

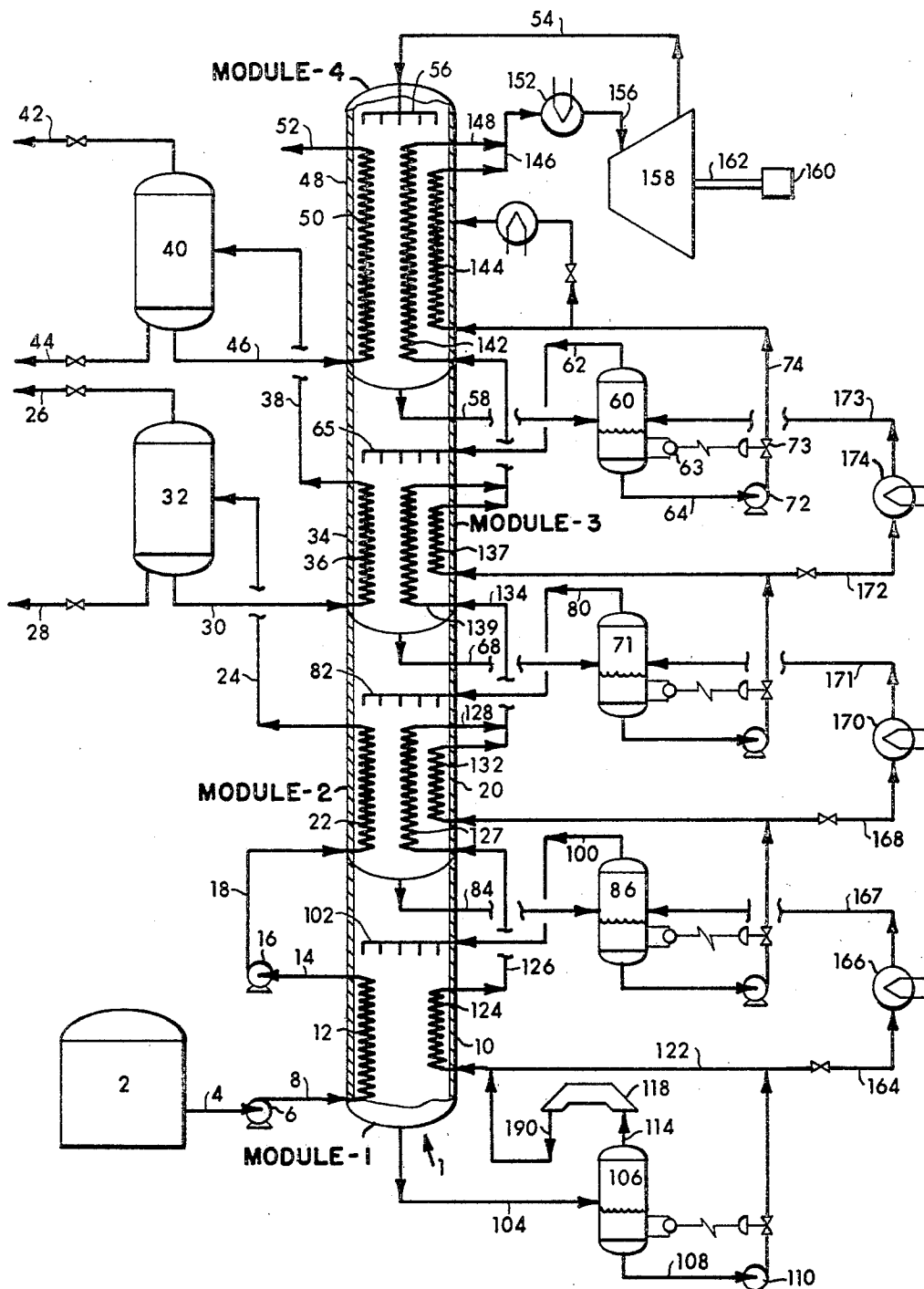
Nov. 25, 1969

J. A. SARSTEN ET AL

3,479,832

PROCESS FOR VAPORIZING LIQUEFIED NATURAL GAS

Filed Nov. 17, 1967



J. A. Sarsten  
M. C. Myers

INVENTORS

Donald F. Washburn  
PATENT ATTORNEY

1

3,479,832

## PROCESS FOR VAPORIZING LIQUEFIED NATURAL GAS

Jan A. Sarsten, Millington, N.J., and Michael C. Myers,  
Rome, Italy, assignors to Esso Research and Engineering  
Company, a corporation of Delaware

Filed Nov. 17, 1967, Ser. No. 683,991

Int. Cl. F17c 7/02

U.S. Cl. 62—52

7 Claims

### ABSTRACT OF THE DISCLOSURE

The instant disclosure is directed to a method for vaporizing liquefied natural gas that can produce byproduct power at low cost by economic utilization of the available liquefied natural gas cold sink. A single multicomponent motive fluid is used as the liquefied natural gas exchange media.

### FIELD OF THE INVENTION

The instant invention relates generally to a method for heating low temperature fluids. More particularly, the process of the instant invention is particularly applicable in the regasification or vaporization of liquefied natural gas, hereinafter referred to as LNG.

Natural gas is often available in areas remote to where it will be ultimately used. Quite often the source of this fuel is separated from the point of utilization by a large body of water and it may then prove necessary to effect bulk transfer of the natural gas by large tankers designed for such transport. Under these circumstances, economics dictate that the natural gas be liquefied so as to greatly reduce its volume and that it be transported at substantially atmospheric pressures. Under these conditions, the LNG is at a temperature in the range of about  $-260$  to  $-265^{\circ}$  F. This temperature represents the boiling point of methane at about atmospheric pressure. It is to be noted, however, that the LNG often contains amounts of heavier hydrocarbons such as ethane, propane, butane and the like. These will vary the boiling range of the LNG so that it usually will fall somewhere between  $-240^{\circ}$  F. and  $-265^{\circ}$  F. However, nitrogen, which is also typically present, may cause the low end of the temperature range to get down to temperatures of about  $-270^{\circ}$  F.

When the LNG arrives at the point of utilization, it is, of course, in liquefied form and consequently it becomes necessary to regasify it before it may be used as a fuel. In addition, it is often highly desirable to utilize some of the higher molecular weight constituents mentioned above as raw materials and as feedstocks for the production of various petrochemicals and for the manufacture of liquefied petroleum gas. Furthermore, it may often prove necessary to adjust the heating value of the natural gas to conform with local requirements prior to its entrance into any actual fuel distribution system.

In the past the reconversion of the LNG to a gaseous form usually required the addition of a substantial amount of work in the form of heat. According to the methods and teachings of the instant invention, the LNG vaporization process herein described can produce byproduct power at low cost by economic utilization of the available LNG cold. The available cold is efficiently utilized by using, as a hot sink, energy sources such as sea water, ambient air, low pressure steam, flue gas, etc. The heat transfer between the sinks is effected by using a single multicomponent motive fluid as the heat exchange media as will be described in further detail hereinafter. Although the use of a multicomponent or auto-refrigeration cycle for the liquefaction of natural gas is known in the art, its use in a reverse cycle to recover the byproduct power potential of the LNG is a new and

2

unique feature. Thus, by means of the present invention approximately 40% of the power required to liquefy the natural gas can be economically recovered in the vaporization process to be herein subsequently discussed.

The process to be described will be useful wherever LNG is vaporized and where this vaporization is conducive at a rapid rate, for example, during energy-short situations, such as may occur in winter heating seasons, the economic byproduct production of power would be especially beneficial to plant economics.

An additional advantage of the vaporization process herein to be discussed is that it allows the option of selectively removing a single component rich phase. This is of great significance where fractionation facilities are to be provided so that the heavier hydrocarbons, for example, ethane, propane, butane, etc., may be produced.

### SUMMARY OF THE INVENTION

According to the instant invention, the above highly desirable results may be achieved by employing a plurality of exchanger circuits which are broken up into modules, the coldest end being designated as Module #1. LNG at  $-265^{\circ}$  and 15 p.s.i.a., at or below its bubble point, is raised to an intermediate pressure of about 150 p.s.i.a. and enters the bottom, coldest end of the equipment, Module #1. On exchange with the heat exchange media, the LNG raises in temperature and leaves Module #1 where it is then raised to its final pressure of about 700 p.s.i.a. The high pressure LNG then enters exchanger equipment designated Module #2 where it continually gives up its cold till it reaches a temperature of about  $100^{\circ}$  F. or any other temperature which would, for process reasons or because of economics, be more advantageous.

At intermediate point in its exchange with the motivating heat transfer fluid, the LNG may be removed from the exchanger equipment and separated into liquid and vapor where a single component rich phase may be removed for other reasons. This selective removing will be discussed in further detail hereinafter. The heat exchange fluid or, as it has been referred to the motivating fluid, arrives at the exchange equipment at about  $105^{\circ}$  F. at about 50 p.s.i.a. from a turboexpander whose function is to recover power. The operation of the turboexpander will be discussed subsequently. Motivating fluid enters the shell side of the exchanger equipment in what has been designated as Module #4. The motivating fluid is cooled against the LNG and the returning liquid and vapor motivating fluid as will be more clearly understood by referring to the detailed description of the preferred embodiment. The shell side fluid leaves Module #4 where it is separated into vapor and liquid. The liquid is boosted in pressure to 450 p.s.i.a. and introduced into the tube side of Module #4. The vapor is then returned to the shell side of Module #3 where it is cooled against LNG and returning liquid and vapor motivating fluid. This cooling, separation and return of the vapor phase is repeated till finally at the coldest end the shell side fluid is removed and separated into vapor and liquid at approximately  $-255^{\circ}$  F. and 50 p.s.i.a.

The vapor from this low temperature separation is compressed to 450 p.s.i.a. and combined with the liquid which is also raised to the same pressure. The combination liquid and vapor is passed on the tube side along with the LNG circuit against the shell side motivating fluid. The returning motivating fluid from Module #1 is then introduced to the tube side of Module #2. The pressured liquid from the separator drum is also introduced into a tube circuit in Module #2 either in a separate circuit or combined with the returning vapor, depending on problems associated with distribution and efficiency determinations. This process is repeated until the returning motivating fluid is at 450 p.s.i.a. and  $100^{\circ}$  F., at which

point the motivating fluid is sent to the turboexpander section where work is recovered from it. The motivating fluid leaves the turboexpander at 105° F. and about 50 p.s.i. and enters the shell side of exchanger #4 as hereinbefore discussed.

Thus, an object of the instant invention is to provide a vaporization process for a cold liquid, which process can produce byproduct power at a relatively low cost by economic utilization of the available cold in the fluid being processed.

Another object of the invention is to facilitate the regasification of LNG so that it is in a suitable condition for distribution and use as a fuel.

Still another object is to provide a regasification method for LNG wherein single component rich phases may be removed from the regasifying LNG stream.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims taken in conjunction with the accompanying drawing.

The drawing is a flow diagram illustrating a process according to the present invention.

Referring to the drawing in detail, reference numeral 2 designates a stationary insulated storage tank which receives the LNG at atmospheric pressure from a tanker (not shown). The LNG in tank 2 will normally have a temperature in the range of about -240 to -270° F. (-265° will be an assumed temperature for purposes of the instant disclosure) and may have, for example, the following composition range:

TABLE I

| Constituent                         | Mole percent |
|-------------------------------------|--------------|
| Methane                             | 65-85        |
| Ethane                              | 7-17         |
| Propane                             | 5-12         |
| Butane and higher hydrocarbons      | 2-5          |
| Nitrogen                            | 0-2          |
| Other C <sub>5</sub> + hydrocarbons | 0-1          |

The LNG from tank 2 is fed through the line 4 into a pump 6 wherein its pressure is increased from about 15 p.s.i.a. to about 150 p.s.i.a. The pressurized LNG is then led via the line 8 into a series of heat exchanger circuits designated generally by the reference numeral 1. The exchanger circuits are broken up into a plurality of modules starting with the coldest end, which is designated Module #1 and is identified by the reference numeral 10. The LNG from line 8 flows through a coil 12 in Module #1 and then leaves this module via the line 14 at a temperature of about -210° F. The pressure of the LNG on line 14 is increased by the pump 16 to a pressure of about 700 p.s.i.a. and is then conducted via the line 18 into a second coil 22. Coil 22 is located in heat exchange Module #2, which is identified by the reference numeral 20. The LNG leaves coil 22 via the line 24, at which point its temperature is in the range of about -120° F.

As was earlier indicated, it is desirable to provide a means whereby a single component rich phase may be removed from the vaporizing LNG stream. According to the teachings of the instant invention, this may be accomplished by feeding the LNG in line 24 to a two-phase redistributor identified by reference numeral 32. The natural gas entering the separator is divided into a vapor, rich in a single component, which may be drawn off through the valved line 26 and a liquid, rich in a single component. A portion of the rich liquid may be removed from the system via the valved line 28, the remaining portion of the liquid being fed via the line 30 into the third module designated by the reference numeral 34. This liquid flows through the coil 36 and then leaves Module #3 via the line 38. Line 38 leads this material to a second redistributor designated by the reference numeral 40. Here, as before, a single component rich vapor (or differing composition than the first component rich vapor) may be withdrawn from the system via the valved line 42.

Similarly, a portion of the single component rich liquid may be withdrawn via the valved line 44, the remaining portion being introduced back into the heat exchange circuits. Thus, the material in line 46 is fed to a coil 50 situated in Module #4 of the heat exchange circuits. Module #4 is identified by the reference numeral 48. The material leaving the coil 50 via the line 52 is fully vaporized and is at a temperature of about 100° F. and a pressure or about 700 p.s.i.a.

## MOTIVE FLUID

Having traced the flow of the vaporizing LNG through the heat exchange circuits, attention will now be directed to the flow of the motive fluid hereinbefore mentioned. This motive fluid or heat transfer media enters the shell side of the exchanger equipment at the top of Module #4 through the line 54 and the spray heads 56. The composition of the motivating fluid is determined depending upon the exact composition of the entering LNG as well as the various temperatures and pressures hereinbefore recited. For purposes of explanation, however, a typical composition is summarized in Table II.

TABLE II

| Component:     | Mole percent |
|----------------|--------------|
| C <sub>1</sub> | 28           |
| C <sub>2</sub> | 38           |
| C <sub>3</sub> | 6            |
| C <sub>4</sub> | 14           |
| C <sub>5</sub> | 9            |
| C <sub>6</sub> | .3           |
| N <sub>2</sub> | ~5           |

The motive fluid entering the top of Module #4 is at a temperature of about 120° F. and is at a pressure of about 50 p.s.i.a. As it flows down the shell side of Module #4, it is cooled and partially condensed against the vaporizing LNG in the coil 50 and against the returning motive fluid liquid in the coil 144 and the returning motive fluid vapor in the coils 142. The returning of the motive fluid in these coils 142 and 144 will be discussed in greater detail hereinafter. The partially condensed shell side motive fluid leaves Module #4 via the line 58 and is then conducted to a liquid vapor separator drum 60. The vapors leaving the drum 60 are conducted via the line 62 into the spray heads 65 situated in the upper portion of Module #3. The liquid from drum 60 is conducted via the line 64 into the pump 72 and then pumped via the line 74 back into Module #4 and through coil 144. Line 74 is provided with a control valve 73 which is operatively associated with a liquid level controller 63 on drum 60.

The vaporized motive fluid entering Module #3 via the spray head 65 flows down the shell side of Module #3 wherein it is partially condensed against the vaporizing LNG in coil 36 and the returning motive fluid liquid and motive fluid vapor in coils 137 and 139 respectively. This partially condensed motive fluid leaves Module #3 via the line 68 and is then conducted to a second vapor liquid separation drum 71 which functions in the same manner as does separator drum 60. Thus, the vapors from the top of drum 71 are conducted into the top of Module #2 via the line 80 and introduced therein by the spray heads 82. This material is in turn partially condensed against the vaporizing LNG in coil 22 and against the return motive fluid liquid in coil 132 and motive fluid vapor in the coil 127. This partially condensed material then leaves the bottom of Module #2 via the line 84 from which it is lead to a third separator drum 86. Drum 86 also functions in a manner analogous to that of drums 60 and 71. Here again the vapor leaving the top of this drum is conducted via the line 100 and the spray heads 102 to the top of Module #1 where it is partially condensed against the vaporizing LNG in coil 12 and the liquid and vapor in the coil 124. The material leaving the bottom of Module #1 via the line 104 is at a temperature of approximately -250° F. and pressure of about 50 p.s.i.a.

As earlier indicated, the motive fluid consists of a mixture of hydrocarbons and nitrogen wherein the hydrocarbons range from C<sub>1</sub> to C<sub>5</sub>. It will be readily appreciated by those skilled in the art that as the motive fluid traverses down through Modules 4-1, the liquid and vapor become lighter and at the bottom of Module #1 it is essentially a mixture of nitrogen and methane.

PROCESS FLOW OF RETURNING  
MOTIVE FLUID

The vapor leaving drum 106 is lead to a compressor 118 via the line 114 wherein its pressure is increased to about 450 p.s.i.a. The liquid from drum 106 leaves via the line 108 and is pumped up to a pressure of about 450 p.s.i.a. by the pump 110. The pressurized liquid and vapors are combined in the line 122 which leads to coil 124 situated in Module #1. The combined liquid and vapor motive fluid stream in coil 124 is heated against the condensing shell side motive fluid in Module #1. The returning motive fluid and vapor from coil 124 is conducted via the line 126 through the coil 127 in Module #2 wherein it is further heated. The material leaves coil 127 via the line 128 and is then combined with the material from the coil 132 in the line 134. As may readily be appreciated from the flow diagram, this process is repeated through Modules #3 and #4 until the returning motive fluid mixture leaves Module #4 via the lines 148 and 146 and is at a temperature of about 100° F. and a pressure of about 450 p.s.i.a.

The motive fluid leaving the tube side of Module #4; that is, leaving the coils 142 and 144, is in a two-phase liquid vapor condition. This material is then conducted to heat exchanger 152 wherein it is heated by a convenient heat exchange media such as water, air, steam or the like, to a temperature of about 270° F. It will be recalled that the pressure of the motive fluid at this point is approximately 450 p.s.i.a. and the expansion of this high pressure motive fluid in gas expander 158 produces the byproduct power which can be used to drive an energy conversion means 160 via the shaft 162. Energy conversion means 160 may be a generator or a compressor or the like. The

expanded motive fluid leaves the turbocompressor 158 via the line 54 at which point it has a temperature of about 120° F. and 50 p.s.i.a. and is then introduced into the top of Module #4 as hereinbefore indicated.

In addition to the main process flow patterns as discussed above, motive fluid liquid draw-off systems may also be provided. These systems are designated by reference numerals 164, 168 and 172, along with their associated valve numbers and heat exchangers designated respectively 166, 170 and 174. These systems allow the drawing off of motive fluid liquid from the separator tanks 106, 86 and 71, for example, and allow the use of the motive fluid liquid as refrigerant sources for any integrated processes requiring refrigeration. After vaporization in the draw-off system heat exchanger (166 for example) the motive fluid vapor is re-introduced into the vaporization-exchange circuit as indicated by the lines 167, 171 and 173.

EXAMPLE

Starting with an LNG feed as indicated in Table III below and using a motive fluid having a composition as indicated in Table II, the following illustrates an exemplary heat and material balance and a byproduct power output for the process of the instant invention.

TABLE III

Starting LNG composition

| Component:           | Mole percent |
|----------------------|--------------|
| C <sub>1</sub> ----- | 71           |
| C <sub>2</sub> ----- | 15           |
| C <sub>3</sub> ----- | 9            |
| C <sub>4</sub> ----- | 4            |
| C <sub>5</sub> ----- | .6           |
| C <sub>6</sub> ----- | .1           |
| N <sub>2</sub> ----- | .7           |

Tracing first the LNG regasification process and assuming a feed rate of approximately 10,100 moles/hour, Table IV summarizes the temperature, pressure, rates and compositions present in this portion of the instant process.

TABLE IV

| Location                   | Coil 12      | Coil 22      | Coil 36     | Coil 50     |
|----------------------------|--------------|--------------|-------------|-------------|
| Temperature, ° F -----     | -265 to -210 | -210 to -120 | -120 to -30 | -30 to +100 |
| Pressure, p.s.i.a. -----   | 150          | 700          | 700         | 700         |
| Rate, moles/hr -----       | 10,100       | 10,100       | 10,100      | 10,100      |
| Composition, mole percent: |              |              |             |             |
| C <sub>1</sub> -----       | 71.3         | 71.3         | 71.3        | 71.3        |
| C <sub>2</sub> -----       | 14.7         | 14.7         | 14.7        | 14.7        |
| C <sub>3</sub> -----       | 8.6          | 8.6          | 8.6         | 8.6         |
| C <sub>4</sub> -----       | 4.0          | 4.0          | 4.0         | 4.0         |
| C <sub>5</sub> -----       | 0.6          | 0.6          | 0.6         | 0.6         |
| C <sub>6</sub> -----       | 0.1          | 0.1          | 0.1         | 0.1         |
| N <sub>2</sub> -----       | 0.7          | 0.7          | 0.7         | 0.7         |

| Location                   | Product in Line 28 | Vapor in Line 26 | Liquid in Line 44 | Vapor in Line 42 |
|----------------------------|--------------------|------------------|-------------------|------------------|
| Temperature, ° F -----     | -120               | -120             | -30               | -30              |
| Pressure, p.s.i.a. -----   | 700                | 700              | 700               | 700              |
| Rate, moles/hr -----       |                    |                  |                   |                  |
| Composition, mole percent: |                    |                  |                   |                  |
| C <sub>1</sub> -----       | 70.3               | 92.0             | 35.8              | 81.6             |
| C <sub>2</sub> -----       | 17.7               | 5.0              | 27.6              | 13.1             |
| C <sub>3</sub> -----       | 8.4                | 0.8              | 24.1              | 3.7              |
| C <sub>4</sub> -----       | 2.4                | 0.1              | 9.7               | .5               |
| C <sub>5</sub> -----       | 0.5                |                  | 2.0               |                  |
| C <sub>6</sub> -----       | 0.1                |                  | .6                |                  |
| N <sub>2</sub> -----       | 0.6                | 2.1              | .2                | 1.1              |

TABLE VI<sup>1</sup>

| Location.....              | Portion 10   | Portion 20   | Portion 34  | Portion 48  |
|----------------------------|--------------|--------------|-------------|-------------|
| Temperature, °F.....       | -250 to -200 | -200 to -110 | -110 to -20 | -20 to +100 |
| Pressure, p.s.i.a.....     | 50           | 50           | 50          | 50          |
| Rate, moles/hr.....        | 6,570        | 14,180       | 21,460      | 29,200      |
| Composition, mole percent: |              |              |             |             |
| C <sub>1</sub> .....       | 78.0         | 54.2         | 37.3        | 27.8        |
| C <sub>2</sub> .....       | 1.4          | 35.0         | 46.0        | 38.0        |
| C <sub>3</sub> .....       |              | 0.8          | 5.0         | 6.0         |
| C <sub>4</sub> .....       |              | 0.1          | 4.4         | 14.5        |
| C <sub>5</sub> .....       |              |              | .7          | 8.6         |
| C <sub>6</sub> .....       |              |              |             | .3          |
| N <sub>2</sub> .....       | 20.6         | 9.9          | 6.6         | 4.8         |

<sup>1</sup> Summarizes the conditions present in the shell side of Modules 4-1.

TABLE VI<sup>1</sup>

| Location.....              | Line 114 | Coil 127     | Coil 139    | Coil 142    |
|----------------------------|----------|--------------|-------------|-------------|
| Temperature, °F.....       | -250     | -210 to -120 | -120 to -30 | -30 to +100 |
| Pressure, p.s.i.a.....     | 450      | 450          | 450         | 450         |
| Rate, moles/hr.....        | 940      | 6,570        | 14,180      | 21,460      |
| Composition, mole percent: |          |              |             |             |
| C <sub>1</sub> .....       | 32.8     | 78.0         | 45.2        | 37.3        |
| C <sub>2</sub> .....       |          | 1.4          | 35.0        | 46.0        |
| C <sub>3</sub> .....       |          |              | 9.8         | 5.0         |
| C <sub>4</sub> .....       |          |              | 0.1         | 4.4         |
| C <sub>5</sub> .....       |          |              |             | .7          |
| C <sub>6</sub> .....       |          |              |             |             |
| N <sub>2</sub> .....       | 67.2     | 20.6         | 9.9         | 6.6         |

<sup>1</sup> Summarizes the composition and processing conditions for the returning motivating fluid vapor.

TABLE VII<sup>1</sup>

| Location.....              | Coil 124     | Coil 132     | Coil 137    | Coil 144    | Line 156 |
|----------------------------|--------------|--------------|-------------|-------------|----------|
| Temperature, °F.....       | -250 to -210 | -200 to -120 | -110 to -30 | -20 to +100 | 270      |
| Pressure, p.s.i.a.....     | 450          | 450          | 450         | 450         | 450      |
| Rate, moles/hr.....        | 6,570        | 7,610        | 7,280       | 7,740       | 29,200   |
| Composition, mole percent: |              |              |             |             |          |
| C <sub>1</sub> .....       | 78.0         | 33.7         | 4.5         | 1.3         | 27.8     |
| C <sub>2</sub> .....       | 1.4          | 64.0         | 76.3        | 16.0        | 38.0     |
| C <sub>3</sub> .....       |              | 1.5          | 13.2        | 8.7         | 6.0      |
| C <sub>4</sub> .....       |              | .2           | 12.9        | 42.4        | 14.5     |
| C <sub>5</sub> .....       |              |              | 2.0         | 30.4        | 8.6      |
| C <sub>6</sub> .....       |              |              |             | 1.1         | .3       |
| N <sub>2</sub> .....       | 20.6         | .6           | 0.1         | .1          | 4.8      |

<sup>1</sup> Summarizes the composition and processing variables of the returning motive fluid liquid.

It should be understood that the specific structures and process conditions herein illustrated and described are intended to be representative only, as certain changes may obviously be made without departing from the clear teachings of the disclosure; for example, the configuration of the exchanger equipment may take many forms. Each module may be of separate construction, grouped in a "cold box arrangement." Similarly, the number of modules may be varied depending on economics. As the number of modules increases, the thermodynamic efficiency of the column increases. Again, the exact composition of the motive fluid heat transfer media may be varied so that it is suitably matched to changing incoming LNG feed.

Thus, in determining the full scope of the invention, reference should be had to the following appended claims.

What is claimed is:

1. A process for regasifying a liquefied gas with simultaneous production of energy which comprises the following steps in combination:

- passing a pressurized multicomponent heat exchange media in heat exchange relationship with said liquefied gas whereby said liquefied gas is vaporized and said heat exchange media is partially condensed;
- heating said partially condensed media with said heat exchange media;
- expanding the heated media resulting from step (b) to a lower pressure whereby energy is produced; and
- recycling the expanded media from step (c) so as to continuously repeat the process.

2. The process of claim 1 wherein said multicomponent media comprises, at the start of step (a), methane, ethane, propane, butane, pentane and nitrogen.

3. A process for regasifying liquefied natural gas with simultaneous production of energy using a pressurized multicomponent heat transfer media, which process comprises the following steps in combination:

- passing said pressurized multicomponent heat transfer media in countercurrent heat-exchange relationship with said liquefied natural gas, whereby said LNG is heated and said media is partially condensed;
- cycling the uncondensed portion of said media to a second countercurrent heat-exchange relationship with said LNG whereby said LNG is heated and the previously uncondensed portion is further condensed;
- repeating steps (a) and (b) until the uncondensed portion of said media has a temperature approaching that of said liquefied natural gas;
- passing the condensed portions of said media resulting from steps (a) through (c) in countercurrent heat-exchange relationship with said liquefied natural gas; and thereafter
- heating the media exiting said countercurrent heat-exchange relationship; and
- expanding the heated media of step (e) to a lower pressure whereby energy is produced and thereafter repeating the above steps in sequence.

4. The process of claim 3 further characterized in that a plurality of sidestream phases rich in a single component are withdrawn from the regasifying natural gas.

5. The process of claim 3 wherein said multicomponent heat transfer media comprises a mixture of hydrocarbons having 1 to 6 carbon atoms per molecule.

6. The process of claim 5 further characterized in that the heating of step (e) is accomplished by using a warm

fluid selected from the group consisting essentially of sea water, air, low pressure steam and flue gas.

7. A process for regasifying liquefied natural gas with simultaneous production of energy which comprises the following steps in combination:

- (a) pressurizing a multicomponent heat exchange media;
- (b) passing said pressurized multicomponent heat exchange media in heat exchange relationship with said liquefied natural gas;
- (c) partially condensing said heat exchange media in said heat exchange relationship whereby said liquefied natural gas is vaporized;
- (d) heating said partially condensed media with said heat exchange media;
- (e) expanding the heated media resulting from step (d) to a lower pressure whereby energy is produced; and

(f) recycling the expanded media from step (e) so as to continuously repeat the process.

References Cited

UNITED STATES PATENTS

|           |         |                  |       |
|-----------|---------|------------------|-------|
| 3,068,659 | 12/1962 | Marshall         | 62—52 |
| 3,183,666 | 5/1965  | Jackson          | 62—52 |
| 3,266,261 | 8/1966  | Anderson         | 62—52 |
| 3,331,214 | 7/1967  | Proctor et al.   | 62—52 |
| 3,347,055 | 10/1967 | Blanchard et al. | 62—52 |

LLOYD L. KING, Primary Examiner

U.S. Cl. X.R.

62—45