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(54) **SCALABLE CAPACITY LIQUEFIED NATURAL GAS PLANT**

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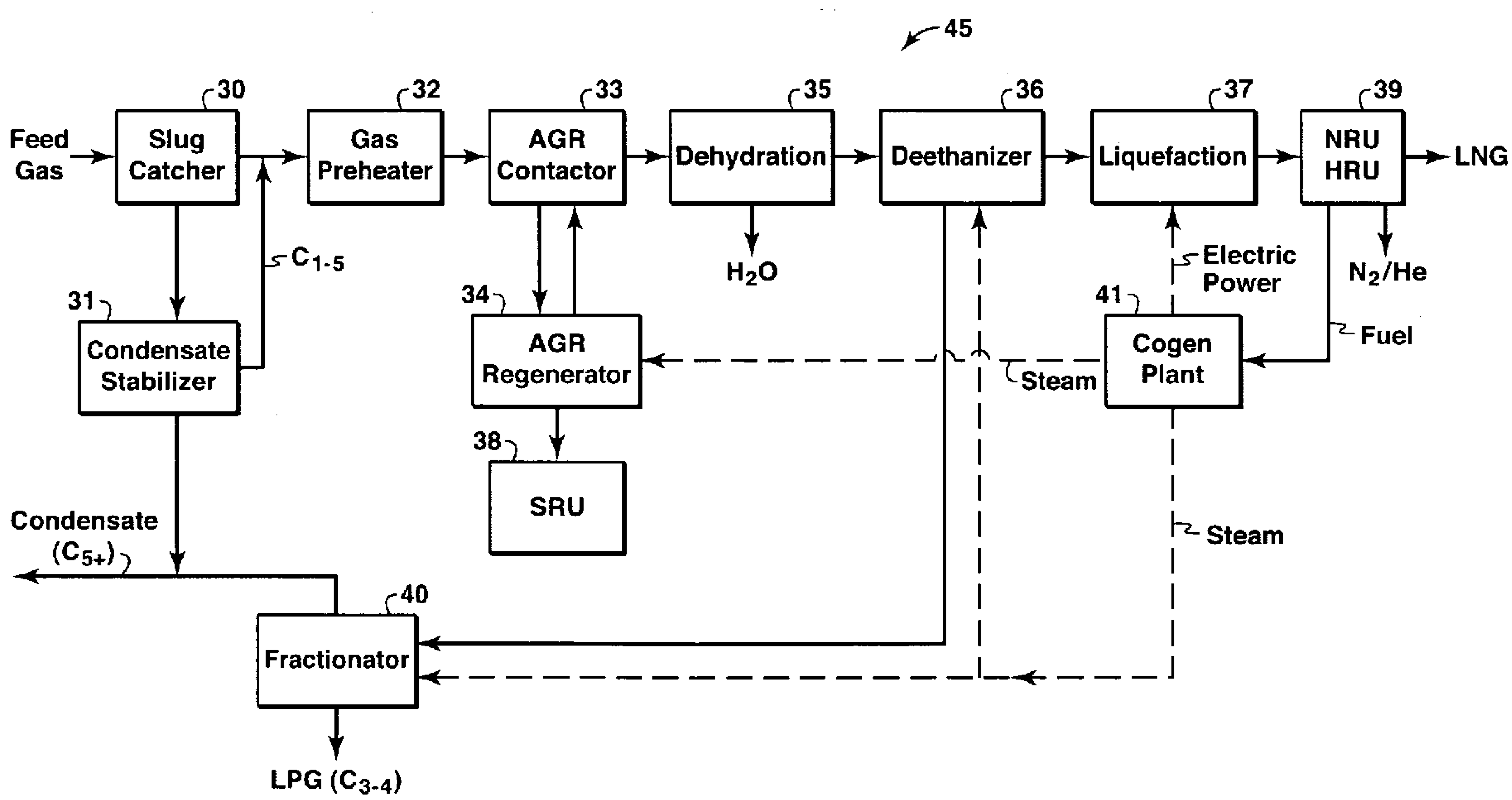
(57) **ABSTRACT**

The current invention is related to hydrocarbon fluid processing plants, methods of designing hydrocarbon fluid processing plants, methods of operating hydrocarbon fluid processing plants, and methods of producing hydrocarbon fluids using hydrocarbon fluid processing plants. More particularly, some embodiments of the invention are related to natural gas liquefaction plants, methods of designing natural gas liquefaction plants, methods of operating natural gas liquefaction plants and methods of producing LNG using natural gas liquefaction plants. One embodiment of the invention includes a hydrocarbon fluid processing plant including a plurality of process unit module types, the plurality of process unit module types including at least a first process unit module type including one or more first process unit modules and a second process unit module type including two or more integrated second process unit modules wherein at least one of the first process unit modules and at least one of the second process unit modules are sized at their respective substantially maximum processing efficiency.



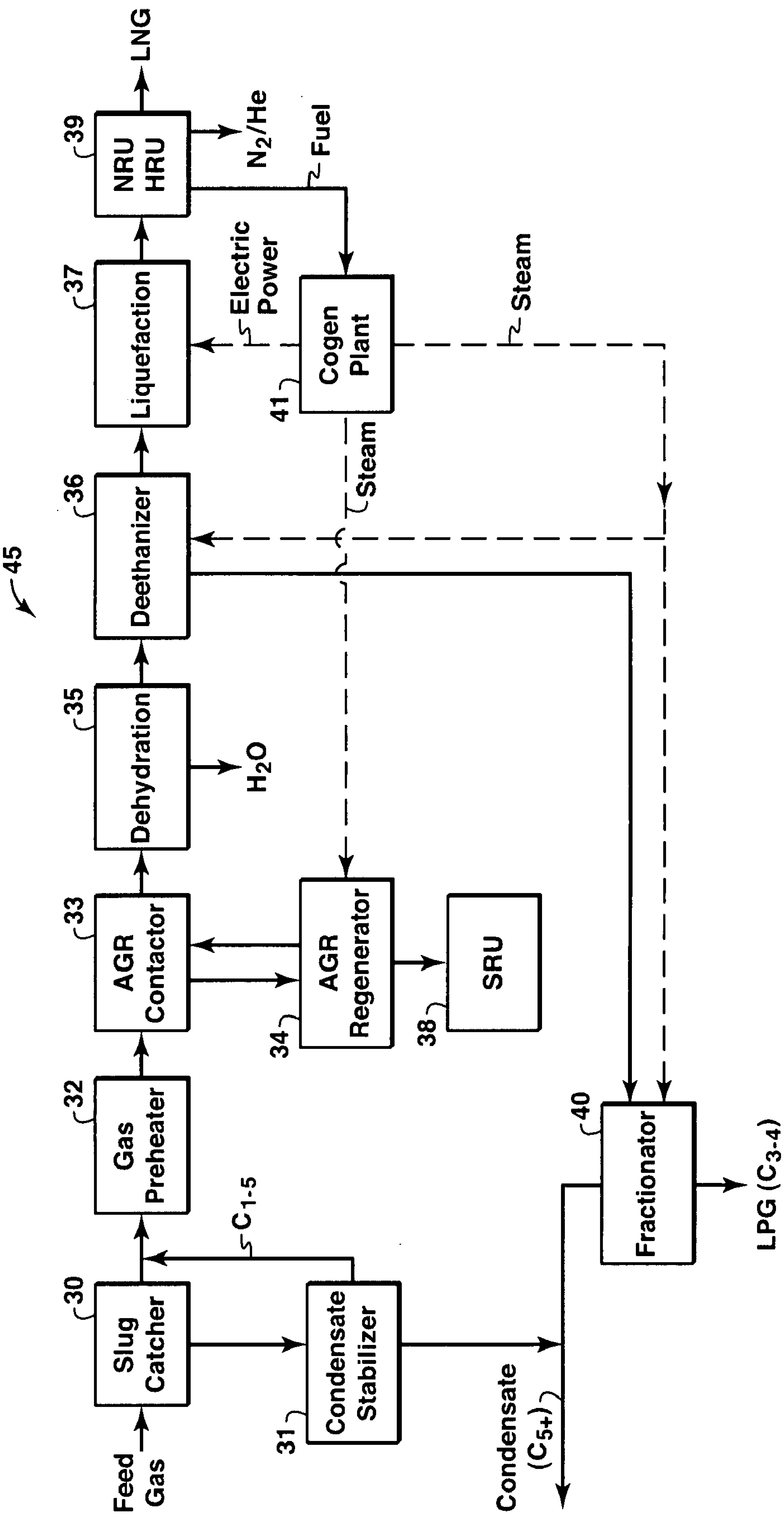

Feed Gas
Slug Catcher
30
Condensate Stabilizer
31
C_{1-5}
Condensate (C_{5+})
Gas Preheater
32
AGR Contactor
33
AGR Regenerator
34
SRU
38
Dehydration
35
H_2O
Deethanizer
36
45
Liquefaction
37
NRU HRU
39
LNG
N_2/He
Fuel
Electric Power
Cogen Plant
41
Steam
Steam
Fractionator
40
LPG (C_{3-4})

FIG. 1

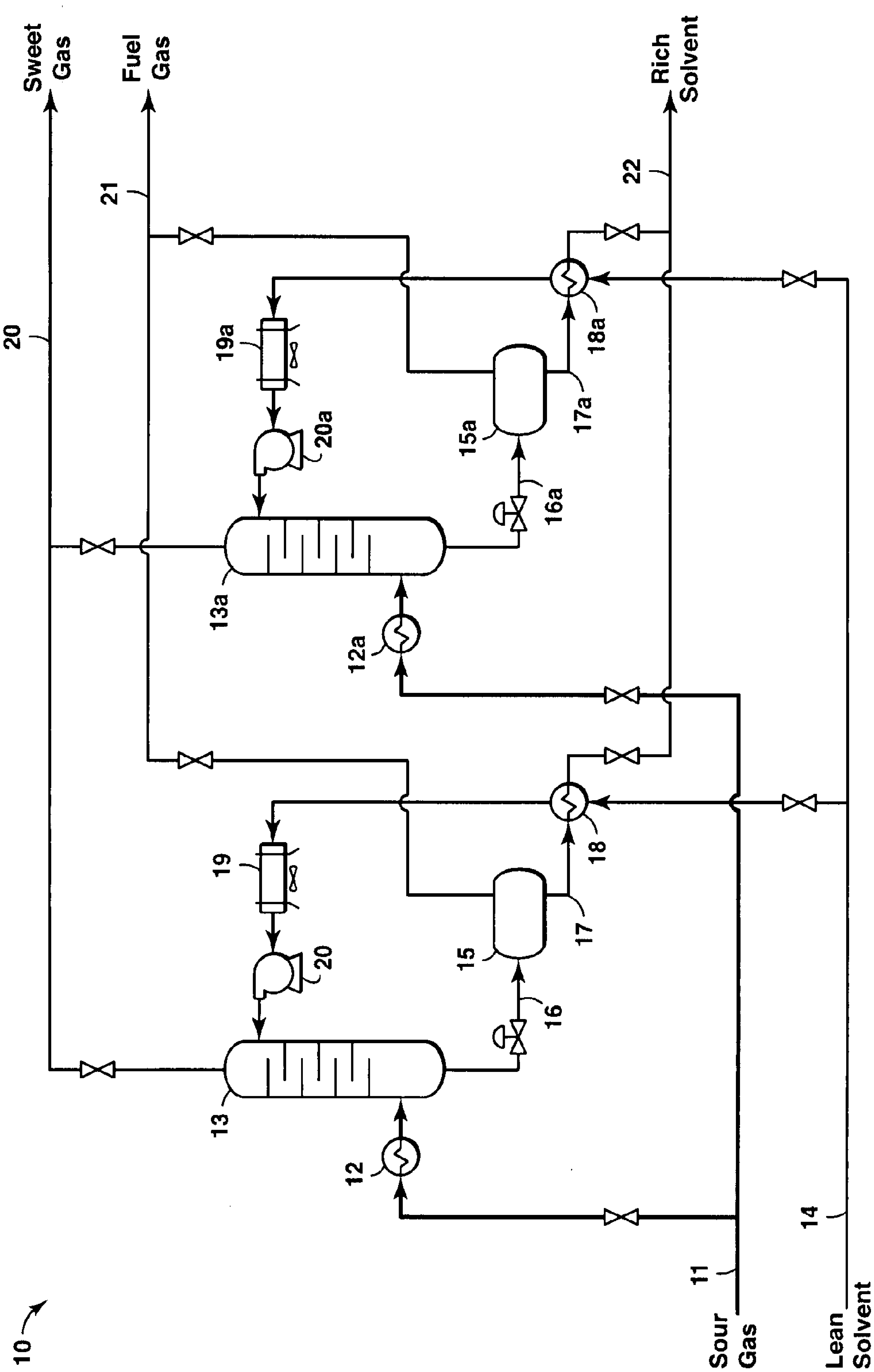
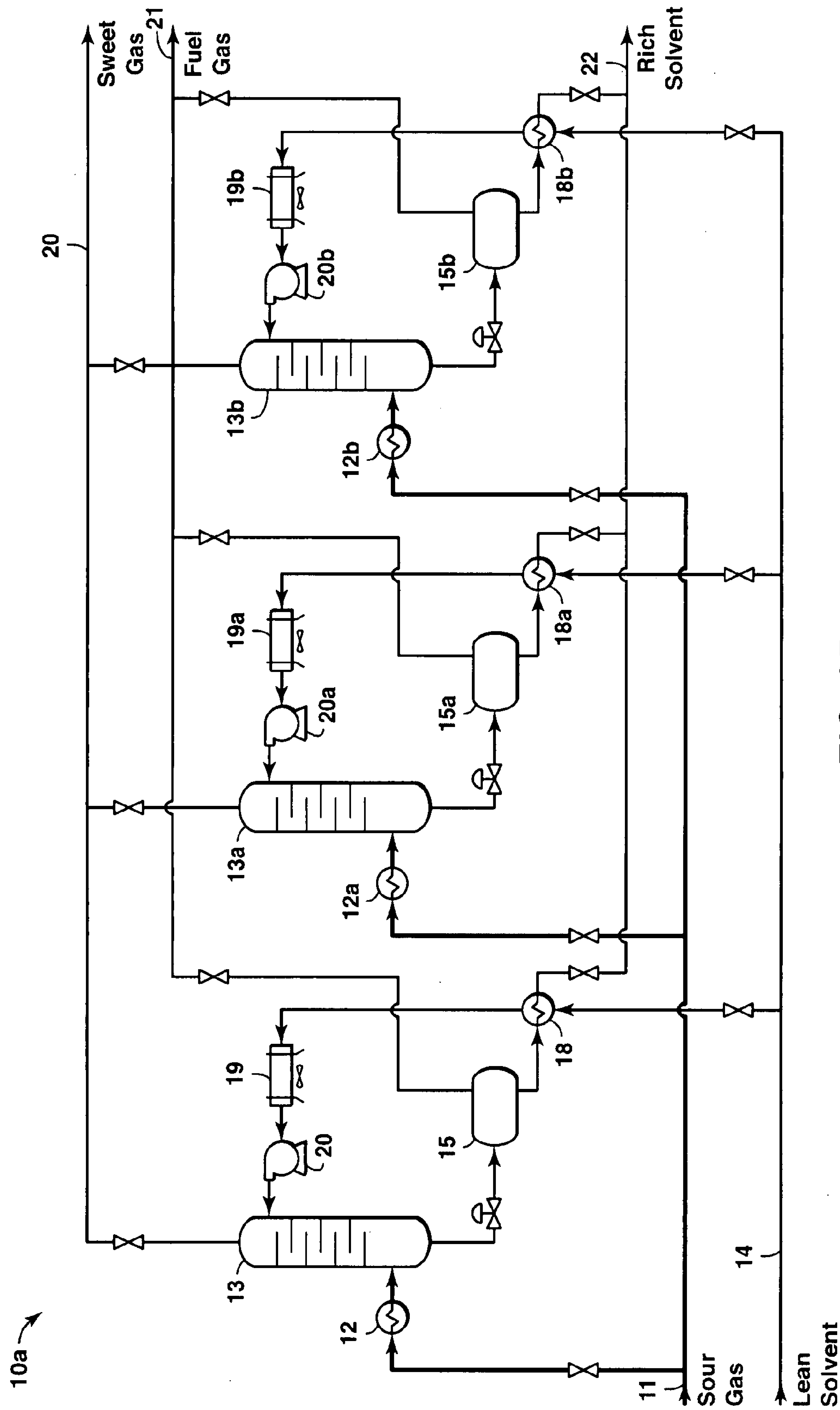

10
Sweet Gas
Fuel Gas
Rich Solvent
Sour Gas
Lean Solvent
11
12
13
14
15
16
17
18
19
20
12a
13a
15a
16a
17a
18a
19a
20a
21
22

FIG. 2A



10a
Sweet Gas
20
21
Fuel Gas
22
Rich Solvent
Sour Gas
11
Lean Solvent
14
12
13
15
18
19
20
12a
13a
15a
18a
19a
20a
12b
13b
15b
18b
19b
20b

FIG. 2B

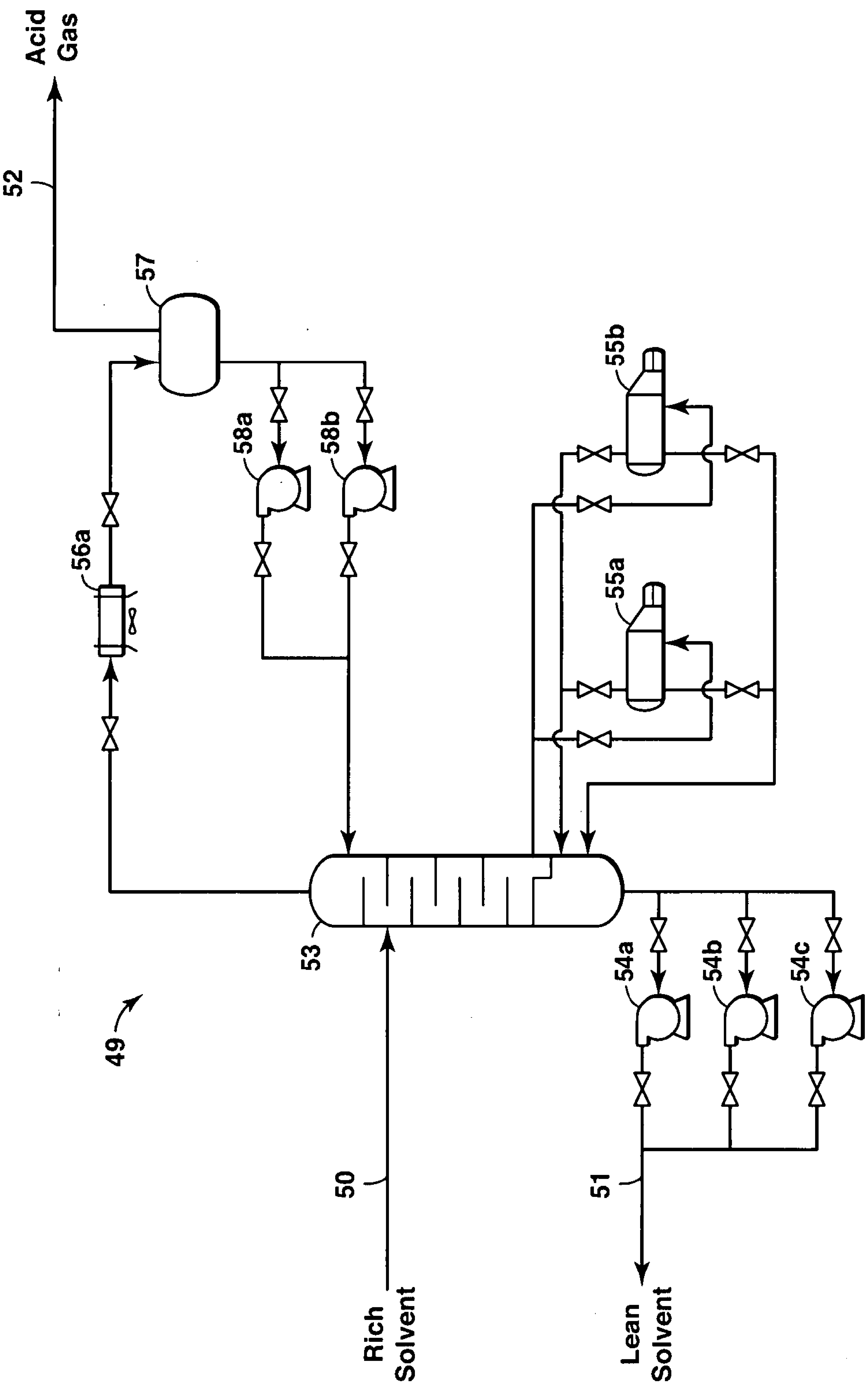

Acid Gas
52
57
56a
58a
58b
55b
55a
53
49
54a
54b
54c
50
51
Rich Solvent
Lean Solvent

FIG. 3A

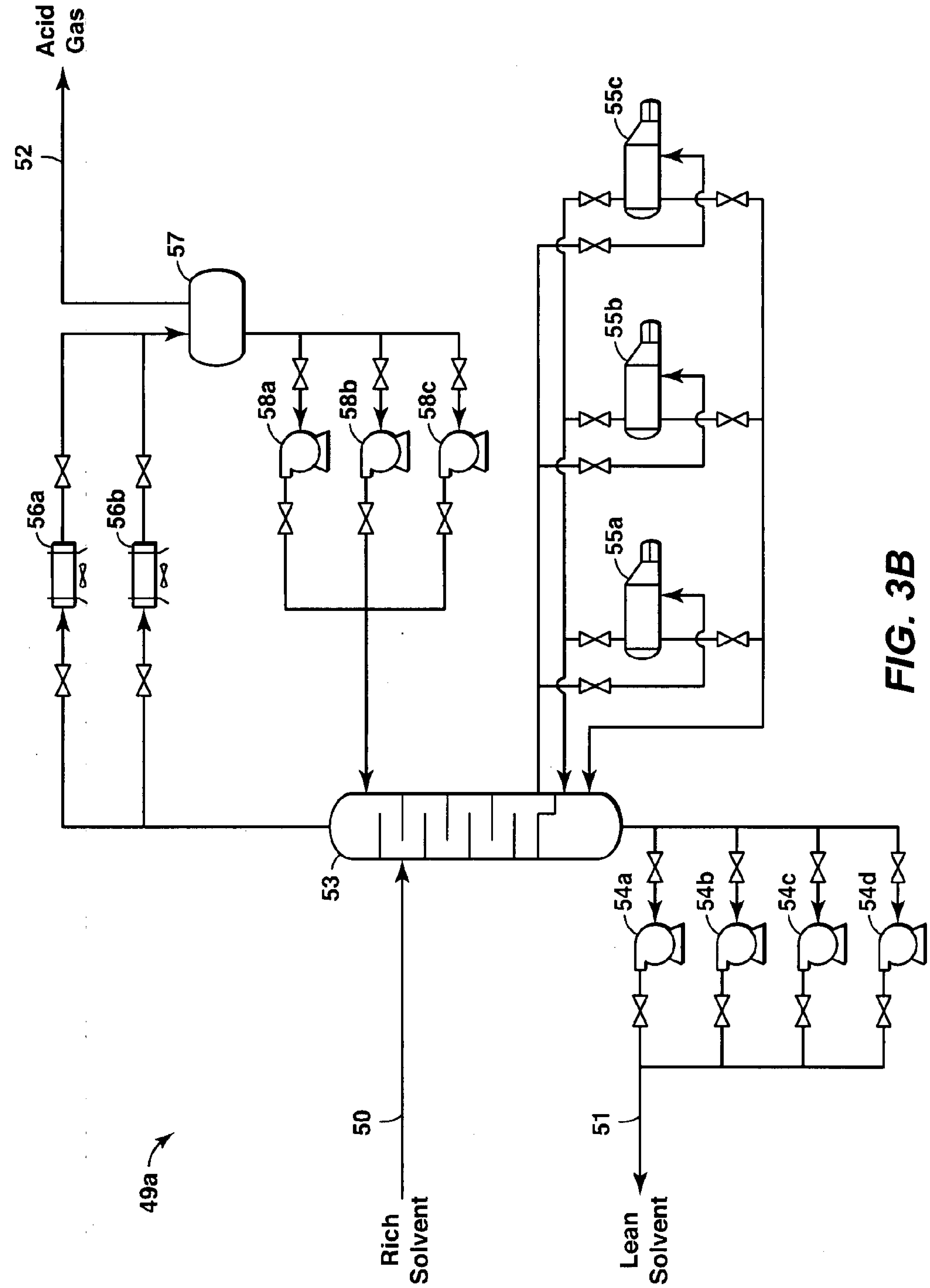

Acid Gas
52
57
55c
55b
55a
56a
56b
58a
58b
58c
53
54a
54b
54c
54d
50
51
49a
Rich Solvent
Lean Solvent

FIG. 3B

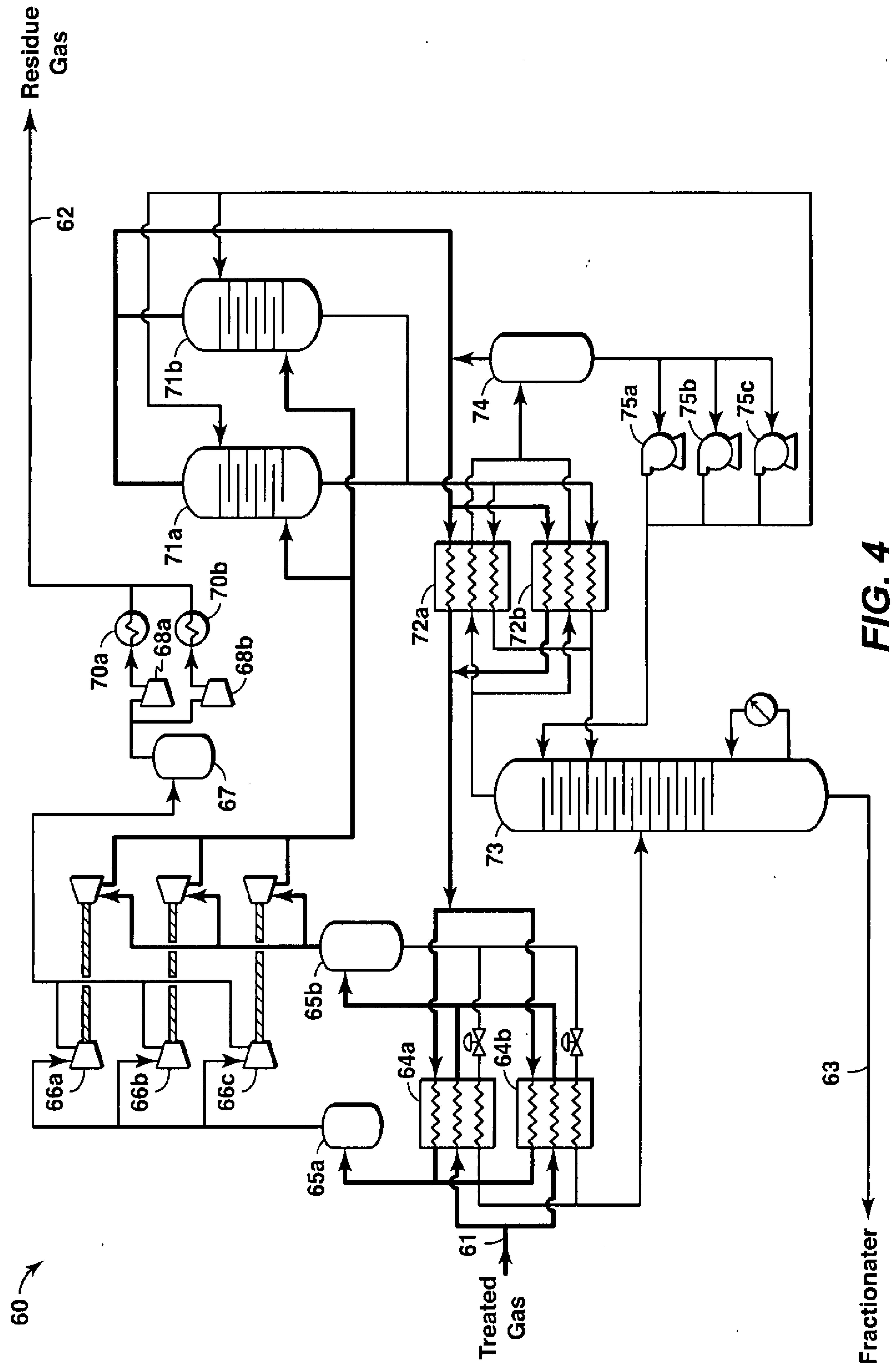

Residue Gas
62
71b
71a
74
75a
75b
75c
70a
68a
70b
68b
72a
72b
67
73
66a
66b
66c
65b
64a
64b
65a
61
Treated Gas
63
Fractionater
60

FIG. 4

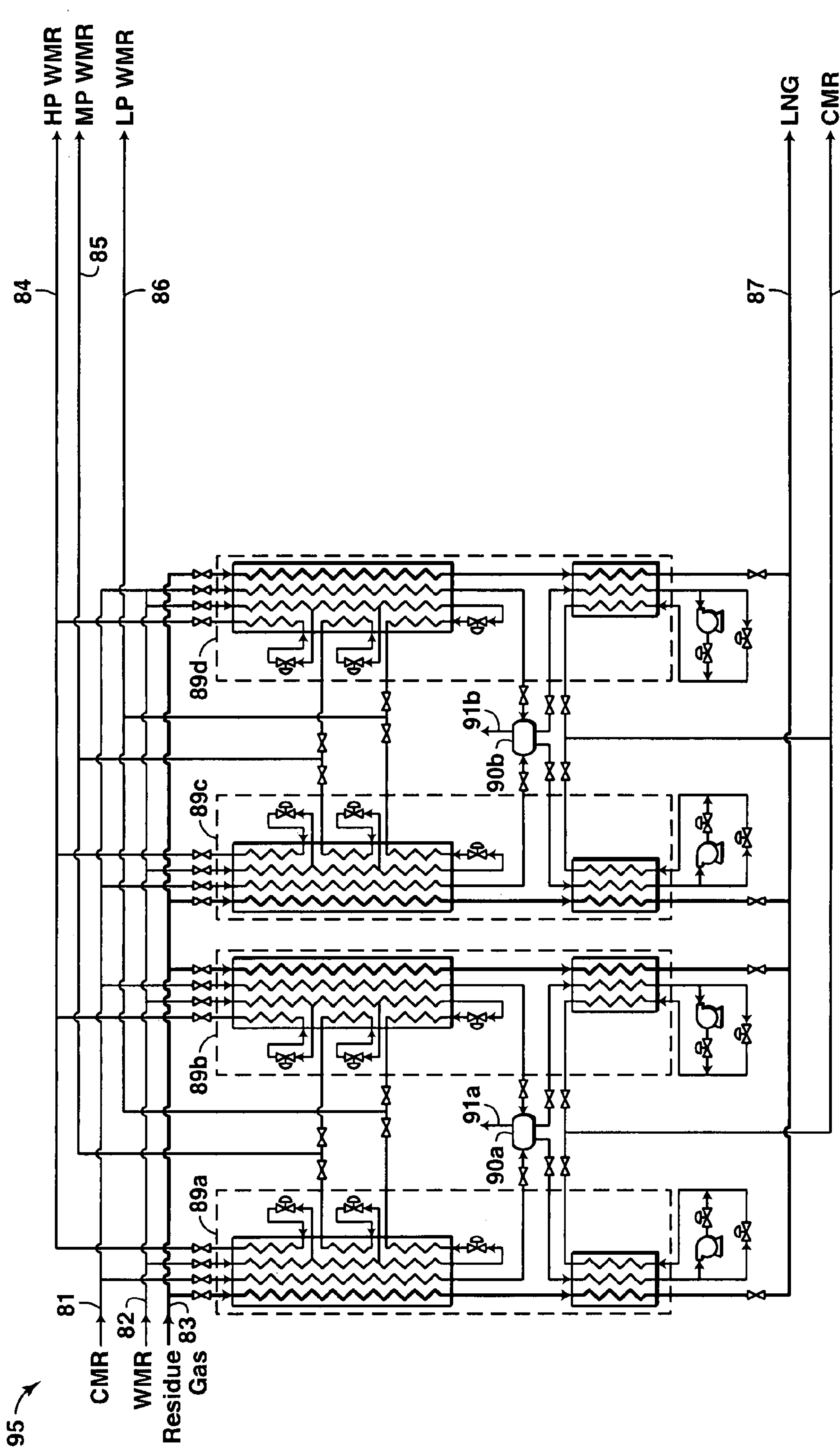

95
CMR
WMR
Residue Gas
81
82
83
84
85
86
87
88
HP WMR
MP WMR
LP WMR
LNG
CMR
89a
89b
89c
89d
90a
90b
91a
91b

FIG. 5

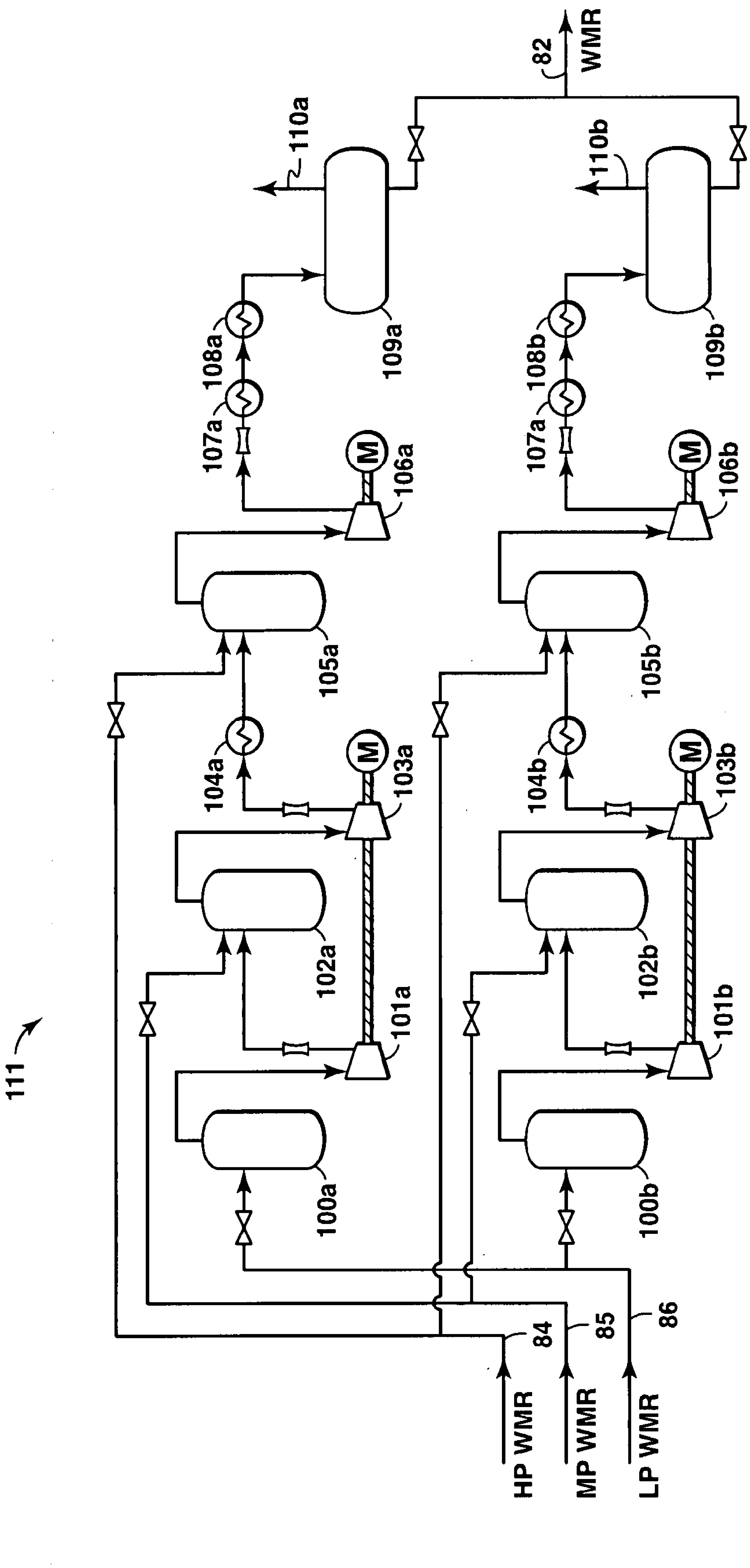
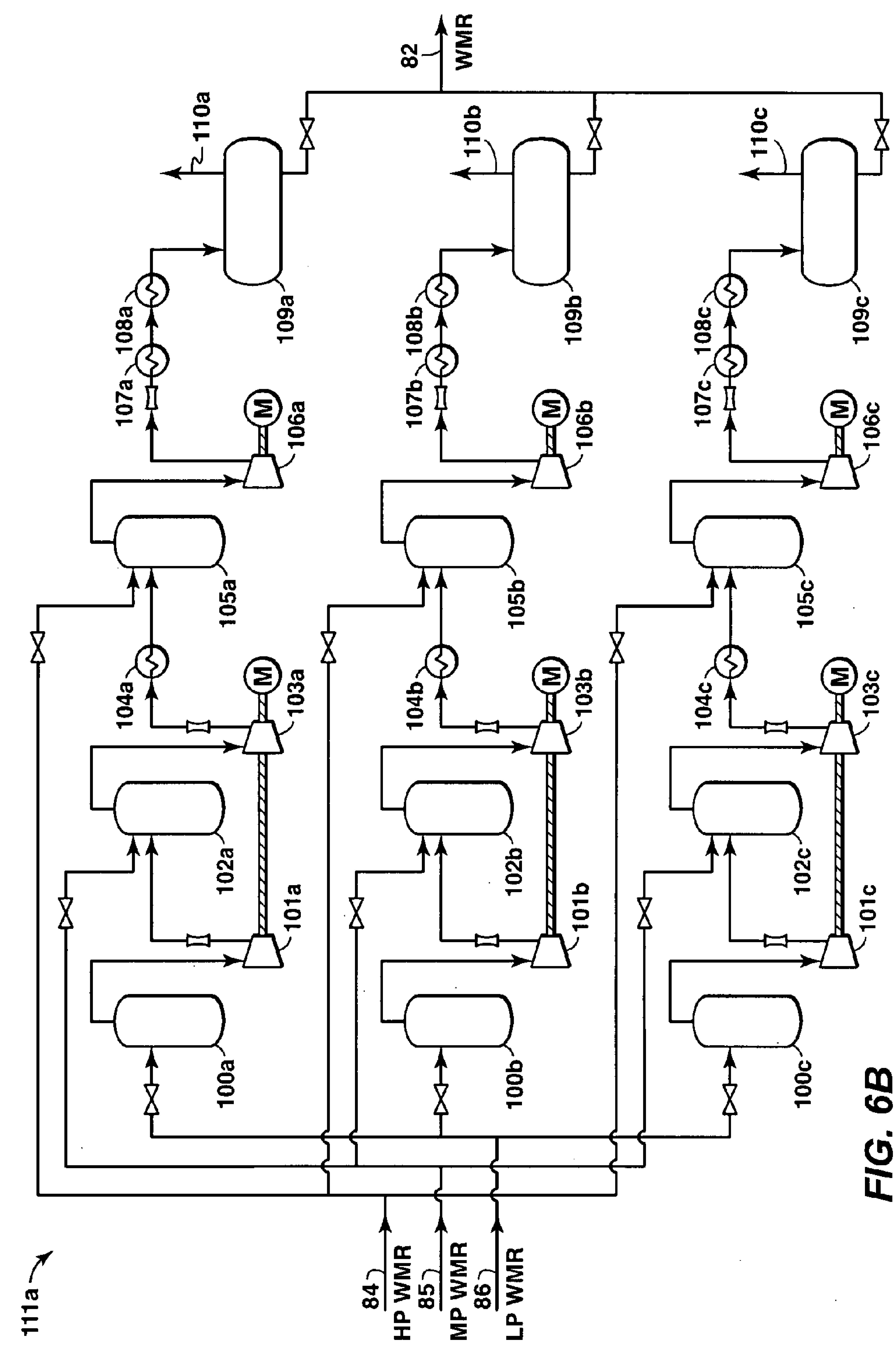

111
HP WMR
MP WMR
LP WMR
84
85
86
100a
101a
102a
103a
104a
105a
106a
107a
108a
109a
110a
100b
101b
102b
103b
104b
105b
106b
107a
108b
109b
110b
M
M
M
M
82
WMR

FIG. 6A


111a
84
HP WMR
85
MP WMR
86
LP WMR
100a
100b
100c
101a
101b
101c
102a
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102c
103a
103b
103c
104a
104b
104c
105a
105b
105c
106a
106b
106c
107a
107b
107c
108a
108b
108c
109a
109b
109c
110a
110b
110c
82
WMR
M

FIG. 6B

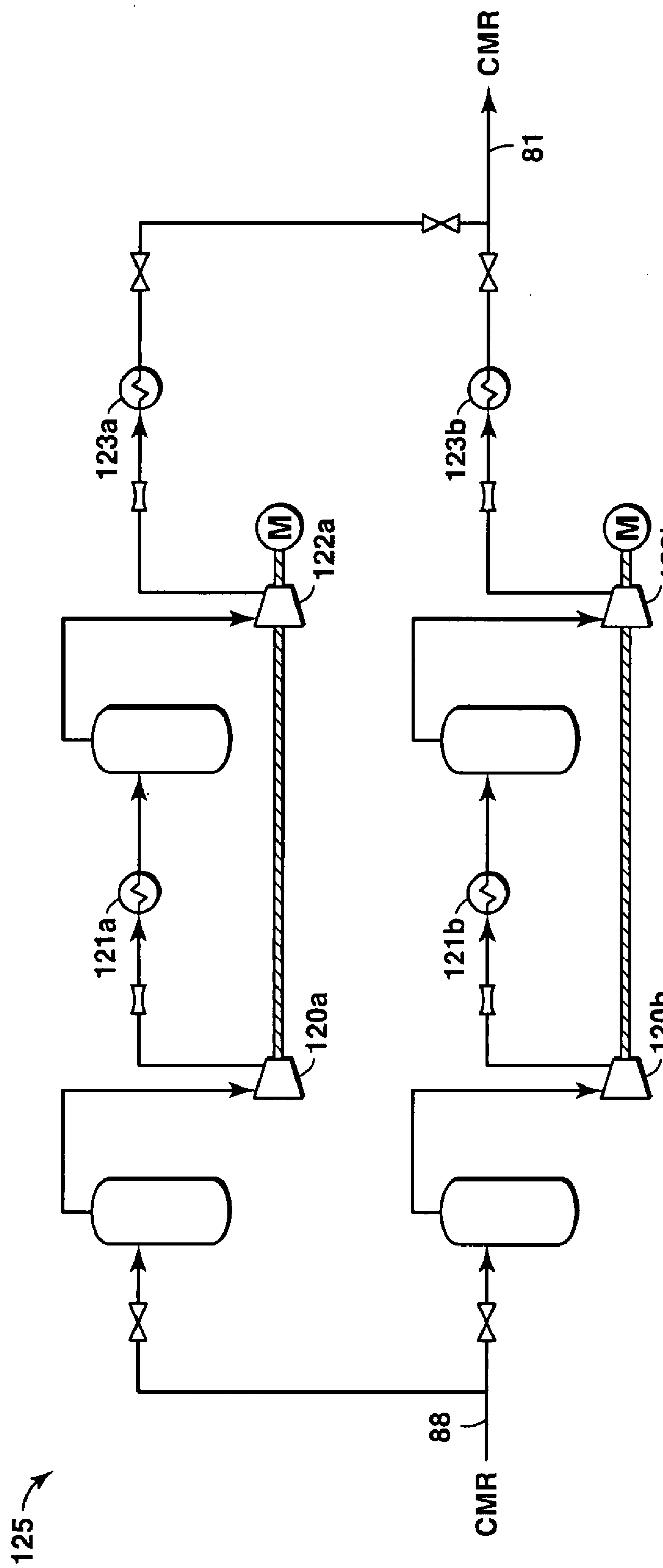

FIG. 7A

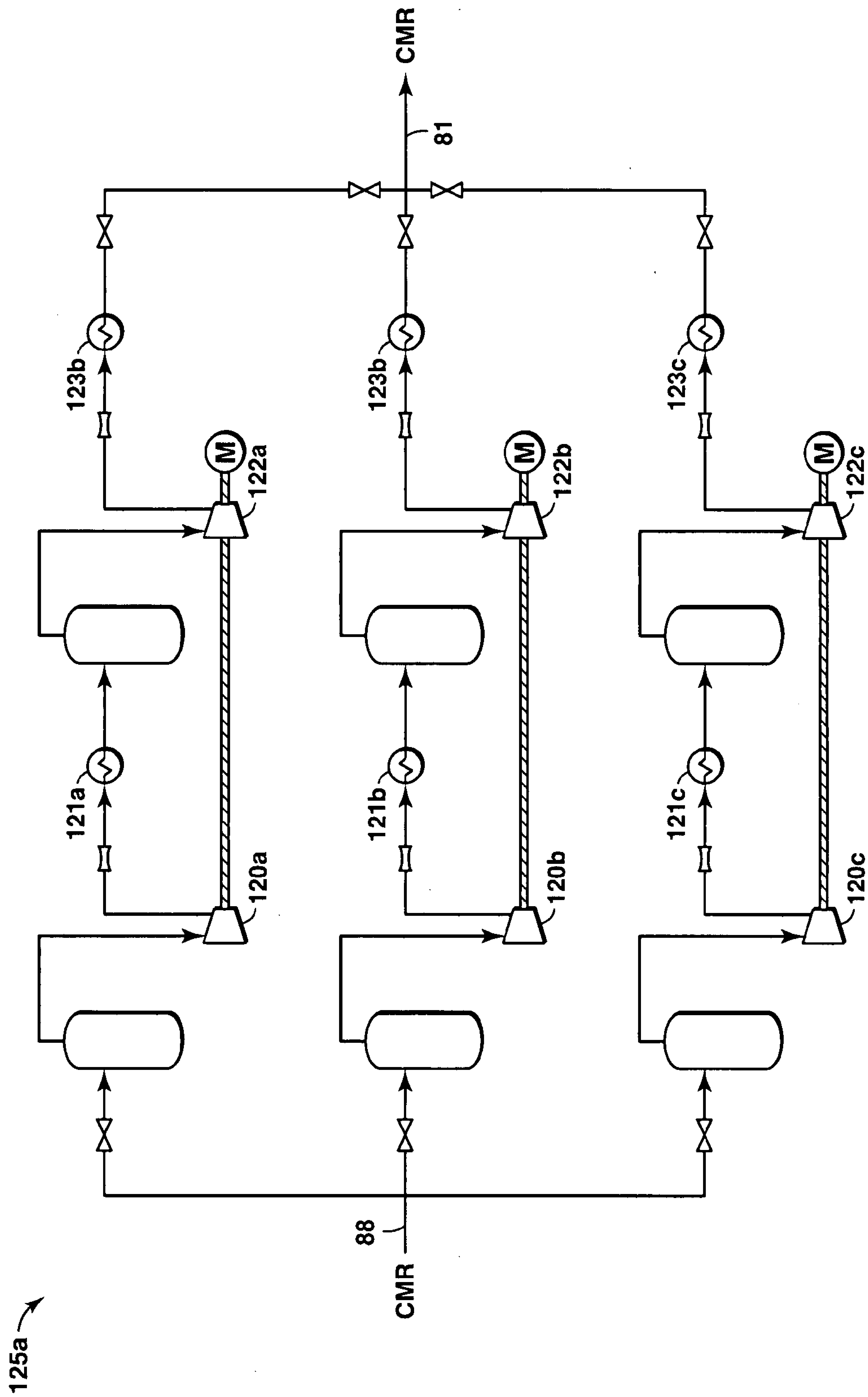
CMR
81
123b
123b
123c
122a
122b
122c
121a
121b
121c
120a
120b
120c
88
CMR
125a

FIG. 7B

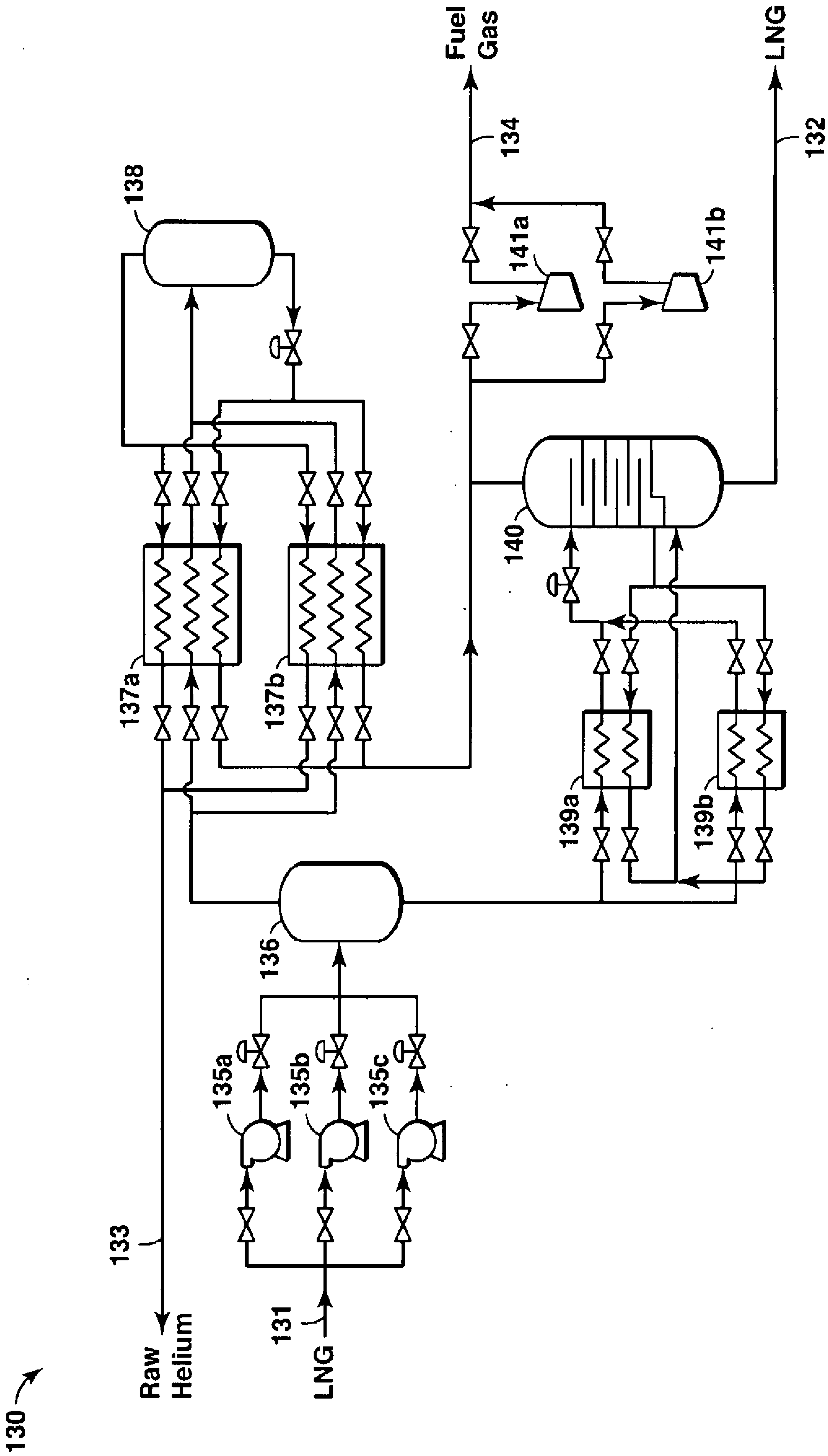
130
Raw Helium
133
LNG
131
135a
135b
135c
136
137a
137b
138
139a
139b
140
141a
141b
134
Fuel Gas
132
LNG

FIG. 8

SCALABLE CAPACITY LIQUEFIED NATURAL GAS PLANT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is the National Stage of International Application No. PCT/US2005/020674, filed Jun. 10, 2005, which claims the benefit of U.S. Provisional Application No. 60/580,746, filed 18 Jun. 2004.

FIELD OF THE INVENTION

[0002] The current invention is related to hydrocarbon fluid processing plants, methods of designing hydrocarbon fluid processing plants, methods of operating hydrocarbon fluid processing plants, and methods of producing hydrocarbon fluids using hydrocarbon fluid processing plants. More particularly, some embodiments of the invention are related to natural gas liquefaction plants, methods of designing natural gas liquefaction plants, methods of operating natural gas liquefaction plants and methods of producing LNG using natural gas liquefaction plants.

BACKGROUND

[0003] Large volumes of natural gas (i.e., primarily methane) are located in remote areas of the world. This gas has significant value if it can be economically transported to market. Where the gas reserves are located in reasonable proximity to a market and the terrain between the two locations permits, the gas is typically produced and then transported to market through submerged and/or land-based pipelines. However, when gas is produced in locations where laying a pipeline is infeasible or economically prohibitive, other techniques must be used for getting this gas to market.

[0004] A commonly used technique for non-pipeline transport of gas involves liquefying the gas at or near the production site and then transporting the liquefied natural gas to market in specially-designed storage tanks aboard transport vessels. The natural gas is cooled and condensed to a liquid state to produce liquefied natural gas ("LNG"). LNG is typically, but not always, transported at substantially atmospheric pressure and at temperatures of about −162° C. (−260° F.), thereby significantly increasing the amount of gas which can be stored in a particular storage tank on a transport vessel. Once an LNG transport vessel reaches its destination, the LNG is typically off-loaded into other storage tanks from which the LNG can then be revaporized as needed and transported as a gas to end users through pipelines or the like. LNG has been an increasingly popular transportation method to supply major energy-consuming nations with natural gas.

[0005] Processing plants used to liquefy natural gas are typically built in stages as the supply of feed gas, i.e. natural gas, and the quantity of gas contracted for sale, increase. One traditional method of building an LNG processing plant is to build up a plant site in several sequential increments, or parallel trains. Each stage of construction may consist of a separate, stand-alone train, which, in turn, is comprised of all the individual processing units or steps necessary to liquefy a stream of feed gas into LNG and send it on to storage. Each train may function as an independent production facility. Train size can depend heavily upon the extent of the resource, technology and equipment used within the train, and the available funds for investment in the project development.

[0006] A traditional LNG train is typically designed to operate at a selected natural gas feed processing rate and normally are not designed or operated at significantly reduced natural gas feed processing rates. This lack of natural gas feed processing rate flexibility reduces the ability of a traditional LNG train plant to adapt to changing market conditions. This lack of natural gas feed processing rate flexibility results in a narrow range of economic operability for a traditional LNG train plant.

[0007] Due to the increase in demand seen in recent years, increased emphasis has been placed on cost and schedule efficiency of new gas liquefaction projects in order to reduce the cost of the delivered gas. Large natural gas liquefaction projects expose the developers to substantial commercial risk due to the large initial capital costs ($5 billion or more) of these projects. Improvements in cost, design, and schedule efficiency can help mitigate the substantial commercial risk associated with large LNG development projects.

SUMMARY

[0008] One embodiment of the invention includes a hydrocarbon fluid processing plant including a plurality of process unit module types, the plurality of process unit module types including at least a first process unit module type including one or more first process unit modules and a second process unit module type including two or more integrated second process unit modules wherein at least one of the first process unit modules and at least one of the second process unit modules are sized at their respective substantially maximum processing efficiency.

[0009] An alternative embodiment of the invention includes a method of designing a hydrocarbon fluid processing plant, including: A) providing the identity of a plurality of process unit module types included in the hydrocarbon fluid processing plant, the plurality of process unit module types including at least a first process unit module type and a second process unit module type; B) determining a first maximum processing efficiency for a first process unit module of the first process unit module type and a second maximum processing efficiency for a second process unit module of the second process unit module type; and C) designing the hydrocarbon fluid processing plant, the hydrocarbon fluid processing plant design including one or more first process unit modules sized to substantially meet the first maximum processing efficiency and one or more second process unit modules sized to substantially meet said second maximum processing efficiency.

[0010] An alternative embodiment of the invention includes a method of designing an expanded processing capacity of a hydrocarbon fluid processing plant having an existing plant maximum feed processing capacity, including: A) providing the existing configuration of the hydrocarbon fluid processing plant, the hydrocarbon fluid processing plant including a plurality of process unit module types; B) determining a first process unit module type requiring additional maximum feed processing capacity to increase the existing plant maximum feed processing capacity; C) determining the maximum processing efficiency of a first process unit module of the first process unit module type; and D) designing an expanded hydrocarbon fluid processing plant, the design including the addition of one or more first process unit modules sized to substantially meet the maximum processing efficiency.

[0011] An alternative embodiment of the invention includes a method of operating a hydrocarbon fluid processing plant having a plurality of process unit module types, the plurality of process unit module types including at least a first process unit module type comprised of one or more first process unit modules and a second process unit module type comprised of two or more integrated second process unit modules wherein at least one of the first process unit modules and at least one of the second process unit modules are sized at their respective substantially maximum processing efficiency, the method including: A) determining a first plant feed processing rate; B) determining the number of process unit modules of each process unit module type required to meet the first plant feed processing rate; C) commissioning at least the number of each process unit module of each process unit module type required to meet the first plant feed processing rate determined in step (B); and D) producing a hydrocarbon fluid product.

[0012] An alternative embodiment of the invention includes a method of producing hydrocarbon fluids using a hydrocarbon fluid processing plant, the hydrocarbon fluid processing plant comprised of a plurality of process unit module types, each of the plurality of process unit module types comprised of one or more process unit modules, the method including: A) providing at least one original process unit module for each process unit module type included in the plurality of process unit module types, one or more of the original process unit modules sized at their respective substantially maximum processing efficiency, thereby providing a first phase hydrocarbon fluid processing plant; B) providing one or more additional process unit module(s) for one or more process unit module type(s) included in the first phase hydrocarbon fluid processing plant, the additional process unit module being integrated with the original process unit module within the process unit module type, thereby providing a second phase hydrocarbon fluid processing plant; and C) producing hydrocarbon fluids from the second phase hydrocarbon fluid processing plant.

[0013] An alternative embodiment of the invention includes a method of producing liquefied natural gas, including: A) providing an LNG liquefaction plant comprising a plurality of product sized process unit module types, the LNG liquefaction plant having a first plant maximum feed processing capacity; B) expanding the maximum feed processing capacity of at least one but less than all of the product sized process unit module types to achieve a second plant maximum feed processing capacity that is 10 percent or greater than the first plant maximum feed processing capacity; and C) producing LNG in the LNG liquefaction plant after initiation of the expanding step (B).

[0014] An alternative embodiment of the invention includes a method of producing liquefied natural gas using an LNG liquefaction plant, the LNG liquefaction plant including a plurality of process unit module types, each of the plurality of process unit module types comprised of one or more process unit modules, the method including: A) providing at least one original process unit module for each process unit module type included in the plurality of process unit module types, thereby providing a first phase LNG liquefaction plant; B) producing first LNG from the first phase LNG liquefaction plant; C) constructing one or more additional process unit modules for one or more process unit module types included in the first phase LNG liquefaction plant while completing at least a portion of the producing step (B); D) placing the one or more additional process unit modules in service, the additional process unit modules being integrated with the original process unit module within the process unit module type, thereby providing a second phase LNG liquefaction plant; and E) producing second LNG from the second phase LNG liquefaction plant.

[0015] An alternative embodiment of the invention includes an LNG liquefaction plant including one or more high construction cost product sized process unit module types and one or more low construction cost product sized process unit module types, at least one of the low construction cost product sized process unit module types having a maximum feed processing capacity that is at least 110 percent of the maximum feed processing capacity of at least one of the high construction cost product sized process unit module types.

[0016] An alternative embodiment of the invention includes a method of producing liquefied natural gas including: A) providing an LNG liquefaction plant comprising a plurality of process unit module types, the LNG liquefaction plant having at least a first refrigerant circuit, the first refrigerant circuit including at least one first refrigerant compressor service type, the first refrigerant compressor service type comprised of one or more original first refrigerant compressors in parallel, the LNG liquefaction plant having a plant maximum feed processing capacity; B) expanding the plant maximum feed processing capacity of the LNG liquefaction plant by adding at least one additional first refrigerant compressor to the first refrigerant compressor service type, the additional first refrigerant compressor being integrated with the one or more original first refrigerant compressors within the first refrigerant compressor service type; and C) producing LNG in the LNG liquefaction plant after initiation of the expanding step (B).

[0017] An alternative embodiment of the invention includes a method of producing liquefied natural gas using an LNG liquefaction plant, the LNG liquefaction plant including a plurality of process unit module types, each of the plurality of process unit module types comprised of one or more process unit modules, the method comprising: A) providing at least one original process unit module for each process unit module type included in the plurality of process unit module types, thereby providing a first phase LNG liquefaction plant; B) providing at least one second process unit module for each process unit module type included in the plurality of process unit module types, thereby providing a second phase LNG liquefaction plant; C) integrating one or more of the original process unit modules with one or more of the second process unit modules for two or more respective process unit module types; and D) producing LNG from the LNG liquefaction plant after initiation of said integrating step (C).

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. 1 is a block flow diagram of one exemplary configuration of an LNG liquefaction plant.

[0019] FIG. 2A is a simplified process flow diagram of an exemplary acid gas removal contactor unit.

[0020] FIG. 2B is a simplified process flow diagram of a second exemplary acid gas removal contactor unit.

[0021] FIG. 3A is a simplified process flow diagram of an exemplary acid gas removal regenerator unit.

[0022] FIG. 3B is a simplified process flow diagram of a second exemplary acid gas removal regenerator unit.

[0023] FIG. 4 is a simplified process flow diagram of an exemplary deethanizer unit.

[0024] FIG. 5 is a simplified process flow diagram of an exemplary cryogenic heat exchanger unit.

[0025] FIG. 6A is a simplified process flow diagram of an exemplary refrigerant compressor unit.

[0026] FIG. 6B is a simplified process flow diagram of a second exemplary refrigerant compressor unit.

[0027] FIG. 7A is a simplified process flow diagram of a second exemplary refrigerant compressor unit.

[0028] FIG. 7B is a simplified process flow diagram of a second exemplary refrigerant compressor unit.

[0029] FIG. 8 is a simplified process flow diagram of an exemplary helium recovery unit.

DETAILED DESCRIPTION

[0030] As used herein and in the claims the phrase "hydrocarbon fluid processing plant" means any processing plant that processes a hydrocarbon fluid feed into a product that is changed in some way from the feed. For example, the feed may be changed in composition, physical state and/or combinations of physical state and composition. One example of a hydrocarbon fluid processing plant is a LNG liquefaction plant.

[0031] As used herein and in the claims the phrase "LNG liquefaction plant" means a hydrocarbon fluid processing plant that includes processing a feed stream which comprises gaseous methane into a product stream that includes liquid methane. For example an LNG liquefaction plant may include a cryogenic heat exchanger, refrigerant compressors and/or an expansion step. An LNG liquefaction plant may optionally include other fluid processing steps. Non-limiting examples of optional fluid processing steps include feed purification processing steps (liquids removal, hydrogen sulfide removal, carbon dioxide removal, dehydration), product purification steps (helium removal, nitrogen removal), and non-methane product production steps (deethanizing, depropanizing, sulfur recovery). One example of an LNG liquefaction plant includes, for example, a plant that converts a gaseous feed stream containing methane, ethane, carbon dioxide, hydrogen sulfide and other species to liquefied natural gas which contains methane and reduced amounts of some other non-methane species as compared to the feed stream.

[0032] As used herein and in the claims the phrase "equipment types" means any type of processing equipment used in any type of process unit module. Non-limiting examples of equipment types include compressors, heat exchangers, distillation columns, flash drums, reactors, pumps, expanders, gas turbines, motors, fired heaters, liquid/gas contactors, liquid/gas separation drums and other processing equipment used in hydrocarbon fluid processing plants.

[0033] As used herein and in the claims the phrase "process unit module" means a single grouping of one or more equipment types that, when taken together, complete a specific process function in a hydrocarbon fluid processing plant or support the completion of that function in a hydrocarbon fluid processing plant. For example, such functions include steps which change the temperature, pressure, composition, physical state and/or combinations of temperature, pressure, physical state and composition of a material. Additionally, process units which support these functions include, for example, process units that provide electricity, steam, and/or cooling water to process units which complete a processing step. Non-limiting examples of process unit modules include utility units, gas preheat units, slug catcher units, offgas compressor units, condensate stabilizer units, acid gas removal contactor units, acid gas removal regenerator units, sulfur recovery units, dehydration units, deethanizer units, depropanizer units, fractionation units, precooling heat exchanger units, cryogenic heat exchanger units, refrigerant compressor units, nitrogen rejection units, cogeneration units, liquefaction units, helium recovery units, compression units, refrigerant preparation units, and combinations thereof.

[0034] As used herein and in the claims the phrase "process unit module type" means the total amount of a particular type of process unit module in a hydrocarbon fluid processing plant. Process unit module types are made up of one or more process unit modules. For example, a particular process unit module type may be made up of multiple process unit modules in parallel, each process unit module having the capacity to perform the same processing step.

[0035] As used herein and in the claims the phrase "maximum feed processing capacity" means the maximum processing capacity of a particular process unit module type included in a hydrocarbon fluid processing plant on a hydrocarbon fluid processing plant feed basis. Maximum feed processing capacity represents the amount of feed to a hydrocarbon fluid processing plant, which may be different from the amount of feed to the particular process unit module type, that can be processed by a hydrocarbon fluid processing plant having a particular process unit module type capacity. For example, if a hydrocarbon fluid processing plant has three process unit module types, A, B and C; if process unit module type A is running at full capacity while the hydrocarbon fluid processing plant is running 100 units of feed, then the maximum feed processing capacity of process unit module type A is 100 units. This is true even if process unit module type A is actually processing 150 units of an intermediate stream, 50 units of an intermediate stream or zero units of an intermediate stream. Further, if process unit module type B is not running at full capacity while the hydrocarbon fluid processing plant is running 100 units of feed, and process unit module type B is 10 percent unloaded on a hydrocarbon fluid processing plant feed basis, meaning that process unit module type B could run at 10 percent greater capacity, then the maximum feed processing capacity of process unit module type B could be stated as 110 units.

[0036] As used herein and in the claims the phrase "plant maximum feed processing capacity" means the maximum feed processing capacity of the entire hydrocarbon fluid processing plant.

[0037] As used herein and in the claims the phrase "plant minimum feed processing capacity" means the minimum feed processing capacity of the entire hydrocarbon fluid processing plant that can be run in a stable operating mode. A stable operating mode is one in which the control system effectively controls the relevant process variables and the equipment types operate at substantially their design effectiveness. For example, in a stable operating mode distillation columns will achieve substantially the desired degree of separation and compressors will be able to develop substantially the required head without entering surge mode.

[0038] As used herein and in the claims the phrase "construction cost" means the total cost for an item, for example a process unit module or a process unit module type, at a location such that the module is ready to be placed into service. Construction costs include fabrication costs, installation costs, equipment costs, procurement costs, licensing costs, training costs, commissioning costs, etc.

[0039] As used herein and in the claims the phrase "construction cost per unit of maximum feed processing capacity" means the "construction cost" divided by the "maximum feed processing capacity" for an item, for example a process unit module or a process unit module type.

[0040] As used herein and in the claims, the phrase "maximum processing efficiency" means the process unit module capacity size for a process unit module type that minimizes its cost per unit of process unit module capacity, where the cost can be selected from the total process module construction cost, the total process unit module operating cost, the total process unit module lifecycle cost, or combinations thereof.

[0041] As used herein and in the claims the phrase "life cycle cost" means a combined measure of the construction cost, and operating cost of an equipment type or process unit module. For example, the life cycle cost can be expressed in present value currency, where the construction cost value is expressed substantially in terms of present value currency, and the present value equivalent of the operating cost can be computed by adjusting the future expenditure to a present value through accounting for the time value of money in methods known to those skilled in the art.

[0042] As used herein and in the claims the term "integrated" used with respect to process unit module types means that the process unit module type is composed of a plurality of process unit modules in parallel with each process unit module providing a portion of the process unit module type maximum feed processing capacity and the process unit module type being configured such that each process unit module is 1) able to process any portion of the hydrocarbon fluid processing plant feed, any portion of the hydrocarbon fluid processing plant product or any portion of a particular intermediate stream of the hydrocarbon fluid processing plant and/or 2) is able to complete any particular processing step in the hydrocarbon fluid processing plant, and/or 3) is able to complete any portion of a particular support service for a process unit module type, a plurality of process unit modules or a plurality of equipment types in the hydrocarbon fluid processing plant, in any of 1, 2 and 3 above without regard to the source of the respective feed, product, intermediate stream, processing step, process unit module type, plurality of process unit modules or plurality of equipment types.

[0043] As used herein and in the claims the phrase "product sized process unit module types" means a process unit module type whose capacity (size) is determined principally by the most valuable product stream rate for the hydrocarbon fluid processing plant. The most valuable product stream is the product stream that yields the highest total revenue (e.g. market price times quantity produced, not necessarily the product with the highest value per unit of quantity). For example, for an LNG liquefaction plant the most valuable product stream is the LNG product stream. Non-limiting examples of product sized process unit module types for an LNG liquefaction plant include acid gas removal contactor units, dehydration units, deethanizer units, cryogenic heat exchanger units, refrigerant compressor units, nitrogen rejection units, liquefaction units, helium recovery units, and combinations thereof. Non-limiting examples of process unit module types that are not product sized process unit module types for an LNG liquefaction plant include utility units, sulfur recovery units, cogeneration units, gas preheat units, slug catcher units, offgas compressor units, condensate stabilizer units, acid gas removal regenerator units, and fractionation units.

[0044] As used herein and in the claims the phrase "high construction cost product sized process unit module types" means a product sized process unit module type that represents more than 10 percent of the cost of constructing a hydrocarbon fluid processing plant containing such process unit.

[0045] As used herein and in the claims the phrase "low construction cost product sized process unit module types" means a product sized process unit module type that represents less than 7 percent of the cost of constructing a hydrocarbon fluid processing plant containing such process unit.

[0046] As used herein and in the claims the phrase "transportation vessel" means any vessel which is capable of transporting a hydrocarbon fluid product over land or water. Transportation vessels may include one or more of rail cars, tanker trucks, barges, ships or other means of traveling over land or water.

[0047] As used herein and in the claims the phrase "capital cost basis" means any cost basis that represents capital and non-capital costs on a capital cost equivalent basis. Capital costs typically represent costs to design, procure, construct, and install equipment, as well as any other costs incurred by a project prior to the initial startup of the plant or plant modification. Non-capital costs, such as continuous operating costs, can be transformed to capital costs equivalent by determining the "Present Value" of such continuous costs or by determining the capital cost that would effect the same economic benefit as the continuous costs. These economic evaluation techniques are commonly employed by those skilled in the art.

[0048] As used herein and in the claims the phrase "modular heat exchanger" means a heat exchanger whose primary exchange function can be expanded easily by the addition of similar sized exchangers.

[0049] As used herein and in the claims the phrase "refrigerant circuit" means the processing steps performed to prepare a spent refrigerant for its subsequent use in performing a cooling function. A refrigerant circuit may include, for example, compression of the spent refrigerant to a high pressure, cooling and condensation of the high-pressure refrigerant, and a means of reducing the condensed refrigerant's pressure (e.g., expansion). After exiting the refrigerant circuit a refrigerant may enter a heat exchanger that accomplishes the desired cooling function.

[0050] As used herein and in the claims the phrase "operating cost" means any costs that are incurred during the routine operation of the plant. For example, operating costs include repair costs, salaries and wages, chemical and catalyst costs, and other routine plant operating costs.

[0051] One embodiment of the invention includes a hydrocarbon fluid processing plant. The hydrocarbon fluid processing plant may include a plurality of process unit module types. For exemplary purposes one general arrangement of one type of hydrocarbon fluid processing plant will be briefly described with reference to FIG. **1** depicting an exemplary LNG liquefaction plant.

[0052] An LNG liquefaction plant **45** may consist of several discrete processing sections. Exemplary processing sections include the inlet facilities, gas treating, dehydration, gas liquefaction, refrigerant compression, and refrigerant preparation, each of which may be carried out in one or more process unit module types. The concept is most easily described through using an example of a LNG liquefaction plant contained in FIG. **1**.

[0053] Feed gas is received into the inlet facilities, which separate the gas from liquid water and any hydrocarbon liquids (condensate) that may be present. The inlet facilities may also stabilize the condensate into a saleable product. The inlet facilities may consist of a slug catcher unit **30**, various separation vessels (not shown), a condensate stabilizer unit **31**, an off gas compressor unit (not shown) to return the condensate stabilizer offgas to the main gas stream, and a feed gas preheat unit **32**. The feed stream is initially passed through a slug catcher and separation equipment (not shown) to remove the bulk of the components that tend to cause freezing and plugging problems in a cryogenic process. Condensed liquids (gas condensate) separated from the gas stream are generally at high pressure, such as 500-1000 psig or higher and contain significant amounts of dissolved methane and ethane. For transportation and subsequent use, the condensate is typically stabilized in the condensate stabilizer unit **31**; that is, the vapor pressure is reduced, typically below atmospheric pressure. Removing the light hydrocarbons to lower the vapor pressure not only increases the heating value of the condensate product, but it also reduces potential problems caused by later off-gassing of the light components, as the pressure and temperature of the condensate change during transport and storage.

[0054] The major process functional areas in the gas treating and dehydration section are the acid gas removal (AGR) system, including the AGR contactor unit **33** and AGR regenerator unit **34**, mercury adsorbent (not shown), and dehydration unit **35**. A variety of processes have been used to treat the gas to remove acid gases (H_2S and CO_2). One process for treating a sour gas stream involves contacting the gas stream in a contactor vessel with a solvent (e.g., organic amines such as methyldiethanolamine and other additives) which absorbs the acid gases and carries them out of the gas stream.

[0055] In order for processes of this type to be economical, the "rich" solvent must be regenerated in the AGR regenerator unit **34** so that it can be reused in the treatment process. That is, the acid gases (both CO_2 and H_2S) and the hydrocarbons are removed or substantially reduced in the rich solvent before it can be reused in the process. The rich solvent may be regenerated by passing it into a regenerator vessel where substantially all of the acid gases are removed, after which the regenerated solvent is returned for use in the treatment process. A sulfur product may then be recovered from the H_2S by processing the recovered acid gas stream through a Sulfur Recovery Unit (SRU) **38**.

[0056] A dehydration unit **35**, using molecular sieves and/or glycol processes for example, removes H_2O to a dew point level compatible with the LNG product temperature of −260° F. The dehydration adsorbent vessels may generally be comprised of parallel vessels which cycle from dehydrating the feed gas to regenerating mode.

[0057] The gas liquefaction section **37** generally contains one or more cryogenic heat exchanger units and optionally one or more pre-cooling heat exchanger units for cooling the natural gas stream from near ambient temperature to cryogenic temperature by heat exchange with one or more refrigerants. The cryogenic heat exchangers used in the cryogenic heat exchanger unit may be, for example, spiral wound heat exchangers, sometimes referred to as spool wound heat exchangers, or brazed aluminum, plate-fin heat exchangers.

[0058] The refrigerant compression units (not shown) take the evaporated refrigerant exiting the cryogenic heat exchangers and/or pre-cooling heat exchangers and compress it to a pressure sufficient for its condensation and re-use. LNG liquefaction plants may have one or more refrigerant compression circuits that may use single component refrigerants (e.g. propane) or mixed refrigerants (e.g. methane, ethane and propane). Where two or more refrigerant circuits are employed the respective circuits may cool and condense the natural gas stream in series, in parallel or in a cascade arrangement where one refrigerant circuit is used to cool a second refrigerant, which in turn cools the natural gas stream.

[0059] Although many refrigeration cycles may be used to liquefy natural gas, the following three types are further illustrated: (1) "cascade cycle" which uses multiple single component refrigerants in heat exchangers arranged progressively to reduce the temperature of the gas to a liquefaction temperature, (2) "expander cycle" which expands gas from a high pressure to a low pressure with a corresponding reduction in temperature, and (3) "multi-component refrigeration cycle" which uses a multi-component refrigerant in heat exchangers. Most natural gas liquefaction cycles use variations or combinations of these three basic types.

[0060] A mixed refrigerant gas liquefaction system involves the circulation of a multi-component refrigeration stream, usually after precooling with propane or another mixed refrigerant. An exemplary multi-component system may comprise methane, ethane, propane, and optionally other light components. Without precooling, heavier components such as butanes and pentanes may be included in the multi-component refrigerant. Mixed refrigerants exhibit the desirable property of condensing and evaporating over a range of temperatures, which allows the design of liquefaction systems that can be thermodynamically more efficient than pure component refrigerant systems.

[0061] The refrigerant preparation unit (not shown) contains one or more distillation columns that can produce from the feed gas ethane, propane, etc., products that can be used to compose some or all of the refrigerants used within the liquefaction unit **37**.

[0062] Another optional component of the gas liquefaction section **37** or a separate stand alone unit, is a distillation tower, such as a scrub tower (not shown), demethanizer unit (not shown), or deethanizer unit **36**, that has as least the function of removing pentane and heavier components from the feed gas to prevent freezing in the cryogenic heat exchangers. Some plants may use a demethanizer unit or deethanizer unit **36** instead in order to produce some natural gas liquids as separate products. Natural gas leaving the dehydration unit **35** may be fractionated. In this schematic, part of the C_{3+} hydrocarbons are separated from the natural gas by means of a deethanizer distillation column. The light fraction collected at the top of the deethanizer column is passed to the liquefaction unit **37**. The liquid fraction collected at the bottom of the deethanizer column is sent to a fractionation unit **40** for recovery of C_3/C_4 liquid petroleum gas (LPG) and C_{5+} liquid (condensate). This arrangement is preferred if the LPG product is intended to be sold separately. In locations where the feed gas has a low LPG content or the LPG has low value, the deethanizer column may be replaced by a scrub tower which removes pentane and heavier hydrocarbons to a specified level.

[0063] An LNG plant may also include a sulfur recovery unit (SRU) **38** and nitrogen rejection unit (NRU) **39**, and perhaps a helium recovery unit (HRU) **39**. Several processes have been developed for direct conversion of H_2S to elemental sulfur. Most conversion processes are based on oxidation-reduction reactions where H_2S is converted directly to sulfur. In large liquefaction trains, the Claus process converts H_2S to sulfur by "burning" a portion of the acid gas stream with air in a reaction furnace. This provides SO_2 for reaction with unburned H_2S to form elemental sulfur by the Claus reaction: $2H_2S+SO_2 \rightarrow 3/2S_2+2H_2O$.

[0064] At the end of the liquefaction process **37**, the LNG may be treated to remove nitrogen (NRU) and perhaps to recover helium (HRU) **39**, if any is present. Processes to accomplish this purification can be provided by licensors. A large portion of the nitrogen that may be present in natural gas is typically removed after liquefaction since nitrogen will not remain in the liquid phase during transport of conventional LNG and having nitrogen in LNG at the point of delivery is undesirable due to sales specifications. For storage and/or shipping the pressure of the liquefied natural gas is usually decreased to near atmospheric pressure. Such pressure reduction is often called an "end flash" reduction, resulting in end flash gas and LNG. An advantage of such an end flash reduction is that low boiling components, such as nitrogen and helium, are at least partially removed from the LNG along with some methane. The end flash gas may be used as fuel gas in the mechanical-drive gas turbines or in a power generation plant **41**. The helium recovery is optional depending on the amount of helium in the natural gas feed stream and the market value of helium.

[0065] Cogeneration units **41** may be used to reduce costs associated with energy usage in commercial and industrial operations. In an exemplary cogeneration unit **41**, a mechanical-drive gas turbine, driving a refrigeration compressor, or an electrical power generator, such as a gas-fired turbine driving a generator, is used to generate electricity for supplying the electrical needs of the plant. Any excess electrical power generated can be sold to a power company or used in the LNG plant, and electrical power is purchased from the power company only to the extent necessary to supplement the amount of electrical power produced by the cogeneration unit **41**. Wastes such as heat loss are reduced by utilizing heat generated as a result of production of electrical power for supplying or at least contributing to the heat and/or cooling demands for the plant. Heat produced as a result of operation of the gas-fired turbine may be extracted from the exhaust gases by way of a heat exchanger and used in supplying heating demands for the plant, such as steam. Alternatively, the steam generated from this process is used to generate more electricity in a steam-driven turbine-generator.

[0066] One embodiment of the invention includes a design concept for a hydrocarbon fluid processing plant, for example an LNG liquefaction plant, that it is both cost effective at any plant capacity and that it is expandable. In alternative embodiments of the invention a portion of the plant can be completed and commissioned while an expansion portion of the same plant can be constructed. Such an arrangement has the advantage that hydrocarbon production can be started earlier than would be allowed had the entire train been constructed at once, therefore improving the overall project economics. This type of arrangement alters the concept of a train in favor of a larger, more integrated plant that can more easily take advantage of economies of scale. Some embodiments of this invention are particularly applicable to an LNG project that is planned for a large resource where an initial liquefaction train would be constructed and later expanded. Such a development plan could be accomplished with some pre-investment in the initial construction phases with the benefit of shortening the required schedule of the expansion.

[0067] One method for designing, constructing, and/or operating a cost effective hydrocarbon fluid processing plant may include designing one or more process unit modules of one or more process unit module types at substantially their respective maximum processing efficiency. A process unit module's maximum processing efficiency is the process unit module capacity or size for a process unit module type that minimizes any one or more of the total process unit module construction cost per unit of process unit module capacity, the total process unit module operating cost per unit of process unit module capacity, the total process unit module life cycle cost per unit of process unit module capacity or combinations of such costs. Preferably the maximum processing efficiency is determined with respect to total process unit module life cycle cost per unit of process unit module capacity as this measure is best suited to realizing the lowest overall cost for a hydrocarbon fluid processing plant over the life of such a plant. Life cycle cost is a combined measure of the construction cost and operating cost of an equipment type or process unit module. Whatever cost measure is used it is preferably to adjust the cost to a capital cost basis. Non-capital costs, such as continuous operating costs, can be equivalently compared to capital costs by determining the "Present Value" of such continuous costs, which is a technique commonly employed by those skilled in the art. The substantially maximum processing efficiency is alternatively within 25 percent of the actual maximum processing efficiency. Alternatively, the substantially maximum processing efficiency is within 20, 15, 10 or 5 percent of the actual maximum processing efficiency.

[0068] To determine the maximum processing efficiency of a process unit module, the relationship of cost and design capacity for one or more equipment items is determined. Preferably, the relationship of cost and design capacity for the higher cost equipment items is determined. This relationship accounts for the design limits for those equipment types by adding parallel equipment, when the design limit is reached for a single piece of equipment. The total cost for a process unit module may include the sum of the major equipment cost, minor equipment cost and installation cost. The last two costs are usually expressed as a fraction of the major equipment cost based on similar modules actually built in the past. Installation costs include the cost of other pieces of hardware, such as pipes, valves and fittings, the costs of labor to install and the costs of other incidental items, such as, welding consumables and tools. For example, the major equipment types of a deethanizer process unit module may consist of a distillation column, several heat exchangers, separator drums, and pumps. Once the cost-capacity relationship is determined, the maximum processing efficiency can be found by locating the minimum cost per process unit module capacity through any standard optimization technique. For example, for complicated process unit modules the most expensive single piece of equipment may be used as an approximation of the overall process unit module cost. Alternatively, multiple pieces of equipment of multiple equipment types may be used to approximate the overall process unit module cost. Preferably, one or more of the high construction cost equipment types are used. For example, a deethanizer process unit module may consist of a distillation column, several heat exchangers, separator drums, and pumps. The most expensive single equipment item in the module may be the deethanizer column, which may be used to approximate the cost-capacity relationship of the module as a whole. Once the cost-capacity relationship is determined or approximated, the maximum processing efficiency can be found be locating the minimum cost per process unit module capacity through any standard optimization technique. The maximum processing efficiency will tend toward larger capacity until some cost, manufacturing, materials, transportation, or installation limit is reached. For example, the size of cryogenic heat exchangers may be limited by manufacturing techniques and/or equipment transportation limits. Building an LNG train for a higher capacity than can be accommodated by a single cryogenic exchanger would necessitate using two smaller exchangers in parallel. This splitting of the exchanger service and the use of smaller exchangers may negate the advantages of the natural economies of scale.

[0069] This design philosophy seeks to determine the optimal size for a process unit module of the respective process unit module types included in a selected hydrocarbon fluid processing plant. Once the optimal size is determined then multiple process unit modules of a process unit module type which are designed at substantially their maximum processing efficiency can be integrated into larger capacity parallel units, either initially during construction of the first phase of a plant or when expanding an existing plant to provide additional feed processing capacity for a particular process unit module type. By designing two or more of the process unit module types to include process unit modules at their respective maximum processing efficiency a more economic plant may be constructed, operated, and expanded as market conditions dictate.

[0070] Prior design philosophies have focused on designing and constructing the most costly piece of equipment just large enough to meet the desired plant processing capacity and then designing the other equipment and units to match the capacity of the most costly piece of equipment. One embodiment of the current invention abandons this prior philosophy and designs the process unit modules of multiple process unit module types at their respective maximum processing efficiency. Once the maximum processing efficiency of a process unit module type is determined, then one or more of the process unit modules can be included in a design to meet the desired plant maximum feed processing capacity for a hydrocarbon fluid processing plant. The design methodologies discussed herein are also applicable to expanding the capacity of an existing hydrocarbon fluid processing plant. An existing hydrocarbon fluid processing plant may also be expanded, before or after commissioning, by adding one or more additional process unit modules to the existing process unit modules in order to expand the process unit module type maximum feed processing capacity.

[0071] In alternative embodiments, multiple process unit modules can be integrated such that the multiple process unit modules act as a single common processing unit within the hydrocarbon fluid processing plant. Examples of particular types of integration include process unit modules that are parallel integrated and/or internally integrated. Parallel integrated includes, for example, where two or more process unit modules share one or more common inlet streams and one or more common outlet streams. Internally integrated includes, for example, one or more process unit modules that contain certain equipment types that share one or more common inlet streams and one or more common outlet streams. FIG. **2**A provides a graphical representation of an exemplary process unit configuration for one integrated acid gas removal contactor unit that could be a part of an LNG liquefaction plant. FIG. **2**A depicts a common feed stream **11** containing sour natural gas (i.e. containing carbon dioxide (CO_2) and hydrogen sulfide (H_2S)) entering the acid gas removal contactor unit **10**. As can be seem in the figure, the exemplified acid gas removal contactor unit **10** is actually composed of two parallel, integrated process unit modules. After being split, the feed stream flows to first heat exchangers **12** and **12***a* of the respective process unit modules for heating before entering solvent contactors **13** and **13***a*. In solvent contactors **13** and **13***a*, the gaseous feed stream **11** is placed into contact with a lean solvent **14**. The solvent **14** may be, for example, an amine solvent, and is depicted entering the acid gas removal contactor unit **10** as one stream before being split and sent to the respective acid gas removal contactor unit modules. In the solvent contactors **13** and **13***a*, the acid gases (H_2S gas, other sulfur containing components, and/or CO_2) contained in the feed stream **11** is dissolved into the liquid solvent **14**. The remaining gaseous hydrocarbon portion of the feed stream exits the top of the solvent contactors as a sweet natural gas stream **20**. After exiting the respective acid gas contactors the respective natural gas streams are combined into a single sweet natural gas stream **20**. The rough cut rich solvent **16** and **16***a* (i.e. containing acid gases, some methane and solvent) exits the bottom of the solvent contactors **13** and **13***a* and enters flash drums **15** and **15***a*. In the flash drums **15** and **15***a*, the pressure of the rough cut rich solvent **16** and **16***a* is reduced, thereby producing a flash gas containing methane which can be used as fuel gas **21** for a plant. After exiting the respective flash drums **15** and **15***a* the respective fuel gas streams are combined into a single fuel gas stream **21**. The liquid streams **17** and **17***a* leaving the flash drums **15** and **15***a* are comprised of rich solvent (i.e. contains acid gases and solvent) and flow to second heat exchangers **18** and **18***a* where the liquid streams **17** and **17***a* are heated before leaving the acid gas removal contactor unit **10** for regeneration in an acid gas removal regeneration unit (not shown). Following regeneration, the hot lean solvent **14** passes through second heat exchangers **18** and **18***a* where the lean solvent **14** is cooled by heat exchange with the liquid streams **17** and **17***a* exiting the flash drums **15** and **15***a*. The lean solvent **14** is further cooled by fin fan heat exchangers **19** and **19***a* before being pumped by pumps **20** and **20***a* into the solvent contactors **13** and **13***a*. FIG. **2**B depicts a second exemplary acid gas removal contactor unit **10** that contains three parallel integrated process unit modules. FIGS. **2**A and **2**B show two examples of process unit modules that are parallel integrated. The level of integration in a process unit module type may vary and the examples depicted in FIGS. **2**A and **2**B are not meant to limit the invention. Additionally, the acid gas removal contactor units depicted in FIGS. **2**A and **2**B are exemplary of one particular acid gas removal contactor unit flow scheme and equipment arrangement and is not intended to limit the invention. Other manners of process unit module integration, acid gas removal contactor unit flow scheme and equipment arrangement are intended to be included within the scope of the invention.

[0072] By integrating multiple process unit modules within a process unit module type, increased operating flexibility can be obtained. In one alternative embodiment, two or more process unit module types are integrated. In one alternative embodiment, three, four, five, six or all the process unit module types of a hydrocarbon fluid processing plant are integrated.

[0073] A hydrocarbon fluid processing plant designed or constructed with multiple process unit module types made up of one or more process unit modules designed at their respective maximum processing efficiency may have process unit module types with different respective maximum feed processing capacities. Because the different process unit modules are designed to an economic efficiency target, as opposed to matching a capacity target, the respective process unit module types are not necessarily of an identical maximum feed processing capacity. In alternative embodiments of the invention, the maximum feed processing capacity of different process unit module types may differ by more than 10 percent. In alternative embodiments, one process unit module type may have a maximum feed processing capacity that is less than 85 or 80 percent of a second and/or third process unit module type.

[0074] In one alternative embodiment of the invention the maximum processing efficiency is determined for a process unit module type and a standardized process unit configuration is determined. Two substantially equally configured process unit modules are process unit modules that have substantially the same general process flow scheme. For example, a process flow scheme for a process unit module includes at least the arrangement of equipment types and the arrangement of flow paths for transporting the process fluids among the equipment types. The standardized process unit configuration may then be repeated for multiple process unit modules for a process unit module type in a hydrocarbon fluid processing plant. Preferably the standardized process unit configuration is also of a standardized size or capacity. Substantially equally sized process unit modules are process unit modules that preferably have the same processing capacity. Alternatively, equally sized process unit modules are process unit modules where their capacity is within 15 percent of each other. Alternatively, their capacity is within 10, 5 or 2 percent of each other. In this way a standardized process unit module can be repeated in parallel to expand the maximum feed processing capacity of the process unit module type in either an initially designed or constructed plant or to expand the plant maximum feed processing capacity of an existing plant. In either case, the individual standardized process unit modules are preferably integrated to provide operational flexibility.

[0075] A process unit module may be comprised of one or more different equipment types. In one alternative embodiment of the invention, the equipment types that make up a standardized process unit module are substantially equally sized and/or equally configured. Two substantially equally sized pieces of equipment means that the two pieces of equipment have about the same processing capacity. Preferably, their capacity is within 15 percent of each other. Alternatively, their capacity is within 10, 5 or 2 percent of each other. Two substantially equally configured pieces of equipment are of essentially the same design. If two pieces of equipment are fabricated and installed at different times then the manufacturer of the equipment can be expected to make incremental changes or improvements to the equipment, however, the two pieces of equipment will remain of essentially the same design to the extent they are relatively interchangeable.

[0076] By standardizing the process unit modules and/or equipment types comprising the process unit modules a designer, constructor, or operator of a hydrocarbon fluid processing plant may realize a more cost efficient plant. For example, a plant designer can design a single process unit module and repeat the design to reach a desired process unit module type maximum feed processing capacity, thus reducing design costs. In essence the process unit module design can be reused multiple times. Savings may be realized when constructing a plant with standardized process unit modules by obtaining lower purchase prices for multiples of certain identical equipment types. Additionally, by targeting equipment sizes that can be provided by multiple manufacturers, competitive bidding may be used to obtain lower costs. For example, where a plant designer or constructor desires a process unit module or equipment type of a certain large capacity and there is only one or limited manufacturers for an equipment type of a certain large size, the desired capacity can be obtained using multiple smaller capacity pieces of equipment which multiple manufacturers can provide. Thus the total equipment cost for a certain desired capacity may actually be lower by purchasing multiple smaller capacity pieces of equipment. Additionally, common spare parts can be stocked for unscheduled repairs, thus reducing or delaying replacement part purchases. Savings may be realized in operating a plant with standardized process unit modules and/or equipment types because the operators of the plant will only have to learn how to operate and repair a limited number of process unit modules and/or equipment types.

[0077] In one alternative embodiment of the invention, a hydrocarbon fluid processing plant with significant feed processing capacity flexibility is provided. A hydrocarbon fluid processing plant that contains process unit module types comprised of multiple integrated process unit modules may have considerable plant feed processing capacity flexibility. For example a process unit module type comprised of four equally sized, integrated process unit modules could be operated in a stable manner at least at 25, 50, 75 and 100 percent of its maximum feed processing capacity by placing into service or taking off line one or more respective process unit modules. Where multiple process unit module types are within each of multiple process unit modules, the respective process unit module types can also be operated at multiple feed processing capacities. Additional feed processing capacity flexibility could be realized through using multiple integrated equipment types within a process unit module, thus providing additional flexibility in feed processing capacity. Alternatively, certain process unit module types could include variable speed (variable capacity) equipment as opposed to fixed speed (fixed capacity) equipment. For example, compressors could be coupled to variable speed electric motors as opposed to fixed speed gas turbines. In one alternative embodiment, the hydrocarbon fluid processing plant may have a plant minimum feed processing capacity that is 75 percent or less than the plant maximum feed processing capacity. Alternatively, the hydrocarbon fluid processing plant may have a plant minimum feed processing capacity that is 70, 65, 60, 55, 50, 45, 40, 35, 30 or 25 percent or less than the plant maximum feed processing capacity.

[0078] The design, construction and operation methodologies discussed above are particularly suited to large LNG liquefaction plants and/or LNG liquefaction plants that increase capacity over time to become large LNG liquefaction plants. In one embodiment the LNG liquefaction plant has a plant maximum feed processing capacity of greater than 4 million tons per year capacity (MTA). In alternative embodiments, the LNG liquefaction plant has a plant maximum feed processing capacity of greater than 5, 6, 7, 8, or 9 million tons per year (MTA). In one embodiment the LNG liquefaction plant can expand over time to be a large LNG liquefaction plant as previously discussed. In one embodiment the LNG liquefaction plant begins at a first phase plant maximum feed processing capacity of 1 to 5 MTA. In alternative embodiments, the LNG liquefaction plant begins at a first phase plant maximum feed processing capacity of 1.5 to 4.5, 2.0 to 4, or 2.5 to 3.5 MTA. In one embodiment the LNG liquefaction plant expands in phases at a phase expansion size in plant maximum feed processing capacity increments of 1 to 5 MTA. In alternative embodiments, the LNG liquefaction plant expands in phases at a phase expansion size in plant maximum feed processing capacity increments of 1.5 to 4.5, 2.0 to 4, or 2.5 to 3.5 MTA. In one embodiment, the LNG liquefaction plant expands in a first phase and 1 to 6 subsequent phases. Alternatively, the LNG liquefaction plant expands in a first phase and 2 to 5, or 2 to 3 subsequent phases.

[0079] One embodiment of the invention includes expanding the plant maximum feed processing capacity of a hydrocarbon fluid processing plant by expanding the maximum feed processing capacity of one or more of the process unit module types but less than all of the process unit module types included in the hydrocarbon fluid processing plant. In one embodiment, the process unit module types are product sized process unit module types. Product sized process unit module types are process unit module types whose capacity (size) is determined principally by the most valuable product stream rate for the hydrocarbon fluid processing plant. In an LNG liquefaction plant the most valuable product stream is LNG. This embodiment of the invention may be implemented with one or more of the various aspects of the invention described herein. In one embodiment of the invention an existing hydrocarbon fluid processing plant which is comprised of one or more product sized process unit module types having product sized process unit modules designed at their respective maximum processing efficiency is expanded by expanding the maximum feed processing capacity of one or more of the product sized process unit module types but less than all of the product sized process unit module types included in the hydrocarbon fluid processing plant. As previously discussed, a hydrocarbon fluid processing plant designed or constructed with multiple process unit module types made up of one or more process unit modules designed at their respective maximum processing efficiency may have process unit module types with different respective maximum feed processing capacities. Because the different process unit modules are designed to an economic efficiency target, as opposed to matching a capacity target, the respective process unit module types are not necessarily of an identical maximum feed processing capacity. One embodiment of the invention takes advantage of the unequal maximum feed processing capacities of different process unit module types in expanding a hydrocarbon fluid processing plant. In this embodiment the plant maximum feed processing capacity can be expanded by adding additional product sized process unit modules for the product sized process unit module types that require additional capacity to increase the plant maximum feed processing capacity while not adding additional product sized process unit modules to one or more of the product sized process unit module types that do not require additional maximum feed processing capacity to increase the plant maximum feed processing capacity. By using such an expansion scheme the life cycle cost of the hydrocarbon fluid processing plant can be lowered as compared to prior art schemes.

[0080] One alternative embodiment includes a hydrocarbon fluid processing plant comprised of one or more high construction cost product sized process unit module types and one or more low construction cost product sized process unit module types where at least one of the low construction cost product sized process unit module types has a maximum feed processing capacity that is at least 110 percent of the maximum feed processing capacity of at least one of the high construction cost product sized process unit module types. This embodiment of the invention may be implemented with one or more of the various aspects of the invention described herein. This embodiment may be used for a LNG liquefaction plant that produces LNG.

[0081] In alternative embodiments of the invention, the maximum feed processing capacity of one or more low construction cost product sized process unit module types is at least 115, 125, 135 or 150 percent of the maximum feed processing capacity of at least one of the high construction cost product sized process unit module types. In alternative embodiments the high construction cost product sized process unit module types have a total construction cost per unit of maximum feed processing capacity that is 1.25, 1.5, 1.75 or 2.0 times or greater the total construction cost per unit of maximum feed processing capacity of the low construction cost product sized process unit module types. In alternative embodiments the low construction cost product sized process unit module types are selected from acid gas removal contactor units, dehydration units, fractionation units, nitrogen rejection units, and helium recovery units. In alternative embodiments the high construction cost product sized process unit module types are selected from inlet facilities units (i.e. slug catcher unit, gas preheat unit and condensate stabilizer unit), refrigerant compression units, cryogenic heat exchanger units, and liquefaction units.

[0082] In an alternative embodiment a first phase hydrocarbon fluid processing plant can be expanded while the first phase hydrocarbon fluid processing plant is producing hydrocarbon fluid products. This method may be used for a LNG liquefaction plant that produces LNG. In this embodiment, a first phase hydrocarbon fluid processing plant may be provided. The first phase hydrocarbon fluid processing plant may be comprised of a plurality of process unit module types and the respective process unit module types may be comprised of one or more process unit modules. The method may include producing a hydrocarbon fluid (e.g. LNG) from the first phase hydrocarbon fluid processing plant while constructing one or more additional process unit modules for one or more of the process unit module types included in the first phase hydrocarbon fluid processing plant. The method may include placing the one or more additional process unit modules in service and integrating the additional process unit modules with the original process unit modules of a process unit module type to provide a second phase hydrocarbon fluid processing plant with increased capacity. The method may include producing hydrocarbon fluid (e.g. LNG) from the second phase hydrocarbon fluid processing plant. This embodiment of the invention may be implemented with one or more of the various aspects of the invention described herein.

[0083] In alternative embodiments of the method the additional process unit modules may be placed in service while producing hydrocarbon fluids in the first phase plant or placed in service during limited downtimes. In one embodiment the method may include placing the one or more additional process unit modules in service while producing hydrocarbon fluids from the first phase hydrocarbon fluid processing plant. Provisions for installing the integrated additional units may be included with the first phase hydrocarbon processing plant and may include tie-ins, block valves, isolation valves, balancing valves, blind flanges, spectacle blinds, headers, and manifolds. In one embodiment the method may include producing hydrocarbon fluids from the first phase hydrocarbon fluid processing plant while at least partially accomplishing placing the one or more additional process unit modules in service. In one embodiment the method may include not producing hydrocarbon fluids from the first phase hydrocarbon fluid processing plant while at least partially accomplishing placing the one or more additional process unit modules in service. In one embodiment the method may include not producing hydrocarbon fluids from the first phase hydrocarbon fluid processing plant for less than 30 days while at least partially accomplishing placing the one or more additional process unit modules in service. In alternative embodiments the method may include not producing hydrocarbon fluids from the first phase hydrocarbon fluid processing plant for less than 20, 10, 5, 2, or 1 days while at least partially accomplishing placing the one or more additional process unit modules in service.

[0084] The method may be used to increase the plant maximum feed processing capacity in an economically advantageous way. For example, the plant maximum feed processing capacity may be increased while continuing to produce hydrocarbon fluids in a first phase hydrocarbon fluid processing plant or by shutting down the hydrocarbon fluid processing plant for only a limited time. In this way the first phase plant can continue to make valuable products while being expanded, thus avoiding or reducing the lost revenues. Alternatively, the additional process unit modules may be placed into service while the hydrocarbon fluid processing plant in down for scheduled maintenance. In addition the method may be used to build a relatively smaller first phase plant, placing the first phase plant in service to generate product revenues and then expanding the plant maximum feed processing capacity once a product revenue stream is established. This stepwise expansion can be repeated as a resource development plan is expanded and/or as buyers are identified for the hydrocarbon fluid processing plant's products. In one embodiment the LNG liquefaction plant begins at a first phase plant maximum feed processing capacity of 1 to 5 MTA. In alternative embodiments, the LNG liquefaction plant begins at a first phase plant maximum feed processing capacity of 1.5 to 4.5, 2.0 to 4, or 2.5 to 3.5 MTA. In one embodiment the LNG liquefaction plant expands in phases at a phase expansion size in plant maximum feed processing capacity increments of 1 to 5 MTA. In alternative embodiments, the LNG liquefaction plant expands in phases at a phase expansion size in plant maximum feed processing capacity increments of 1.5 to 4.5, 2.0 to 4, or 2.5 to 3.5 MTA. In one embodiment, the LNG liquefaction plant expands in a first phase and 1 to 6 subsequent phases. Alternatively, the LNG liquefaction plant expands in a first phase and 2 to 5, or 2 to 3 subsequent phases. In this way capital plant costs can be more evenly balanced with revenue generation, thus lowering a plant's life cycle cost by delaying capital investment to a later time when market conditions may be more favorable.

[0085] One embodiment of the invention includes a method of producing hydrocarbon fluids. The method includes providing a hydrocarbon fluid processing plant having a plant maximum feed processing capacity, the plant comprising a plurality of process unit module types and having at least a first refrigerant circuit. The first refrigerant circuit may include at least one first refrigerant compressor service type comprised of one or more original first refrigerant compressors in parallel. The method may include expanding the plant maximum feed processing capacity of the plant by adding at least one additional first refrigerant compressor to the first refrigerant compressor service type, where the additional first refrigerant compressor is integrated with the one or more original first refrigerant compressors within the first refrigerant compressor service type. The method may include producing a hydrocarbon fluid (e.g. LNG) in the hydrocarbon fluid processing plant (e.g. LNG liquefaction plant) after initiation of the expansion step. This embodiment of the invention may be implemented with one or more of the various aspects of the invention described herein. This embodiment may be used for a LNG liquefaction plant that produces LNG.

[0086] In alternative embodiments the compressors may be of certain character to enhance the design, construction and operation of a hydrocarbon fluid processing plant. In one embodiment the method may include at least one of the original first refrigerant compressors and at least one of the additional first refrigerant compressors being substantially equally sized. In one embodiment the method may include at least one of the original first refrigerant compressors and at least one of the additional first refrigerant compressors being substantially equally mechanically configured. In one embodiment the method may include the original first refrigerant compressors being comprised of a plurality of first refrigerant compressors and the plurality of original first refrigerant compressors having a maximum combined processing capacity where the maximum combined processing capacity is less than the processing capacity of the largest commercially available compressor for that service. In one embodiment the method may include each of the plurality of original first refrigerant compressors having a processing capacity less than the processing capacity of the largest commercially available compressor. As previously discussed, savings may be realized when constructing a plant with standardized process unit modules by obtaining lower purchase prices for identical multiples of certain equipment types, for example compressors. Additionally, by targeting compressor sizes that can be provided by multiple manufacturers, competitive bidding may be used to obtain lower costs. For example, where a plant designer or constructor desires a process unit module having a certain compression capacity, there may be only one or a limited number of manufacturers of certain large size compressors. Alternatively, multiple smaller capacity compressors which may be provided by multiple manufactures can be used to obtain the desired capacity, thus potentially lowering the overall compression circuit cost.

[0087] In one embodiment the method may include the original and/or additional first refrigerant compressors being electric-motor drive compressors. In one embodiment the method may include the original and/or additional first refrigerant compressors being gas-turbine drive compressors. Depending on the circumstances, it may be desirable to use variable speed electric-motor drive compressors which have the benefit of being capable of operating over a range of capacities. Especially when the plant is coupled with a cogeneration unit that generates enough electricity for the electric drive compressors. Cogeneration units may be used to reduce costs associated with energy usage for compressor drives. In an exemplary cogeneration system, an electrical power generator, such as a gas-fired turbine driving a generator, may be used to generate electricity for supplying the electrical needs of the electric motor drive compressors. Wastes such as heat loss may be reduced by utilizing heat generated as a result of production of electrical power for supplying or at least contributing to the heat and/or cooling demands for the plant. Heat produced as a result of operation of the gas-fired turbine may be extracted from the exhaust gases by way of waste heat boilers used to generate steam which may be used in supplying heating demands for the plant. Alternatively, the steam generated in the waste heat boiler may be used to generate more electricity in a steam-driven turbine-generator. Where variable operating capacity is not important or there is insufficient electricity available, gas turbines may alternatively be desirable.

[0088] In one embodiment the method may include the first refrigerant circuit further including one or more plate-fin heat exchangers and/or one or more spiral wound heat exchangers, where respective heat exchangers are adapted to cool a natural gas stream through heat exchange with refrigerant compressed by the first refrigerant compressors. In one embodiment the method may include the one or more plate-fin heat exchangers, for example brazed aluminum plate-fin heat exchangers. Alternatively, the plurality of plate-fin heat exchangers may be arranged in a cold box. Traditionally large spiral wound heat exchangers have been used to provide the surface area needed in large LNG liquefaction plants. However, these large spiral wound heat exchangers are often more expensive compared to plate fin heat exchangers. In some cases it may be more economic to manifold together multiple smaller plate-fin heat exchangers into a cold box in place of using a large spiral wound heat exchanger. As previously discussed, savings may be realized when constructing a plant with standardized process unit modules by obtaining lower purchase prices for multiples of certain identical equipment types, for example plate-fin heat exchangers. Additionally, by targeting smaller plate-fin heat exchangers that can be provided by multiple manufactures, competitive bidding may be used to obtain lower costs.

[0089] One embodiment of the invention includes a method of producing hydrocarbon fluids using a hydrocarbon fluid processing plant where the hydrocarbon fluid processing plant is comprised of a plurality of process unit module types and each of the plurality of process unit module types is comprised of one or more process unit modules. This embodiment may be used for a LNG liquefaction plant that produces LNG. The method may include providing a first phase LNG liquefaction plant by providing at least one original process unit module for each process unit module type included in the plurality of process unit module types. The first phase plant may be a stand-alone plant that can be placed into service to begin generating product revenues. The method may include providing a second phase LNG liquefaction plant by providing at least one second process unit module for each process unit module type included in the plurality of process unit module types, integrating one or more of the original process unit modules with one or more of the second process unit modules for two or more respective process unit module types, and producing hydrocarbon fluids from the hydrocarbon fluid processing plant after initiation of integrating one or more of the original process unit modules with one or more of the second process unit modules for two or more respective process unit module types. The method may alternatively include integrating one or more of the original process unit modules with one or more of the second process unit modules of three, four, five, six, seven or more or all of the respective process unit module types. The integration of the process unit modules of the first phase plant with those of the second phase plant may provide additional operational flexibility as previously discussed for other embodiments of the invention. In addition, this embodiment of the invention may be implemented with one or more of the various aspects of the invention described herein to obtain further benefits.

[0090] The scale to which large hydrocarbon fluid processing plants, for example large LNG liquefaction trains, are built may require many of the larger equipment items to be installed in multiple, parallel process unit modules. As discussed herein additional benefits are obtained when the multiple parallel process unit modules are integrated. As hydrocarbon fluid processing plant sizes increase, more pieces of equipment must be designed, for example 2×50%, 3×33%, 4×25%, etc. (or 3×50%, 4×33%, 5×25%, etc, if an installed spare is used), parallel process unit modules, because a single item would be prohibitively large, heavy, or outside of experience limits. In order to maximize economy of scale, it may be preferable to purchase each individual equipment item as large as possible.

[0091] An LNG liquefaction plant typically consists of several discrete processing sections, as previously discussed. In order to take advantage of some embodiments of the plant design concepts discussed herein, each process unit module type within a process functional area may be designed in as few multiples as possible, taking maximum advantage of economies of scale and/or at sizes which are consistent with a respective process unit module types maximum processing efficiency. One embodiment of this concept is most easily described through using an example of a large, 20 million ton per annum (MTA) LNG liquefaction plant.

[0092] A single slug catcher unit can likely handle all of the feed gas for this very large plant, although two condensate stabilizer units may be necessary. Even though two condensate stabilizer units may be necessary, only one offgas compressor unit may be required due to the relatively small volume through this operation. However, four or more gas preheat units may be needed due to the large flow rate through each of these items.

[0093] The AGR system often contains one of the heaviest items in the liquefaction plant: the AGR contactor vessel. Up to four of these high pressure vessels may be required in the plant. Exemplary acid gas removal contactor units containing multiple acid gas contactor vessels were previously discussed with reference to FIGS. **2**A and **2**B. While up to four acid gas contactor vessels may be required in the plant, it may be possible to regenerate all of the solvent in one or two AGR solvent regenerator units. Exemplary acid gas removal regenerator units **49** are depicted in FIGS. **3**A and **3**B. FIG. **3**A shows the rich solvent **50** entering the acid gas regenerator vessel **53**. The acid gas regenerator vessel **53** is serviced by two parallel, integrated acid gas regenerator reboilers **55***a* and **55***b* which provide the duty to heat the rich solvent in the acid gas regenerator vessel **53** and liberate the acid gases from the solvent. The hot acid gases travel up the regenerator and leave the top of the acid gas regenerator vessel **53** and are cooled in overhead cooler **56***a* before entering settling drum **57**. In settling drum **57** acid gas vapors are separated from any condensed liquids which are refluxed to the acid gas regenerator vessel **53** through pumps **58***a* and **58***b*. Removed acid gas **52** leaves the settling drum **57** and exits the acid gas removal regenerator unit **49**. The lean solvent **51** exits the bottom of the acid gas regenerator vessel **53** through parallel, integrated pumps **54***a, b*, and *c*. FIG. **3**B depicts an expanded acid gas removal regenerator unit **49**, which has been expanded by the addition of a parallel, integrated pumps **54***d* and **58***c*, overhead cooler **56***c*, and acid gas regenerator reboilers **55***c*. Depending on the initial design of the acid gas regenerator vessel **53**, internal modifications may also be required, however in this embodiment the acid gas regenerator vessel **53** itself is not replaced. FIGS. **3**A and **3**B show one form of internal integration. The level of integration in a process unit module type may vary and the examples depicted in FIGS. **3**A and **3**B are not meant to limit the invention. Additionally, the acid gas removal regenerator units depicted in FIGS. **3**A and **3**B are exemplary of one particular acid gas removal regenerator unit flow scheme and equipment arrangement and is not intended to limit the invention. Other manners of process unit module integration, acid gas removal regenerator unit flow scheme and equipment arrangement are intended to be included within the scope of the invention.

[0094] In the exemplary plant, several mercury adsorbent vessels may be required. Molecular sieve systems generally consist of two or more parallel vessels, even for the smallest plants. In this large scale plant, it would not be unusual to require fifteen or more vessels, depending on the technology specified.

[0095] In some LNG liquefaction plants, the gas liquefaction unit limits the capacity of the train because of the heat exchange technology employed, e.g., a spiral-wound heat exchanger. Due to the fabrication cost of these exchangers, there is a strong incentive to purchase them near their maximum capacity. For example, if an exchanger's maximum capacity was 5 MTA, building a 6 MTA plant using two 3 MTA exchangers would not be cost-effective. One embodiment of the concept described herein preferably uses instead a modular heat exchanger type, typically a brazed aluminum, plate-fin heat exchanger. Such a large liquefaction plant may require dozens of the largest plate-fin heat exchangers that can be built. Alternatively, a liquefaction plant this large may be able to employ multiples (five or more) of the spiral wound heat exchangers, as long as each of the exchangers is near the maximum available size to take advantage of economies of scale.

[0096] In the pre-cooling heat exchanger unit, cryogenic heat exchanger unit and refrigerant compression units, multiple like service compressors may be integrated to provide refrigerant compression to one or more like service cryogenic heat exchangers. A single refrigerant preparation unit may be used to prepare single component or mixed component refrigerants. In one embodiment, the entire plant requirements could be served by a single fractionation unit. FIG. **5** depicts one embodiment of a cryogenic heat exchanger unit **95** that contains multiple parallel, integrated cold boxes (**89***a, b, c*, and *d*) containing multiple cryogenic heat exchangers. The feed gas **83** is split into four stream and cooled in the multiple cryogenic heat exchangers contained in the four cold boxes (**89***a, b, c*, and *d*) and exits the four cold boxes (**89***a, b, c*, and *d*) as LNG **87**. In the cryogenic heat exchangers, the feed gas **83** is cooled by refrigerants (e.g. Cold Mixed Refrigerant **81** and Warm Mixed Refrigerant **82**). The Warm Mixed Refrigerant **82** is removed from the cryogenic heat exchangers at three different pressures **84**, **85** and **86** for return to the Warm Mixed Refrigerant compression circuit **111** (see FIGS. **6**A and **6**B). The Cold Mixed Refrigerant **81** is removed from the cryogenic heat exchangers after cooling the feed gas **83** and returned **88** to the Cold Mixed Refrigerant compression circuit **125** (see FIGS. **7**A and **7**B). FIG. **5** shows examples of process unit modules that are parallel integrated. The level of integration in a process unit module type may vary and the examples depicted in FIG. **5** are not meant to limit the invention. Additionally, the cryogenic heat exchanger unit depicted in FIG. **5** is exemplary of one particular cryogenic heat exchanger unit flow scheme and equipment arrangement and is not intended to limit the invention. Other manners of process unit module integration, cryogenic heat exchanger unit flow scheme and equipment arrangement are intended to be included within the scope of the invention.

[0097] FIG. **6**A depicts an exemplary integrated Warm Mixed Refrigerant compression circuit **111** comprising three stages of refrigerant compression. The low pressure warm mixed refrigerant stream **86** returning for the cryogenic heat exchanger unit **95** is split and enters parallel first stage feed surge drums **100***a* and **100***b* before being compressed in first stage compressors **101***a* and **101***b*. After exiting the first stage compressors **101***a* and **101***b*, the low pressure warm mixed refrigerant streams, now at an elevated pressure, enter the second stage feed surge drums **102***a* and **102***b* together with the medium pressure warm mixed refrigerant stream **85** returning from the cryogenic heat exchanger unit **95**. The combined stream is compressed in second stage compressors **103***a* and **103***b* and then enter the third stage feed surge drums **105***a* and **105***b* together with the high pressure warm mixed refrigerant stream **84** returning from the cryogenic heat exchanger unit **95**. The respective outlets of the second and third stage compressors are cooled by interstage coolers **104***a* and **104***b* and final stage coolers **107***a*, **107***b*, **108***a* and **108***b* before entering warm mixed refrigerant final separation drums **110***a* and **110***b*. The respective liquid warm mixed refrigerant streams are then combined **82** and returned to the cryogenic heat exchanger unit **95**. FIG. **6**B presents a second exemplary Warm Mixed Refrigerant compression circuit **111** that contains three parallel, integrated Warm Mixed Refrigerant compression circuit modules. FIGS. **6**A and **6**B show two examples of process unit modules that are parallel integrated. The level of integration in a process unit module type may vary and the examples depicted in FIGS. **6**A and **6**B are not meant to limit the invention. Additionally, the Warm Mixed Refrigerant compression circuit units depicted in FIGS. **6**A and **6**B are exemplary of one particular Warm Mixed Refrigerant compression circuit unit flow scheme and equipment arrangement and is not intended to limit the invention. Other manners of process unit module integration, Warm Mixed Refrigerant compression circuit unit flow scheme and equipment arrangement are intended to be included within the scope of the invention.

[0098] FIG. **7**A depicts an exemplary integrated Cold Mixed Refrigerant compression circuit **125** comprising two stages of refrigerant compression. The cold mixed refrigerant stream **88** returning for the cryogenic heat exchanger unit **95** is split and enters parallel first stage feed surge drums before being compressed in first stage compressors **120***a* and **120***b*. After exiting the first stage compressors **120***a* and **120***b*, the respective cold mixed refrigerant streams enter the second stage feed surge drums. The refrigerant streams are then compressed in second stage compressors **122***a* and **122***b*. The respective outlets of the first and second stage compressors are cooled by first stage coolers **121***a* and **121***b* and final stage coolers **123***a* and **123***b*. The respective liquid cold mixed refrigerant streams are then combined **81** and returned to the cryogenic heat exchanger unit **95**. FIG. **7**B presents a second exemplary Cold Mixed Refrigerant compression circuit **125** that contains three parallel, integrated Cold Mixed Refrigerant compression circuit modules. FIGS. **7**A and **7**B show two examples of process unit modules that are parallel integrated. The level of integration in a process unit module type may vary and the examples depicted in FIGS. **7**A and **7**B are not meant to limit the invention. Additionally, the Cold Mixed Refrigerant compression circuit units depicted in FIGS. **7**A and **7**B are exemplary of one particular Cold Mixed Refrigerant compression circuit unit flow scheme and equipment arrangement and is not intended to limit the invention. Other manners of process unit module integration, Cold Mixed Refrigerant compression circuit unit flow scheme and equipment arrangement are intended to be included within the scope of the invention.

[0099] Another component of the gas liquefaction section or a stand alone unit is a distillation tower such as a scrub tower, demethanizer column, or deethanizer column, that has as least the function of removing pentane and heavier components from the feed gas to prevent freezing in the cryogenic heat exchangers. For a 20 MTA plant, two to three parallel columns of whichever variety is selected may be required. FIG. **4** depicts one embodiment of a deethanizer unit **60** that includes many parallel, integrated equipment. Treated gas **61** enters the deethanizer unit **60** as a common feed stream and is split into two streams which enter two parallel heat exchangers **64***a* and **64***b* before entering one common knock out drum **65***b* and being fed to three parallel, integrated expander-compressor sets **66***a, b* and *c*. The expanded gas then flows to two columns **71***a* and *b* to recover the desired amount of NGLs from the gas. The cold gas flowing from the tops of these columns are sent through exchanger sets **72***a*, **72***b*, **64***a* and **64***b* to recover the cold energy from the gas. The gas is then compressed in the expander-compressor sets, **66***a, b* and *c* and **68***a* and *b* to the desired liquefaction pressure. The gas is cooled in ambient-medium exchangers, **70***a* and *b* before entering the cryogenic exchanger unit. The liquid from the bottom of the columns, **71***a* and *b* is warmed in exchangers **72***a* and *b* before entering the deethanizer column, **73**. The deethanizer column removes the remaining light hydrocarbons from the liquid. The overhead gas stream from this column is partially condensed in exchangers, **72***a* and *b* and phase separated in reflux drum, **74**. Vapors from this drum combine with the vapor from columns **71***a* and *b* before cold recovery and compression. Liquid from this drum is pumped in pumps **75***a, b* and *c* to provide cold reflux for both sets of distillation column, **71***a* and *b* and **73**. FIG. **4** show one form of internal integration. The level of integration in a process unit module type may vary and the examples depicted in FIG. **4** are not meant to limit the invention. Additionally, the deethanizer unit depicted in FIG. **4** is exemplary of one particular deethanizer unit flow scheme and equipment arrangement and is not intended to limit the invention. Other manners of process unit module integration, deethanizer unit flow scheme and equipment arrangement are intended to be included within the scope of the invention.

[0100] At the end of the liquefaction process, the LNG is treated to remove nitrogen in a nitrogen rejection unit

(NRU) and perhaps to recover helium, if any is present. An LNG liquefaction plant would also typically require a sulfur recovery unit (SRU) These units could be designed with the methodologies described herein. Processes to accomplish these purifications are provided by licensors, who can be instructed and supervised to design their systems in accordance with this philosophy. FIG. **8** depicts an exemplary combined nitrogen rejection and helium recovery unit **130**. The LNG feed **131** is reduced in pressure through parallel, integrated expanders **135***a, b* and *c* into common feed flash drum **136**. The vapor stream from the flash drum **136** is cooled in parallel, integrated heat exchangers **137***a* and **137***b* before entering helium product flash drum **138**. The vapor stream from the helium product flash drum **138** is a helium rich stream which becomes the raw helium product stream **133**. The liquid stream from drum **138** is vaporized in exchangers **137***a* and *b* to provide the needed cooling. The liquid stream from the common feed flash drum **136** is passed to parallel, integrated heat exchangers **139***a* and **139***b* before entering fuel gas flash drum **140**. The liquid stream from the fuel gas flash distillation column **140** becomes the LNG product **132** while the vapor stream is combined with the vaporized stream from exchangers **137***a* and *b* and then compressed in parallel, integrated fuel gas compressors **141***a* and **141***b* before entering the fuel gas system **134**. FIG. **8** show one form of internal integration. The level of integration in a process unit module type may vary and the examples depicted in FIG. **8** are not meant to limit the invention. Additionally, the HRU unit depicted in FIG. **8** is exemplary of one particular HRU unit flow scheme and equipment arrangement and is not intended to limit the invention. Other manners of process unit module integration, HRU unit flow scheme and equipment arrangement are intended to be included within the scope of the invention.

[0101] In order to maximize the benefit of one embodiment of this invention, the evolution of the plant capacity could always be planned so that the most expensive equipment types and/or process unit modules are always fully utilized. For example, if the refrigerant compression unit module or modules were the most expensive, then the initial LNG liquefaction plant could be designed with perhaps two refrigerant compression unit modules and an appropriate number of other functional process unit modules of the other process unit module types to handle the desired plant throughput. If upon plant expansion, one more refrigerant compression unit modules were required, then an appropriate number of other process unit modules of the other functional process unit module types could be added in order to fully utilize the available capacity of the most costly process unit module.

[0102] The overall unit cost of a plant designed, constructed and/or operated using the methodologies described herein may be lower than a plant designed by the traditional train concept because each of the equipment types and/or process unit modules would be constructed at a very large scale and/or at its respective maximum processing efficiency. Engineering costs could also be reduced because only one piece of equipment of an equipment type must be designed, although several would be fabricated. Costs could also be reduced through the sharing of a control system and large-scale utility systems.

[0103] One potential advantage of a plant of this design is its modularity. Because nearly every equipment item is provided in multiple, a portion of the plant could be completed and commissioned while other portions of the plant are still under construction. This concept could have enormous benefits for project economics because more revenue would be generated early in the project lifetime. Also, without shutting down the entire plant various portions of the plant can be taken down for maintenance, which results in higher plant availability.

[0104] The methods described herein may be used to design one or more process unit module types or a complete hydrocarbon fluid processing plant. The methods may also be used to expand the capacity of an existing process unit module type or hydrocarbon fluid processing plant. A unit or plant so designed may be constructed and operated more efficiently using the methods described herein. Such units and plants may be used to produce salable products (e.g. LNG) which may be transported to market through pipelines and/or through the use of transportation vessels. Transportation vessels may include one or more of rail cars, tanker trucks, barges, ships or other means of traveling over land or seas.

[0105] Certain features of the present invention are described in terms of a set of numerical upper limits and a set of numerical lower limits. It should be appreciated that ranges formed by any combination of these limits are within the scope of the invention unless otherwise indicated. Although some of the dependent claims have single dependencies in accordance with U.S. practice, each of the features in any of such dependent claims can be combined with each of the features of one or more of the other dependent claims dependent upon the same independent claim or claims.

[0106] The present invention has been described in connection with its preferred embodiments. However, to the extent that the foregoing description is specific to a particular embodiment or a particular use of the invention, this is intended to be illustrative only and is not to be construed as limiting the scope of the invention. On the contrary, it is intended to cover all alternatives, modifications, and equivalents that are included within the spirit and scope of the invention, as defined by the appended claims.

1. A method of producing liquefied natural gas using a LNG liquefaction plant, wherein the LNG liquefaction plant includes a plurality of process unit module types, said plurality of process unit module types including at least a first process unit module type comprised of one or more first process unit modules and a second process unit module type comprised of two or more integrated second process unit modules, wherein further at least one of said first process unit modules and at least one of said second process unit modules are sized at their respective substantially maximum processing efficiency, said LNG liquefaction plant including two or more integrated process unit module types, said method comprising producing liquefied natural gas from said LNG liquefaction plant.

2. The method according to claim 1, wherein said substantially maximum processing efficiency is within 25 percent of the actual maximum processing efficiency.

3. The method according to claim 2, wherein said substantially maximum processing efficiency is within 15 percent of the actual maximum processing efficiency.

4. The method according to claim 3, wherein said substantially maximum processing efficiency is within 10 percent of the actual maximum processing efficiency.

5. The method according to claim 4, wherein said maximum processing efficiency is the process unit module capacity size for each process unit module type that minimizes total process unit module life cycle cost per unit of process unit module capacity.

6. The method according to claim 4, wherein said LNG liquefaction plant is further comprised of a third process unit module type comprised of one or more third process unit modules.

7. The method according to claim 4, wherein the maximum feed processing capacity of said second process unit module type at least equals the maximum feed processing capacity of said first process unit module type.

8. The method according to claim 7, wherein said first and second process unit module types have first and second construction costs per unit of maximum feed processing capacity, said first construction cost per unit of maximum feed processing capacity exceeding said second construction costs per unit of maximum feed processing capacity.

9. The method according to claim 6, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally sized process unit modules in parallel.

10. The method according to claim 9, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally configured process unit modules in parallel.

11. The method according to claim 6, wherein said third process unit module type includes third process unit modules sized at their substantially maximum processing efficiency.

12. The method according to claim 6, wherein said first process unit module is comprised of first equipment types, said second process unit module is comprised of second process equipment types and said third process unit module is comprised of third process equipment types

13. The method according to claim 12, wherein at least some of said respective equipment types are substantially equally configured.

14. The method according to claim 13, wherein at least some of said respective equipment types are substantially equally sized.

15. The method according to claim 6, wherein the maximum feed processing capacity of said first process unit module type differs by more than 10 percent from said second process unit module type.

16. The method according to claim 15, wherein said second process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

17. The method according to claim 15, wherein said first process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

18. The method according to claim 16, wherein said second process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said first process unit module type.

19. The method according to claim 17, wherein said first process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said second process unit module type.

20. The method according to claim 15, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

21. The method according to claim 15, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

22. The method according to claim 6, wherein said LNG liquefaction plant includes a liquefaction unit, said liquefaction unit comprised of one or more cryogenic heat exchangers and a plurality of refrigerant compressors of like service.

23. The method according to claim 22, wherein at least two of said plurality of compressors are arranged in parallel.

24. The method according to claim 23, wherein said liquefaction unit includes a plurality of cryogenic heat exchanges of like service, said cryogenic heat exchanges arranged in parallel.

25. The method according to claim 24, wherein each of said plurality of compressors is in fluid communication with two or more cryogenic heat exchangers.

26. The method according to claim 25, wherein said liquefaction unit is configured so that each of said plurality of compressors may be placed in fluid communication with any of said cryogenic heat exchangers.

27. The method according to claim 26, wherein said plurality of cryogenic heat exchangers includes one or more modular heat exchangers.

28. The method according to claim 27, wherein said plurality of cryogenic heat exchangers includes one or more plate-fin heat exchangers.

29. The method according to claim 27, wherein said plurality of cryogenic heat exchangers includes one or more spiral wound heat exchangers.

30. The method according to claim 6, wherein said LNG liquefaction plant has a plant maximum feed processing capacity and a plant minimum feed processing capacity, said plant minimum feed processing capacity being 75 percent or less of said plant maximum feed processing capacity.

31. The method according to claim 30, wherein said plant minimum feed processing capacity is 65 percent or less of said plant maximum feed processing capacity.

32. The method according to claim 31, wherein said plant minimum feed processing capacity is 55 percent or less of said plant maximum feed processing capacity.

33. The method according to claim 6, wherein at least one of said process unit module types includes variable speed compressors, variable speed expanders, or combinations thereof.

34. The method according to claim 6, wherein said plant maximum feed processing capacity is greater than 4 million tons per year.

35. The method according to claim 34, wherein said plant maximum feed processing capacity is greater than 6 million tons per year.

36. The method according to claim 1, wherein said LNG liquefaction plant contains three or more integrated process unit module types.

37. The method according to claim 36, wherein said LNG liquefaction plant contains four or more integrated process unit module types.

38. A method of designing a LNG liquefaction plant, comprising:

A) providing the identity of a plurality of process unit module types included in said LNG liquefaction plant, said plurality of process unit module types including at least a first process unit module type and a second process unit module type;

B) determining a first maximum processing efficiency for a first process unit module of said first process unit module type and a second maximum processing efficiency for a second process unit module of said second process unit module type; and

C) designing said LNG liquefaction plant, said LNG liquefaction plant design including one or more first process unit modules sized to substantially meet said first maximum processing efficiency and one or more second process unit modules sized to substantially meet said second maximum processing efficiency.

39. The method of claim 38, wherein said substantially meeting said maximum processing efficiency is within 25 percent of the actual maximum processing efficiency.

40. The method of claim 39, wherein said substantially meeting said maximum processing efficiency is within 15 percent of the actual maximum processing efficiency.

41. The method of claim 40, wherein said substantially meeting said maximum processing efficiency is within 10 percent of the actual maximum processing efficiency.

42. The method of claim 41, wherein said maximum processing efficiency is the process unit module capacity size for each process unit module type that minimizes total process unit module life cycle cost per unit of process unit module capacity.

43. The method of claim 41, wherein said LNG liquefaction plant design further includes a third process unit module type comprised of one or more third process unit modules.

44. The method of claim 41, wherein the maximum feed processing capacity of said second process unit module type at least equals the maximum feed processing capacity of said first process unit module type.

45. The method of claim 44, wherein said first and second process unit module types have first and second construction costs per unit of maximum feed processing capacity, said first construction cost per unit of maximum feed processing capacity exceeding said second construction costs per unit of maximum feed processing capacity.

46. The method of claim 43, wherein said LNG liquefaction plant design includes at least one of said process unit module types having a plurality of substantially equally sized process unit modules in parallel.

47. The method of claim 46, wherein said LNG liquefaction plant design includes at least one of said process unit module types having a plurality of substantially equally configured process unit modules in parallel.

48. The method of claim 43, wherein said third process unit module type includes third process unit modules sized at their substantially maximum processing efficiency.

49. The method of claim 43, wherein said first process unit module is comprised of first equipment types, said second process unit module is comprised of second process equipment types and said third process unit module is comprised of third process equipment types

50. The method of claim 49, wherein at least some of said respective equipment types are substantially equally configured.

51. The method of claim 50, wherein at least some of said respective equipment types are substantially equally sized.

52. The method of claim 43, wherein the maximum feed processing capacity of said first process unit module type differs by more than 10 percent from said second process unit module type.

53. The method of claim 52, wherein said second process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

54. The method of claim 52, wherein said first process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

55. The method of claim 53, wherein said second process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said first process unit module type.

56. The method of claim 54, wherein said first process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said second process unit module type.

57. The method of claim 52, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

58. The method of claim 52, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

59. The method of claim 43, wherein said LNG liquefaction plant design includes a liquefaction unit, said liquefaction unit comprised of one or more cryogenic heat exchangers and a plurality of refrigerant compressors of like service.

60. The method of claim 59, wherein at least two of said plurality of compressors are arranged in parallel.

61. The method of claim 60, wherein said liquefaction unit includes a plurality of cryogenic heat exchanges of like service, said cryogenic heat exchanges arranged in parallel.

62. The method of claim 61, wherein each of said plurality of compressors is in fluid communication with two or more cryogenic heat exchangers.

63. The method of claim 62, wherein said liquefaction unit is configured so that each of said plurality of compressors may be placed in fluid communication with any of said cryogenic heat exchangers.

64. The method of claim 63, wherein said plurality of cryogenic heat exchangers includes one or more modular heat exchangers.

65. The method of claim 64, wherein said plurality of cryogenic heat exchangers includes one or more plate-fin heat exchangers.

66. The method of claim 64, wherein said plurality of cryogenic heat exchangers includes one or more spiral wound heat exchangers.

67. The method of claim 43, wherein said LNG liquefaction plant design has a plant maximum feed processing capacity and a plant minimum feed processing capacity, said plant minimum feed processing capacity being 75 percent or less of said plant maximum feed processing capacity.

68. The method of claim 67, wherein said plant minimum feed processing capacity is 65 percent or less of said plant maximum feed processing capacity.

69. The method of claim 68, wherein said plant minimum feed processing capacity is 55 percent or less of said plant maximum feed processing capacity.

70. The method of claim 43, wherein at least one of said process unit module types includes variable speed compressors, variable speed expanders, or combinations thereof.

71. The method of claim 43, wherein said plant maximum feed processing capacity is greater than 4 million tons per year.

72. The method of claim 71, wherein said plant maximum feed processing capacity is greater than 6 million tons per year.

73. The method of claim 43, wherein said LNG liquefaction plant design contains two or more integrated process unit module types.

74. The method of claim 73, wherein said LNG liquefaction plant design contains three or more integrated process unit module types.

75. The method of claim 74, wherein said LNG liquefaction plant design contains four or more integrated process unit module types.

76. A method of designing an expanded processing capacity of a LNG liquefaction plant having an existing plant maximum feed processing capacity, comprising:

A) providing the existing configuration of said LNG liquefaction plant, said LNG liquefaction plant including a plurality of process unit module types;

B) determining a first process unit module type requiring additional maximum feed processing capacity to increase said existing plant maximum feed processing capacity;

C) determining the maximum processing efficiency of a first process unit module of said first process unit module type; and

D) designing an expanded LNG liquefaction plant, said design including the addition of one or more first process unit modules sized to substantially meet said maximum processing efficiency.

77. The method of claim 76, wherein said substantially meeting said maximum processing efficiency is within 25 percent of the actual maximum processing efficiency.

78. The method of claim 77, wherein said substantially meeting said maximum processing efficiency is within 15 percent of the actual maximum processing efficiency.

79. The method of claim 78, wherein said substantially meeting said maximum processing efficiency is within 10 percent of the actual maximum processing efficiency.

80. The method of claim 79, wherein said maximum processing efficiency is the process unit module capacity size for each process unit module type that minimizes total process unit module life cycle cost per unit of process unit module capacity.

81. The method of claim 80, wherein said LNG liquefaction plant design further includes a second process unit module type comprised of one or more second process unit modules and a third process unit module type comprised of one or more third process unit modules.

82. The method of claim 81, wherein the maximum feed processing capacity of said second process unit module type at least equals the maximum feed processing capacity of said first process unit module type.

83. The method of claim 82, wherein said first and second process unit module types have first and second construction costs per unit of maximum feed processing capacity, said first construction cost per unit of maximum feed processing capacity exceeding said second construction costs per unit of maximum feed processing capacity.

84. The method of claim 81, wherein said LNG liquefaction plant design includes at least one of said process unit module types having a plurality of substantially equally sized process unit modules in parallel.

85. The method of claim 84, wherein said LNG liquefaction plant design includes at least one of said process unit module types having a plurality of substantially equally configured process unit modules in parallel.

86. The method of claim 81, wherein said third process unit module type includes third process unit modules sized at their substantially maximum processing efficiency.

87. The method of claim 81, wherein said first process unit module is comprised of first equipment types, said second process unit module is comprised of second process equipment types and said third process unit module is comprised of third process equipment types

88. The method of claim 87, wherein at least some of said respective equipment types are substantially equally configured.

89. The method of claim 88, wherein at least some of said respective equipment types are substantially equally sized.

90. The method of claim 81, wherein the maximum feed processing capacity of said first process unit module type differs by more than 10 percent from said second process unit module type.

91. The method of claim 90, wherein said second process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

92. The method of claim 90, wherein said first process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

93. The method of claim 91, wherein said second process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said first process unit module type.

94. The method of claim 92, wherein said first process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said second process unit module type.

95. The method of claim 90, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

96. The method of claim 90, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

97. The method of claim 81, wherein said LNG liquefaction plant design includes a liquefaction unit, said liquefaction unit comprised of one or more cryogenic heat exchangers and a plurality of refrigerant compressors of like service.

98. The method of claim 97, wherein at least two of said plurality of compressors are arranged in parallel.

99. The method of claim 98, wherein said liquefaction unit includes a plurality of cryogenic heat exchanges of like service, said cryogenic heat exchanges arranged in parallel.

100. The method of claim 99, wherein each of said plurality of compressors is in fluid communication with two or more cryogenic heat exchangers.

101. The method of claim 100, wherein said liquefaction unit is configured so that each of said plurality of compressors may be placed in fluid communication with any of said cryogenic heat exchangers.

102. The method of claim 101, wherein said plurality of cryogenic heat exchangers includes one or more modular heat exchangers.

103. The method of claim 102, wherein said plurality of cryogenic heat exchangers includes one or more plate-fin heat exchangers.

104. The method of claim 102, wherein said plurality of cryogenic heat exchangers includes one or more spiral wound heat exchangers.

105. The method of claim 81, wherein said LNG liquefaction plant design has a plant maximum feed processing capacity and a plant minimum feed processing capacity, said plant minimum feed processing capacity being 75 percent or less of said plant maximum feed processing capacity.

106. The method of claim 105, wherein said plant minimum feed processing capacity is 65 percent or less of said plant maximum feed processing capacity.

107. The method of claim 106, wherein said plant minimum feed processing capacity is 55 percent or less of said plant maximum feed processing capacity.

108. The method of claim 85, wherein at least one of said process unit module types includes variable speed compressors, variable speed expanders, or combinations thereof.

109. The method of claim 81, wherein said plant maximum feed processing capacity is greater than 4 million tons per year.

110. The method of claim 109, wherein said plant maximum feed processing capacity is greater than 6 million tons per year.

111. The method of claim 81, wherein said LNG liquefaction plant design contains two or more integrated process unit module types.

112. The method of claim 111, wherein said LNG liquefaction plant design contains three or more integrated process unit module types.

113. The method of claim 112, wherein said LNG liquefaction plant design contains four or more integrated process unit module types.

114. A method of operating a LNG liquefaction plant having a plurality of process unit module types, said plurality of process unit module types including at least a first process unit module type comprised of one or more first process unit modules and a second process unit module type comprised of two or more integrated second process unit modules wherein at least one of said first process unit modules and at least one of said second process unit modules are sized at their respective substantially maximum processing efficiency, said method comprising:

A) determining a first plant feed processing rate;

B) determining the number of process unit modules of each process unit module type required to meet said first plant feed processing rate;

C) commissioning at least the number of each process unit module of each process unit module type required to meet said first plant feed processing rate determined in step (B); and

D) producing LNG.

115. The method of claim 114, wherein said substantially maximum processing efficiency is within 25 percent of the actual maximum processing efficiency.

116. The method of claim 115, wherein said substantially maximum processing efficiency is within 15 percent of the actual maximum processing efficiency.

117. The method of claim 116, wherein said substantially maximum processing efficiency is within 10 percent of the actual maximum processing efficiency.

118. The method of claim 117, wherein said maximum processing efficiency is the process unit module capacity size for each process unit module type that minimizes total process unit module life cycle cost per unit of process unit module capacity.

119. The method of claim 117, wherein said LNG liquefaction plant further includes a third process unit module type comprised of one or more third process unit modules.

120. The method of claim 117, wherein the maximum feed processing capacity of said second process unit module type at least equals the maximum feed processing capacity of said first process unit module type.

121. The method of claim 120, wherein said first and second process unit module types have first and second construction costs per unit of maximum feed processing capacity, said first construction cost per unit of maximum feed processing capacity exceeding said second construction costs per unit of maximum feed processing capacity.

122. The method of claim 117, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally sized process unit modules in parallel.

123. The method of claim 122, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally configured process unit modules in parallel.

124. The method of claim 119, wherein said third process unit module type includes third process unit modules sized at their substantially maximum processing efficiency.

125. The method of claim 119, wherein said first process unit module is comprised of first equipment types, said second process unit module is comprised of second process equipment types and said third process unit module is comprised of third process equipment types

126. The method of claim 125, wherein at least some of said respective equipment types are substantially equally configured.

127. The method of claim 126, wherein at least some of said respective equipment types are substantially equally sized.

128. The method of claim 119, wherein the maximum feed processing capacity of said first process unit module type differs by more than 10 percent from said second process unit module type.

129. The method of claim 128, wherein said second process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

130. The method of claim 128, wherein said first process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

131. The method of claim 129, wherein said second process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said first process unit module type.

132. The method of claim 130, wherein said first process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said second process unit module type.

133. The method of claim 128, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

134. The method of claim 128, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

135. The method of claim 119, wherein said LNG liquefaction plant includes a liquefaction unit, said liquefaction unit comprised of one or more cryogenic heat exchangers and a plurality of refrigerant compressors of like service.

136. The method of claim 135, wherein at least two of said plurality of compressors are arranged in parallel.

137. The method of claim 136, wherein said liquefaction unit includes a plurality of cryogenic heat exchanges of like service, said cryogenic heat exchanges arranged in parallel.

138. The method of claim 137, wherein each of said plurality of compressors is in fluid communication with two or more cryogenic heat exchangers.

139. The method of claim 138, wherein said liquefaction unit is configured so that each of said plurality of compressors may be placed in fluid communication with any of said cryogenic heat exchangers.

140. The method of claim 139, wherein said plurality of cryogenic heat exchangers includes one or more modular heat exchangers.

141. The method of claim 140, wherein said plurality of cryogenic heat exchangers includes one or more plate-fin heat exchangers.

142. The method of claim 140, wherein said plurality of cryogenic heat exchangers includes one or more spiral wound heat exchangers.

143. The method of claim 119, wherein said LNG liquefaction plant has a plant maximum feed processing capacity and a plant minimum feed processing capacity, said plant minimum feed processing capacity being 75 percent or less of said plant maximum feed processing capacity.

144. The method of claim 143, wherein said plant minimum feed processing capacity is 65 percent or less of said plant maximum feed processing capacity.

145. The method of claim 144, wherein said plant minimum feed processing capacity is 55 percent or less of said plant maximum feed processing capacity.

146. The method of claim 119, wherein at least one of said process unit module types includes variable speed compressors, variable speed expanders, or combinations thereof.

147. The method of claim 119, wherein said plant maximum feed processing capacity is greater than 4 million tons per year.

148. The method of claim 147, wherein said plant maximum feed processing capacity is greater than 6 million tons per year.

149. The method of claim 119, wherein said LNG liquefaction plant contains two or more integrated process unit module types.

150. The method of claim 149, wherein said LNG liquefaction plant contains three or more integrated process unit module types.

151. The method of claim 150, wherein said LNG liquefaction plant contains four or more integrated process unit module types.

152. The method of claim 119, further comprising;

E) determining a second plant feed processing rate;

F) determining the number of process unit modules of each process unit module type required to meet said second plant feed processing rate; and

G) commissioning at least the number of each process unit module of each process unit module type required to meet said second plant feed processing rate determined in step (F).

153. A method of producing LNG using a LNG liquefaction plant, said LNG liquefaction plant comprised of a plurality of process unit module types, each of said plurality of process unit module types comprised of one or more process unit modules, said method comprising:

A) providing at least one original process unit module for each process unit module type included in said plurality of process unit module types, one or more of said original process unit modules sized at their respective substantially maximum processing efficiency, thereby providing a first phase LNG liquefaction plant;

B) providing one or more additional process unit module(s) for one or more process unit module type(s) included in said first phase LNG liquefaction plant, said additional process unit module being integrated with said original process unit module within said process unit module type, thereby providing a second phase LNG liquefaction plant; and

C) producing LNG from said second phase LNG liquefaction plant.

154. The method of claim 153, wherein said substantially maximum processing efficiency is within 25 percent of the actual maximum processing efficiency.

155. The method of claim 154, wherein said substantially maximum processing efficiency is within 15 percent of the actual maximum processing efficiency.

156. The method of claim 155, wherein said substantially maximum processing efficiency is within 10 percent of the actual maximum processing efficiency.

157. The method of claim 156, wherein said maximum processing efficiency is the process unit module capacity size for each process unit module type that minimizes total process unit module life cycle cost per unit of process unit module capacity.

158. The method of claim 156, wherein said LNG liquefaction plant further includes a third process unit module type comprised of one or more third process unit modules.

159. The method of claim 156, wherein the maximum feed processing capacity of said second process unit module type at least equals the maximum feed processing capacity of said first process unit module type.

160. The method of claim 159, wherein said first and second process unit module types have first and second construction costs per unit of maximum feed processing capacity, said first construction cost per unit of maximum feed processing capacity exceeding said second construction costs per unit of maximum feed processing capacity.

161. The method of claim 156, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally sized process unit modules in parallel.

162. The method of claim 161, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally configured process unit modules in parallel.

163. The method of claim 158, wherein said third process unit module type includes third process unit modules sized at their substantially maximum processing efficiency.

164. The method of claim 158, wherein said first process unit module is comprised of first equipment types, said second process unit module is comprised of second process equipment types and said third process unit module is comprised of third process equipment types

165. The method of claim 164, wherein at least some of said respective equipment types are substantially equally configured.

166. The method of claim 165, wherein at least some of said respective equipment types are substantially equally sized.

167. The method of claim 158, wherein the maximum feed processing capacity of said first process unit module type differs by more than 10 percent from said second process unit module type.

168. The method of claim 167, wherein said second process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

169. The method of claim 167, wherein said first process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

170. The method of claim 168, wherein said second process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said first process unit module type.

171. The method of claim 169, wherein said first process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said second process unit module type.

172. The method of claim 167, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

173. The method of claim 167, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

174. The method of claim 158, wherein said LNG liquefaction plant includes a liquefaction unit, said liquefaction unit comprised of one or more cryogenic heat exchangers and a plurality of refrigerant compressors of like service.

175. The method of claim 174, wherein at least two of said plurality of compressors are arranged in parallel.

176. The method of claim 175, wherein said liquefaction unit includes a plurality of cryogenic heat exchanges of like service, said cryogenic heat exchanges arranged in parallel.

177. The method of claim 176, wherein each of said plurality of compressors is in fluid communication with two or more cryogenic heat exchangers.

178. The method of claim 177, wherein said liquefaction unit is configured so that each of said plurality of compressors may be placed in fluid communication with any of said cryogenic heat exchangers.

179. The method of claim 178, wherein said plurality of cryogenic heat exchangers includes one or more modular heat exchangers.

180. The method of claim 179, wherein said plurality of cryogenic heat exchangers includes one or more plate-fin heat exchangers.

181. The method of claim 179, wherein said plurality of cryogenic heat exchangers includes one or more spiral wound heat exchangers.

182. The method of claim 158, wherein said LNG liquefaction plant has a plant maximum feed processing capacity and a plant minimum feed processing capacity, said plant minimum feed processing capacity being 75 percent or less of said plant maximum feed processing capacity.

183. The method of claim 182, wherein said plant minimum feed processing capacity is 65 percent or less of said plant maximum feed processing capacity.

184. The method of claim 183, wherein said plant minimum feed processing capacity is 55 percent or less of said plant maximum feed processing capacity.

185. The method of claim 158, wherein at least one of said process unit module types includes variable speed compressors, variable speed expanders, or combinations thereof.

186. The method of claim 158, wherein said plant maximum feed processing capacity is greater than 4 million tons per year.

187. The method of claim 186, wherein said plant maximum feed processing capacity is greater than 6 million tons per year.

188. The method of claim 158, wherein said LNG liquefaction plant contains two or more integrated process unit module types.

189. The method of claim 188, wherein said LNG liquefaction plant contains three or more integrated process unit module types.

190. The method of claim 189, wherein said LNG liquefaction plant contains four or more integrated process unit module types.

191. A method of producing liquefied natural gas, comprising:

A) providing an LNG liquefaction plant comprising a plurality of product sized process unit module types, said LNG liquefaction plant having a first plant maximum feed processing capacity;

B) expanding the maximum feed processing capacity of at least one but less than all of said product sized process unit module types to achieve a second plant maximum feed processing capacity that is 10 percent or greater than said first plant maximum feed processing capacity, wherein the expanding includes adding at least one additional process unit module; and

C) producing LNG in said LNG liquefaction plant after initiation of said expanding step (B).

192. The method of claim 191, wherein said product sized process unit module types are selected from acid gas removal contactor units, dehydration units, deethanizer units, cryogenic heat exchanger units, refrigerant compressor units, nitrogen rejection units, liquefaction units, helium recovery units, and combinations thereof.

193. The method of claim 192, wherein said product sized process unit module types include at least a first process unit module type comprised of one or more first process unit modules and a second process unit module type comprised of two or more integrated second process unit modules wherein at least one of said first process unit modules and at least one of said second process unit modules are sized at their respective substantially maximum processing efficiency.

194. The method of claim 193, wherein said substantially maximum processing efficiency is within 25 percent of the actual maximum processing efficiency.

195. The method of claim 194, wherein said substantially maximum processing efficiency is within 15 percent of the actual maximum processing efficiency.

196. The method of claim 195, wherein said substantially maximum processing efficiency is within 10 percent of the actual maximum processing efficiency.

197. The method of claim 196, wherein said maximum processing efficiency is the process unit module capacity size for each process unit module type that minimizes total process unit module life cycle cost per unit of process unit module capacity.

198. The method of claim 196, wherein said LNG liquefaction plant further includes a third process unit module type comprised of one or more third process unit modules.

199. The method of claim 196, wherein the maximum feed processing capacity of said second process unit module type at least equals the maximum feed processing capacity of said first process unit module type.

200. The method of claim 199, wherein said first and second process unit module types have first and second construction costs per unit of maximum feed processing capacity, said first construction cost per unit of maximum feed processing capacity exceeding said second construction costs per unit of maximum feed processing capacity.

201. The method of claim 196, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally sized process unit modules in parallel.

202. The method of claim 201, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally configured process unit modules in parallel.

203. The method of claim 198, wherein said third process unit module type includes third process unit modules sized at their substantially maximum processing efficiency.

204. The method of claim 198, wherein said first process unit module is comprised of first equipment types, said second process unit module is comprised of second process equipment types and said third process unit module is comprised of third process equipment types

205. The method of claim 204, wherein at least some of said respective equipment types are substantially equally configured.

206. The method of claim 205, wherein at least some of said respective equipment types are substantially equally sized.

207. The method of claim 199, wherein the maximum feed processing capacity of said first process unit module type differs by more than 10 percent from said second process unit module type.

208. The method of claim 207, wherein said second process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

209. The method of claim 207, wherein said first process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

210. The method of claim 208, wherein said second process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said first process unit module type.

211. The method of claim 209, wherein said first process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said second process unit module type.

212. The method of claim 207, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

213. The method of claim 207, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

214. The method of claim 198, wherein said LNG liquefaction plant includes a liquefaction unit, said liquefaction unit comprised of one or more cryogenic heat exchangers and a plurality of refrigerant compressors of like service.

215. The method of claim 214, wherein at least two of said plurality of compressors are arranged in parallel.

216. The method of claim 215, wherein said liquefaction unit includes a plurality of cryogenic heat exchanges of like service, said cryogenic heat exchanges arranged in parallel.

217. The method of claim 216, wherein each of said plurality of compressors is in fluid communication with two or more cryogenic heat exchangers.

218. The method of claim 217, wherein said liquefaction unit is configured so that each of said plurality of compressors may be placed in fluid communication with any of said cryogenic heat exchangers.

219. The method of claim 218, wherein said plurality of cryogenic heat exchangers includes one or more modular heat exchangers.

220. The method of claim 219, wherein said plurality of cryogenic heat exchangers includes one or more plate-fin heat exchangers.

221. The method of claim 219, wherein said plurality of cryogenic heat exchangers includes one or more spiral wound heat exchangers.

222. The method of claim 198, wherein said LNG liquefaction plant has a plant maximum feed processing capacity and a plant minimum feed processing capacity, said plant minimum feed processing capacity being 75 percent or less of said plant maximum feed processing capacity.

223. The method of claim 222, wherein said plant minimum feed processing capacity is 65 percent or less of said plant maximum feed processing capacity.

224. The method of claim 223, wherein said plant minimum feed processing capacity is 55 percent or less of said plant maximum feed processing capacity.

225. The method of claim 198, wherein at least one of said process unit module types includes variable speed compressors, variable speed expanders, or combinations thereof.

226. The method of claim 198, wherein said plant maximum feed processing capacity is greater than 4 million tons per year.

227. The method of claim 226, wherein said plant maximum feed processing capacity is greater than 6 million tons per year.

228. The method of claim 118, wherein said LNG liquefaction plant contains two or more integrated process unit module types.

229. The method of claim 228, wherein said LNG liquefaction plant contains three or more integrated process unit module types.

230. The method of claim 229, wherein said LNG liquefaction plant contains four or more integrated process unit module types.

231. A method of producing liquefied natural gas using an LNG liquefaction plant, said LNG liquefaction plant comprised of a plurality of process unit module types, each of said plurality of process unit module types comprised of one or more process unit modules, said method comprising:

A) providing at least one original process unit module for each process unit module type included in said plurality of process unit module types, thereby providing a first phase LNG liquefaction plant;

B) producing first LNG from said first phase LNG liquefaction plant;

C) constructing one or more additional process unit modules for one or more process unit module types included in said first phase LNG liquefaction plant while completing at least a portion of said producing step (B);

D) placing said one or more additional process unit modules in service, said additional process unit modules being integrated with said original process unit module within said process unit module type, thereby providing a second phase LNG liquefaction plant; and

E) producing second LNG from said second phase LNG liquefaction plant.

232. The method of claim 231, wherein said placing step D is accomplished while producing first LNG in step B.

233. The method of claim 231, wherein said placing step D is at least partially accomplished while producing first LNG in step B.

234. The method of claim 231, wherein said placing step D is at least partially accomplished while not producing first LNG in step B.

235. The method of claim 234, wherein said placing step D is at least partially accomplished while not producing first LNG in step B for less than 10 days.

236. The method of claim 231, wherein at least one of said additional process unit modules is sized at its respective substantially maximum processing efficiency.

237. The method of claim 236, wherein said substantially maximum processing efficiency is within 25 percent of the actual maximum processing efficiency.

238. The method of claim 237, wherein said substantially maximum processing efficiency is within 15 percent of the actual maximum processing efficiency.

239. The method of claim 238, wherein said substantially maximum processing efficiency is within 10 percent of the actual maximum processing efficiency.

240. The method of claim 239, wherein said maximum processing efficiency is the process unit module capacity size for each process unit module type that minimizes total process unit module life cycle cost per unit of process unit module capacity.

241. The method of claim 240, wherein said original and additional process unit modules are substantially equally configured.

242. The method of claim 241, wherein said original process unit module is comprised of original equipment types and said additional process unit module is comprised of additional process equipment types.

243. The method of claim 242, wherein at least some of said respective equipment types are substantially equally configured.

244. The method of claim 243, wherein at least some of said respective equipment types are substantially equally sized.

245. The method of claim 244, wherein said LNG liquefaction plant includes a liquefaction unit, said liquefaction unit comprised of one or more cryogenic heat exchangers and a plurality of refrigerant compressors of like service.

246. The method of claim 245, wherein at least two of said plurality of compressors are arranged in parallel.

247. The method of claim 246, wherein said liquefaction unit includes a plurality of cryogenic heat exchanges of like service, said cryogenic heat exchanges arranged in parallel.

248. The method of claim 247, wherein each of said plurality of compressors is in fluid communication with two or more cryogenic heat exchangers.

249. The method of claim 248, wherein said liquefaction unit is configured so that each of said plurality of compressors may be placed in fluid communication with any of said cryogenic heat exchangers.

250. The method of claim 249, wherein said plurality of cryogenic heat exchangers includes one or more modular heat exchangers.

251. The method of claim 250, wherein said plurality of cryogenic heat exchangers includes one or more plate-fin heat exchangers.

252. The method of claim 250, wherein said plurality of cryogenic heat exchangers includes one or more spiral wound heat exchangers.

253. The method of claim 244, wherein said LNG liquefaction plant has a plant maximum feed processing capacity and a plant minimum feed processing capacity, said plant minimum feed processing capacity being 75 percent or less of said plant maximum feed processing capacity.

254. The method of claim 243, wherein said plant minimum feed processing capacity is 65 percent or less of said plant maximum feed processing capacity.

255. The method of claim 253, wherein said plant minimum feed processing capacity is 55 percent or less of said plant maximum feed processing capacity.

256. The method of claim 244, wherein at least one of said process unit module types includes variable speed compressors, variable speed expanders, or combinations thereof.

257. The method of claim 244, wherein said plant maximum feed processing capacity is greater than 4 million tons per year.

258. The method of claim 257, wherein said plant maximum feed processing capacity is greater than 6 million tons per year.

259. The method of claim 244, wherein said LNG liquefaction plant contains two or more integrated process unit module types.

260. The method of claim 259, wherein said LNG liquefaction plant contains three or more integrated process unit module types.

261. The method of claim 260, wherein said LNG liquefaction plant contains four or more integrated process unit module types.

262. An LNG liquefaction plant, comprised of one or more high construction cost product sized process unit module types and one or more low construction cost product sized process unit module types, at least one of said low construction cost product sized process unit module types having a maximum feed processing capacity that is at least 110 percent of the maximum feed processing capacity of at least one of said high construction cost product sized process unit module types.

263. An LNG liquefaction plant according to claim 262, wherein said high construction cost product sized process unit module types have a total construction cost per unit of maximum feed processing capacity that is 1.25 times or greater the total construction cost per unit of maximum feed processing capacity of said low construction cost product sized process unit module types.

264. An LNG liquefaction plant according to claim 262, wherein said low construction cost product sized process unit module types are selected from acid gas removal units, dehydration units, fractionation units, nitrogen rejection units, and helium recovery units.

265. An LNG liquefaction plant according to claim 262, wherein said high construction cost product sized process unit module types are selected from inlet facilities units, refrigerant compression units, cryogenic heat exchanger units, and liquefaction units.

266. The method of claim 262, wherein said product sized process unit module types include at least a first process unit module type comprised of one or more first process unit modules and a second process unit module type comprised of two or more integrated second process unit modules wherein at least one of said first process unit modules and at least one of said second process unit modules are sized at their respective substantially maximum processing efficiency.

267. The method of claim 266, wherein said substantially maximum processing efficiency is within 25 percent of the actual maximum processing efficiency.

268. The method of claim 267, wherein said substantially maximum processing efficiency is within 15 percent of the actual maximum processing efficiency.

269. The method of claim 268, wherein said substantially maximum processing efficiency is within 10 percent of the actual maximum processing efficiency.

270. The method of claim 269, wherein said maximum processing efficiency is the process unit module capacity size for each process unit module type that minimizes total process unit module life cycle cost per unit of process unit module capacity.

271. The method of claim 269, wherein said LNG liquefaction plant further includes a third process unit module type comprised of one or more third process unit modules.

272. The method of claim 269, wherein the maximum feed processing capacity of said second process unit module type at least equals the maximum feed processing capacity of said first process unit module type.

273. The method of claim 272, wherein said first and second process unit module types have first and second construction costs per unit of maximum feed processing capacity, said first construction cost per unit of maximum feed processing capacity exceeding said second construction costs per unit of maximum feed processing capacity.

274. The method of claim 269, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally sized process unit modules in parallel.

275. The method of claim 274, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally configured process unit modules in parallel.

276. The method of claim 271, wherein said third process unit module type includes third process unit modules sized at their substantially maximum processing efficiency.

277. The method of claim 271, wherein said first process unit module is comprised of first equipment types, said second process unit module is comprised of second process equipment types and said third process unit module is comprised of third process equipment types

278. The method of claim 277, wherein at least some of said respective equipment types are substantially equally configured.

279. The method of claim 278, wherein at least some of said respective equipment types are substantially equally sized.

280. The method of claim 271, wherein the maximum feed processing capacity of said first process unit module type differs by more than 10 percent from said second process unit module type.

281. The method of claim 280, wherein said second process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

282. The method of claim 280, wherein said first process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

283. The method of claim 281, wherein said second process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said first process unit module type.

284. The method of claim 282, wherein said first process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said second process unit module type.

285. The method of claim 280, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

286. The method of claim 280, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

287. The method of claim 271, wherein said LNG liquefaction plant includes a liquefaction unit, said liquefaction unit comprised of one or more cryogenic heat exchangers and a plurality of refrigerant compressors of like service.

288. The method of claim 287, wherein at least two of said plurality of compressors are arranged in parallel.

289. The method of claim 288, wherein said liquefaction unit includes a plurality of cryogenic heat exchanges of like service, said cryogenic heat exchanges arranged in parallel.

290. The method of claim 289, wherein each of said plurality of compressors is in fluid communication with two or more cryogenic heat exchangers.

291. The method of claim 290, wherein said liquefaction unit is configured so that each of said plurality of compressors may be placed in fluid communication with any of said cryogenic heat exchangers.

292. The method of claim 291, wherein said plurality of cryogenic heat exchangers includes one or more modular heat exchangers.

293. The method of claim 292, wherein said plurality of cryogenic heat exchangers includes one or more plate-fin heat exchangers.

294. The method of claim 292, wherein said plurality of cryogenic heat exchangers includes one or more spiral wound heat exchangers.

295. The method of claim 271, wherein said LNG liquefaction plant has a plant maximum feed processing capacity and a plant minimum feed processing capacity, said plant minimum feed processing capacity being 75 percent or less of said plant maximum feed processing capacity.

296. The method of claim 295, wherein said plant minimum feed processing capacity is 65 percent or less of said plant maximum feed processing capacity.

297. The method of claim 296, wherein said plant minimum feed processing capacity is 55 percent or less of said plant maximum feed processing capacity.

298. The method of claim 271, wherein at least one of said process unit module types includes variable speed compressors, variable speed expanders, or combinations thereof.

299. The method of claim 271, wherein said plant maximum feed processing capacity is greater than 4 million tons per year.

300. The method of claim 299, wherein said plant maximum feed processing capacity is greater than 6 million tons per year.

301. The method of claim 271, wherein said LNG liquefaction plant contains two or more integrated process unit module types.

302. The method of claim 301, wherein said LNG liquefaction plant contains three or more integrated process unit module types.

303. The method of claim 302, wherein said LNG liquefaction plant contains four or more integrated process unit module types.

304. A method of producing liquefied natural gas, comprising:

A) providing an LNG liquefaction plant comprising a plurality of process unit module types, said LNG liquefaction plant having at least a first refrigerant circuit, said first refrigerant circuit comprising at least one first refrigerant compressor service type, said first refrigerant compressor service type comprised of one or more original first refrigerant compressors in parallel, said LNG liquefaction plant having a plant maximum feed processing capacity;

B) expanding the plant maximum feed processing capacity of said LNG liquefaction plant by adding at least one additional first refrigerant compressor to said first refrigerant compressor service type, said additional first refrigerant compressor being integrated with said one or more original first refrigerant compressors within said first refrigerant compressor service type; and

C) producing LNG in said LNG liquefaction plant after initiation of said expanding step (B).

305. The method of claim 304, wherein at least one of said original first refrigerant compressors and at least one of said additional first refrigerant compressors are substantially equally sized.

306. The method of claim 305, wherein at least one of said original first refrigerant compressors and at least one of said additional first refrigerant compressors are substantially equally mechanically configured.

307. The method of claim 306, wherein said original first refrigerant compressors are comprised of a plurality of first refrigerant compressors, said plurality of original first refrigerant compressors having a maximum combined processing capacity.

308. The method of claim 307, wherein said maximum combined processing capacity is less than the processing capacity of the largest commercially available compressor.

309. The method of claim 307, wherein each of said plurality of original first refrigerant compressors has a processing capacity less than the processing capacity of the largest commercially available compressor.

310. The method of claim 307, wherein said original first refrigerant compressors include electric drive compressors.

311. The method of claim 306, wherein said original first refrigerant compressors include gas turbine drive compressors.

312. The method of claim 306, wherein said first refrigerant circuit further includes one or more plate fin heat exchangers, said plate fin heat exchangers adapted to cool a natural gas stream through heat exchange with refrigerant compressed by said first refrigerant compressors.

313. The method of claim 312, wherein said one or more plate fin heat exchangers includes a plurality of plate fin heat exchangers arranged in a cold box.

314. The method of claim 306, wherein said first refrigerant circuit further includes one or more spiral wound heat exchangers, said spiral wound heat exchangers adapted to cool a natural gas stream through heat exchange with refrigerant compressed by said first refrigerant compressors.

315. The method of claim 304, wherein said process unit module types include at least a first process unit module type comprised of one or more first process unit modules and a second process unit module type comprised of two or more integrated second process unit modules wherein at least one of said first process unit modules and at least one of said second process unit modules are sized at their respective substantially maximum processing efficiency.

316. The method of claim 315, wherein said substantially maximum processing efficiency is within 25 percent of the actual maximum processing efficiency.

317. The method of claim 316, wherein said substantially maximum processing efficiency is within 15 percent of the actual maximum processing efficiency.

318. The method of claim 317, wherein said substantially maximum processing efficiency is within 10 percent of the actual maximum processing efficiency.

319. The method of claim 318, wherein said maximum processing efficiency is the process unit module capacity size for each process unit module type that minimizes total process unit module life cycle cost per unit of process unit module capacity.

320. The method of claim 318, wherein said LNG liquefaction plant further includes a third process unit module type comprised of one or more third process unit modules.

321. The method of claim 318, wherein the maximum feed processing capacity of said second process unit module type at least equals the maximum feed processing capacity of said first process unit module type.

322. The method of claim 321, wherein said first and second process unit module types have first and second construction costs per unit of maximum feed processing capacity, said first construction cost per unit of maximum feed processing capacity exceeding said second construction costs per unit of maximum feed processing capacity.

323. The method of claim 318, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally sized process unit modules in parallel.

324. The method of claim 323, wherein said LNG liquefaction plant includes at least one of said process unit module types having a plurality of substantially equally configured process unit modules in parallel.

325. The method of claim 320, wherein said third process unit module type includes third process unit modules sized at their substantially maximum processing efficiency.

326. The method of claim 320, wherein said first process unit module is comprised of first equipment types, said second process unit module is comprised of second process equipment types and said third process unit module is comprised of third process equipment types

327. The method of claim 326, wherein at least some of said respective equipment types are substantially equally configured.

328. The method of claim 327, wherein at least some of said respective equipment types are substantially equally sized.

329. The method of claim 320, wherein the maximum feed processing capacity of said first process unit module type differs by more than 10 percent from said second process unit module type.

330. The method of claim 329, wherein said second process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

331. The method of claim 329, wherein said first process unit module type has a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

332. The method of claim 330, wherein said second process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said first process unit module type.

333. The method of claim 331, wherein said first process unit module type has a maximum feed processing capacity less than 80 percent of the maximum feed processing capacity of said second process unit module type.

334. The method of claim 329, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said first process unit module type.

335. The method of claim 329, wherein at least two of said process unit module types have a maximum feed processing capacity less than 85 percent of the maximum feed processing capacity of said second process unit module type.

336. The method of claim 320, wherein said LNG liquefaction plant includes a liquefaction unit, said liquefaction unit comprised of one or more cryogenic heat exchangers and a plurality of refrigerant compressors of like service.

337. The method of claim 326, wherein at least two of said plurality of compressors are arranged in parallel.

338. The method of claim 337, wherein said liquefaction unit includes a plurality of cryogenic heat exchanges of like service, said cryogenic heat exchanges arranged in parallel.

339. The method of claim 338, wherein each of said plurality of compressors is in fluid communication with two or more cryogenic heat exchangers.

340. The method of claim 339, wherein said liquefaction unit is configured so that each of said plurality of compressors may be placed in fluid communication with any of said cryogenic heat exchangers.

341. The method of claim 340, wherein said plurality of cryogenic heat exchangers includes one or more modular heat exchangers.

342. The method of claim 341, wherein said plurality of cryogenic heat exchangers includes one or more plate-fin heat exchangers.

343. The method of claim 341, wherein said plurality of cryogenic heat exchangers includes one or more spiral wound heat exchangers.

344. The method of claim 320, wherein said LNG liquefaction plant has a plant maximum feed processing capacity and a plant minimum feed processing capacity, said plant minimum feed processing capacity being 75 percent or less of said plant maximum feed processing capacity.

345. The method of claim 344, wherein said plant minimum feed processing capacity is 65 percent or less of said plant maximum feed processing capacity.

346. The method of claim 346, wherein said plant minimum feed processing capacity is 55 percent or less of said plant maximum feed processing capacity.

347. The method of claim 320, wherein at least one of said process unit module types includes variable speed compressors, variable speed expanders, or combinations thereof.

348. The method of claim 320, wherein said plant maximum feed processing capacity is greater than 4 million tons per year.

349. The method of claim 348, wherein said plant maximum feed processing capacity is greater than 6 million tons per year.

350. The method of claim 320, wherein said LNG liquefaction plant contains two or more integrated process unit module types.

351. The method of claim 350, wherein said LNG liquefaction plant contains three or more integrated process unit module types.

352. The method of claim 351, wherein said LNG liquefaction plant contains four or more integrated process unit module types.

353. A method of producing liquefied natural gas using an LNG liquefaction plant, said LNG liquefaction plant comprised of a plurality of process unit module types, each of said plurality of process unit module types comprised of one or more process unit modules, said method comprising:

A) providing at least one original process unit module for each process unit module type included in said plurality of process unit module types, thereby providing a first phase LNG liquefaction plant;

B) providing at least one second process unit module for each process unit module type included in said plurality of process unit module types, thereby providing a second phase LNG liquefaction plant;

C) integrating one or more of said original process unit modules with one or more of said second process unit modules for two or more respective process unit module types; and

D) producing LNG from said LNG liquefaction plant after initiation of said integrating step (C).

354. The method of claim 353, wherein said integrating step C includes integrating one or more of said original process unit modules with one or more of said second process unit modules of three or more respective process unit module types.

355. The method of claim 354, wherein said integrating step C includes integrating one or more of said original process unit modules with one or more of said second process unit modules of four or more respective process unit module types.

356. The method of claim 355, wherein said integrating step C includes integrating one or more of said original process unit modules with one or more of said second process unit modules of all of said plurality of process unit module types.

357. The method of claim 353, wherein at least one of said second process unit modules is sized at its respective substantially maximum processing efficiency.

358. The method of claim 357, wherein said substantially maximum processing efficiency is within 25 percent of the actual maximum processing efficiency.

359. The method of claim 358, wherein said substantially maximum processing efficiency is within 15 percent of the actual maximum processing efficiency.

360. The method of claim 359, wherein said substantially maximum processing efficiency is within 10 percent of the actual maximum processing efficiency.

361. The method of claim 360, wherein said maximum processing efficiency is the process unit module capacity size for each process unit module type that minimizes total process unit module life cycle cost per unit of process unit module capacity.

362. The method of claim 360, wherein said original and second process unit modules of the same process unit module type are substantially equally configured.

363. The method of claim 362, wherein said original process unit module is comprised of original equipment types and said second process unit module is comprised of second process equipment types.

364. The method of claim 363, wherein at least some of said respective equipment types are substantially equally configured.

365. The method of claim 364, wherein at least some of said respective equipment types are substantially equally sized.

366. The method of claim 365, wherein said LNG liquefaction plant includes a liquefaction unit, said liquefaction unit comprised of one or more cryogenic heat exchangers and a plurality of refrigerant compressors of like service.

367. The method of claim 366, wherein at least two of said plurality of compressors are arranged in parallel.

368. The method of claim 367, wherein said liquefaction unit includes a plurality of cryogenic heat exchanges of like service, said cryogenic heat exchanges arranged in parallel.

369. The method of claim 368, wherein each of said plurality of compressors is in fluid communication with two or more cryogenic heat exchangers.

370. The method of claim 369, wherein said liquefaction unit is configured so that each of said plurality of compressors may be placed in fluid communication with any of said cryogenic heat exchangers.

371. The method of claim 370, wherein said plurality of cryogenic heat exchangers includes one or more modular heat exchangers.

372. The method of claim 371, wherein said plurality of cryogenic heat exchangers includes one or more plate-fin heat exchangers.

373. The method of claim 371, wherein said plurality of cryogenic heat exchangers includes one or more spiral wound heat exchangers.

374. The method of claim 360, wherein said LNG liquefaction plant has a plant maximum feed processing capacity and a plant minimum feed processing capacity, said plant minimum feed processing capacity being 75 percent or less of said plant maximum feed processing capacity.

375. The method of claim 374, wherein said plant minimum feed processing capacity is 65 percent or less of said plant maximum feed processing capacity.

376. The method of claim 375, wherein said plant minimum feed processing capacity is 55 percent or less of said plant maximum feed processing capacity.

377. The method of claim 360, wherein at least one of said process unit module types includes variable speed compressors, variable speed expanders, or combinations thereof.

378. The method of claim 360, wherein said plant maximum feed processing capacity is greater than 4 million tons per year.

379. The method of claim 378, wherein said plant maximum feed processing capacity is greater than 6 million tons per year.

380-383. (canceled)

384. A LNG liquefaction plant comprising: a plurality of process unit module types, said plurality of process unit module types including at least a first process unit module type comprised of one or more first process unit modules and a second process unit module type comprised of two or more integrated second process unit modules, wherein at least one of said first process unit modules and at least one of said second process unit modules are sized at their respective substantially maximum processing efficiency; and two or more integrated process unit module types.

385. A method according to claim 1, wherein said LNG liquefaction plant contains one or more internally integrated process unit modules.

386. A method according to claim 38, wherein said LNG liquefaction plant contains one or more internally integrated process unit modules.

387. A method according to claim 76, wherein said LNG liquefaction plant contains one or more internally integrated process unit modules.

388. A method according to claim 114, wherein said LNG liquefaction plant contains one or more internally integrated process unit modules.

389. A method according to claim 153, wherein said LNG liquefaction plant contains one or more internally integrated process unit modules.

390. A method according to claim 191, wherein said LNG liquefaction plant contains one or more internally integrated process unit modules.

391. A method according to claim 231, wherein said LNG liquefaction plant contains one or more internally integrated process unit modules.

392. A method according to claim 304, wherein said LNG liquefaction plant contains one or more internally integrated process unit modules.

393. A method according to claim 353, wherein said LNG liquefaction plant contains one or more internally integrated process unit modules.

394. A method according to claim 1, wherein said LNG liquefaction plant contains two or more parallel integrated process unit modules.

395. A method according to claim 38, wherein said LNG liquefaction plant contains two or more parallel integrated process unit modules.

396. A method according to claim 76, wherein said LNG liquefaction plant contains two or more parallel integrated process unit modules.

397. A method according to claim 114, wherein said LNG liquefaction plant contains two or more parallel integrated process unit modules.

398. A method according to claim 153, wherein said LNG liquefaction plant contains two or more parallel integrated process unit modules.

399. A method according to claim 191, wherein said LNG liquefaction plant contains two or more parallel integrated process unit modules.

400. A method according to claim 231, wherein said LNG liquefaction plant contains two or more parallel integrated process unit modules.

401. A method according to claim 304, wherein said LNG liquefaction plant contains two or more parallel integrated process unit modules.

402. A method according to claim 353, wherein said LNG liquefaction plant contains two or more parallel integrated process unit modules.

403. A LNG liquefaction plant according to claim 262, wherein said LNG liquefaction plant contains one or more internally integrated process unit modules.

404. A LNG liquefaction plant according to claim 384, wherein said LNG liquefaction plant contains one or more internally integrated process unit modules.

405. A LNG liquefaction plant according to claim 262, wherein said LNG liquefaction plant contains two or more parallel integrated process unit modules.

406. A LNG liquefaction plant according to claim 384, wherein said LNG liquefaction plant contains two or more parallel integrated process unit modules.

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