NATURAL GAS LIQUEFACTION WITH CONTROLLED B.t.u. CONTENT

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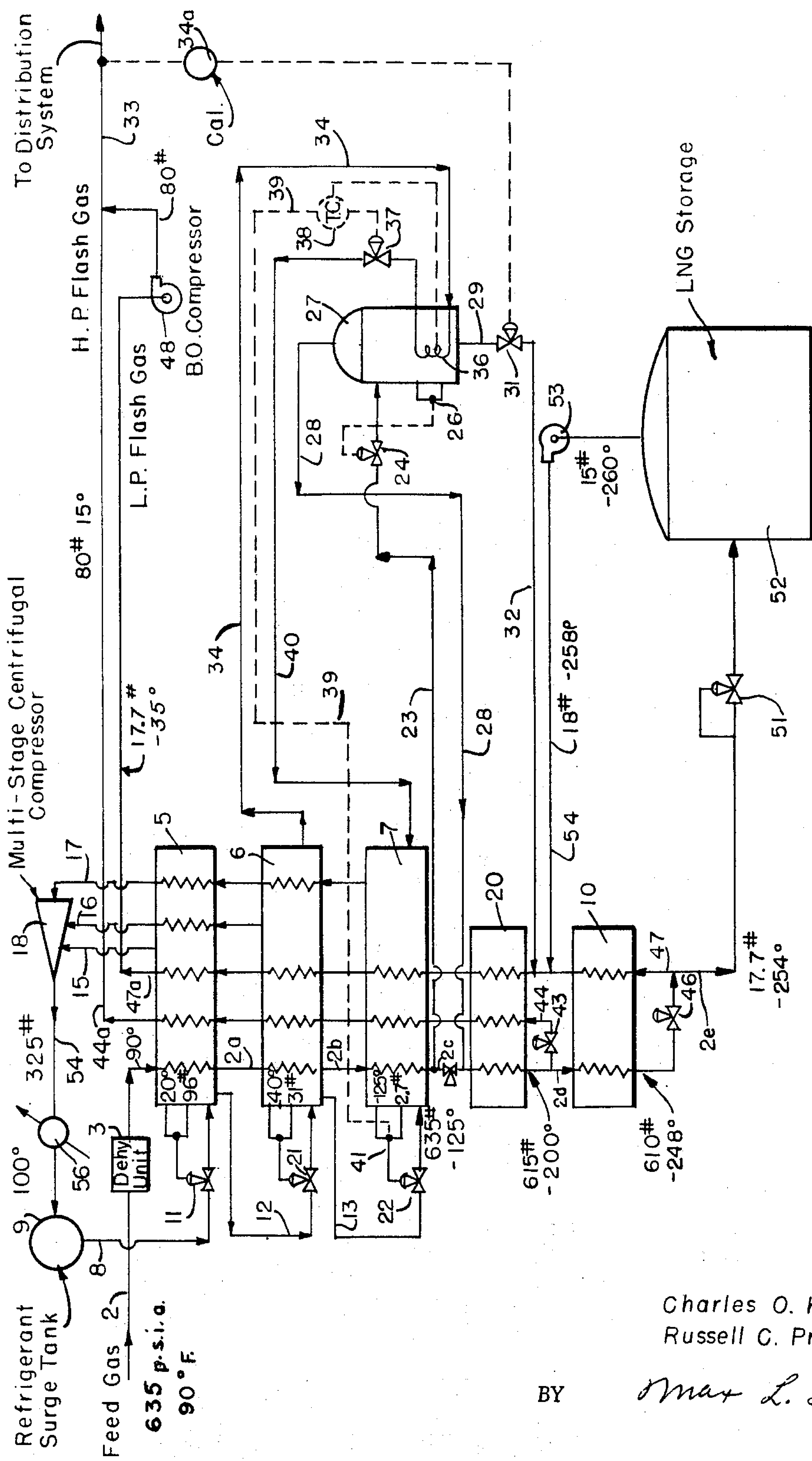

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NATURAL GAS LIQUEFACTION WITH CONTROLLED B.t.u. CONTENT

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ABSTRACT OF THE DISCLOSURE

A process for maintaining a gaseous stream supplied to a distribution system at a desired B.t.u. value in which a high pressure natural gas stream is liquefied while being maintained at high pressure. A major portion of the liquefied natural gas is reduced in pressure and stored or passed back in heat exchange with the natural gas being liquefied thereafter passing to the distribution system. A minor portion of the liquefied natural gas is flashed to produce a heavier fraction of liquefied hydrocarbons which are removed under calorimeter control, regasified, and added to the distribution system at a rate to maintain the B.t.u. value of the gaseous stream supplied to the distribution at the desired value.

Background of the invention

This invention relates generally to the same problem as is dealt with in the copending application of Bodle and Young, Ser. No. 282,727, now Patent No. 3,285,719, assigned to the assignee of the present invention, over which it has the advantages chiefly of increased operating efficiency and lower capital investment. This is made possible by the use of a single external refrigerant in the place of two or more external refrigerants commonly employed, and by the process of separating out the heavier hydrocarbon constituents from the feed gas after it has been converted to a liquid, and while it is still at high pressure, relying mainly upon a reduction in pressure of the liquefied gas to produce the required separation.

Description of the invention

The specific nature of the invention as well as other objects and advantages thereof will clearly appear from a description of a preferred embodiment as shown in the accompanying drawing in which the single figure is a highly simplified schematic flow chart showing the principle of the invention.

Referring to the drawing, the feed gas is typically supplied in a main feed gas line **2** at a fairly high pressure, in the range from 400 to 1,000 p.s.i.a., typically 635 p.s.i.a. and at 90° F. After passing through a conventional dehydration unit **3**, in order to remove moisture, the gas is cooled, without reducing its pressure, in three heat exchanger stages **5**, **6**, and **7**. The refrigerant employed should be capable of cooling the treated feed gas at a pressure of 635 p.s.i.a. from 90° F. to —125° F., replacing both the propane and ethylene stages as commonly used in many known systems. A suitable refrigerant for this purpose is Freon 13 B–1. This refrigerant is supplied in line **8** from storage tank **9** to the interior of heat exchanger **5** under control of a suitable flash valve and level control valve **11**. Typical operating conditions for the refrigerant in exchanger **5** are 20° F. and 96 p.s.i.a. The refrigerant is then conducted in line **12** to the second exchanger, in which suitable operating conditions would be —40° F., and 31 p.s.i.a.; and the refrigerant is then conducted in line **13** to exchanger **7** where it may be maintained at a temperature of —125° F. and 2.7 p.s.i.a. Vaporized refrigerant from exchangers **5**, **6** and **7** is fed

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back in lines **15**, **16** and **17** respectively to refrigerant compressor **18**, the vapor from exchanger **7** being passed through exchangers **6** and **5**, and that from exchanger **6** being passed through exchanger **5**, for further interchange of heat energy in order to improve the efficiency.

The pressure and temperature reductions in exchangers 6 and 7 are successively achieved by proper settings of the reduction valves **21** and **22** as is well-known in the art.

The main feed gas in line **2** emerges from heat exchanger **7** still at substantially its initial pressure of 635 pounds, but is now at a temperature of —125° F. A minor proportion of this gas is taken off in line **23**, and is reduced in pressure at valve **24**, under control of level control **26**, to produce in heavies flash drum **27** flash gases consisting of the lighter components, which are returned in line **28**, and also a heavier fraction of liquid hydrocarbons remaining in the bottom portion of the drum, which remain in the drum at a pressure of 620 pounds and a temperature of —92° F.; and are withdrawn in line **29**, and supplied through valve **31** and lines **32** and **47*a*** to the outlet line **33** of the distribution system, under control of calorimeter **34*a***, in an amount sufficient to make up the required B.t.u. content.

Refrigerant from exchanger **6** is also taken in line **34** and heat-exchanged with the cold heavier fraction in drum **27**, by means of coil **36**, and then returned to heat exchanger **7** through valve **37** and line **40**, under control of temperature controller **38** which is in turn controlled by a thermocouple (not shown) located in the kettle portion of the drum **27**, but can be overridden by a signal in line **39** from the liquid level controller **41** associated with exchanger **7**, in order to ensure that the liquid level in **7** remains at the desired value.

Flash gases from drum **27** are returned in line **28** to main line **2** at a point below the reduction valve **42** through which the pressure in the main line is reduced from 635 pounds down to approximately 615 pounds, and is still further cooled in exchanger **20** by auto-refrigeration, for which purposes a small amount of the gas is taken off line **2*d*** through pressure-reduction valve **43**, and returned at 80 pounds pressure and a temperature of —208° F. through line **44**, which is subsequently extended through the heat exchangers **5**, **6** and **7** in order to utilize the remaining refrigeration potential of the gas in this line, finally emerging from exchanger **5** at **44*a***, still at 80 pounds pressure and a temperature of approximately 15° F., where it is fed to line **33** of the distribution system as output. The feed gas continues in line **2*d*** at a temperature of —200° F. into exchanger **10**, where again a minor portion of the gas is taken through all of the above-described exchangers in series to provide further refrigeration effect, finally emerging in line **47*a*** as low pressure flash gas, at 17.7 p.s.i.a. and —35° F., and is thereafter compressed by boil-off compressor **48** to 80 pounds pressure and fed to line **33** for distribution.

The LNG emerging from exchanger **10** in line **2*e*** at about 17.7 p.s.i.a. and —254° F. is reduced to substantially atmospheric pressure in reduction valve **51** and fed to LNG storage tank **52**, which may be any suitable large-scale storage facility such as an in-ground storage tank. The boil-off gas from tank **52** at approximately **15** pounds pressure and —260° F. is compressed by means of any suitable compressor **53** to 18 p.s.i.a. and —258° F., and is supplied in line **54** to join the gas in line **47**, for subsequent further compression by boil-off compressor **48** to 80 p.s.i.a., at which pressure it is supplied to the distribution line **33**, as previously described.

The refrigerant vapors in lines **15**, **16** and **17** are fed to successive stages of a multistage centrifugal compressor **18**, which is another advantage of the present system.

In the past, it has been difficult to utilize centrifugal compressors for liquefaction rates as large as those envisaged in a typical system for which the invention would be used (5.0 MM s.c.f.d.) because of their low inlet volume. However, using a refrigerant such as Freon 13 B–1, exchanger **8** has a vapor pressure of 2.7 p.s.i.a., and with this low suction pressure the use of a centrifugal compressor is feasible due to the high inlet a.c.f.m. (actual cubic feet per minute). The arrangement of injecting the other feed streams at the inner stages increases the a.c.f.m. to each stage, which is desirable in the use of centrifugal compressors in this type of service. The compressed refrigerant emerges in line **54** at approximately 325 p.s.i.a., and is cooled, preferably by water cooler **56** to 100° F., after which it is supplied to surge tank **9**, from which it is withdrawn on line **8** as previously described.

It will be noted that the above system, in addition to being highly efficient with respect to power requirements, thus enables the use of a single compressor, with consequent reduction in cost. Furthermore, the heat exchangers, for a liquefaction plant ranging in size up to 5.0 MM s.c.f.d. can be incorporated in a unitized construction of exchangers stacked one above the other, all within a cold box structure and skid mounted for convenient transportation. It is thus apparent that the above-described system is economical in cost as well as efficient in operation. The removal of heavies while the gas is at high pressure and prior to subcooling has the further advantage of minimizing the possibility of riming problems which these heavies could cause in the subsequent exchangers **21**, **10** which are used for subcooling the gas stream. Furthermore, the external refrigeration system can be easily derimed when necessary by passing warm feed gas through the exchangers **5**, **6** and **7**, and collecting the deriming product in the B.t.u. heavies vessel **27**; alternatively, methanol can be injected into the feed gas stream for rime removal and collection in the same vessel, thus minimizing the time needed for the liquefaction unit to be out of service or bypassed. It will be apparent that the above simplified design lends itself to shop fabrication resulting in reduced field cost and direction. When the LNG stored in the tank **52** is needed to supplement the normal supply provided to the consumer distribution system, e.g., during periods of peak demand, it is pumped out of storage and regasified in any known manner, and supplied to the distribution line without any further B.t.u. treatment being required, as it has the proper B.t.u. content by virtue of the above-described process.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined in the appended claims.

We claim:

1. A process for supplying natural gas containing different hydrocarbon constituents as an outlet gas stream from a natural gas liquefaction process to a distribution system at a desired B.t.u. value, comprising the following steps:

(a) supplying a main stream of natural gas at superatmospheric pressure well above the normal pressure of the distribution system,

(b) liquefying said main stream of natural gas at high pressure to produce liquefied natural gas at high pressure,

(c) reducing the pressure of a major portion of said liquefied natural gas to a low storage pressure and storing it at said low pressure,

(d) removing a minor proportion of said liquefied natural gas at high pressure and reducing its pressure to produce flash gases and a heavier fraction of liquefied hydrocarbons, removing the heavier fraction from the separator exclusive of the flashed gases under calorimeter control, and

(e) regasifying said heavier fraction and adding it to the distribution system at a rate to maintain the B.t.u. value of the outlet gas stream at a desired value.

2. A process according to claim **1**, including the step of returning the flash gases from step (d) of claim **1** to the main stream.

3. A process for supplying natural gas containing different hydrocarbon constituents as an outlet gas stream from a natural gas liquefaction process to a distribution system at a desired B.t.u. value comprising

(a) supplying a main stream of natural gas at superatmospheric pressure well above the normal pressure of the distribution system,

(b) liquefying the main stream of supply gas at superatmospheric pressure by heat exchange with a single external refrigerant and by auto-refrigerative heat exchange with returning flashed gases derived from the supply gas,

(c) reducing the pressure of the thus liquefied natural gas in stages to a low storage pressure, and storing the liquefied natural gas at said low pressure,

(d) supplying boil-off gas from said storage, together with flashed gas from the pressure reduction stages to said distribution system,

(e) prior to a pressure reduction stage, taking off, from the main stream of liquefied gas, a minor portion of liquefied gas and reducing its pressure to produce flash gases and a heavier fraction of liquid hydrocarbons, removing the heavier fraction from the separator exclusive of the flashed gases under calorimeter control, and

(f) regasifying said heavier fraction and adding it to the distribution system at a rate to maintain the B.t.u. value of the outlet gas stream at a desired value.

4. A process as claimed in claim **3**, and the further step of returning the flash gases from said minor proportion of liquefied natural gas to the main stream.

5. A process as claimed in claim **3**, said superatmospheric pressure being in the order of 635 p.s.i.a., and the single refrigerant being capable of cooling the feed gas at said pressure from 90° F. to −125° F.

6. A process as claimed in claim **3**, wherein the heat exchanger with a single refrigerant is performed in three successive stages of refrigeration.

7. A process as claimed in claim **6**, wherein the auto-refrigeration is performed in two successive stages following the external refrigeration, by withdrawing a small proportion of liquefied natural gas from the main stream at each of said two stages, reducing the pressure of said withdrawing liquefied natural gas, and passing it in heat exchange relationship with the main stream in all of the preceding stages.

8. A process for supplying natural gas containing different hydrocarbon constituents to a distribution system at a desired B.t.u. value, comprising the following steps:

(a) supplying a main stream of natural gas at superatmospheric pressure well above the normal pressure of the distribution system,

(b) liquefying said main stream of natural gas at high pressure in three stages of cooling by heat exchange with Freon and by auto-refrigerative heat exchange with returning flashed gases derived from the natural gas to produce liquid natural gas at high pressure, said Freon being at a successively lower temperature and pressure in each successive cooling stage,

(c) removing a minor portion of said liquid natural gas at high pressure and reducing its pressure to produce flash gases and a heavier fraction of liquefied hydrocarbons, while another portion of the liquid natural gas is further cooled, then expanded and divided into a first and second stream of liquid natural gas,

(d) passing said second stream to storage at low pressure,

(e) adding vapor from the low pressure storage to said first stream,

(f) combining said heavier fraction of liquefied hydrocarbons with said first stream of step (e) and regasifying the heavier hydrocarbon fraction, said combined stream of first stream, vapor from storage and heavier fraction forming an outlet gas which is passed in heat exchange with said natural gas stream to supply the auto refrigeration of step (b), said heavier hydrocarbon fraction being added at a rate to maintain the B.t.u. value of the outlet gas at a desired value,

(g) passing a stream of refrigerant Freon vapor from each stage of cooling, after the first, through the preceding stages of cooling in heat exchange relationship therewith without significant change in pressure, each said stream being at the pressure of its respective stage,

(h) compressing said respective refrigerant vapor streams of different pressures by single multistage centrifugal compression, to an initial operating

pressure, removing at least some of the heat of compression by heat exchange with an external coolant, and supplying the resultant liquid refrigerant at said initial pressure for said liquefaction of the main stream of natural gas.

References Cited

UNITED STATES PATENTS

2,198,098	4/1940	Vaughan.	
2,557,171	6/1951	Bodle et al.	62—39 XR
2,940,271	6/1960	Jackson	62—23 XR
2,960,837	11/1960	Swenson et al.	
3,020,723	2/1962	De Lury	62—40 XR
3,194,025	7/1965	Grossmann	62—40 XR
3,271,965	9/1966	Maher et al.	62—23
3,285,719	11/1966	Bodle et al.	
3,315,477	4/1967	Carr	62—23

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