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(54) METHOD AND APPARATUS FOR COOLING A HYDROCARBON STREAM

VERFAHREN UND VORRICHTUNG ZUR KÜHLUNG EINES KOHLENWASSERSTOFFREICHEN STROMES

PROCÉDÉ ET DISPOSITIF POUR RÉFRIGÉRER UN COURANT D'HYDROCARBURES

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EP 2 082 178 B1

Description

[0001] The present invention relates to a method and apparatus for cooling, optionally also liquefying, a hydrocarbon stream such as natural gas according to the preamble of claims 1 and 10 respectively. Such a method respectively apparatus is known from WO 2006/087331 A1. Several methods of liquefying a natural gas stream thereby obtaining liquefied natural gas (LNG) are known. It is desirable to liquefy 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 a high pressure.

[0002] Usually natural gas, comprising predominantly methane, enters an LNG plant at elevated pressures and is pre-treated to produce a purified feed stock 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 stage can be used as a source of plant fuel gas.

[0003] In addition to methane, natural gas usually includes some heavier hydrocarbons and impurities, including but not limited to carbon dioxide, sulphur, hydrogen sulphide and other sulphur compounds, nitrogen, helium, water and other non-hydrocarbon acid gases, ethane, propane, butanes, C_5+ hydrocarbons and aromatic hydrocarbons. These and any other common or known heavier hydrocarbons and impurities either prevent or hinder the usual known methods of liquefying the methane, especially the most efficient methods of liquefying methane. Most if not all known or proposed methods of liquefying hydrocarbons, especially liquefying natural gas, are based on reducing as far as possible the levels of at least most of the heavier hydrocarbons and impurities prior to the liquefying process.

[0004] Meanwhile, the capacity of a liquefaction plant is usually determined by the availability of the gas feed stream, and the market or expected markets for products provided by the plant. Thus, it can be desirable to be flexible as to the capacity of the liquefaction plant. Hitherto, extra capacity at a liquefaction plant has simply involved the complete replication of all of the units dealing with the gas feed stream, from its source to its storage. All such units are often termed a "train". Some commonality of some units of a train or its support units such as refrigeration units have been suggested, but no flexibility in the pre-treatment of the gas has been suggested.

[0005] The costs in creating and running a liquefying natural gas (LNG) plant or system are naturally high. Thus any flexibility and so reduction in the energy requirements of the plant or system has significant cost benefit.

[0006] In a paper entitled "Large Capacity LNG Plant Development", Paper PS5-3, J.J.B. Pek et al, presented at 14th International Conference & Exhibition on Liquefied Natural Gas (Doha, Qatar), on 21 March 2004, there is shown a general process for liquefying natural gas comprising the general steps of a gas receiving stage, a gas treating stage, a pre-cooling stage which feeds two separate but parallel liquefaction stages, and an end flash stage to provide LNG to an LNG tank.

[0007] WO 2006/009646 A2 relates to a hydrocarbon fluid processing plant including a plurality of process unit module types, including first and second process unit module types having modules intended to be sized at their respective substantially maximum processing efficiency. WO 2006/009646 A2 shows a number of plant arrangements but a problem with these arrangements is that there are always complete 'trains' for treating and liquefying the hydrocarbon fluids, without flexibility therebetween.

[0008] WO 2006/087331 A1 discloses a plant for liquefying natural gas. The plant comprises a natural gas pre-cooling heat exchanger train, a distributor, two main cryogenic systems, and two natural gas liquids extraction units.

[0009] It is an object of the present invention to improve the efficiency of a treatment plant or method.

[0010] It is a further object of the present invention to better streamline the hydrocarbon stream or streams through a treatment plant or method.

[0011] The present invention provides a method of cooling a hydrocarbon stream such as natural gas according to claim 1.

[0012] In a further aspect, the present invention provides an apparatus for cooling a hydrocarbon stream such as natural gas according to claim 10.

[0013] The invention will now be further illustrated by way of example only, and with reference to embodiments, examples and the accompanying diagrammatic and non-limiting drawings in which:

Figure 1 is a block scheme of part of an LNG plant according to one embodiment of the present invention;

Figure 2 is a block scheme of part of an LNG plant according to a second embodiment of the present invention; and

Figure 3 is a block scheme of part of an LNG plant according to a third embodiment of the present invention.

[0014] 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. Same reference numbers refer to similar components.

[0015] The method and apparatus described herein comprises a gas treatment stage, an NGL extraction stage and a cooling stage. The gas treatment stage comprises one or more parallel gas treatment units; the NGL extraction stage comprises more than one parallel NGL extraction units; and the cooling stage comprises one or more parallel cooling systems. The number of gas treatment units will hereinafter be represented by the letter X; the number of NGL extraction units as Y, and the number of cooling systems as Z.

[0016] For the purpose of this specification, "parallel" means arranged or operated in parallel with respect to other units or systems of same type when more than one of that type of unit or system is provided. As described herein, an asymmetric arrangement between the number of gas treatment units, the number of NGL extraction units, and the number of cooling systems is provided. An asymmetric configuration offers benefits in terms of overall plant availability and matching of individual unit equipment sized design capacity constraints. According to the invention, the number of NLG extraction units is higher than the number of cooling systems (i.e. Y > Z). This advantageous choice is based on an insight that limits in vapour expander size are typically more restrictive than the size of a cooling system in terms of production capacity. NGL extraction units are typically based on an expander. Thus, production capacity can be increased by operating in parallel more expander-based extraction units than there are cooling systems.

[0017] Moreover, providing Y > Z offers the possibility of providing an excess of NGL extraction capacity relative to cooling capacity. Generating excess NGL-extracted gas may be useful to provide domestic gas from a hydrocarbon stream cooling site.

[0018] In a group of embodiments, both X and Y are unequal to Z, whereby at least Y is greater than one.

[0019] The asymmetry provided herein also allows the energy requirements of the liquefaction facility or plant to be more balanced.

[0020] An asymmetric configuration also offers the user of a plant options and flexibility should a gas treatment unit or an NGL extraction unit be off-line, i.e. non-operational, either accidentally or deliberately for maintenance, etc.. Whilst there may be some reduction in plant output or in one or more stream flows, overall, the plant can remain operational through the use of other gas treatment units and NGL extraction units.

[0021] In the gas treatment stage, the level or levels of certain impurities generally not being hydrocarbons can be reduced. Two common impurities are carbon dioxide and sulphur (and sulphur-based compounds), usually present with water in the form of 'acid gas'. Many processes for the removal of acid gas from a feed stream are known to those skilled in the art. One common method is the use of an aqueous amine solution, often used in an extraction column termed a 'scrubber'. The aqueous amine may be one or more of known materials including for example DGA, DEA, MDEA, MEA and SULFINOLTM (Shell), and combinations thereof. Typically acid gas removal can result in the reduction of carbon dioxide to levels of less than about 60ppm, whilst sulphur can be reduced to levels of less than about 4 ppm. The gas treatment stage comprises one or more parallel gas treatment units. By "gas treatment unit" is meant a unit comprising one or more solvent-fed extraction columns which remove acid gas from the hydrocarbon stream under elevated pressure (relative to solvent regeneration pressure) to produce enriched solvent and a treated hydrocarbon stream. The enriched solvent is then passed within the gas treatment unit to one or more pressure letdown devices and then to one or more heaters or regeneration columns which separate the solvent from the acid gas and recycle at least a portion of the solvent to the one or more extraction columns. The extraction columns and heaters or regeneration columns of the gas treatment unit represent equipment which is dedicated to a single gas treatment unit such that they are not shared with any other gas treatment units.

[0022] The NGL extraction stage comprises more than one parallel NGL extraction units. By "NGL extraction unit" is meant a unit comprising one or more knock-out drums from which the hydrocarbon stream is passed, via an expansion step, to one or more NGL separators which produce an NGL stream or streams, which each comprise, for instance, less than 5 mole % methane. The knock-out drums and NGL separators of the NGL extraction unit represent equipment which is dedicated to a single NGL extraction unit such that they are not shared with any other NGL extraction units. However, subsequent separation of the NGL stream into individual hydrocarbon streams, often referred to as fractionation, can be carried out in a facility shared between NGL extraction units.

[0023] NGL extraction units as such are known to those skilled in the art. Generally, they are designed to reduce the level or levels of hydrocarbon compounds other than methane in a feed stream. One common NGL extraction unit includes a separator or separation vessel, able to provide a gaseous stream that is methane-enriched, and one or more other streams. Such other stream or streams usually but not always include separate or combined streams of heavier hydrocarbons. The methane-enriched stream may be passed through the cooling stage.

[0024] In one example, an NGL extraction unit provides a single heavier hydrocarbon rich stream, which is subsequently used either per se, or is further divided into particular heavier hydrocarbon rich streams in a separate location or unit. The division of a heavier hydrocarbon rich stream can be carried out by one or more separators known in the art, such as a fractionator. A fractionator using one or more columns could provide individual streams of certain heavier hydrocarbons. For example, with multiple columns, each column could be designed to provide an individual hydrocarbon stream, such as an ethane-rich stream, a propane-rich stream, a butane-rich stream, and a C_5+ -rich stream, the latter sometimes also termed a 'light condensate stream'. Propane, butane and C_5+ hydrocarbons are sometimes collectively termed "natural gas liquids" (NGL), and have known uses.

[0025] An example of a fractionation tower as a conventional distillation column for NGL extraction is shown in US 2004/0079107 A1.

[0026] In another example, an NGL extraction unit can include a fractionator which integrally provides individual streams of certain heavier hydrocarbons such as those listed hereinbefore.

[0027] Cooling systems for the cooling stage are known in the art. The cooling system may be a liquefying system. Cooling systems and liquefying systems may be embodied in various ways, and generally involve one or more heat exchangers and refrigerant circuits.

[0028] The cooling stage comprises one or more parallel cooling systems. By "cooling system" is meant a liquefying system comprising one or more closed, independent refrigerant cycles. A closed refrigerant cycle does not exchange refrigerant with another cooling cycle under normal operation. The closed, independent refrigerant cycle or cycles are dedicated to a single cooling system such that they are not shared with any other cooling systems.

[0029] A liquefying system useable with the present invention may involve a number of separate serial cooling steps, and the or each cooling step may involve one or more heat exchangers, levels or sections. One arrangement involves the cooling stage having a first cooling step for pre-cooling, followed by a second cooling step for main cryogenic cooling and liquefying.

[0030] A first or pre-cooling step may involve reducing the temperature of a feed stream to below -0 °C, for example in the range -10 °C to -30 °C.

[0031] A second or main cryogenic cooling step may involve cooling a feed stream to below -90 °C or below -100 °C, for example between -100 °C to -130 °C, which usually creates a hydrocarbon stream which is now liquefied, such as liquefied natural gas.

[0032] Each unit or system of the stages of the present invention may use the same or different parameters, such as flowrate, temperature, pressure, etc.

[0033] By providing units and systems which may operate independently, a unit or system may be taken offline for maintenance without having to shut down the entire hydrocarbon cooling plant.

[0034] As described herein, the number of streams for each of the stages is intended to be shared to match the number of units or systems in each stage. This may therefore require the division, sharing or combination of the feed stream or the stream or streams provided by the previous stage. Such division, sharing and/or combination may or may not involve the complete mixing of previous streams, or the complete separation of previous streams.

[0035] Any division, sharing and/or combination of the feed stream or stream or streams provided by a previous stage may be unequally distributed. Preferably the distribution is equal, that is, there is equidistribution of the stream or streams amongst the lines to the units or systems to which the stream or streams are intended to be passed to.

[0036] The division or sharing of any of the feed streams or any of the subsequent treated or cooled hydrocarbon stream or streams, could be provided by any suitable divisor, for example a stream splitter. Preferably any division or sharing creates two or more streams having the same composition and phases.

[0037] All possible arrangements for changes in the number of streams before or after each stage are envisaged. For example, where X is 1, Y is 2 and Z is 1, the first treated stream provided by the gas treatment stage is divided into two first treated streams for each of the NGL extraction units in the NGL extraction stage. The two second treated streams provided thereby are then combined into a single second treated stream for the single cooling system in the cooling stage.

[0038] In another example, X can be 2, Y can be 3, and Z can be 2. In this example, the feed stream is shared or divided into two part-feed streams for the two gas treatment units in the gas treatment stage. The two first treated streams provided thereby are then shared to provide three first treated streams, one for each of the NGL extraction units in the NGL extraction stage. The change from two to three first treated streams may be through a common manifold, or may be by any other sharing arrangement not having a common union or junction of all streams. Similarly, the three second treated streams provided by the NGL extraction stage are then shared to create two second treated streams for the two cooling systems. This sharing of the second treated streams may be through a common manifold, or through any other arrangement not involving commonality or union of all the second treated streams.

[0039] The present invention may also be used to create a facility or plant where X is 2, Y is 2 and Z is 1. Should there be a wish or need to enlarge the capacity of the facility or plant, one or more further gas treatment units, NGL extraction units, and/or cooling systems, can be added, taking into account the design capacity of existing units, thereby avoiding the hitherto expedient of having to supply a complete and separated liquefaction 'train'.

[0040] The feed stream may be any suitable hydrocarbon-containing gas stream to be cooled, but is usually a natural gas stream obtained from natural gas or petroleum reservoirs. As an alternative the natural gas stream may also be obtained from another source, also including a synthetic source such as a Fischer-Tropsch process.

[0041] Usually the natural gas stream is comprised substantially of methane. Preferably the feed stream comprises at least 60 mol% methane, more preferably at least 80 mol% methane.

[0042] Although the method described herein is applicable to various hydrocarbon feed streams, it is particularly suitable for natural gas streams to be liquefied. As the person skilled readily understands how to liquefy a hydrocarbon stream, this is not further discussed here.

[0043] Figure 1 shows a block scheme of part of a liquefied natural gas plant 1. It shows an initial feed stream 10 containing natural gas. The feed stream 10 is divided by a stream splitter 12 into two part-feed streams 20a, 20b. The division of the feed stream 10 could be based on any ratio of mass and/or volume and/or flow rate. The ratio may be based on the size or capacity of the subsequent parts, systems or units of the plant, or due to other considerations. One example of the ratio is an equal division of the cooled stream mass.

[0044] The two part-feed streams 20a, 20b pass to a gas treatment stage 2 comprising two parallel gas treatment units 14a, 14b. Such gas treatment units 14a, 14b are adapted to reduce impurities, including but not limited to acid gas, in the part feed-streams 20a, 20b, and so provide two first treated streams 30a, 30b respectively. Operation of gas treatment units 14a, 14b such as scrubbers are well known in the art. Figure 1 shows an exit stream 15a, 15b for carbon dioxide, sulphur and any sulphur-based compounds from each gas treatment unit 14a, 14b.

[0045] The first treated streams 30a, 30b are passed to an NGL extraction stage 4 which comprises two parallel NGL extraction units 16a, 16b. The NGL extraction units 16a, 16b provide two second treated streams 40a, 40b, which streams are methane-enriched, and which are combined to provide a combined treated stream 50. The second treated feed streams 40a, 40b can be combined using a combiner 18 known in the art. The combiner may be any suitable arrangement, generally involving a union or junction or piping or conduits, optionally involving one or more valves.

[0046] The NGL extraction units 16a, 16b also provide two heavier hydrocarbon enriched streams 17a, 17b which pass to a common fractionator 24. The enriched streams 17a, 17b may be combined prior to entry into the common fractionator 24 as shown in Figure 1, or may be passed separately into the common fractionator 24.

[0047] The common fractionator 24 is designed to provide separate enriched streams of one or more hydrocarbons such as propane, butane and C_5+ hydrocarbons, and optionally also ethane. Such enriched streams are useful products for use in the liquefying plant 1 or outside the plant. Such enriched streams are shown collectively in Figure 1 as streams 26.

[0048] The fractionator 24 may be a single fractionation unit, or have one or more columns, wherein each column is usually dedicated to separating and providing a particular heavier hydrocarbon. Fractionation is well known in the art and the benefit and use of individual streams of propane, butane and C_5+ are also well known in the art.

[0049] Although not shown in Figure 1, any methane stream or methane-enriched stream provided by the fractionator 24 may be returned or recycled back into the path of the second treated streams 40a, 40b or the combined stream 50.

[0050] The combined treated stream 50 is then passed to a cooling stage 6. In Figure 1, the cooling stage 6 provides a cooled hydrocarbon stream 60.

[0051] The cooling of the combined treated stream 50 in the cooling stage 6 may involve any degree of cooling using any number of units, devices or systems or combinations thereof known in the art. One example is the use of one or more heat exchangers. Usually, cooling is effected by passing the combined treated stream 50 against one or more cooling or refrigerant streams and/or through one or more valves and/or separators, as known in the art.

[0052] In one embodiment of the present invention, the cooling stage 6 is adapted to liquefy the combined treated stream 50 so as to provide a liquefied hydrocarbon stream such as liquefied natural gas. Liquefaction of the combined treated stream 50 can be carried out by passing it through a cooling system being a liquefying system 22 using one or more heat exchangers and cooling it against one or more refrigerants, either being dedicated refrigerants or other cooled streams. The liquefying can involve one or more cooling and/or liquefying steps.

[0053] Generally, it is intended to provide a liquefied natural gas stream having a temperature below -150 °C, more usually between -160 °C and -165 °C.

[0054] Between the gas treatment stage 2, NGL extraction stage 4 and the cooling stage 6, one or more other units or features may be involved such as valves or further treatments, or to control of the path or flow of the streams thereinbetween.

[0055] Figure 1 shows a method of treating a hydrocarbon stream such as natural gas wherein X is 2, Y is 2, and Z is 1. There is therefore asymmetry between the number of gas treatment units, the number of NGL extraction units, and the number of cooling systems. An asymmetric configuration, particularly where $Y > Z$ as in the embodiment of Figure 1, offers benefits as explained hereinabove.

[0056] Figure 2 shows a block scheme of part of a liquefied natural gas plant 1a according to a second embodiment of the present invention. In Figure 2, a feed stream 10 is divided by a divider 12 into three part-feed streams 20a, 20b and 20c, either equally or unequally as described above. The three part-feed streams 20a, 20b, 20c pass into three respective and parallel gas treatment units 14a, 14b and 14c which comprise the gas treatment stage 2. The action and effect of the gas treatment units 14a, 14b, 14c is similar to those described hereinbefore. They provide three first treated streams 30a, 30b, 30c, and three other streams 15a, 15b, 15c, being for example, sulphur, carbon dioxide, etc.

[0057] The three first treatment streams 30a,b,c pass into respective and parallel NGL extraction units 16a, 16b, 16c, whose action and effect is similar to those described hereinbefore. The units 16a, 16b, 16c provide three second treated streams 40a, 40b, 40c which are then shared for the cooling stage 6, and three heavier hydrocarbon streams 17a, 17b, 17c, whose use and/or separation can be the same or similar to that described above in Figure 1.

[0058] The sharing of the three second treated streams 40a, 40b, 40c may not involve the complete combination and mixing of the second treated streams 40a, 40b, 40c within one position, location, line or stream. Thus, references herein to the second treated streams being "shared", include the second treated streams being able to provide one or more streams to a cooling stage, which cooling stage may comprise one or more cooling systems. The one or more streams supplying the cooling system or systems may therefore comprise flow from two or more second treated streams, without involving flow from all of the second treated streams.

[0059] It is intended by the present invention that all the second treated streams collectively supply their flow to the or all of the cooling systems of the cooling stage.

[0060] In Figure 2, it is diagrammatically represented that the three second treated streams 40a, 40b, 40c provide, via linked piping or conduits at junctions 19a, 19b, combined treated streams 50a, 50b, which pass respectively into two cooling systems 22a, 22b which comprise the cooling stage 6. The cooling systems 22a, 22b preferably liquefy the combined treated streams 50a, 50b to provide two liquefied hydrocarbon streams 52a, 52b, which can be combined to provide a combined liquefied hydrocarbon stream 60, such as liquefied natural gas.

[0061] Thus, Figure 2 shows a method of treating a hydrocarbon stream such as natural gas wherein X is 3, Y is 3, and Z is 2.

[0062] Figure 3 shows a simplified block scheme of part of a liquefied natural gas plant 1b according to a third embodiment of the present invention. In Figure 3, a feed stream 10 passes into a single gas treatment unit 100 for the gas treatment stage 2. The action and effect of the gas treatment unit 100 is similar to those described hereinbefore. This provides a first treated stream 30d which is optionally passed through a separate or integral drying unit 101 to reduce its water content, and provide a drier treated stream 30e.

[0063] The drier treated stream 30e is then divided by a divider 32, preferably equally, into 3 part-streams 30f, 30g, 30h, which pass into three respective and parallel NGL extraction units 102a, 102b and 102c, whose action and effect is similar to those described hereinbefore, and which comprise the NGL extraction stage 4. The units 102a, b, c provide three second treated streams 40a, 40b, 40c, which are then combined using a combiner 34 to provide a single combined stream 50.

[0064] The combined stream 50 is then divided by a divider 36 into two part-streams 50a, 50b, optionally unequally or equally, to pass into two cooling systems 103a, 103b, similar to those described above, and which comprise the cooling stage 6. The cooling systems 103a,b are preferably adapted to liquefy the part-streams 50a, 50b, to provide two liquefied hydrocarbon streams 52a, 52b, which can then be combined by a combiner 38 to provide a combined liquefied hydrocarbon stream 60, such as liquefied natural gas. The liquefied natural gas 60 can pass through an endflash unit 104 in a manner commonly known in the art, to provide a final liquefied product stream 70.

[0065] Thus, Figure 3 shows another embodiment of the present invention having a gas treatment stage with one gas treatment unit, an NGL extraction stage having three NGL extraction units, and a cooling stage comprising two parallel cooling systems, i.e. a method of treating a hydrocarbon stream such as natural gas wherein X is 1, Y is 3, and Z is 2.

[0066] 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 cooling a hydrocarbon stream such as natural gas, the method at least comprising the steps of:

(a) providing a feed stream (10);
(b) passing the feed stream (10) through a gas treatment stage (2) comprising X gas treatment units (14a, 14b), X being one or more, the gas treatment units being operated in parallel in case X is more than one, the feed stream (10) being divided into two or more part-feed streams (20a, 20b) if there is more than one gas treatment unit, to provide one or more first treated streams (30a, 30b);
(c) passing the first treated stream or streams (30a, 30b) of step (b) through an NGL extraction stage (4) comprising Y parallel NGL extraction units (16a, 16b), Y being more than one, the first treated stream or streams (30a, 30b) being shared to match the number of NGL extraction units (16a, 16b), to provide one or more second treated stream or streams (40a, 40b); and
(d) passing the second treated stream or streams (40a, 40b) of step (c) through a cooling stage (6) comprising Z cooling system or systems (22), Z being one or more, the cooling systems being operated in parallel in case Z is more than one, the Z cooling system or systems being liquefying system or systems comprising one or more closed, independent refrigerant cycle or cycles, the second treated stream or streams (40a, 40b) being shared to match the number of cooling system or systems (22), to provide a cooled hydrocarbon stream or streams;

characterized in that Y > Z.

2. Method as claimed in claim 1, wherein the feed stream (10) is divided into two part-feed streams (20a, 20b), and X is 2 and Z is 1, and/or wherein Y is 2 and Z is 1.

3. Method as claimed in claim 1, wherein the feed stream (10) is divided into three part-feed streams (20a, 20b, 20c), and X is 3 and Z is 1 or 2, and/or wherein Y is 3 and Z is 1 or 2.

4. Method according to one or more of the preceding claims, wherein each NGL extraction unit (16a, 16b) provides a second treated stream (40a, 40b) and one or more separate streams (17a, 17b).

5. Method as claimed in claim 4, wherein 5 the one or more separate streams comprise one or more of a propane stream, a butane stream and a C5+ stream.

6. Method as claimed in claim 4, wherein the one or more separate streams (17a, 17b) are fractionated to provide one or more fractionated streams (26).

7. Method as claimed in claim 5, wherein the one or more fractionated streams (26) comprise one or more of a propane stream, a butane stream and a C5+ stream.

8. Method according to one or more of the preceding claims, wherein X is different from Z.

9. A method according to one or more of the preceding claims wherein the cooling step (d) liquefies the second treated stream or streams (40a, 40b) to provide a liquefied hydrocarbon stream (60) or streams, preferably liquefied natural gas.

10. Apparatus for cooling a hydrocarbon stream such as natural gas, the apparatus at least comprising:

(i) a gas treatment stage (2) to receive a feed stream (10) comprising X gas treatment Z unit or units (14a, 14b), X being one or more, the gas treatment units being arranged in parallel in case X is more than one, the feed stream (10) being divided if there is more than one gas treatment unit;
(ii) an NGL extraction stage (4) to receive the treated feed stream or streams from the gas treatment stage, comprising Y parallel NGL extraction units (16a, 16b), Y being more than one; and
(iii) a cooling stage (6) to receive the NGL extracted stream or streams from the NGL extraction stage, comprising Z cooling system or systems (22), Z being one or more, the cooling systems being arranged in parallel in case Z is more than one, the Z cooling system or systems being liquefying system or systems comprising one or more closed, independent refrigerant cycle or cycles, to provide a treated hydrocarbon stream or streams;

characterized in that Y > Z.

11. Apparatus as claimed in claim 10, 5 wherein X is 2 and Z is 1, and/or wherein Y is 2 and Z is 1.

12. Apparatus as claimed in claim 10, wherein X is 3 and Z is 1 or 2, and/or wherein Y is 3 and Z is 1 or 2.

13. Apparatus as claimed in one or more of claims 10 to 12, further comprising a fractionator (24) to fractionate all of one or more separate streams (17a, 17b) provided by the NGL extraction units.

14. Apparatus according to one or more of claims 10 to 13, wherein X is different from Z.

Patentansprüche

1. Verfahren zum Kühlen eines Kohlenwasserstoffstroms, wie zum Beispiel Erdgas, wobei das Verfahren mindestens die folgenden Schritte umfasst:

(a) Bereitstellen eines Zufuhrstroms (10);
(b) Leiten des Zufuhrstroms (10) durch eine Gasbehandlungsstufe (2), die X Gasbehandlungseinheiten (14a, 14b) umfasst, wobei X eins oder größer ist, wobei die Gasbehandlungseinheiten parallel betrieben werden, falls X größer als eins ist, wobei der Zufuhrstrom (10) in zwei oder mehr Teilzufuhrströme (20a, 20b) aufgeteilt wird, wenn mehr als eine Gasbehandlungseinheit vorhanden ist, um einen oder mehrere erste behandelte Ströme (30a, 30b) bereitzustellen;
(c) Leiten des ersten behandelten Stroms bzw. der ersten behandelten Ströme (30a, 30b) von Schritt (b) durch eine NGL-Extraktionsstufe (4), die Y parallele NGL-Extraktionseinheiten (16a, 16b) umfasst, wobei Y eins oder größer, wobei der erste behandelte Strom bzw. die ersten behandelten Ströme (30a, 30b) geteilt werden, um der Anzahl der NGL-Extraktionseinheiten (16a, 16b) zu entsprechen, um einen zweiten behandelten Strom oder mehrere zweite behandelte Ströme (40a, 40b) bereitzustellen; und
(d) Leiten des zweiten behandelten Stroms bzw. der zweiten behandelten Ströme (40a, 40b) von Schritt (c) durch eine Kühlstufe (6), die Z Kühlsystem oder Z Kühlsysteme (22) umfasst, wobei Z eins oder größer ist, wobei die Kühlsysteme parallel betrieben werden, falls Z größer als eins ist, wobei es sich bei dem Z Kühlsystem bzw. bei den Z Kühlsystemen um ein verflüssigendes System bzw. verflüssigende Systeme handelt, umfassend einen geschlossenen, unabhängigen Kühlmittelkreislauf oder mehrere geschlossene, unabhängige Kühlmittelkreisläufe, wobei der zweite behandelte Strom bzw. die zweiten behandelten Ströme (40a, 40b) geteilt werden,

um der Anzahl des Kühlsystems bzw. der Kühlsysteme (22) zu entsprechen, um einen gekühlten Kohlenwasserstoffstrom oder gekühlte Kohlenwasserströme bereitstellen,

dadurch gekennzeichnet, dass Y > Z ist.

2. Verfahren nach Anspruch 1, wobei der Zufuhrstrom (10) in zwei Teilzufuhrströme (20a, 20b) aufgeteilt wird und X 2 ist und Z 1 ist und/oder wobei Y 2 ist und Z 1 ist.

3. Verfahren nach Anspruch 1, wobei der Zufuhrstrom (10) in drei Teilzufuhrströme (20a, 20b, 20c) aufgeteilt wird und X 3 ist und Z 1 oder 2 ist und/oder wobei Y 3 ist und Z 1 oder 2 ist.

4. Verfahren nach einem oder mehreren der vorhergehenden Ansprüche, wobei jede NGL-Extraktionseinheit (16a, 16b) einen zweiten behandelten Strom (40a, 40b) und einen oder mehrere getrennte Ströme (17a, 17b) bereitstellt.

5. Verfahren nach Anspruch 4, wobei der eine oder die mehreren getrennten Ströme einen oder mehrere von einem Propanstrom, einem Butanstrom und einem C5+-Strom umfassen.

6. Verfahren nach Anspruch 4, wobei der eine oder die mehreren getrennten Ströme (17a, 17b) fraktioniert werden, um einen oder mehrere fraktionierte Ströme (26) bereitzustellen.

7. Verfahren nach Anspruch 5, wobei der eine oder die mehreren fraktionierten Ströme (26) einen oder mehrere von einem Propanstrom, einem Butanstrom und einem C5+-Strom umfassen.

8. Verfahren nach einem oder mehreren der vorhergehenden Ansprüche, wobei X von Z verschieden ist.

9. Verfahren nach einem oder mehreren der vorhergehenden Ansprüche, wobei der Kühlschritt (d) den zweiten behandelten Strom bzw. die zweiten behandelten Ströme (40a, 40b) verflüssigt, um einen verflüssigten Kohlenwasserstoffstrom (60) oder verflüssigte Kohlenwasserstoffströme, vorzugsweise verflüssigtes Erdgas, bereitzustellen.

10. Vorrichtung zum Kühlen eines Kohlenwasserstoffstroms, wie beispielsweise Erdgas, wobei die Vorrichtung mindestens Folgendes umfasst;

(i) eine Gasbehandlungsstufe (2) zum Empfangen eines Zufuhrstroms (10), die X Gasbehandlungseinheit oder X Gasbehandlungseinheiten (14a, 14b) umfasst, wobei X eins oder größer ist, wobei die Gasbehandlungseinheiten parallel angeordnet sind, falls X größer als eins ist, wobei der Zufuhrstrom (10) geteilt wird, wenn mehr als eine Gasbehandlungseinheit vorhanden ist;
(ii) eine NGL-Extraktionsstufe (4) zur Aufnahme des behandelten Zufuhrstroms bzw. der behandelten Zufuhrströme aus der Gasbehandlungsstufe, die Y parallele NGL-Extraktionseinheiten (16a, 16b) umfasst, wobei Y größer als eins ist; und
(iii) eine Kühlstufe (6) zur Aufnahme des durch NGL extrahierten Stroms bzw. der durch NGL extrahierten Ströme aus der NGL-Extraktionsstufe, das Z Kühlsystem oder Z Kühlsysteme (22) umfasst, wobei Z eins oder größer ist, wobei die Kühlsysteme parallel angeordnet sind, falls Z größer als eins ist, wobei es sich bei dem Z Kühlsystem bzw. den Z Kühlsystemen um ein verflüssigendes System bzw. um verflüssigende Systeme handelt, die einen geschlossenen unabhängigen Kühlmittelkreislauf oder mehrere geschlossene, unabhängige Kühlmittelkreisläufe umfassen, um einen oder mehrere behandelte Kohlenwasserstoffströme bereitzustellen, **dadurch gekennzeichnet, dass** Y > Z ist.

11. Vorrichtung nach Anspruch 10, wobei X 2 ist und Z 1 ist und/oder wobei Y 2 ist und Z 1 ist.

12. Vorrichtung nach Anspruch 10, wobei X 3 ist und Z 1 oder 2 ist und/oder wobei Y 3 ist und Z 1 oder 2 ist.

13. Vorrichtung nach einem oder mehreren der Ansprüche 10 bis 12, ferner umfassend einen Fraktionator (24) zum Fraktionieren von allen von einem oder mehreren getrennten Strömen (17a, 17b), die von den NGL-Extraktionseinheiten bereitgestellt werden.

14. Vorrichtung nach einem oder mehreren der Ansprüche 10 bis 13, wobei sich X von Z unterscheidet.

Revendications

1. Procédé de refroidissement d'un flux d'hydrocarbures tel que du gaz naturel, le procédé comprenant au moins les étapes suivantes :

(a) produire un flux d'alimentation (10) ;
(b) faire passer le flux d'alimentation (10) à travers un étage de traitement de gaz (2) comprenant X unités de traitement de gaz (14a, 14b), X étant une ou plusieurs, les unités de traitement de gaz fonctionnant en parallèle dans le cas où X est supérieur à un, le flux d'alimentation (10) étant divisé en deux ou plus de deux flux d'alimentation partiels (20a, 20b) s'il y a plus d'une unité de traitement de gaz, pour produire un ou

plusieurs premiers flux traités (30a, 30b) ;

(c) faire passer le ou les premiers flux traités (30a, 30b) de l'étape (b) par un étage d'extraction de LGN (4) comprenant Y unités d'extraction de LGN (16a, 16b) parallèles, Y étant supérieur à un, le ou les premiers flux traités (30a, 30b) étant partagés pour correspondre au nombre d'unités d'extraction de LGN (16a, 16b), pour produire un ou plusieurs deuxièmes flux traités (40a, 40b) ; et

(d) faire passer le ou les deuxièmes flux traités (40a, 40b) de l'étape (c) par un étage de refroidissement (6) comprenant un ou Z systèmes de refroidissement (22), Z étant un ou plusieurs, les systèmes de refroidissement fonctionnant en parallèle dans le cas où Z est supérieur à un, le ou les Z systèmes de refroidissement étant un ou plusieurs systèmes de liquéfaction comprenant un ou plusieurs cycles de réfrigérant indépendants fermés, le ou les deuxièmes flux traités (40a, 40b) étant partagés pour correspondre au nombre de systèmes de refroidissement (22), pour produire un ou des flux d'hydrocarbures refroidis ;

caractérisé en ce que Y > Z.

2. Procédé selon la revendication 1, dans lequel le flux d'alimentation (10) est divisé en deux flux d'alimentation partiels (20a, 20b), et X est 2 et Z est 1, et/ou dans lequel Y est 2 et Z est 1.

3. Procédé selon la revendication 1, dans lequel le flux d'alimentation (10) est divisé en trois flux d'alimentation partiels (20a, 20b, 20c), et X est 3 et Z est 1 ou 2, et/ou dans lequel Y est 3 et Z est 1 ou 2.

4. Procédé selon l'une ou plusieurs des revendications précédentes, dans lequel chaque unité d'extraction de LGN (16a, 16b) produit un deuxième flux traité (40a, 40b) et un ou plusieurs flux séparés (17a, 17b).

5. Procédé selon la revendication 4, dans lequel le ou les flux séparés comprennent un ou plusieurs parmi un flux de propane, un flux de butane et un flux de C5+.

6. Procédé selon la revendication 4, dans lequel le ou les flux séparés (17a, 17b) sont fractionnés pour produire un ou plusieurs flux fractionnés (26).

7. Procédé selon la revendication 5, dans lequel le ou les flux fractionnés (26) comprennent un ou plusieurs parmi un flux de propane, un flux de butane et un flux de C5+.

8. Procédé selon l'une ou plusieurs des revendications précédentes, dans lequel X est différent de Z.

9. Procédé selon l'une ou plusieurs des revendications précédentes, dans lequel l'étape de refroidissement (d) liquéfie le ou les deuxièmes flux traités (40a, 40b) pour produire un ou des flux d'hydrocarbures liquéfiés (60, de préférence du gaz naturel liquéfié.

10. Appareil permettant de refroidir un flux d'hydrocarbures tel que du gaz naturel, l'appareil comprenant au moins :

(i) un étage de traitement de gaz (2) pour recevoir un flux d'alimentation (10), comprenant une ou X unités de traitement de gaz (14a, 14b), X étant un ou plusieurs, les unités de traitement de gaz étant agencées en parallèle dans le cas où X est supérieur à un, le flux d'alimentation (10) étant divisé s'il y a plus d'une unité de traitement de gaz ;

(ii) un étage d'extraction de LGN (4) pour recevoir le ou les flux traités à partir de l'étage de traitement de gaz, comprenant Y unités d'extraction de LGN (16a, 16b) parallèles, Y étant supérieur à un ; et

(iii) un étage de refroidissement (6) pour recevoir le ou les flux extraits de LGN à partir de l'étage d'extraction de LGN, comprenant un ou Z systèmes de refroidissement (22), Z étant un ou plusieurs, les systèmes de refroidissement étant agencés en parallèle dans le cas où Z est supérieur à un, le ou les Z systèmes de refroidissement étant un ou plusieurs systèmes de liquéfaction comprenant un ou plusieurs cycles de réfrigérant indépendants fermés, pour produire un ou des flux d'hydrocarbures traités ;

caractérisé en ce que Y > Z.

11. Appareil selon la revendication 10, dans lequel X est 2 et Z est 1, et/ou dans lequel Y est 2 et Z est 1.

12. Appareil selon la revendication 10, dans lequel X est 3 et Z est 1 ou 2, et/ou dans lequel Y est 3 et Z est 1 ou 2.

13. Appareil selon l'une ou plusieurs des revendications 10 à 12, comprenant en outre une colonne de fractionnement (24) pour fractionner tous les flux parmi un ou plusieurs flux séparés (17a, 17b) produits par les unités d'extraction de LGN.

14. Appareil selon l'une ou plusieurs des revendications 10 à 13, dans lequel X est différent de Z.

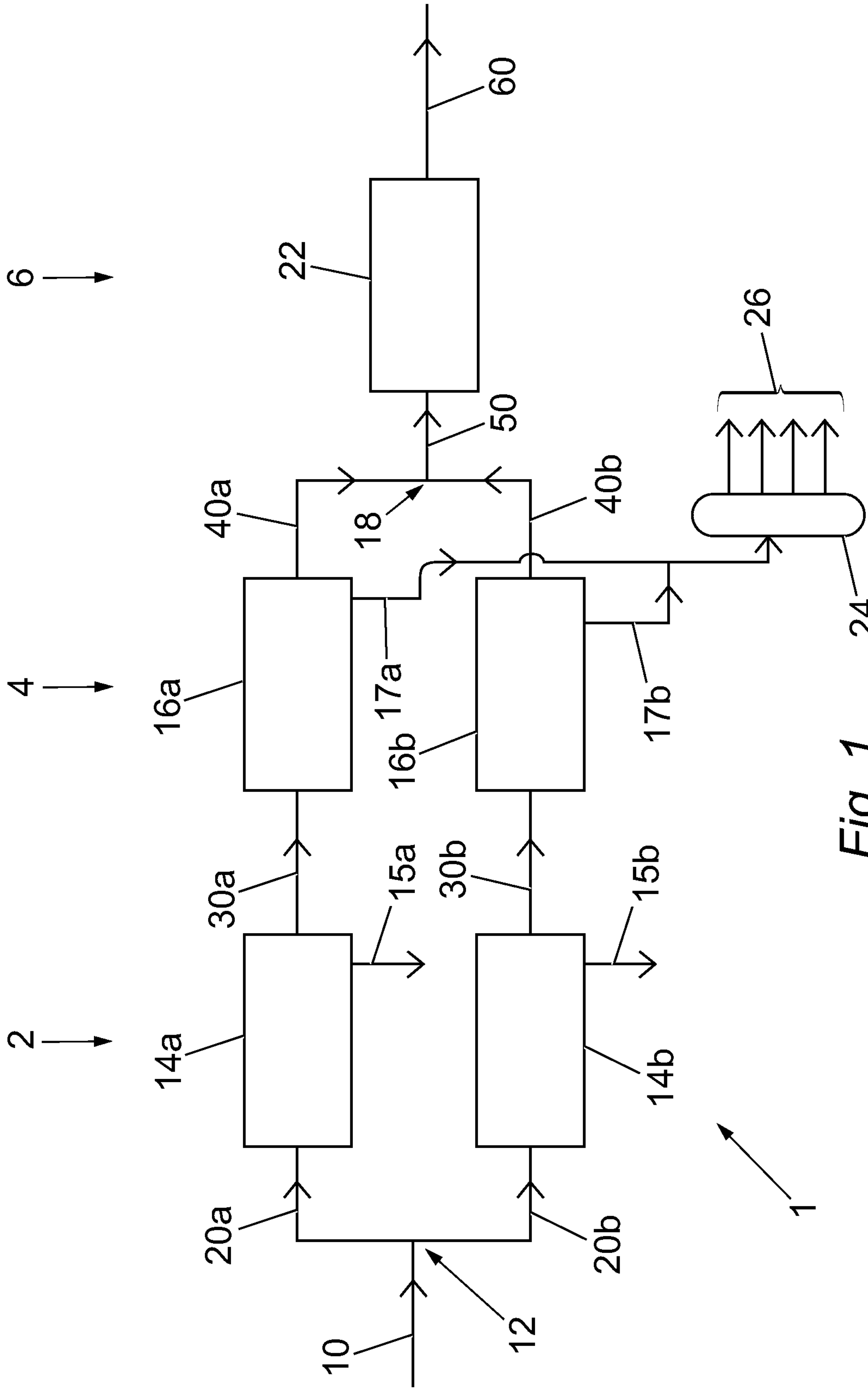

6
4
2
60
22
50
26
40a
18
40b
24
16a
17a
16b
17b
30a
15a
30b
15b
14a
14b
20a
20b
10
12
1

Fig. 1

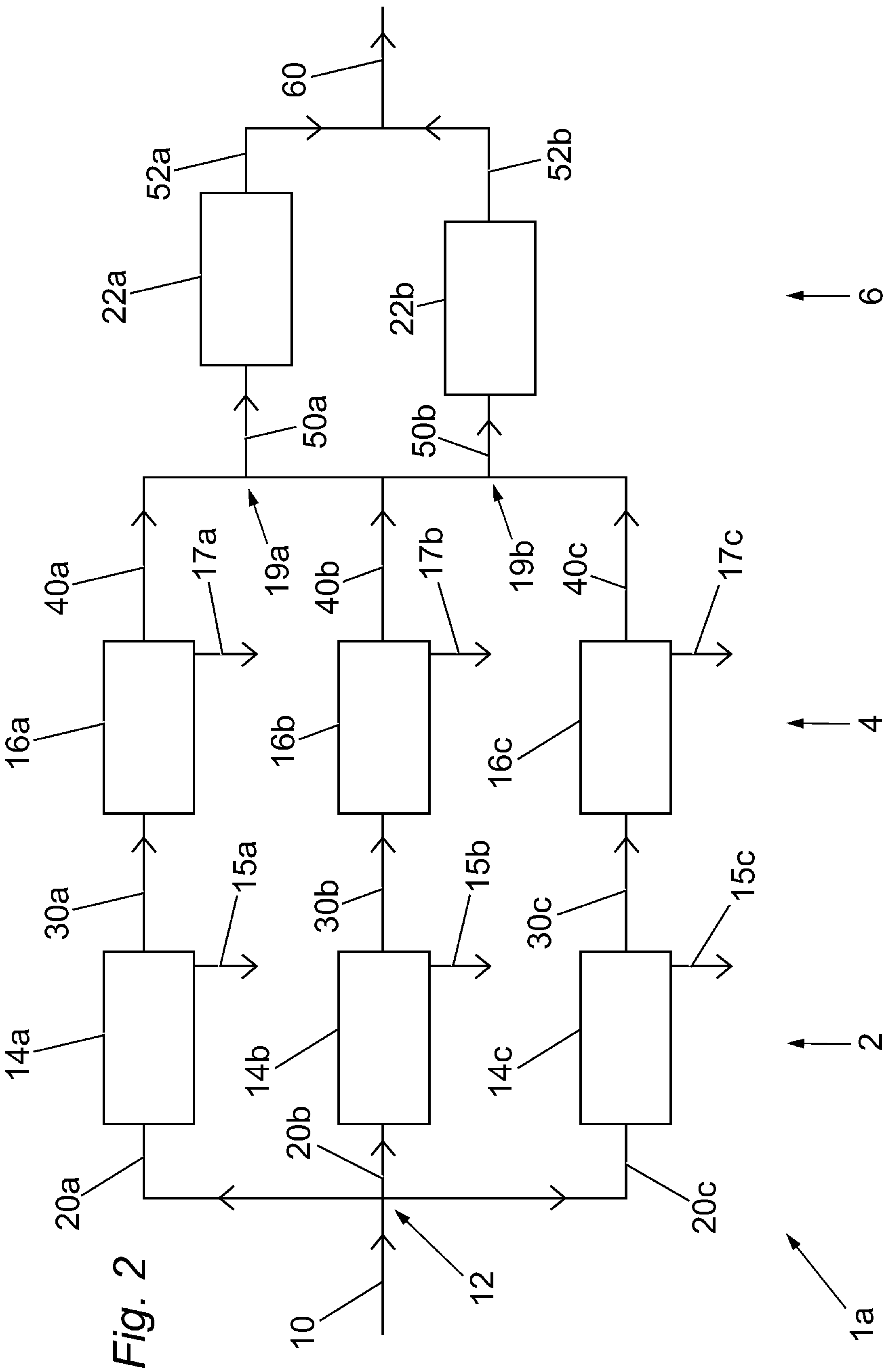
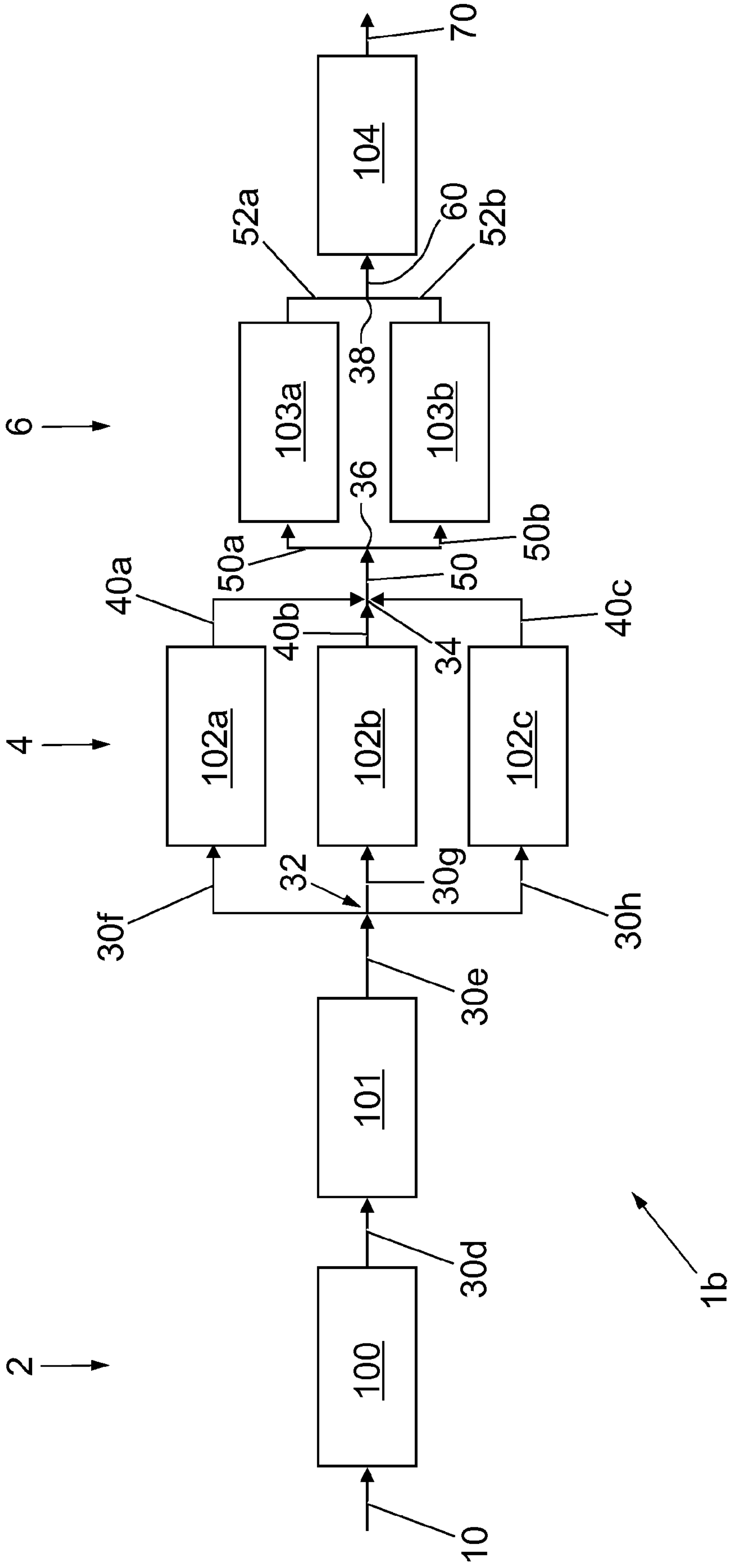

10
12
1a
20a
20b
20c
14a
14b
14c
15a
15b
15c
2
30a
30b
30c
16a
16b
16c
17a
17b
17c
4
40a
40b
40c
19a
19b
50a
50b
22a
22b
6
52a
52b
60

Fig. 2



100
101
102a
102b
102c
103a
103b
104
2
4
6
10
30d
30e
30f
30g
30h
32
34
36
38
40a
40b
40c
50
50a
50b
52a
52b
60
70
1b

Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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