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(54) Method and apparatus for preparing a lean methane-containing gas stream

(57) A hydrocarbon feed stream is passed to an extraction column. A first portion of a liquid bottom stream from the extraction column is partly depressurized and subsequently passed, at reduced pressure, into a first fractionation column of a fractionation system. A recycle portion derived from a first residue liquid bottom stream removed as liquid from the first fractionation column is recycled into the extraction column, whereby the recycle portion enters the extraction column in liquid phase. The recycle portion has the same composition as the first residue liquid bottom stream being withdrawn from the first fractionation column. A vaporous overhead stream is withdrawn from the extraction column, from which a lean methane-containing gas stream is produced.

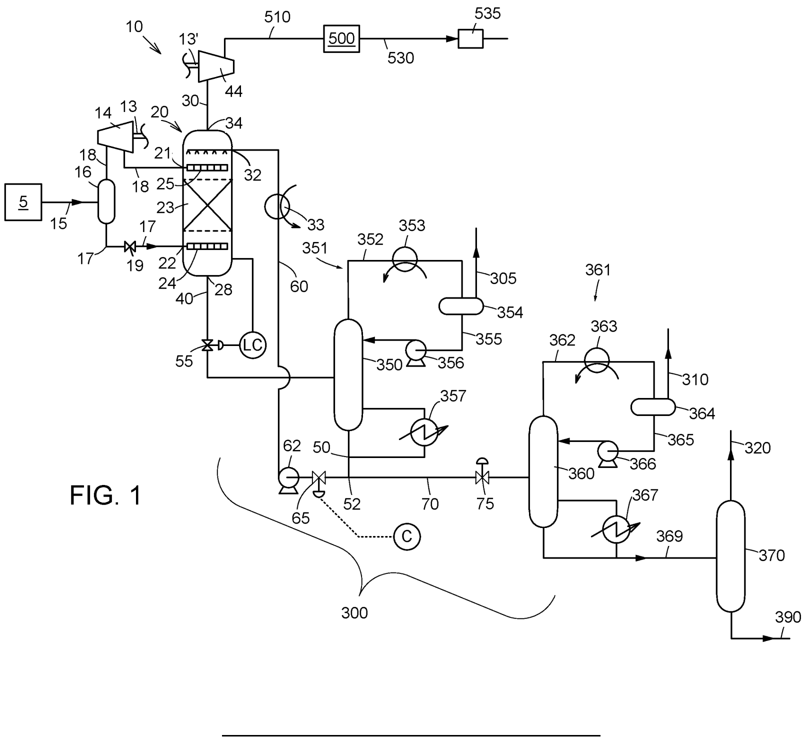

FIG. 1

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Description

[0001] The present invention relates to a method and apparatus for preparing a lean methane-containing gas stream. At least part of the lean methane-containing gas may subsequently be subjected to full condensation and subcooling, to provide a liquefied methane-containing stream.

[0002] An important example of a methane-containing gas is natural gas. Natural gas, and other methane-containing gases, may in addition to methane ("C_1") contain amounts of hydrocarbons heavier than methane ("C_2+"; sometimes referred to as "higher hydrocarbons"), including ethane ("C_2"), propane ("C_3"), butanes ("C_4"), and hydrocarbons heavier than butanes ("C_5+"), such as pentanes ("C_5") and higher. Various hydrocarbons heavier than methane may be extracted from the methane-containing gas to various degrees. The resulting gas is referred to as lean methane-containing gas stream, which means that the content of hydrocarbons heavier than methane in the gas stream is lower than in the methane-containing gas prior to said extracting.

[0003] The resulting lean methane-containing gas may be employed in various ways, including sending to a pipeline or gas network, for instance to be sold as sales gas, e.g. in the form of domestic gas, and liquefying. When liquefied, the methane-containing gas stream can be transported and sold in the form of Liquefied Natural Gas (LNG).

[0004] The heavier hydrocarbons are usually extracted in condensed form as natural gas liquids and fractionated to yield valuable hydrocarbon products.

[0005] US patent application publication 2006/0260355 describes a process and apparatus for integrated natural gas liquids (NGL) recovery and liquefied natural gas production. An admixture of methane with ethane and higher hydrocarbons is separated in a scrub column into a methane-rich overhead stream and a liquid methane-depleted bottoms liquid. The methane-rich overhead stream is partially condensed to provide reflux to the scrub column. Additional reflux is derived from an ethane-enriched stream from fractionation of the bottoms liquid. Absorber liquid containing C_4 and/or C_5 from the fractionation may also be introduced into the scrub column. Such absorber liquid, sometimes referred to as "lean oil", functions as a washing liquid that helps to improve NGL recovery. The vapour fraction remaining after partial condensation can be liquefied to provide an LNG product.

[0006] A drawback of the process and apparatus described in this US patent application publication is that it requires various consecutive fractionation columns in a fractionation train to be operative.

[0007] In a first aspect, the present invention provides a method of preparing a lean methane-containing gas stream, comprising:

- feeding a hydrocarbon feed stream into an extraction column at a first feeding position and at an actual feed rate, said hydrocarbon feed stream containing at least methane and one or more C_2+ hydrocarbons;
- withdrawing from the extraction column a vaporous overhead stream containing at least the majority of the methane from the hydrocarbon feed stream;
- producing a lean methane-containing gas stream from said vaporous overhead stream;
- withdrawing from the extraction column a liquid bottom stream, from a first withdrawal level being gravitationally lower than the first feeding position;
- reducing the pressure of at least a first portion of the liquid bottom stream and subsequently passing the first portion at reduced pressure into a first fractionation column of at least three consecutive fractionation columns of a fractionation system, whereby the first portion being passed into said first fractionation column has the same composition as said liquid bottom stream being withdrawn the extraction column;
- withdrawing from the first fractionation column a first fractionated overhead stream in vapour phase comprising at least a majority of any methane left in the first portion of the liquid bottom stream;
- withdrawing from the first fractionation column a first residue liquid bottom stream;
- increasing the pressure of at least a recycle portion, being a portion of the first residue liquid bottom stream, with a recycle pump; and subsequently
- recycling the recycle portion at increased pressure into the extraction column whereby said recycle portion enters the extraction column in liquid phase, which recycle portion has the same composition as the first residue liquid bottom stream being withdrawn from the first fractionation column.

[0008] In another aspect, the present invention provides an apparatus for preparing a lean methane-containing gas stream, comprising:

- an extraction column comprising a first feeding inlet located in a first feeding position, an overhead vapour outlet for discharging a vaporous overhead stream containing the lean methane-containing gas stream, and a liquid bottom stream outlet located at a first withdrawal level, said first withdrawal level being gravitationally lower than the first feeding position, and said first feeding inlet fluidly connected to a feed supply of a hydrocarbon feed stream;
- a flow control system arranged to control an actual feed rate of the hydrocarbon feed stream flowing into the extraction

column;

- a fractionation system comprising at least three consecutively arranged fractionation columns, a first fractionation column of the at least three consecutively arranged fractionation columns being in fluid communication contact with the liquid bottom stream outlet via a pressure reduction device, to receive a first portion of the liquid bottom stream from the extraction column at a reduced pressure and the same composition as the liquid bottom stream, said first fractionation column being fluidly connected to a first overhead discharge line through which a first fractionated overhead stream in vapour phase can be discharged from the first fractionation column and said first fractionation column being fluidly connected to a first residue liquid discharge line through which a first residue liquid bottom stream in liquid phase can be discharged from the first fractionation column;
- a recycling line fluidly connected to first residue liquid discharge line and the extraction column, arranged to allow recycling of a recycle portion of the first residue liquid bottom stream in liquid phase and having the same composition as the first residue liquid bottom stream;
- a recycle pump arranged between the first fractionation column and the extraction column to increase the pressure of at least the recycle portion.

[0009] The present invention will now be further illustrated by way of example, and with reference to the accompanying non-limiting drawings, in which:

Figure 1 schematically shows a process line up for preparing a lean methane-containing gas stream wherein a first embodiment of the invention is employed;
Figure 2 schematically shows a process line up for preparing a lean methane-containing gas stream wherein a second embodiment of the invention is employed;
Figure 3 schematically shows a process line up for preparing a lean methane-containing gas stream wherein a third embodiment of the invention is employed.

[0010] 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. The same reference numbers refer to similar components, streams or lines.

[0011] In the method and system disclosed herein, a first portion of the liquid bottom stream from an extraction column is partly depressurized and subsequently passed, at reduced pressure, into a first fractionation column of a fractionation system. The first portion being passed into the first fractionation column has the same composition as the liquid bottom stream being withdrawn from the extraction column. A recycle portion derived from a first residue liquid bottom stream removed as liquid from the first fractionation column is recycled into the extraction column, whereby the recycle portion enters the extraction column in liquid phase. The recycle portion has the same composition as the first residue liquid bottom stream being withdrawn from the first fractionation column. The amount of the first residue liquid bottom stream comprised in the recycle portion is more than zero, expressed as a fraction of the first residue liquid bottom stream being withdrawn from the first fractionation column.

[0012] It has been found that the recovery of ethane and/or propane improves when applying recycling in this way, while the second further consecutive fractionation columns in the fractionation system do not need to be operative. In fact, the first fractionation column does not need to be fully operative, either, although operation of the first fractionation column has been found to improve the recovery rates of ethane and propane.

[0013] It has been found that, even if the first fractionation column is not refrigerated or reboiled (equivalent to the first fractionation column not being "fully operative"), whereby all of the liquid bottom stream from the extraction column that passes into the first fractionation column is withdrawn in the form of the first residue liquid bottom stream from the first fractionation column, the recovery of both ethane and propane is improved. Due to the depressurization, from an extraction pressure to a reduced pressure, of the first portion of the liquid bottom stream from the extraction column, some of the lighter components from the liquid bottom stream, such as methane and possibly nitrogen and helium, flash off and are removed from the residual liquid phase in the first fractionation column. Herewith the effectiveness of the recycling on the recovery rate of ethane and/or propane in the extraction column is improved.

[0014] If the first fractionation column is operated, by refrigerating a reflux condenser providing reflux to the first fractionation column and/or heating a reboiler providing a stripping vapour to the first fractionation column, the amount of methane and components lighter than methane (more volatile than methane) in the recycle portion will be lower.

[0015] In any case, since the recycle portion has the same composition as the first residue liquid bottom stream being withdrawn from the first fractionation column, further fractionation of first residue liquid bottom stream can be dispensed with in the context of the present invention, or applied only to a remaining portion of first residue liquid bottom stream, which is not recycled.

[0016] Thus, preferably the recycle path bypasses any subsequent fractionation columns within the fractionation system downstream of the first fractionation column, so that the recycle portion does not pass through more than one fractionation column downstream of the extraction column.

[0017] Another benefit of the invention is that it decouples the quality, particularly the C_5+ content, of the lean methane-containing gas stream that is produced from the start-up of any fractionation unit. This may comprise initially recycling a substantial amount of, for instance more than 75 % of, the liquid bottom stream to achieve the targeted the C_5+ content in the lean methane-containing gas stream, and subsequently to gradually reduce the recycle fraction, for instance by opening a valve to a fractionation system.

[0018] The invention can be applied with any type of extraction column, such as a scrub column or an NGL extraction column. A scrub column is typically operated at a higher pressure than an NGL extraction column (40 bara or above, as compared to between 25 and 35 bara for a typical NGL extraction column). Therefore the invention is typically more beneficial when applied on a scrub column, as recovery of ethane (and propane) in a scrub column is typically less deep than in NGL extraction columns.

[0019] Furthermore, while the invention can be applied on any hydrocarbon feed stream that contains methane and one or more C_2+ hydrocarbons, the invention is typically more beneficial when applied on relatively lean hydrocarbon feed streams. It is envisaged that the invention becomes increasingly beneficial when treating hydrocarbon feed streams having a methane content of at least 80 mol% and a non-zero ethane content of less than 5 mol% and/or a total content of C_2 + C_3 of less than 7 mol%.

[0020] Figure 1 shows a schematic line up containing an embodiment of the invention. Part of the line up is an apparatus 10 for preparing a lean methane-containing gas stream 510. It employs an extraction column 20 with a first feeding inlet 22 located in a first feeding position. The first feeding inlet may be any suitable inlet including optional feed internals 24. The extraction column 20 also has an overhead vapour outlet 26, for discharging a vaporous overhead stream 30. The lean methane-containing gas stream 510 can be produced from the vaporous overhead stream 30.

[0021] In the example of Figure 1, the producing of the lean methane-containing gas stream 510 from the vaporous overhead stream 30 involves recompression via at least overhead compressor 44, optionally followed by one or more booster compressors (not shown). An optional overhead cold recovery heat exchanger (not shown, but reference is made to e.g. US patent application publication No. 2009/0064713 which contains an example) may optionally be provided, wherein the lean methane-containing gas stream 510 is in indirect heat exchanging contact with the vaporous overhead stream 30 before it is recompressed in the overhead compressor 44. Various suitable options are available for said producing of the lean methane-containing gas stream 510 from the vaporous overhead stream 30, including merely accepting the vaporous overhead stream 30 as discharged from the extraction column 20 to form the lean methane-containing gas stream 510. In Figure 2 another way of producing the lean methane-containing gas stream 510 from the vaporous overhead stream 30 is illustrated. This will be discussed in more detail herein below.

[0022] The extraction column 20 also has a liquid bottom stream outlet 28 located at a first withdrawal level. The first withdrawal level is gravitationally lower than the first feeding position. The extraction column 20 may further comprise other internals, such as for example one or more contacting devices 23 in the form of a plurality of contacting trays and/or packing (structured packing or non-structured packing).

[0023] The first feeding inlet 22 is in fluid communication with a feed supply 5 of a hydrocarbon feed stream 15. In the embodiment as shown, this feeding inlet 22 is arranged below at least one of the one or more contacting devices 23. In the embodiment of Figure 1, an optional inlet phase separator 16 is provided between the feed supply 5 and the first feeding inlet 22. A liquid phase feed line 17 extends between a liquid outlet of the optional inlet phase separator 16 and the first feeding inlet 22. A Joule Thomson valve 19 is provided in the liquid phase feed line 17.

[0024] A vapour phase feed line 18 extends between a vapour outlet of the optional inlet phase separator 16 and an auxiliary feeding inlet 21 into the extraction column 20. The auxiliary feeding inlet 21 may be any suitable inlet including optional feed internals 25. Means for partially condensing the vapour phase is provided in line 18. Such means for partially condensing the vapour phase may comprise at least one from the group consisting of a heat exchanger to extract heat from the vapour phase in line 18 and an expansion device to lower the pressure and a combination thereof. The expansion device may be in the form of a Joule Thomson valve and/or a dynamic expander such as, for example, an expansion turbine, and/or a combination thereof.

[0025] In the example of Figure 1, the means for partially condensing the vapour phase is represented by an expander in the form of a turbo expander 14. The turbo expander 14 is shaft-coupled to an overhead compressor 44 via shaft 13-13'.

[0026] A flow control system comprising a flow rate controller is arranged to control an actual feed rate of the hydrocarbon feed stream 15 flowing into the extraction column 20. The flow control system may take any suitable form. It may, for instance, be provided in the form of a flow restriction valve in the feed line 15 between the feed supply 5 and the extraction column 20. In the example of Figure 1, however, it is embodied as part of a depressurizing system 535 downstream of an (optional) liquefaction system 500. More about such optional liquefaction system 500 and optional depressurizing system 535 will be described below.

[0027] The liquid bottom stream outlet 28 feeds into a liquid bottom stream discharge line 40, provided with a pressure reduction device, here represented in the form of a bottom stream control valve 55. The liquid bottom stream discharge line 40 is fluidly connected to a fractionation system 300, whereby the bottom stream control valve 55 separates the fractionation system 300 from the extraction column 20. The bottom stream control valve is suitable on liquid level control

LC of the extraction column 20.

[0028] Fractionation systems are well known to the person skilled in the art and many of its details are not essential in the context of the present invention. In the context of the present invention, the fractionation system employs at least three consecutively arranged fractionation columns. Generally, the fractionation system 300 receives at least a part of the liquid bottom stream 40 from the extraction column 20 that is to be subjected to fractionation into one or more fractionated streams 310, 320, each of single component with a relatively high purity compared to the liquid bottom stream 40. Such fractionated streams can be used as refrigerant make-up, or sold separately or sold as natural gas liquids (NLG) and/or liquefied petroleum gas (LPG) products. The fractionated streams 310, 320 often consist of hydrocarbon components that are vaporous under atmospheric pressure and temperature. Typically, the fractionation system also produces a so-called stabilized liquid stream 390, which can remain in liquid phase under atmospheric pressure and ambient temperature conditions. However, this is entirely optional. Moreover, the fractionation system 300 does not have to be fully operative, when carrying out the present invention.

[0029] A first fractionation column 350 of the at least three consecutively arranged fractionation columns is in direct fluid communication contact, via the bottom stream control valve 55, with the liquid bottom stream outlet 28 of the extraction column 20. The first fractionation column 350 is in fluid communication with a first overhead discharge line 352, and with a first residue liquid discharge line 50. An optional reboiler 357 may be connected to the first residue liquid discharge line 50, or optionally directly to the first fractionation column 350 without using the first residue liquid discharge line 50. A first fractionated stream discharge line 305 is in fluid communication with the first overhead discharge line 352, so that at least a part of the first fractionation overhead stream that is withdrawn from the first fractionation column 350 can be discharged in the form of a first fractionated stream 305.

[0030] A stream splitter 52 is provided in the first residue liquid discharge line 50, via which a remaining portion discharge line 70 is connected to the first residue liquid discharge line 50. A recycling line 60 is fluidly connected to the stream splitter 52. More will be disclosed about the recycling line 60 below.

[0031] The remaining portion discharge line 70 is in fluid communication with a second fractionation column 360. The second fractionation column 360 is in fluid communication with a second overhead discharge line 362, and with a second residue liquid discharge line 369. A second fractionated stream discharge line 310 is in fluid communication with the second overhead discharge line 352 - in the embodiment as shown via a second fractionation overhead gas/liquid separator 364 as will be further discussed in the next paragraph. An optional second reboiler 367 may be connected to the second residue liquid discharge line 369.

[0032] In the embodiment as shown, an optional second fractionation reflux system 361 is provided to serve the second fractionation column 360 with a second reflux stream 365 in liquid phase. The second fraction reflux system 361 employs a second fractionation overhead condenser 363 arranged to partly condense the second fractionation overhead vapour stream 362 that is discharged from the second fractionation column 360. The second fractionation overhead condenser 363 is fluidly connected to the second fractionation overhead gas/liquid separator 364. The second fractionated stream discharge line 310 is in fluid communication with the second fractionation overhead gas/liquid separator 364 via a vapour outlet. A second fractionation reflux line 365 is also in fluid communication with the second fractionation overhead gas/liquid separator 364, via a liquid outlet. The second fractionation column 360 is in fluid connection with the second fractionation overhead gas/liquid separator 364 via second first fractionation reflux line 365. An optional second fractionation reflux pump 366 is arranged in the second fractionation reflux line 365 to assist the flow of the second reflux stream 365.

[0033] A third fractionation column 370 is connected he second residue liquid discharge line 369. More fractionation columns may be provided if desired. However, in the embodiment as shown, the third fractionation column 370 is in fluid communication with a third fractionated stream discharge line 320 and with a stabilized liquid discharge line 390. Optionally, a third fractionation reflux system (not shown) is associated with the third fractionation column 370, similarly to the second fractionation reflux system 361 being associated with the second fractionation column 360.

[0034] Preferably, the first fractionation column 350 is a demethanizer. Herewith it is achieved that a relatively small amount of methane and lighter - and/or more volatile - components are present in the first residue liquid discharge line 50 that can end up in the recycling line 60, while a broad spectrum of C_2+ hydrocarbons are available to be drawn off into the recycling line 60. The first fractionated stream 305 is not expected to be comprised of essentially pure methane, as together with the methane also more volatile components are expected to end up preferentially in the first fractionation overhead vapour stream 352.

[0035] At least one the at least three consecutive fractionation columns of the fractionation system, other than the first fractionation column, may be a debutanizer. Preferably, at least one of the fractionation columns upstream of the stabilized liquid discharge line is a debutanizer. In the example of Figure 1, the last fractionation column of the three consecutive fractionation columns, in the present example the third fractionation column 370, is a debutanizer.

[0036] An optional first fractionation reflux system 351 may be provided at the top of the first fractionation column 350. In the embodiment as shown, the optional first fractionation reflux circuit 351 which employs a reflux condenser in the form of a first fractionation overhead condenser 353 arranged to partly condense the first fractionation overhead vapour stream 352 that is discharged from the first fractionation column 350. The first fractionation overhead condenser 353 is fluidly connected to a first fractionation overhead gas/liquid separator 354. A first fractionated stream discharge line 305 is in fluid communication with the first fractionation overhead gas/liquid separator 354, as well as a first fractionation reflux line 355. The first fractionation column 350 is in fluid connection with the first fractionation overhead gas/liquid separator 354 via the first fractionation reflux line 355. An optional first fractionation reflux pump 356 is arranged in the first fractionation reflux line 355, to assist the flow of the first reflux stream 355.

[0037] In the embodiment of Figure 1, a recycle pump 62 and a recycle chiller 32 are arranged in the recycling line 60 between the first fractionation column 350 and the extraction column 20. The recycling line 60 follows a recycle path to a location into the extraction column 20 that is preferably gravitationally higher than the first feeding position. In this case, the recycle path extends from the first fractionation column 350, through the first residue liquid discharge line 50, the stream splitter 52, a recycle pump 62, and a recycle chiller 33, to a second feeding inlet 32 into the extraction column 20. Preferably, the second feeding inlet 32 is in a second feeding position that is gravitationally higher than the first feeding position.

[0038] The recycle chiller 33 does not have to be provided, but it is a preferred option to have one, because the temperature of the first residue liquid bottom stream in the first residue liquid discharge line 50 may be higher than the temperature anywhere in the extraction column 20. In one group of embodiments, the recycle chiller 33 may be a stand-alone chiller unit with chilling of the recycle stream 60 as its sole specific function. In other groups of embodiments, the recycle chiller 33 may be integrated with any other heat exchanger arrangement in the process. It may be integrated with, for instance, the liquefaction system 500 if provided and/or exercise a combined function. For instance, it may share a heat exchanger with another stream to be cooled, such as a stream derived from the lean methane-containing gas stream 510 and/or it may share in refrigeration duty from a refrigerant circuit that also refrigerates another stream.

[0039] The second feeding inlet 32 may comprise any suitable form of internals for handling liquids, such as for example a liquid nozzle distributor 34. In specific embodiments, the second feeding inlet 32 and/or its associate internals, may optionally be integrated with and/or combined with the auxiliary inlet 21 and/or its associated internals.

[0040] A remaining portion flow control valve 75 is provided in the remaining portion discharge line 70, suitable on liquid level control of the first fractionation column 350.

[0041] A recycle control valve 65 is provided in the recycling line 60 to control how large a fraction of the first residue liquid bottom stream 50 is split off to be discharged into the recycling line 60. The recycle flow control valve 65 may be operated under manual control by an operator, or it may be operationally connected to a split ratio controller C.

[0042] In preferred embodiments, the split ratio controller C is arranged to lower the recycle fraction, which is the fraction of first residue liquid bottom stream 50 that is drawn from the liquid bottom stream 50 into the recycle portion over the course of time. Preferably, the reduction is applied in response to an actual increase of the actual feed rate over said course of time. Preferably, the reduction is applied in response to an actual increase of the actual feed rate over said course of time. For example of Figure 1, a signal to represent the actual feed rate originates from a rundown flow rate sensor F downstream of the optional liquefaction system 500. Generally, a flow rate signal may be obtained from any suitable location upstream or downstream of the extraction column 20, including locations selected from the non-exhaustive list consisting of: the overhead vapour stream 30; the lean methane-containing gas stream 510; the first residue liquid bottom stream 50; the feed supply 5; the hydrocarbon feed stream 15; and anywhere else between the feed supply 5 of the hydrocarbon feed stream 15 and the extraction column 20.

[0043] The liquefaction system 500 is entirely optional. If it is provided, as is the case in Figure 1, it is arranged in fluid communication with the overhead vapour outlet 26 of the extraction column 20. In such a liquefaction system 500, the lean methane-containing gas stream 510 can be subjected to full condensation and subcooling, to provide a liquefied methane-containing stream 530. Many possible liquefaction processes are available to the person skilled in the art, including processes that employ heat exchanging of the lean methane-containing gas stream 510, or parts thereof, against evaporating refrigerants that are circulated in two or more refrigeration circuits. Various parts of the apparatus described herein, including for instance the feed supply 5 and/or the recycle chiller 33 may be integrated with, and/or form part of, the liquefaction system 500, for instance by sharing or making use of refrigeration duty from the liquefaction system 500 (not shown in the drawing).

[0044] An optional depressurization system 535 may be provided downstream of the liquefaction system 500, to depressurize the liquefied methane-containing stream 530, preferably to a pressure of between 1 and 2 bara. The depressurization system 535 may comprise one or more expander turbines and/or one or more Joule Thomson valves and/or a combination thereof, as well as a flash vapour separator arranged to receive the depressurized liquefied methane-containing stream 530 and remove flashed-off vapours from the depressurized liquefied methane-containing stream 530 (not shown). In specific embodiments, the depressurization system 535 may be integrated with the liquefaction system 500 and/or form a part of the liquefaction system 500. In one example, part of the flashed-off vapours is re-compressed and reinjected into the process stream in the liquefaction system 500 (not shown).

[0045] The apparatus of Figure 1 works as follows. A hydrocarbon feed stream 15 is fed from the feed supply 5 into the extraction column 20 at the first feeding position and at an actual feed rate. The hydrocarbon feed stream 15 contains methane, and one or more C_2+ hydrocarbons. In preferred embodiments, the hydrocarbon feed stream 15 contains ethane as one of the C_2+ hydrocarbons, in any non-zero amount.

[0046] In the embodiment of Figure 1, the feeding of the hydrocarbon feed stream 15 into the extraction column 20 comprises separating a liquid phase of the hydrocarbon feed stream 15 from a vapour phase. The liquid phase is discharged from the optional inlet phase separator 16 into the liquid phase feed line 17, and in the embodiment of Figure 1 only essentially this liquid phase 17 is passed into the extraction column 20 via said first feeding inlet 22. The Joule Thomson valve 19 serves to match the pressure of the liquid phase 17 to the operating pressure in the extraction column 20 (corresponding to the extraction pressure). The vapour phase is discharged into the vapour phase feed line 18, then partially condensed by refrigeration and/or expansion, and passed to and into the extraction column 20 via the auxiliary inlet 21. In the embodiment of Figure 1, the partial condensation of the vapour phase in line 18 is achieved by expanding in the turbo expander 14. Work generated in the turbo expander 14 is optionally used to drive the overhead compressor 44 via the shaft 13-13'.

[0047] The hydrocarbon feed stream from the feed supply 5 may be formed out of any hydrocarbon containing gas stream. A common example of such hydrocarbon containing gas stream is a natural gas stream, obtained from natural gas or petroleum reservoirs. As an alternative the hydrocarbon feed stream may also be obtained from another supply source, including for instance a synthetic source, such as a Fischer-Tropsch process.

[0048] When the hydrocarbon feed stream 15 is obtained from a natural gas stream, it is usually comprised primarily of methane. The hydrocarbon feed stream 15 may comprise at least 50 mol% methane, and often at least 80 mol% methane as is often the case with natural gas.

[0049] Depending on the source, hydrocarbon feed stream may contain varying amounts of hydrocarbons heavier than methane, such as in particular ethane, propane and the butanes, and possibly lesser amounts of pentanes and aromatic hydrocarbons. The composition varies depending upon the type and location of the gas.

[0050] 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, which may be removed to various degrees as well. Particularly, CO_2 and hydrocarbons heavier than butanes should be removed in order to avoid freezing out of these components during subsequent liquefaction.

[0051] Thus, if desired, the hydrocarbon feed stream 15 may have been pre-treated as part of being supplied from the feed supply 5. 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.

[0052] Hydrocarbons heavier than methane are removed in various degrees from the hydrocarbon feed stream 15, as part of producing the lean methane-containing gas stream. The extraction column 20 that is employed for this purpose may be operated at an extraction pressure in a range of from 20 bara to 65 bara, preferably in a range of from 40 bara to 65 bara, more preferably in a range of from 40 bara to 60 bara.

[0053] In the embodiment of Figure 1, the removing of the hydrocarbons heavier than methane from the hydrocarbon feed stream 15 involves withdrawing a vaporous overhead stream 30 from the extraction column 20. The vaporous overhead stream contains at least the majority of the methane from the hydrocarbon feed stream 15. The lean methane-containing gas stream 510 is produced from the vaporous overhead stream 30. In the embodiment of Figure 1, this involves recompression of the vaporous overhead stream 30 in the overhead compressor 14, which is driven by turbo-expander 14.

[0054] At the same time, a liquid bottom stream 40 is withdrawn from the extraction column 20 from the first withdrawal level. The liquid bottom stream 40 contains at least a recovery fraction of the C_2+ hydrocarbons from the hydrocarbon feed stream 15.

[0055] Next, the pressure of at least a first portion of the liquid bottom stream 40 is reduced. The pressure is reduced preferably by at least 5 bar (at least 10 bar in case the extraction column 20 is provided in the form of a scrub column). The pressure reduction may typically be between from 10 bar to 30 bar. The first portion is subsequently passed, at reduced pressure, into the first fractionation column 350 of the at least three consecutive fractionation columns of the fractionation system 300. Hereby, the first portion being passed into the first fractionation column 350 has the same composition as the liquid bottom stream 40 being withdrawn the extraction column 20.

[0056] A first fractionated overhead stream 352 is withdrawn from the first fractionation column 350 in vapour phase. The first fractionated overhead stream 352 comprises at least the majority of any methane that remains in the first portion of the liquid bottom stream 40.

[0057] A first residue liquid bottom stream 50 is simultaneously withdrawn from the first fractionation column 350. The first residue liquid bottom stream contains at least a recycle portion 60. This recycle portion 60 is recycled, at increased pressure, into the extraction column 20. To this end, the first residue liquid bottom stream 50 is split into the recycle portion 60 and a remaining portion 70. The recycle portion 60 has the same composition as the first residue liquid bottom stream 50 being withdrawn from the first fractionation column 350. The content of C_5+ hydrocarbons in the first residue liquid bottom stream 50 and the recycle portion 60 may be between 40 and 75 mol%, whereby the remainder up to 99.0 mol%, preferably up to 99.5 mol%, of the first residue liquid bottom stream 50, respectively the recycle portion 60, may consist of C_2-C_4 hydrocarbons (i.e. one or more hydrocarbons selected from the group consisting of C_2, C_3, and C_4 hydrocarbons).

[0058] The recycle portion 60 contains a recycle fraction of less than unity (1.00) from the first residue liquid bottom stream 50 being withdrawn from the first fractionation column 350, and it is fed back into the extraction column 20 in liquid phase, preferably fully liquid phase free from any vapour. The fraction of the first residue liquid bottom stream 50 comprised in the recycle portion is more than zero.

[0059] In the embodiment of Figure 1, the recycle portion 60 is fed back into the extraction column 20 via the second feeding inlet 32. To that end, the pressure of at least the recycle portion 60 is increased, with the recycle pump 62. The recycle portion 60 is optionally refrigerated (sub-cooled) in the recycle chiller 33, by heat exchanging the recycle portion 60 against a chilling stream. Preferably, the recycle portion 60 enters the extraction column 60 gravitationally higher than the first feeding position.

[0060] The remaining portion 70 may optionally be subjected to further fractionation in the fractionation system 300, thereby obtaining at least one fractionation product stream (310,320) being enriched in a selected hydrocarbon component from the remaining stream 70. The remaining portion 70 may for instance be passed to the second fractionation column 360 in the fractionation system 300 at reduced pressure.

[0061] The fraction of the first residue liquid bottom stream 50 that is split off from the first residue liquid bottom stream 50 into the recycle portion 60 may be controlled using the split ratio controller C. This split ratio controller C is preferably programmed to reduce the fraction of the liquid bottom stream 50 that is split off into the recycle portion 60 over a course of time. There can be several reasons for this. One reason could be that in specific embodiments the function of the recycle stream 60 may slowly be taken over by another absorber liquid, such as a fractionated stream 320 from the fractionation system 300 (if provided) when such fractionated stream 320 becomes available. A second reason could be that liquid build-up in the extraction column 20 limits the allowable flow rate of the recycle portion 60 over the course of time. Particularly if, in the course of time, the actual feed rate is allowed to increase, the fraction of the first residue liquid bottom stream 50 that is split off in the recycle portion 60 may have to be lowered to avoid overloading the recycle pump 62 and/or the extraction column 20.

[0062] Figure 2 illustrates an embodiment that combines the recycle capability of Figure 1 with a reflux capability to generate a reflux stream from the vaporous overhead stream 30. In this embodiment, the hydrocarbon feed stream 15 from the feed supply 5 is in fluid communication with the first feeding inlet 22 without first being separated in the inlet separator 16 of Figure 1.

[0063] Furthermore, the embodiment of Figure 2 is provided with an overhead condenser 31 which is fluidly connected to the overhead vapour outlet 26, arranged to receive and partially condense the vaporous overhead stream from the extraction column 20. The overhead condenser 31 may comprise a plurality of consecutive heat exchangers operating at progressively decreasing temperature levels, for instance each operating with a different refrigerant composition and/or at different pressure level. In one group of embodiments, the overhead condenser 31 may be a stand-alone heat exchange unit having as its sole specific function removing of heat from the overhead vapour stream 30. In other groups of embodiments, the overhead condenser 31 may be integrated with any other heat exchanger arrangement in the process. It may be integrated with, for instance, the liquefaction system 500 if provided and/or exercise a combined function. For instance, it may share a heat exchanger with another stream to be cooled, such as a stream derived from the lean methane-containing gas stream 510 and/or it may share in refrigeration duty from a refrigerant circuit that also refrigerates another stream.

[0064] An overhead phase separator 39 is fluidly connected to the overhead condenser 31 to receive the partially condensed effluent stream from the overhead condenser 31. It is arranged to receive and phase separate a partially condensed overhead stream from the overhead condenser 31, into the lean methane-containing gas stream 510 and a liquid reflux stream 36. The lean methane-containing gas line 510 communicates with the overhead phase separator 39 via a vapour outlet. The overhead phase separator 39 is furthermore connected to the second feeding inlet 32 into the extraction column 20, via a reflux line 36, for feeding the liquid reflux stream into the extraction column 20. A reflux pump 38 is optionally provided in the reflux line 36. Alternatively, flow of the liquid reflux stream 36 can be driven by gravity if the overhead phase separator 39 is arranged sufficiently high above the second feeding position.

[0065] In the embodiment of Figure 2, the vaporous overhead stream 30 is partially condensed in the overhead condenser 31, by removing heat from the vaporous overhead stream 30 by indirect heat exchanging. An effluent stream containing the partially condensed overhead stream 30 is discharged from the overhead condenser 31, and passed to the overhead phase separator 39 where the partially condensed overhead stream is allowed to separate into two phases. The lean methane-containing gas stream is drawn from the overhead phase separator 39 in vapour phase, while a liquid reflux stream 36 is drawn from the overhead phase separator 39 in liquid phase.

[0066] The liquid reflux stream 36 is fed into the extraction column 20 at the second feeding position, optionally assisted by the reflux pump 38 and/or gravity.

[0067] A mixing junction 37 is optionally provided in the overhead vapour line 30, for admixing the recycle portion 60 with the vaporous overhead stream upstream of the overhead condenser 31. In the embodiment of Figure 2 the mixing junction 37 is arranged in fluid communication with the recycling line 60 and upstream of the overhead condenser 31 between the overhead vapour outlet 26 and the overhead condenser 31. The mixing junction 37 is in fluid communication with the overhead condenser 31. Preferably, a recycle chiller 33 is provided in the recycling line 60 similar to the embodiment of Figure 1. In the embodiment of Figure 2, the recycle chiller 33 can be arranged in the recycling line 60 between the stream splitter 52 and the mixing junction 37.

[0068] Other elements that have not been described with specific reference to Figure 2 may be identical to, or similar to, corresponding elements of the embodiment of Figure 1, and work in the same way as described above with reference to Figure 1.

[0069] In operation, the recycle portion 60 in the embodiment of Figure 2 is split off from the first residue liquid bottom stream 50 in the same way as described above with reference to the embodiment of Figure 1. However, in the embodiment of Figure 2 the recycle portion 60 flows through the recycling line 60 to and into the mixing junction 37, where the recycle portion 60 is admixed with the vaporous overhead stream 30 thereby forming an admixed stream. The admixed stream flows through the overhead condenser 31, where it is subjected to the indirect heat exchanging by which the partial condensing of the vaporous overhead stream 30 is accomplished while a the same time the recycle portion 60 in the admixed stream is (further) subcooled.

[0070] The embodiment of Figure 3 is similar to the embodiment of Figure 2, except for the location of the mixing junction 37 which in the case of Figure 3 is located in the reflux line 36. Preferably, the mixing junction 37 is arranged between the reflux pump 38 (if provided) and the second feeding inlet 32, which has as advantage that the recycle flow from the recycling line 60 does not load the reflux pump 38. Alternatively (not shown), the reflux stream 36 and the recycle stream 60 are fed into the extraction column 20 via mutually separate inlets, which can be at the same gravitational level or at mutually different gravitational levels in the extraction column 20.

[0071] Model calculations have been performed using the line up of Figure 2 as example, to illustrate the effect of the recycle stream 60 on the recovery of C_2. Table 1 shows the composition of the hydrocarbon feed stream 15, which is fed into the extraction column 20 at a pressure of 58 bara and a temperature of 20°C. Under these conditions, the hydrocarbon feed stream 15 is practically fully vaporous. The full capacity feed rate in this example is 180 kg/s. However, in these calculations the extraction column 20 has been operated at 50 % of its full capacity, thereby simulating circumstances during a start up procedure, and allowing spare capacity in the extraction column 20 for handling a substantial recycle stream 60.

Table 1: Composition of the hydrocarbon feed stream

Nitrogen (N_2)	8.20 mol%
Methane (C_1)	86.6 mol%
Ethane (C_2)	3.17 mol%
Propane (C_3)	1.12 mol%
Butanes (C_4)	0.52 mol%
Heavies (C_5+)	0.41 mol%

[0072] According to the model calculation, cooling the overhead condenser 31 at a base duty of 8.55 MW results in 7.14 kg/s of reflux stream in reflux line 36 at a temperature of about -46°C. The recovery of ethane, without recycle, is 1.78 % while the amount of C_5+ in the lean methane-containing gas stream 510 is 0.040 mol%. Unless otherwise stated, in the present context recovery of a selected component (e.g. C_2 or C_3) is defined as the flow rate of that selected component in the liquid bottom stream 40 minus the flow rate of that component in the recycle stream 60, expressed as a percentage of the flow rate of the same component in the hydrocarbon feed stream 15 as it is delivered from the feed source 5.

[0073] Calculated values of the recovery percentages of ethane (C_2 recovery) and propane (C_3 recovery) in the liquid bottom stream 40, the overhead condenser 31 cooling duty, and the total liquid flow rate of liquid passing through reflux line 36, are presented in Table 2 for a variety of recycle portions consisting of various recycle fractions from the first residue liquid bottom stream 50, varying from 0 % (no recycle) to about 75 %. Each time the overhead condenser 31 duty was adapted to achieve 0.040 mol% of C_5+ in the lean methane-containing gas stream 510.

[0074] In the calculations, the first fractionation column 350 was assumed to be a demethanizer operating at a pressure of 30 bara (corresponding to the reduced pressure of the at least first portion of the liquid bottom stream 40). The temperature in the first overhead discharge line 352 was about -17 °C, the temperature of the first residue liquid bottom stream 50 was about +56 °C.

Table 2: Ethane and propane recovery in the liquid bottom stream 40. In each case the C_5+ content in the lean methane-containing gas stream 510 is 0.040 mol%.

Recycle fract. (%)	Flow in reflux line 36 (kg/s)	Duty in overhead condenser 31 (MW)	C_2 recov. (%)	C_3 recov. (%)
0	7.14	8.55	1.78	5.93
25	7.70	8.41	1.94	6.01
50	9.40	8.38	2.32	6.53
67	14.0	9.58	3.57	9.04
75	18.5	10.5	4.68	11.0

[0075] It can be seen that with the recycle from the first residue liquid bottom stream 50, the C_2 and C_3 recovery improves significantly compared to no recycle, while the C_5+ specification in the lean methane-containing stream 510 can be maintained at the same level. Up to recycle fraction of about 0.55 the required duty on the overhead condenser 31 can even be lowered compared to the case of no recycling (0 %). Starting with recycling at recycle fraction of 0.50 the recycling becomes relatively effective (per recycled amount) at improving both C_2 and C_3 recovery. However, it is not recommended to employ recycle fractions of above 75% for a prolonged duration. Preferably, the recycle fraction is limited to a value whereby the total flow rate of the reflux stream 36 and the recycle stream 60 combined exceeds the reflux flow rate attained when the extraction column 20 is operated at 130 % of its capacity. Otherwise, the total liquid loading of the extraction column 20 may exceed its capacity. In the present example, this translates to maintaining the recycle fraction to 0.75, to avoid overloading the extraction column 20 by adding too much of the liquids at the top.

[0076] It is preferred to limit the total flow rate of the reflux stream 36 and the recycle stream 60 combined to the reflux flow rate attained when the extraction column 20 is operated at 100 % of its capacity. In the present example, this translates to limiting the recycle fraction to about 0.67 or lower.

[0077] Table 3, below, presents a reference case (not according to the present invention) wherein instead of a recycle portion from the first residue liquid bottom stream 50, an alternative recycle portion is drawn off from the liquid bottom stream 40 at a range of recycle fractions. The temperature of the liquid bottom stream 40 was about -13 °C.

Table 3: Comparative example based on an alternative recycle from the liquid bottom stream 40 instead of the recycle from the first residue liquid bottom stream 50.

Recycle fract. (%)	Flow in reflux line 36 (kg/s)	Duty in overhead condenser 31 (MW)	C_2 recov. (%)	C_3 recov. (%)
0	7.14	8.55	1.78	5.93
25	7.69	8.30	1.79	5.96
50	9.42	8.02	1.85	6.17
67	14.2	8.71	2.35	8.14
75	18.8	9.10	2.64	9.45

[0078] For the purpose of interpreting Table 3, recovery of a component (e.g. C_2 or C_3) is defined as the flow rate of that component in the not-recycled remainder of the liquid bottom stream 40 (this is what would be passed to the fractionation system) as a percentage of the flow rate of the same component in the hydrocarbon feed stream 15 as it is delivered from the feed source 5. The C_5+ content in the lean methane-containing gas stream 510 is 0.040 mol% in all cases of Table 3.

[0079] By comparing Table 2 with Table 3, it can be seen that the recycle from the first residue liquid bottom stream 50 back to the extraction column 20 is more effective in providing a higher recovery of C_2 and C_3. In particular the recovery of ethane is much better in the case of the invention than in the comparative example.

[0080] The recovery percentages are higher in Table 2 compared to those in Table 3 for equal recycle fractions, and on top of that it should be noted that the corresponding flow rate of the recycle streams in the reference case are between approximately 13 and 18% higher than in the case of the invention (because in the invention parts of the liquid bottom stream 40 are not available for recycling as they end up in the first overhead discharge line 352).

[0081] The improved recovery percentages over the reference case come at the cost of higher refrigeration duty. However, it is noted that the relative recovery percentages of ethane in the invention case of Table 2 compared to the reference case of Table 3 is about 5 to 6 times as high as the relative difference in refrigeration duty.

[0082] Table 4 shows, for the same conditions as for Table 2, effective ethane and propane recovery values defined as the flow rate of ethane (respectively propane) in the remaining portion 70 of the first residue liquid bottom stream 50, expressed as a percentage of the flow rate of that same component in the hydrocarbon feed stream 15 as it is delivered from the feed source 5.

Table 4: Effective ethane and propane recovery in the first residue liquid bottom stream 50. Same conditions as in Table 2.

Recycle Fraction (%)	Effective C_2 recovery (%)	Effective C_3 recovery (%)
0	1.32	5.56
25	1.32	5.59
50	1.36	5.77
67	1.70	7.53
75	1.89	8.66

[0083] The effective recovery rates are lower than the recovery rates in the liquid bottom stream 40 shown in Table 2, because some of the ethane and propane ends up in the vapour phase in the first fractionated stream discharge line 305. The degree that this happens depends on the operation conditions in the first fractionation column 350, and the type of column employed for this first fractionation column 350. In the present example, the first fractionation column 350 was optimized to minimize the amount of methane in the first residue liquid bottom stream 50. This can be mitigated by operating the first fractionation column 350 at a lower temperature, which increases the effective recovery values. The loss of propane through the first fractionated stream discharge line 305 is less pronounced the loss of ethane.

[0084] The calculations above assume an actual feed rate of 50 % of the full capacity, which represents a typical condition during start-up phase of a line-up. It is not unusual in the start-up phase of a full natural gas liquefaction plant that the fraction system is not fully operative and thus holding up the start-up of the liquefaction system. Gradually, as the liquefaction system is cooled down, the actual feed rate can be increased. It is envisaged that the recycle fraction is lowered as the actual feed rate increases.

[0085] The invention has been illustrated with reference to non-reboiled extraction columns. In particular, in the specific embodiments shown at least part of the hydrocarbon feed stream 15 is fed into the extraction column 20 below the lowest of the contacting devices 23 arranged in the extraction column 20. However, the invention can be applied to extraction column arrangements, including reboiled extraction columns. Likewise, different fractionation column arrangements can be applied than the one example embodiment of Figure 1.

[0086] The increased recovery of ethane (and propane) allows for faster production of refrigerant make-up for initial loading of refrigeration cycles in a liquefaction system.

[0087] 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.

Claims

1. Method of preparing a lean methane-containing gas stream, comprising:

- feeding a hydrocarbon feed stream into an extraction column at a first feeding position and at an actual feed rate, said hydrocarbon feed stream containing at least methane and one or more C_2+ hydrocarbons;
- withdrawing from the extraction column a vaporous overhead stream containing at least the majority of the methane from the hydrocarbon feed stream;
- producing a lean methane-containing gas stream from said vaporous overhead stream;
- withdrawing from the extraction column a liquid bottom stream, from a first withdrawal level being gravitationally lower than the first feeding position;
- reducing the pressure of at least a first portion of the liquid bottom stream and subsequently passing the first portion at reduced pressure into a first fractionation column of at least three consecutive fractionation columns

of a fractionation system, whereby the first portion being passed into said first fractionation column has the same composition as said liquid bottom stream being withdrawn the extraction column;
- withdrawing from the first fractionation column a first fractionated overhead stream in vapour phase comprising at least a majority of any methane left in the first portion of the liquid bottom stream;
- withdrawing from the first fractionation column a first residue liquid bottom stream;
- increasing the pressure of at least a recycle portion, being a portion of the first residue liquid bottom stream, with a recycle pump; and subsequently
- recycling the recycle portion at increased pressure into the extraction column whereby said recycle portion enters the extraction column in liquid phase, which recycle portion has the same composition as the first residue liquid bottom stream being withdrawn from the first fractionation column.

2. The method of claim 1, wherein said recycle portion enters the extraction column gravitationally higher than the first feeding position.

3. The method of claim 1 or 2, wherein the content of C_5+ hydrocarbons in the recycle portion is be between 40 and 75 mol%.

4. The method of claim 4, wherein the remainder of the recycle portion up to 99.0 mol% of the recycle portion consists of C_2-C_4 hydrocarbons.

5. The method of any one of the preceding claims, further comprising splitting of the first residue liquid bottom stream into said recycle portion and a remaining portion, wherein said recycle portion contains a fraction of less than 1.00 of the first residue liquid bottom stream being withdrawn from the first fractionation column.

6. The method of claim 5, wherein said remaining portion is passed to a second fractionation column of the at least three fractionation columns of the fractionation system, thereby obtaining at least one fractionation product stream being enriched in a selected hydrocarbon component from the residue stream.

7. The method of claim 5 or 6, further comprising lowering the fraction of the first residue liquid bottom stream in the recycle portion over the course of time.

8. The method of claim 7, comprising allowing the actual feed rate to increase over said course of time.

9. The method of any one of the preceding claims, wherein the first fractionation column is a demethanizer.

10. The method of any one of the preceding claims, wherein one of the at least three consecutive fractionation columns of the fractionation system, other than the first fractionation column, is a debutanizer.

11. The method of any one of the preceding claims, wherein said producing of said lean methane-containing gas stream from the vaporous overhead stream comprises:

- partially condensing the vaporous overhead stream comprising removing heat from the vaporous overhead stream by indirect heat exchanging thereby providing a partially condensed overhead stream;
- phase separating the partially condensed overhead stream thereby providing the lean methane-containing gas stream in vapour phase and a liquid reflux stream in liquid phase;
and wherein said method further comprises:
- feeding the liquid reflux stream into the extraction column at a second feeding position, said second feeding position being located gravitationally higher than the first feeding position.

12. The method of claim 11, further comprising forming an admixed stream by admixing the recycle portion and the vaporous overhead stream upstream of said partially condensing of the vaporous overhead stream and upstream of said indirect heat exchanging, whereby said admixed stream is subjected to said indirect heat exchanging.

13. The method of any one of the preceding claims, further comprising subjecting at least part of said lean methane-containing gas stream to full condensation and subcooling, optionally followed by depressurization, to provide a liquefied methane-containing stream.

14. Apparatus for preparing a lean methane-containing gas stream, comprising:

- an extraction column comprising a first feeding inlet located in a first feeding position, an overhead vapour outlet for discharging a vaporous overhead stream containing the lean methane-containing gas stream, and a liquid bottom stream outlet located at a first withdrawal level, said first withdrawal level being gravitationally lower than the first feeding position, and said first feeding inlet fluidly connected to a feed supply of a hydrocarbon feed stream;
- a flow control system arranged to control an actual feed rate of the hydrocarbon feed stream flowing into the extraction column;
- a fractionation system comprising at least three consecutively arranged fractionation columns, a first fractionation column of the at least three consecutively arranged fractionation columns being in fluid communication contact with the liquid bottom stream outlet via a pressure reduction device, to receive a first portion of the liquid bottom stream from the extraction column at a reduced pressure and the same composition as the liquid bottom stream, said first fractionation column being fluidly connected to a first overhead discharge line through which a first fractionated overhead stream in vapour phase can be discharged from the first fractionation column and said first fractionation column being fluidly connected to a first residue liquid discharge line through which a first residue liquid bottom stream in liquid phase can be discharged from the first fractionation column;
- a recycling line fluidly connected to first residue liquid discharge line and the extraction column, arranged to allow recycling of a recycle portion of the first residue liquid bottom stream in liquid phase and having the same composition as the first residue liquid bottom stream;
- a recycle pump arranged between the first fractionation column and the extraction column to increase the pressure of at least the recycle portion.

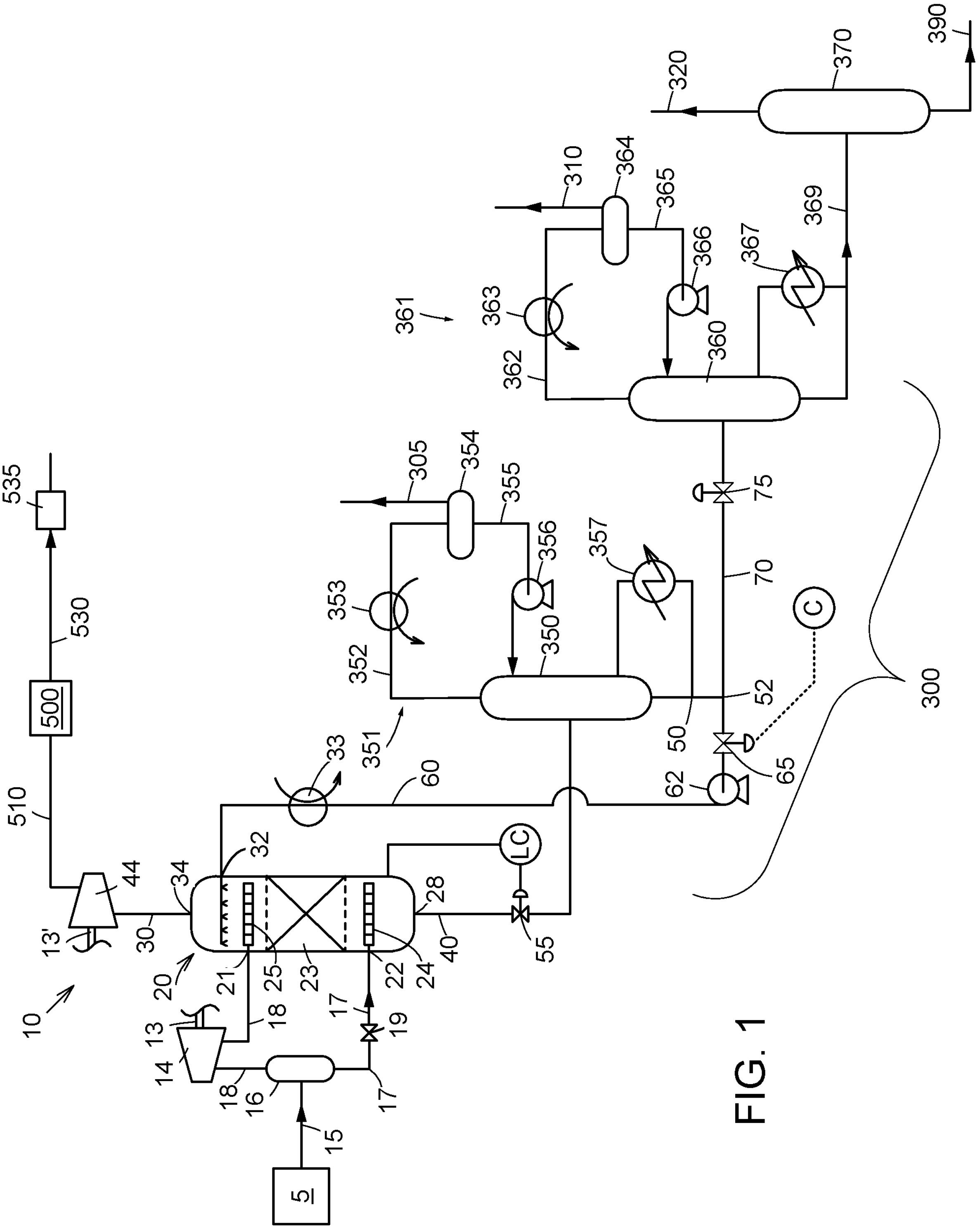
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FIG. 1

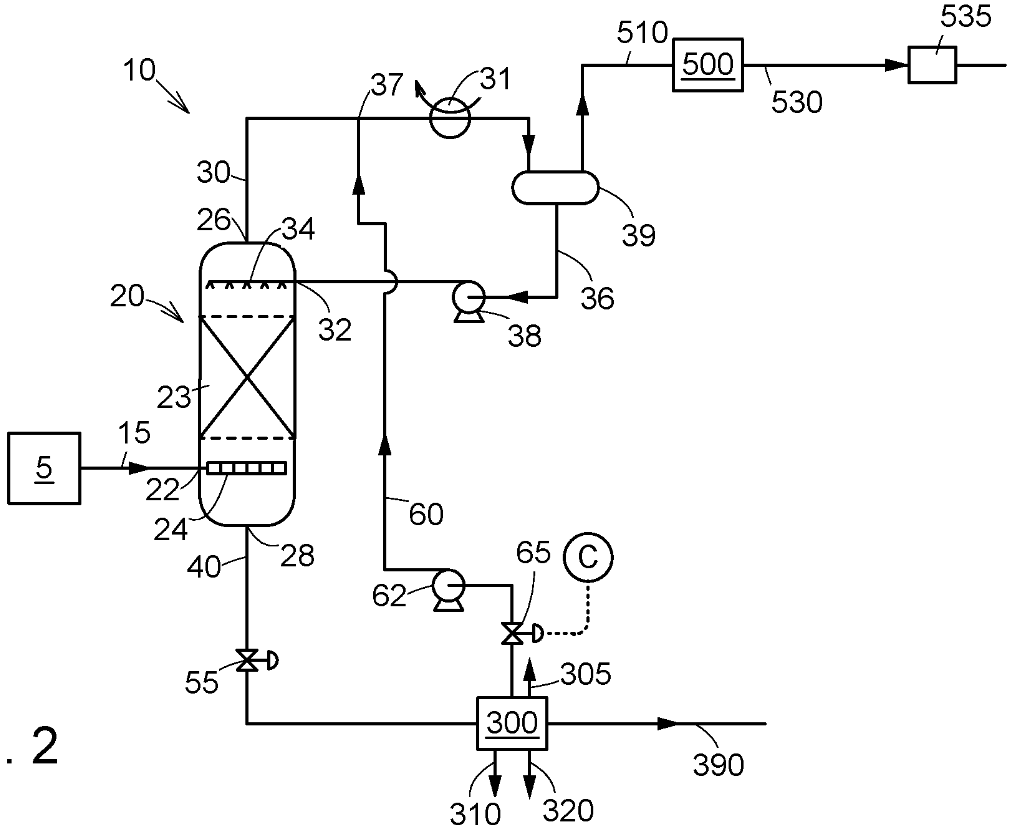
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FIG. 2

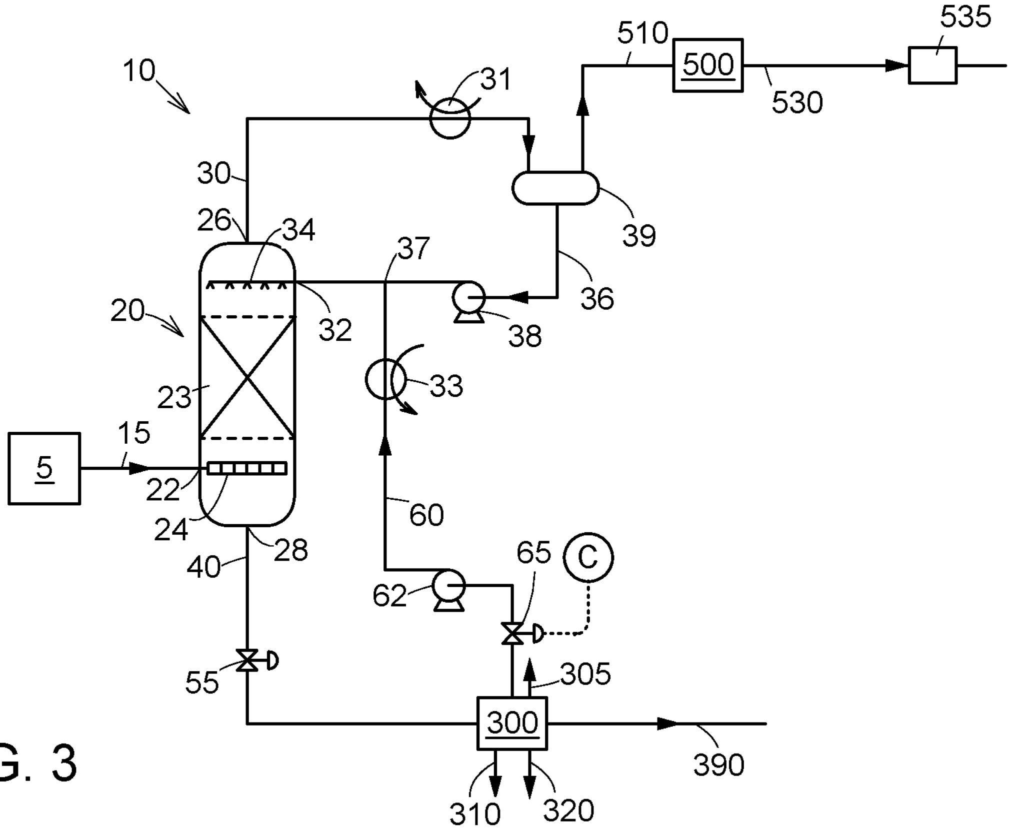
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FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 11 19 0287

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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CATEGORY OF CITED DOCUMENTS

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