchanger **210** against the first separator hydrocarbon vapour stream **205** to provide a cooled process stream **365**;

[0101] passing the cooled process stream **365** to one of the one or more hydrocarbon stream expansion devices **120**,**140**.

[0102] Thus, the apparatus may comprise one or more cooling stages **110** to cool and at least partially, preferably fully, liquefy the continuing hydrocarbon stream **108** to provide the at least partially, preferably fully, liquefied hydrocarbon stream **115**. Said one or more cooling stages **110** may suitably have an inlet **109** for the continuing hydrocarbon stream **108** in fluid communication with the second outlet **82** of the supply stream separation device **80** and an outlet **112** for the at least partially, preferably fully, liquefied hydrocarbon stream **115** connected to an inlet **118** of the one or more hydrocarbon stream expansion devices **120**,**140**.

[0103] The hydrocarbon feed stream **85**, which can be a natural gas stream, is provided as a pressurised stream, usually at a pressure in the range of from 30 to 90 bara. The hydrocarbon feed stream **85** may be passed to an acid gas removal unit **90**. The acid gas removal unit **90** lowers the content of acid gases such as carbon dioxide and hydrogen sulphide in the hydrocarbon feed stream **85** by known methods to provide a treated hydrocarbon stream **95**.

[0104] The treated hydrocarbon stream **95**, which will be depleted in acid gases, may then be passed to a Natural Gas Liquids (NGL) extraction unit **100**, optionally via a dryer (not shown). In the NGL extraction unit **100**, at least a portion of any natural gas liquids such as propane, butanes and pentanes, together with heavier hydrocarbons, can be removed, for instance using one or more scrub columns or fractionation columns. The NGL extraction unit **100** provides a hydrocarbon supply stream **105**, which can be depleted in natural gas liquids.

[0105] FIG. **2** shows the hydrocarbon supply stream **105** being passed to the inlet **78** of a supply stream separation device **80**, in which it is split into a high pressure fuel gas stream **107** at a first outlet **81** and a continuing hydrocarbon stream **108** at a second outlet **82**.

[0106] In an alternative embodiment not shown in FIG. **2**, the high pressure fuel gas stream **107** can be drawn from hydrocarbon feed stream **85** and/or treated hydrocarbon stream **95** instead of the hydrocarbon supply stream **105**. The bleed point for the high pressure fuel gas stream **107** will be determined by the composition of the hydrocarbon mixture. For example, if the hydrocarbon mixture is naturally low in acid gasses, the high pressure fuel gas stream **107** can be drawn from the hydrocarbon feed stream **85** and the pressure be reduced in a device such as valve **106** provided in line **107**, to match the high pressure fuel pressure requirements as desired.

[0107] Alternatively (not shown), the high pressure fuel gas stream may be drawn from the NGL extraction unit **100** at a lower pressure if the NGL extraction unit **100** is operated at a lower pressure. Herewith it can be avoided to spend power to needlessly recompress the portion of the hydrocarbon supply stream **105** that is going to be extracted as fuel gas.

[0108] The high pressure fuel gas stream **107** can then be passed to a high pressure fuel gas network, or as shown in FIG. **2** directly to one or more high pressure fuel gas consumers **300**, such as gas turbines. The gas turbines may mechanically drive electric generators for power production, or more

preferably mechanically drive compressors, such as those present in a refrigerant circuit.

[0109] The continuing hydrocarbon stream **108** from the second outlet **82** of the supply stream separation device **80**, can then be passed to a cooling and liquefaction unit **110**, where it is cooled and at least partially, preferably fully, liquefied. The liquefaction unit **100** provides an at least partially, preferably fully, liquefied hydrocarbon stream **115** at a first outlet **112**. Such liquefaction units are well known in the art, from instance from U.S. Pat. No. 6,370,910.

[0110] The liquefaction unit **110** shown in FIG. **2** comprises a first and a second cooling stage. The first cooling stage comprises one or more pre-cooling heat exchangers **110***a*, which cool the continuing hydrocarbon stream **108** against a pre-cooling refrigerant in a pre-cooling refrigerant circuit (not shown). The one or more pre-cooling heat exchangers **110***a* provide a pre-cooled hydrocarbon stream **113**.

[0111] Pre-cooled hydrocarbon stream **113** can be passed to pre-cooled stream separation device **70**, where it may optionally be split into a (continuing) pre-cooled hydrocarbon stream part **113***b* and a process stream to be employed as warming stream **355**.

[0112] The pre-cooled hydrocarbon stream **113**, or the continuing pre-cooled hydrocarbon stream part **113***b*, is passed to a second cooling stage. The second cooling stage comprises one or more main cooling heat exchangers **110***b*, which at least partially, preferably fully, liquefy the pre-cooled hydrocarbon stream **113**, or at least the continuing part **113***b* thereof, against a main cooling refrigerant in a main cooling refrigerant circuit (not shown). The one or more main cooling heat exchangers **110***b* provide an at least partially, preferably fully, liquefied hydrocarbon stream **115**.

[0113] In an alternative embodiment, the NGL extraction unit **100** may be located somewhere in the liquefaction unit **110** instead of upstream thereof such as depicted in FIG. **2**. In such a case, the supply stream separation device **80** may also be located in the liquefaction unit **110**. Both the NGL extraction unit **100** as well as the supply stream separation device **80** would preferably be located upstream of where full condensation of the feed stream is accomplished. A good place would typically be upstream of the second cooling stage.

[0114] The at least partially, preferably fully, liquefied hydrocarbon stream **115** can be passed to an inlet **118** of one or more hydrocarbon stream expansion devices **120**, **140**, such as two or more expansion devices in series which sequentially reduce the pressure of the stream to provide the multi-phase hydrocarbon stream **145** at outlet **142**. In the embodiment shown in FIG. **2**, the at least partially, preferably fully, liquefied hydrocarbon stream **115** can be passed to a first hydrocarbon stream expansion device **120**, which may be a turbine, in which it is dynamically expanded to provide expanded hydrocarbon stream **125**. The energy released in the dynamic expansion of the at least partially, preferably fully, liquefied hydrocarbon stream **115** in the first expansion device **120** can be recovered, e.g. by mechanically driving an electric generator **130** or another device such as a compressor (not shown).

[0115] The expanded hydrocarbon stream **125** can then be passed to an expanded hydrocarbon stream splitting device **60** to provide expanded hydrocarbon slip stream **305** and (continuing) expanded hydrocarbon stream **125***b*. The (continuing) expanded hydrocarbon stream **125***b* can then be passed through the second expansion device **140**, such as a Joule-Thomson valve, in which it is expanded to provide the multi-phase hydrocarbon stream **145**.

[0116] In the embodiment of FIG. **2** the warming stream **355**, after it has been cooled in fuel gas heat exchanger **210** to provide the cooled warming stream **365**, is suitable form part of stream **145**. In such a case, after appropriate depressurization, e.g. in an expander or Joule Thomson device **121**, the cooled warming stream **365**, may be injected into the (continuing) expanded hydrocarbon stream **125***b* to be sent to the second hydrocarbon stream expansion device **140** as already discussed. In some embodiments, it may be beneficial to recombine the cooled warming stream **365** with the liquefied hydrocarbon stream **115** upstream of the expansion device **120** so that these streams can be jointly expanded.

[0117] In the embodiment of FIG. **2**, the warming stream **355** is provided in the form of the slip stream withdrawn from pre-cooled hydrocarbon stream **113** by pre-cooled stream separation device **70**. However, the warming stream may also be obtained at different pressures from other sources, including but not limited to from the NGL extraction unit **100** or a fractionation train (not shown) that is typically installed to fractionate the NGL product obtained from the NGL extraction unit **100**.

[0118] In a different group of embodiments, the pre-cooled hydrocarbon stream may not be split at all whereby the warming stream **355** consist of an entirely different process stream such as a refrigerant (slip) stream or an intermediate chilling fluid stream.

[0119] The multi-phase hydrocarbon stream **145** can be passed to a first inlet **148** of a first gas/liquid separator **150***a*, in which it is separated into vapour and liquid fractions, in a similar manner to the embodiment of FIG. **1**. The first separator vapour stream **205** exits the first gas/liquid separator **150***a* overhead via a first outlet **151** therein. The first separator bottoms stream **155***a*, which is a liquid stream, exits via second outlet **152** at or near the bottom of the first gas/liquid separator **150***a*. A combined stripping vapour stream **185***a* is passed to the first gas/liquid separator **150***a* a second inlet **149** which is situated gravitationally lower than the first inlet **148**. The second inlet **149** can be above second outlet **152**.

[0120] The expanded hydrocarbon slip stream **305** is further expanded, e.g. using Joule Thomson valve **310**, and the thus further expanded hydrocarbon slip stream **315** is passed through reflux condenser **320** to recondense some of the vapours at the top of the first gas/liquid separator **150***a*. The reflux condenser **320** may be located at a level between the first inlet **148** and the first outlet **151**, to provide reflux to enhance the separation of the lighter components of the multi-phase hydrocarbon stream. As known to the person skilled in the art, an external reflux condenser may be used instead of such an internal condenser **320**.

[0121] The further expanded hydrocarbon slip stream **315** is warmed in condenser **320** thereby providing a warmed hydrocarbon slip stream **325**, which can be passed to the (expanded) first separator bottoms stream **155***b*. The (expanded) first separator bottoms stream **155***b* carrying the warmed hydrocarbon from the warmed hydrocarbon slip stream **325** can be passed to the inlet **158** of the second gas/liquid separator **160** as a combined stream **155***c*. Reference is made to FIG. **1** and its description hereinabove for a description of the streams drawn from the second gas/liquid separator **160** and their further processing.

[0122] Returning to the first gas/liquid separator **150***a*, this may comprise two zones with contact enhancing means

(**154***a*, **156***a*), e.g. formed of trays and/or packing, to enhance separation and nitrogen rejection. A first zone of the two zones is situated between the first inlet **148** and the second inlet **149** in a similar manner to the embodiment of FIG. **1**. A second zone of the two zones **156***a* is situated between the first outlet **151** for the first separator hydrocarbon vapour stream **205** and the first inlet **148** for the multi-phase hydrocarbon stream **145**. The second zone **156***a* should be below the condenser **320**, or below an inlet means for reflux from an external condenser, in order to take advantage of the reflux provided by the condensation of the hydrocarbon vapour on the condenser **320**.

[0123] The first separator hydrocarbon vapour stream **205** which exits the first outlet **151** can be passed to fuel gas heat exchanger **210** where it is warmed against warming stream **355**, to provide the low pressure fuel gas stream **215** and cooled warming stream **365**. If the warming stream is provided in the form of a process stream, a portion of the cold energy of the first separator hydrocarbon vapour stream **205** can thus be used to cool the process stream, allowing it to bypass the one or more main heat exchangers **110***b*, enhancing thermal efficiency.

[0124] As already touched on hereinabove, the warming stream **355** may be also be a process stream in the form of a refrigerant stream, such as a pre-cooling and/or main cooling refrigerant stream. In this case, a part of the cold energy of the first separator hydrocarbon vapour stream **205** can be returned to one or both of the cooling stages **110**, by cooling the refrigerant.

[0125] The advantages of the method and apparatus disclosed herein will be apparent from the following non-limiting Example.

EXAMPLE

[0126] This Example provides a comparison of the nitrogen contents of various streams produced from a natural gas hydrocarbon supply stream **105** according to the line-up of FIG. **2**, with three comparative examples calculated according to the embodiment of FIG. 3 of US 2008/0066493 discussed above.

[0127] The nitrogen contents of a hydrocarbon supply stream **105**, composed of natural gas, the high and low pressure fuel gas streams **107**, **215** respectively, the boil off gas stream **195** and the LNG stream **165** were calculated, together with additional data for the line-up of FIG. **2** disclosed herein and is presented in the Table below under "Invention".

[0128] In the embodiment of FIG. 3 of US 2008/0066493, the high pressure fuel gas stream is provided by conduit 34a, from the overhead 25 of the upper part 10u of column 10' after heat exchange and compression combined with the overhead 42 of flash vessel 101 after heat exchange and compression. It is pointed out that conduit 33, arising solely form the heat exchange and compression of the overhead 25 of the upper part 10u of column 10' was unable to provide sufficient high pressure fuel gas, such that it was drawn instead from conduit 34a in this comparison. In the absence of a check valve in line 34, the conduits 33 and 34a would be in fluid communication.

[0129] US 2008/0066493 does not disclose a corresponding low pressure fuel gas stream. For the purposes of this comparison, a low pressure fuel gas stream was assumed to have been extracted from conduit 25 carrying the overhead of the upper part 10u of column 10'. The boil of gas stream is found in conduit 22.

[0130] The data calculated according to the modified line-up of FIG. 3 of US 2008/0066493 is shown in the Table below under "Comp. 1", "Comp. 2" and "Comp. 3". "Comp. 1" represents a comparison with the method according to FIG. **2** disclosed herein taken at the same natural gas feed stream, low pressure fuel stream, high pressure fuel stream, boil off gas stream and LNG stream production rates. "Comp. 2" represents a comparison with the method according to FIG. **2** disclosed herein taken at the same natural gas feed stream rates and low pressure and high pressure fuel gas heating values. "Comp. 3" represents a comparison with the method according to FIG. **2** disclosed herein taken at the same natural gas feed stream and LNG stream rates and low pressure fuel gas heating value.

[0131] It is apparent from the Table below that the method and apparatus disclosed herein provides nitrogen rejection to the low pressure fuel gas stream **215**, while producing an LNG stream **165** and a high pressure fuel gas stream **107** having acceptably low nitrogen content.

TABLE

	Invention	Comp. 1	Comp. 2	Comp. 3
N_2 mol. fraction natural gas feed stream	0.056	0.056	0.056	0.056
N_2 mol. fraction HP fuel gas stream	0.056	0.248	0.285	0.298
N_2 mol. fraction LP fuel gas stream	0.805	0.418	0.409	0.445
N_2 mol. fraction BOG stream	0.223	0.154	0.141	0.154
N_2 mol. fraction treated liquid hydrocarbon stream	0.009	0.006	0.005	0.006
Heating value low pressure fuel gas stream	64	234	65	64
Specific power/ (kW/tpd LNG)	14.8	14.2	14.4	14.3
Net power/ (kW/tpd LNG)	14.6	13.9	14.1	14.1
Production 340 stream days/MTPA	3.60	3.60	3.56	3.60

[0132] The person skilled in the art will understand that the present invention can be carried out in many various ways without departing from the scope of the appended claims.

1. A method of treating a multi-phase hydrocarbon stream to provide a treated liquid hydrocarbon stream, comprising at least the steps of:

producing a multi-phase hydrocarbon stream from natural gas, said multi-phase hydrocarbon stream comprising a vapour phase and a liquid phase;

passing the multi-phase hydrocarbon stream to a first gas/liquid separator;

separating the multi-phase hydrocarbon stream in the first gas/liquid separator at a first pressure to provide a first separator hydrocarbon vapour stream, comprising hydrocarbons and nitrogen, and a first separator bottoms stream;

separating the first separator bottoms stream in a second gas/liquid separator at a second pressure to provide a second separator hydrocarbon vapour stream and a treated liquid hydrocarbon stream in the form of LNG, wherein the second pressure is lower than the first pressure;

compressing the second separator hydrocarbon vapour stream in an overhead stream compressor to provide a stripping vapour stream; and

passing the stripping vapour stream to the first gas/liquid separator at a level gravitationally lower than the level at which the multi-phase hydrocarbon stream is passed to the first gas/liquid separator.

2. The method according to claim **1**, wherein said compressing of the second separator hydrocarbon vapour stream by the overhead stream compressor provides the stripping vapour stream at a third pressure, which is equal to or greater than the first pressure.

3. The method according to claim **1**, further comprising:

deriving a low pressure fuel gas stream from the first separator hydrocarbon vapour stream;

passing the low pressure fuel gas stream to a combustion device at a fuel gas pressure not higher than the pressure of the first separator hydrocarbon vapour stream.

4. The method according to claim **3**, wherein the first pressure of the first gas/liquid separator is at or above the fuel gas pressure and the first separator hydrocarbon vapour stream nor the low pressure fuel gas stream is compressed before use in the combustion device.

5. The method according to claim **3**, wherein the combustion device is one from the group consisting of a furnace, a boiler, a dual fuel diesel engine.

6. The method according to claim **3**, wherein the step of deriving the low pressure fuel gas stream from the first separator hydrocarbon vapour stream comprises the step of:

warming the first separator hydrocarbon vapour stream against a warming stream in fuel gas heat exchanger to provide the low pressure fuel gas stream and a cooled warming stream.

7. The method according to claim **6**, wherein the step of producing a multi-phase hydrocarbon stream from said natural gas comprises:

cooling a part of the natural gas as said warming stream in the fuel gas heat exchanger against the first separator hydrocarbon vapour stream, to provide said cooled warming stream in the form of a cooled process stream.

8. The method according to claim **1**, wherein the first separator hydrocarbon vapour stream comprises between from 30 mol % to 95 mol % of nitrogen.

9. The method according to claim **1**, wherein the treated liquid hydrocarbon stream contains less than 1 mol % nitrogen.

10. The method according to claim **1**, wherein the step of producing the multi-phase hydrocarbon stream from said natural gas comprises cooling.

11. The method according to claim **1**, wherein the step of producing the multi-phase hydrocarbon stream from said natural gas comprises:

providing a hydrocarbon supply stream from a natural gas stream at elevated pressure;

extracting a continuing hydrocarbon stream from the hydrocarbon supply stream;

passing the continuing stream to a cooling and liquefaction unit wherein it is cooled an at least partially liquefied to provide an at least partially liquefied hydrocarbon stream;

passing the at least partially liquefied hydrocarbon stream to an inlet of at least one hydrocarbon stream expansion device and therein reducing the pressure of the at least partially liquefied hydrocarbon stream to provide the multi-phase hydrocarbon stream.

12. The method according to claim **11**, further comprising:

splitting the hydrocarbon supply stream into a high pressure fuel gas stream and said continuing hydrocarbon stream, which high pressure fuel gas stream has one or both of a nitrogen content of lower than 15 mol % and a pressure of higher than 15 bara.

13. An apparatus for treating a multi-phase hydrocarbon stream comprising a liquid phase and a vapour phase to provide a treated liquid hydrocarbon stream in the form of LNG, comprising at least:

means for producing a multi-phase hydrocarbon stream from natural gas, said means comprising at least one of a liquefaction unit and one or more hydrocarbon stream expansion devices;

a first gas/liquid separator arranged to receive the multi-phase hydrocarbon stream and separate it into a first separator hydrocarbon vapour stream, comprising hydrocarbons and nitrogen, and a first separator bottoms stream, said first gas/liquid separator having a first inlet for feeding the multi-phase hydrocarbon stream into the first gas/liquid separator, a first outlet for discharging the first separator hydrocarbon vapour stream from the first gas/liquid separator, a second outlet for discharging the first separator bottoms stream from the first gas/liquid separator and a second inlet, located at a level gravitationally lower than said first inlet, for feeding a stripping vapour stream into the first gas/liquid separator;

a second gas/liquid separator arranged to receive the first separator bottoms stream and separate it into a second separator hydrocarbon vapour stream and a treated liquid hydrocarbon stream in the form of LNG, said second gas/liquid separator having a first inlet in fluid communication with the second outlet of the first gas/liquid separator, for feeding the first separator bottoms stream into the second gas/liquid separator, a first outlet for discharging the second separator hydrocarbon vapour stream from the second gas/liquid separator and a second outlet for discharing the treated liquid hydrocarbon stream from the second gas/liquid separator;

a bottoms stream expansion device arranged between the second outlet of the first gas/liquid separator and the first inlet of the second gas/liquid separator, to reduce the pressure of the first separator bottoms stream; and

an overhead stream compressor to compress the second separator hydrocarbon vapour stream to provide the stripping vapour stream, said overhead stream compressor having an inlet in fluid communication with the first outlet of the second gas/liquid separator to receive the second separator hydrocarbon vapour stream, and an outlet in fluid communication with the second inlet of the first gas/liquid separator for discharging the stripping vapour stream.

14. The apparatus according to claim **13**, wherein the one or more hydrocarbon stream expansion devices is connected to the liquefaction unit and downstream thereof, to expand an at least partially liquefied hydrocarbon stream discharged from the liquefaction unit, to provide the multi-phase hydrocarbon stream, said one or more hydrocarbon stream expansion devices having an inlet for receiving the at least partially liquefied hydrocarbon stream and an outlet for discharging the multi-phase hydrocarbon stream, wherein said outlet is connected to the first inlet of the first gas/liquid separator.

15. The apparatus according to claim **13**, further comprising:

a combustion device operating at a fuel gas pressure not higher than the pressure of the first separator hydrocarbon vapour stream, the combustion device arranged to receive low pressure fuel gas derived from the first separator hydrocarbon stream.

16. The apparatus according to claim **15**, wherein there is no compressor between the first outlet of the first gas/liquid separator and the combustion device.

17. The apparatus according to claim **15**, wherein the combustion device is one from the group consisting of a furnace, a boiler, a dual fuel diesel engine.

18. The method according to claim **1**, wherein the first separator hydrocarbon vapour stream has a pressure in the range of from 2 to 15 bara.

19. The method according to claim **8**, wherein the first separator hydrocarbon vapour stream has a pressure in the range of from 2 to 15 bara.

20. The method according to claim **10**, wherein the step of producing the multi-phase hydrocarbon stream from said natural gas further comprises changing the pressure of the natural gas.

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