

[SS 16] closed and refriger+ and mix+ and gas and cool+ and expand+

Results in EPODOC 71

[SS 17] 16 and (licuef+ or subcool+) and (cycle or circuit or loop)

Results in EPODOC 9

EPODOC: No term found in index 'BI' for the truncation 'LICUEF+'. WARNING(401)

[SS 18] 16 and (licu+ or subcool+) and (cycle or circuit or loop)

Results in EPODOC 9

[SS 19] .li

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[SS 19] ..li



1/9 © EPODOC / EPO

PN - [US2017051968](#) A1 20170223

PR - US201615345957
20161108; US201615227235
20160803; US20100726142
20100317

AP - US201615345957 20161108

DT - **

CCI - [F25J1/0012](#) ; [F25J1/0015](#) ;
[F25J1/0022](#) ; [F25J1/0055](#) ;
[F25J1/0212](#) ; [F25J1/0214](#) ;
[F25J1/0216](#) ; [F25J1/0279](#) ;
[F25J1/0291](#)

CQI - [F25J1/0217](#) ; [F25J1/0218](#) ;
[F25J1/0292](#) ; [F25J1/0297](#)

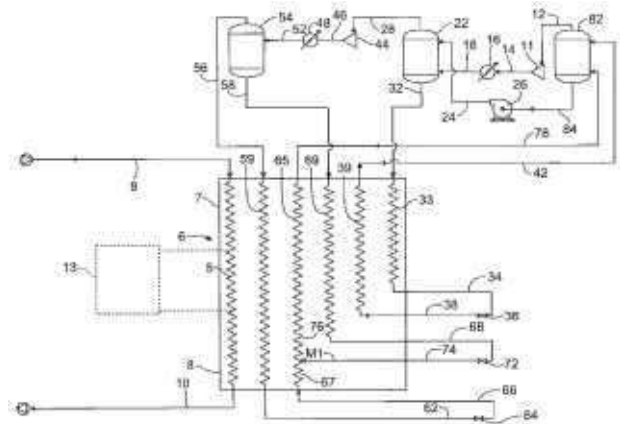
CCA - [F25J2205/90](#) ; [F25J2220/62](#) ;
[F25J2220/64](#)

CQA - [F25J2205/02](#) ; [F25J2235/02](#) ;
[F25J2270/60](#) ; [F25J2270/66](#)

PA - CHART ENERGY & CHEMICALS INC
[US]

TI - Integrated Pre-Cooled Mixed
Refrigerant System and Method

AB - A system and method for **cooling**

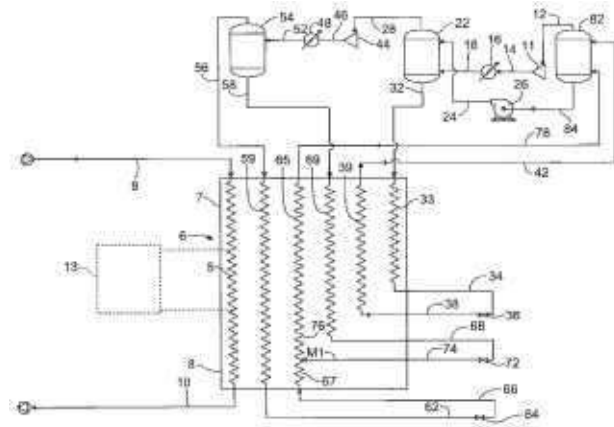


and liquefying a **gas** in a heat exchanger that includes compressing and **cooling a mixed refrigerant** using first and last compression and **cooling** cycles so that high pressure liquid and vapor streams are formed. The high pressure liquid and vapor streams are **cooled** in the heat exchanger and then **expanded** so that a primary **refrigeration** stream is provided in the heat exchanger. The **mixed refrigerant** is **cooled** and equilibrated between the first and last compression and **cooling** cycles so that a pre-cool liquid stream is formed and **subcooled** in the heat exchanger. The stream is then **expanded** and passed through the heat exchanger as a pre-cool **refrigeration** stream. A stream of **gas** is passed through the heat exchanger in countercurrent heat exchange with the primary **refrigeration** stream and the pre-cool **refrigeration** stream so that the **gas** is **cooled**. A resulting vapor stream from the primary **refrigeration** stream passage and a two-phase stream from the pre-cool **refrigeration** stream passage exit the warm end of the exchanger and are combined and undergo a simultaneous heat and mass transfer operation prior to the first compression and **cooling cycle** so that a reduced temperature vapor stream is provided to the first stage compressor so as to lower power consumption by the system. Additionally, the warm end of the **cooling** curve is nearly **closed** further reducing power consumption. Heavy components of the **refrigerant** are also kept

out of the cold end of the process, reducing the possibility of **refrigerant** freezing, as well as facilitating a **refrigerant** management scheme.

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- PN - [US2016341471](#) A1 20161124
- PR - US201615227235
20160803; US20100726142
20100317
- AP - US201615227235 20160803
- DT - **
- CCI - [F25J1/0012](#) ; [F25J1/0015](#) ;
[F25J1/0022](#) ; [F25J1/0055](#) ;
[F25J1/0212](#) ; [F25J1/0214](#) ;
[F25J1/0216](#) ; [F25J1/0279](#) ;
[F25J1/0291](#)
- CQI - [F25J1/0217](#) ; [F25J1/0218](#) ;
[F25J1/0292](#) ; [F25J1/0297](#)
- CCA - [F25J2205/90](#) ; [F25J2220/62](#) ;
[F25J2220/64](#)
- CQA - [F25J2205/02](#) ; [F25J2235/02](#) ;
[F25J2270/60](#) ; [F25J2270/66](#)
- PA - CHART ENERGY & CHEMICALS INC
[US]
- TI - Integrated Pre-Cooled Mixed
Refrigerant System and Method
- AB - A system and method for **cooling**
and liquefying a **gas** in a heat
exchanger that includes
compressing and **cooling a mixed**
refrigerant using first and last
compression and **cooling** cycles
so that high pressure liquid and
vapor streams are formed. The
high pressure liquid and vapor
streams are **cooled** in the heat
exchanger and then **expanded** so
that a primary **refrigeration**
stream is provided in the heat
exchanger. The **mixed refrigerant**
is **cooled** and equilibrated
between the first and last
compression and **cooling** cycles
so that a pre-cool liquid stream



is formed and **subcooled** in the heat exchanger. The stream is then **expanded** and passed through the heat exchanger as a **pre-cool refrigeration** stream. A stream of **gas** is passed through the heat exchanger in countercurrent heat exchange with the primary **refrigeration** stream and the **pre-cool refrigeration** stream so that the **gas** is **cooled**. A resulting vapor stream from the primary **refrigeration** stream passage and a two-phase stream from the **pre-cool refrigeration** stream passage exit the warm end of the exchanger and are combined and undergo a simultaneous heat and mass transfer operation prior to the first compression and **cooling cycle** so that a reduced temperature vapor stream is provided to the first stage compressor so as to lower power consumption by the system. Additionally, the warm end of the **cooling** curve is nearly **closed** further reducing power consumption. Heavy components of the **refrigerant** are also kept out of the cold end of the process, reducing the possibility of **refrigerant** freezing, as well as facilitating a **refrigerant** management scheme.

PN - [TW201200829](#) A 20120101

PNFP - TWI547676B B 20160901

PR - US20100726142 20100317

AP - TW20110108179 20110310

DT - I

CCI - [F25J1/0012](#) ; [F25J1/0015](#) ;
[F25J1/0022](#) ; [F25J1/0055](#) ;
[F25J1/0212](#) ; [F25J1/0214](#) ;
[F25J1/0216](#) ; [F25J1/0279](#) ;
[F25J1/0291](#)

CQI - [F25J1/0217](#) ; [F25J1/0218](#) ;
[F25J1/0292](#) ; [F25J1/0297](#)

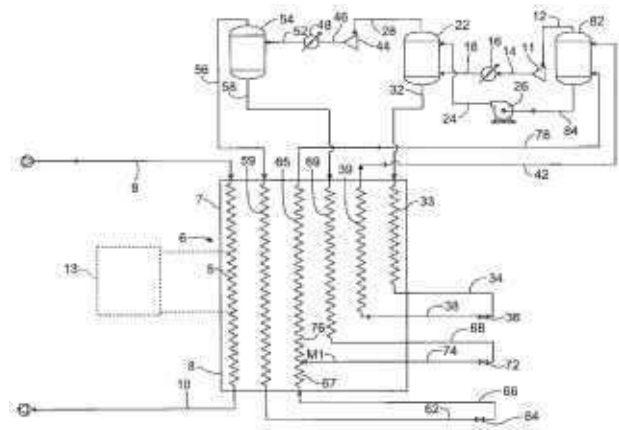
CCA - [F25J2205/90](#) ; [F25J2220/62](#) ;
[F25J2220/64](#)

CQA - [F25J2205/02](#) ; [F25J2235/02](#) ;
[F25J2270/60](#) ; [F25J2270/66](#)

PA - (A B)
CHART INC [US]

TI - (A B)
Integrated pre-cooled mixed
refrigerant system and method

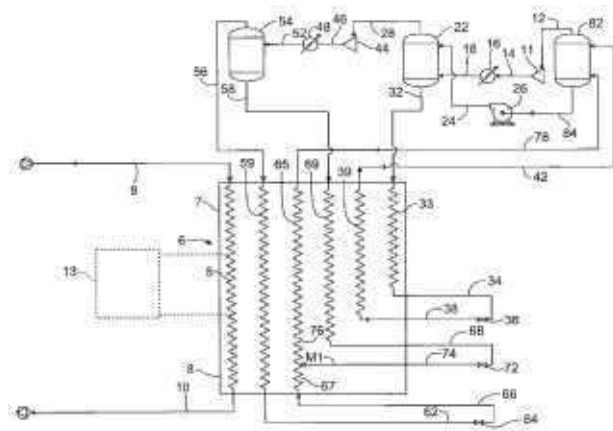
AB - (A)
A system and method for **cooling**
and liquefying a **gas** in a heat
exchanger that includes
compressing and **cooling a mixed**
refrigerant using first and last
compression and **cooling** cycles
so that high pressure liquid and
vapor streams are formed. The
high pressure liquid and vapor
streams are **cooled** in the heat
exchanger and then **expanded** so
that a primary **refrigeration**
stream is provided in the heat
exchanger. The **mixed refrigerant**
is **cooled** and equilibrated
between the first and last
compression and **cooling** cycles
so that a pre-cool liquid stream
is formed and **subcooled** in the
heat exchanger. The stream is
then **expanded** and passed
through the heat exchanger as a
pre-cool **refrigeration** stream. A
stream of **gas** is passed through



the heat exchanger in countercurrent heat exchange with the primary **refrigeration** stream and the pre-cool **refrigeration** stream so that the **gas** is **cooled**. A resulting vapor stream from the primary **refrigeration** stream passage and a two-phase stream from the pre-cool **refrigeration** stream passage exit the warm end of the exchanger and are combined and undergo a simultaneous heat and mass transfer operation prior to the first compression and **cooling cycle** so that a reduced temperature vapor stream is provided to the first stage compressor so as to lower power consumption by the system. Additionally, the warm end of the **cooling** curve is nearly **closed** further reducing power consumption. Heavy components of the **refrigerant** are also kept out of the cold end of the process, reducing the possibility of **refrigerant** freezing, as well as facilitating a **refrigerant** management scheme.

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- PN - [US2011226008](#) A1 20110922
- PNFP - US9441877 B2 20160913
- PR - US20100726142 20100317
- AP - US20100726142 20100317
- DT - *; Rep
- CT - || R141 (A1)
[WO2008006867](#) A2 20080117 [] (SHELL INT RESEARCH [NL], et al);
[US5813250](#) A 19980929 [] (UENO KOICHI [JP], et al);
[DE19612173](#) C1 19970528 [] (LINDE AG [DE]);
[US4901533](#) A 19900220 [] (FAN CHUNG T [US], et al);
[US2009205366](#) A1 20090820 []



	] (SCHMIDT HANS [DE]); US2007227185 A1 20071004 [] (STONE JOHN B [US], et al); US2007283718 A1 20071213 [] (HULSEY KEVIN H [US], et al)
	- STSE (B2) US4901533 A 19900220 [] (FAN CHUNG T [US], et al); US5813250 A 19980929 [] (UENO KOICHI [JP], et al); DE19612173 C1 19970528 [] (LINDE AG [DE]); WO2008006867 A2 20080117 [] (SHELL INT RESEARCH [NL], et al)
CTNP	- R141 (A1) [] - Translation of DE patent aboveprinted 1/13/2015 - STSE (B2) [] - Translation of DE patent above, printed Jan. 132015.
CCI	- F25J1/0012 ; F25J1/0015 ; F25J1/0022 ; F25J1/0055 ; F25J1/0212 ; F25J1/0214 ; F25J1/0216 ; F25J1/0279 ; F25J1/0291
CQI	- F25J1/0217 ; F25J1/0218 ; F25J1/0292 ; F25J1/0297
CCA	- F25J2205/90 ; F25J2220/62 ; F25J2220/64
CQA	- F25J2205/02 ; F25J2235/02 ; F25J2270/60 ; F25J2270/66
PA	- (B2) GUSHANAS TIM [US]; DUCOTE JR DOUG DOUGLAS [US]; PODOLSKI JAMES [US]; CHART INC [US]
TI	- (A1) INTEGRATED PRE-COOLED MIXED REFRIGERANTSYSTEM AND METHOD - (B2) Integrated pre-cooled mixed refrigerant system and method
AB	- (A1 B2) A system and method for cooling and liquefying a gas in a heat exchanger that includes compressing and cooling a mixed

refrigerant using first and last compression and **cooling** cycles so that high pressure liquid and vapor streams are formed. The high pressure liquid and vapor streams are **cooled** in the heat exchanger and then **expanded** so that a primary **refrigeration** stream is provided in the heat exchanger. The **mixed refrigerant** is **cooled** and equilibrated between the first and last compression and **cooling** cycles so that a pre-cool liquid stream is formed and **subcooled** in the heat exchanger. The stream is then **expanded** and passed through the heat exchanger as a pre-cool **refrigeration** stream. A stream of **gas** is passed through the heat exchanger in countercurrent heat exchange with the primary **refrigeration** stream and the pre-cool **refrigeration** stream so that the **gas** is **cooled**. A resulting vapor stream from the primary **refrigeration** stream passage and a two-phase stream from the pre-cool **refrigeration** stream passage exit the warm end of the exchanger and are combined and undergo a simultaneous heat and mass transfer operation prior to the first compression and **cooling cycle** so that a reduced temperature vapor stream is provided to the first stage compressor so as to lower power consumption by the system. Additionally, the warm end of the **cooling** curve is nearly **closed** further reducing power consumption. Heavy components of the **refrigerant** are also kept out of the cold end of the process, reducing the possibility of **refrigerant** freezing, as well as

facilitating a **refrigerant**
management scheme.

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- PN - [US3818714](#) A 19740625
- PR - DE19712110417 19710304
- AP - US19720231984 19720306
- DT - **
- CT - [US2823523](#) A []; [US3180709](#) A [];
[US3274787](#) A []; [US3342037](#) A [];
[US3596472](#) A []; [US3616652](#) A [];
[US3677019](#) A []; [CA635337](#) A []
- CTNP - [] Kleemenko, One Flow Cascade Cycle, Progress in Refrigeration Science and Technology, Vol. 1 (1960)
- CCI - [F25J1/0022](#) ; [F25J1/0037](#) ;
[F25J1/004](#) ; [F25J1/0045](#) ;
[F25J1/005](#) ; [F25J1/0055](#) ;
[F25J1/0214](#) ; [F25J1/0219](#) ;
[F25J1/0249](#) ; [F25J1/025](#) ;
[F25J1/0279](#) ; [F25J1/0288](#) ;
[F25J3/0209](#) ; [F25J3/0233](#) ;
[F25J3/0257](#)
- CCA - [F25J2200/02](#) ; [F25J2200/74](#) ;
[F25J2205/04](#) ; [F25J2210/06](#) ;
[F25J2215/04](#) ; [F25J2220/64](#) ;
[F25J2245/02](#) ; [F25J2290/10](#)
- PA - LINDE AG
- TI - PROCESS FOR THE LIQUEFACTION AND **SUBCOOLING** OF NATURAL GAS
- AB - A process for the liquefaction and **subcooling** of natural gas with a Claude **closed refrigerating cycle** comprising compressing gaseous **cycle** medium; **cooling** resultant compressed gaseous **cycle** medium; dividing **cooled** compressed **gas** into two streams; engine- **expanding** one stream; and **cooling** the other

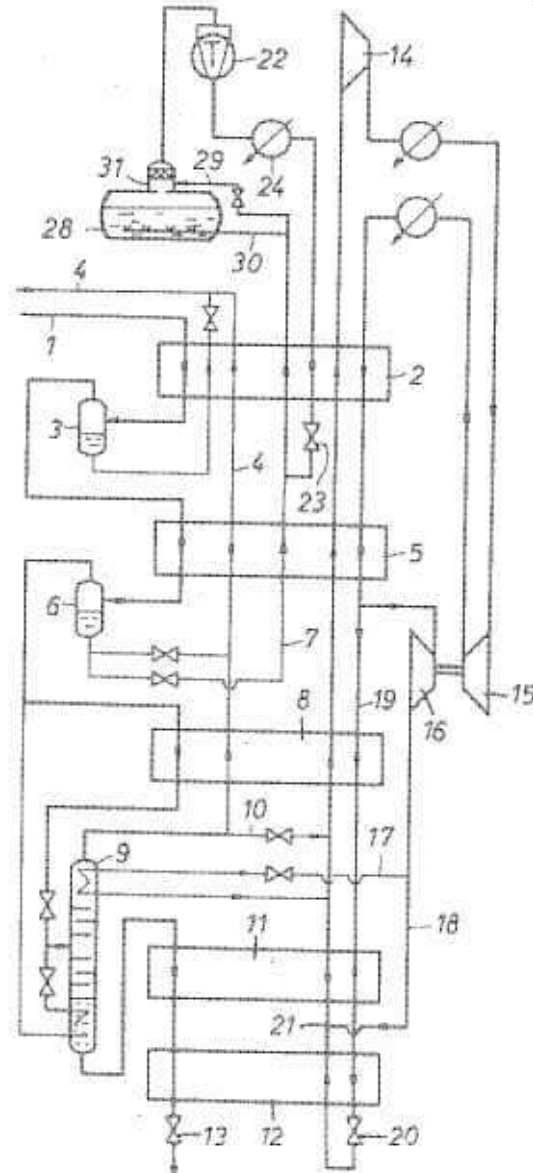
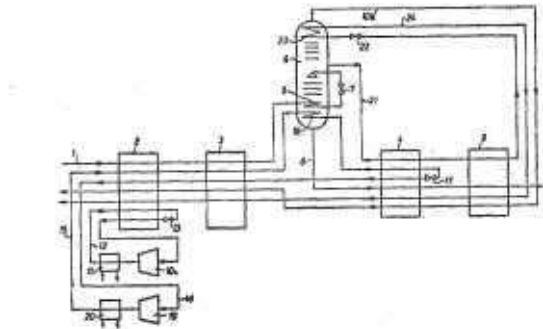


Figure 1 consists of two schematic diagrams of a test stand. Diagram (a) shows a single actuator (1) connected to a control system (2) and a power source (3). Diagram (b) shows two actuators (1 and 2) connected to a control system (2) and a power source (3).



a line 8, pure nitrogen through a line 10b and a partly gaseous **mixture** of methane and nitrogen is withdrawn through a line 21, liquefied in an exchanger 4 **cooled** by the colder of the two **refrigerants**, undercooled in an exchanger 9 in countercurrent heat exchange with itself after expansion through a valve 22, and the cold so produced is used in exchangers 9, 4 to sub-**cool** the nitrogen free L.N.G. in line 8 to a storage temperature of about -160 C.; the so-vaporized methane-nitrogen **mixture** being warmed to ambient temperature in exchanger 2, 3 and delivered as fuel **gas**. The first **refrigerant** comprises a **mixture** of C 1 to C 4 saturated hydrocarbons which having been compressed at 10 to 40 atmosphere and **cooled** to ambient temperature in a water-**cooled** heat exchanger 11 is in the liquid phase, and is **cooled** to - 75 C. in exchanger 2 by heat exchange with itself after expansion through a valve 13. The second **refrigerant** comprises a **mixture** of methane, ethane and nitrogen which is delivered by a compressor 19 and a water-**cooled** exchanger 20 into a line 15 in the gaseous phase and is liquefied and **cooled** in exchangers 2, 3, further **cooled** in a coil 16 of column 6 and is thereafter further **cooled** in exchanger 4 in heat exchange with itself after expansion through a valve 17, after which the **refrigerant** is warmed to ambient temperature in exchanger 3, 2 and returned to the compressor inlet.

PN - [GB1181049](#) A 19700211

PR - DE19671551611 19671220

AP - GB19680057848 19681205

DT - **

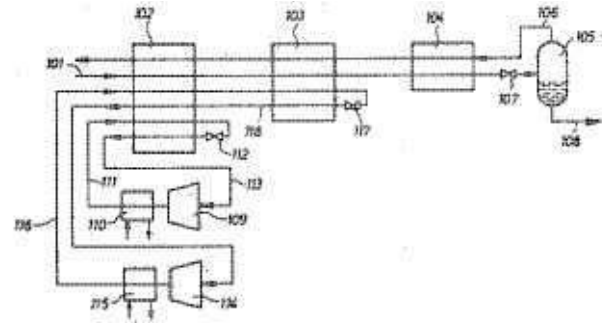
CCI - [F25J1/0022](#) ; [F25J1/004](#) ;
[F25J1/0045](#) ; [F25J1/0052](#) ;
[F25J1/0072](#) ; [F25J1/0214](#) ;
[F25J1/0218](#) ; [F25J1/0219](#) ;
[F25J3/0209](#) ; [F25J3/0233](#) ;
[F25J3/0257](#)

CCA - [F25J2200/02](#) ; [F25J2200/50](#) ;
[F25J2200/74](#) ; [F25J2200/94](#) ;
[F25J2270/12](#) ; [F25J2270/42](#) ;
[F25J2270/60](#) ; [F25J2290/34](#) ;
[Y10S62/927](#)

PA - MESSER GRIESHEIM GMBH [DE]

TI - Process for the Liquifaction of Natural Gas

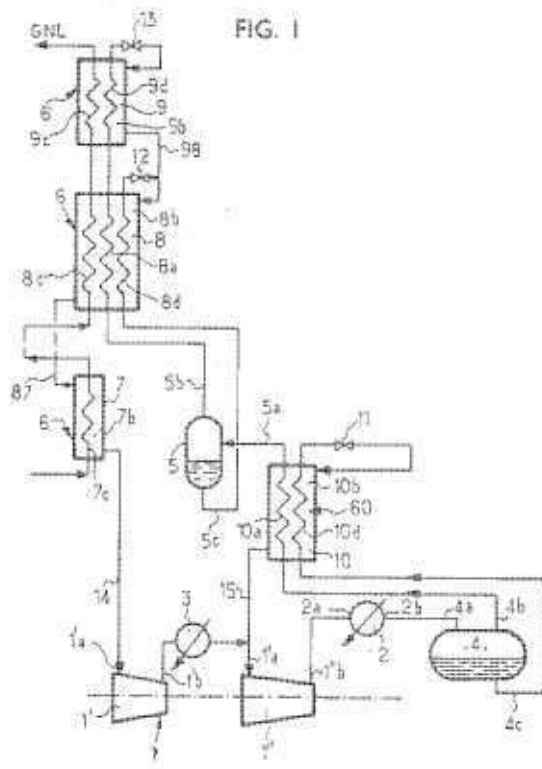
AB - 1,181,049. Natural gas liquefaction process. MESSER GRIESHEIM G.m.b.H. 5 Dec., 1968 [20 Dec., 1967]. No. 57848/68. Heading F4P. **Cooling**, followed by liquefaction and **subcooling** of compressed natural hydrocarbon **gas** in feed line 101 is effected in heat-exchangers 102, 103, respectively, and the sub-**cooled** liquid is then further **cooled** at 104 and **expanded** at a valve 107 into a separator 105; exchanger 102 being **cooled** by passage therethrough of a first multicomponent **refrigerant**, e.g. a **mixture** of C 1 to C 4 saturated hydrocarbons in a **closed, cycle**, exchanger 103 being **cooled** by a second multicomponent **refrigerant**, e.g. a **mixture** of nitrogen, methane and ethane also in a **closed cycle** and in cascade arrangement with the first **refrigeration cycle** and the **refrigerant** of each **cycle** undergoes only one compression stage and is **expanded** to above



atmospheric pressure. Exchanger 104 is **cooled** by flash **gas** from separator 105 which **gas** also **cools** exchangers 102, 103. In operation, the first **refrigerant** is compressed at 109 to about 40 atmosphere liquefied in a water-**cooled** exchanger 110, further **cooled** in exchanger 102 in countercurrent heat exchange with itself after expansion at 112 to about 3 atmosphere, and the **refrigerant** after leaving the warm end of exchanger 102 is returned to the compressor inlet. The second **refrigerant** is compressed at 114, **cooled** by water at 115, liquefied in exchanger 102, further **cooled** in exchanger 103, **expanded** at a valve 117 and returned through exchangers 103, 102 to the inlet of compressor 114.

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- PN - [GB1463649](#) A 19770202
- PR - FR19740019008 19740531
- AP - GB19750023467 19750529
- DT - **
- CCI - [F25J3/0257](#) ; [F25J1/0022](#) ;
[F25J1/0055](#) ; [F25J1/0212](#) ;
[F25J1/0238](#) ; [F25J1/0265](#) ;
[F25J1/0291](#) ; [F25J1/0292](#) ;
[F25J3/0209](#) ; [F25J3/0233](#) ;
[F25J3/0238](#)
- CCA - [F25J2200/02](#) ; [F25J2200/70](#) ;
[F25J2210/06](#) ; [F25J2270/18](#) ;
[F25J2270/66](#)
- PA - TECHNIP CIE
- TI - METHOD AND APPARATUS
FOR **COOLING** A
GASEOUS **MIXTURE**
- AB - 1463649 Liquefying gases
COMPAGNIE FRANCAISE D'ETUDES
ET DE CONSTRUCTION TECHNIP
29 May 1975 [31 May 1974]
23467/75 Heading F4P A method

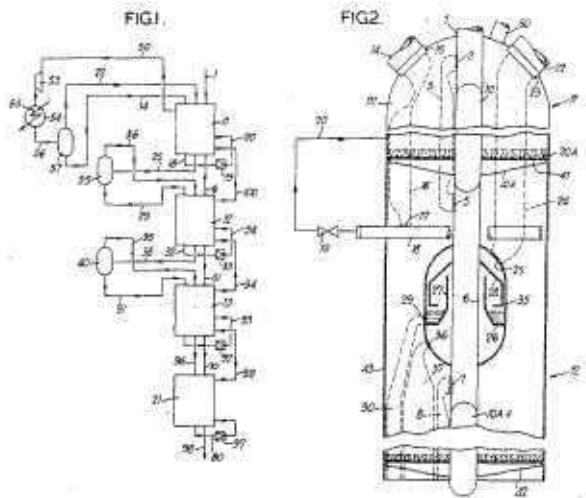


of **cooling** a **gas** in line 7c, 8c, 9c,
 e.g. in the liquefaction of
 natural **gas**, by means of a **closed**
refrigerating cycle comprises
 compressing, partially
 condensing and
 separating **refrigerant** at 1, 2, 4,
 sub-**cooling** liquid fraction 4c in
 exchanger 10 in counter-current
 with vaporizing **refrigerant** in
 shell 10b which is derived
 by **expanding** at 11 the sub-
cooled liquid fraction, returning
 revaporized **refrigerant** from
 shell 10b via line 15 to an
 intermediate pressure stage of
 compressor 1, partially
 condensing and separating
 vapour fraction 4b at 10, 5,
 condensing vapour fraction 5b
 in exchanger 8 in counter-
 current with
 vaporizing **refrigerant** in shell 8b
 derived by **expanding** the
 condensed vapour fraction 5c at
 12, and **subcooling** this
 condensed vapour fraction in
 exchanger 9 in countercurrent
 with vaporizing **refrigerant** in
 shell 9b derived by **expanding** at
 13 the sub-**cooled** fraction, the
 vaporizing **refrigerant** in shell 9b
 being combined via line 98 with
 that in shell 8b and the thus
 combined
 revaporized **refrigerant** being
 returned to the compressor inlet
 1<SP>1</SP>a. A further
 separating stage may be located
 between 4, 5 (Fig. 2, not shown)
 and the apparatus further
 modified by the insertion of a
 further compression stage before
 the last stage, the **refrigerant**
 being partially condensed and
 separated between the further
 and last compression stages,
 and then recombined after the
 last stage (Fig. 3, not shown). The

natural **gas** may be pre-cooled in an exchanger located between two successive separators (Fig. 4, not shown), and a demethanizer and denitrogenizer may be included to extract components from the natural **gas** during liquefaction (Fig. 5, not shown).

9/9 © EPODOC / EPO

PN - [GB1213072](#) A 19701118
 PR - FR19670100919 19670331
 AP - GB19680015379 19680329
 DT - **
 CCI - [B01D5/0036](#) ; [F25J5/002](#) ;
[F28D7/00](#) ; [F25J1/0022](#) ;
[F28D7/024](#) ; [F25J1/0055](#) ;
[F25J1/0212](#)
 CCA - [Y10S62/903](#) ; [Y10S165/193](#) ;
[Y10S62/905](#)
 PA - AIR LIQUIDE [FR]
 TI - INDIRECT HEAT EXCHANGE
 ASSEMBLY
 AB - 1,213,072. **Gas** liquefaction process. L'AIR LIQUIDE SOC. ANON. POUR L'ETUDE ET L'EXPLOITATION DES PROCEDES GEORGES CLAUDE. 29 March, 1968 [31 March, 1967], No. 15379/68. Heading F4P. **Cooling** of a compressed **gas mixture**, e.g. natural **gas**, to effect fractional condensation, is effected by passing it from a line 1, Fig. 2, through a nest of tubes 3, 8 within series arranged superposed heat exchangers 11, 12, 13, 21, Fig. 1, from which is discharged L.N.G. through a line 98 to store, and the exchangers are **cooled** by indirect heat exchange with a reverse flow of a **closed cycle refrigerant** having been **expanded** at valves 19, 33, 92, 97 and the so-warmed **expanded refrigerant** is



compressed at 53, **cooled** in a water condenser 55, separated into condensate and residual **gas** at 57 which is re-**cooled** by passage through lines 14, 22 and exchanger 11 in the same direction as the feed **gas mixture** to provide high pressure liquid **refrigerant** for valve 19 and partly liquid highpressure **refrigerant** which is fed through a line 25 to a separator 35 through which passes a section 6 of the feed line 1 and from which separator condensate and residual **gas** is passed through lines 29, 26 down exchanger 12 to provide liquid **refrigerant** for valve 33 and wet **subcooled refrigerant** for a further separator 40. Condensate and residual **gas** from 40 are **cooled** in exchanger 13 to provide feed for valve 92 and feed for exchanger 21 and valve 97. The down flow paths in each exchanger comprise nests of coiled tubes whereas the upflow of **expanded refrigerant** occurs in the shell space of each exchanger. In a modification the separators have their bases common with those of adjacent exchangers and their lateral walls externally of the exchangers. A suitable **refrigerant gas mixture** comprises 0 to 3% nitrogen, 20 to 32% methane, 34 to 44% ethane, 12 to 20% propane, 8 to 15% butanes and 3 to 8% pentanes and heavier hydrocarbons as described in Specification 1,122,860.