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[54] **PROCESS AND APPARATUS FOR TREATING AND UTILIZING VAPORIZED GAS IN A SHIP FOR TRANSPORTING LIQUIFIED GAS**

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[58] **Field of Search** ..... 114/74 A; 62/7, 50, 51, 62/54, 240; 60/651, 671

[56] **References Cited**

UNITED STATES PATENTS

2,795,937	6/1957	Sattler et al.	62/7
2,940,268	6/1960	Morrison	62/240 X
3,229,473	1/1966	Schumacher et al.	62/240 X
3,303,660	2/1967	Berg	62/51
3,383,881	5/1968	Bailey	62/50 X
3,768,271	10/1973	Denis	62/55

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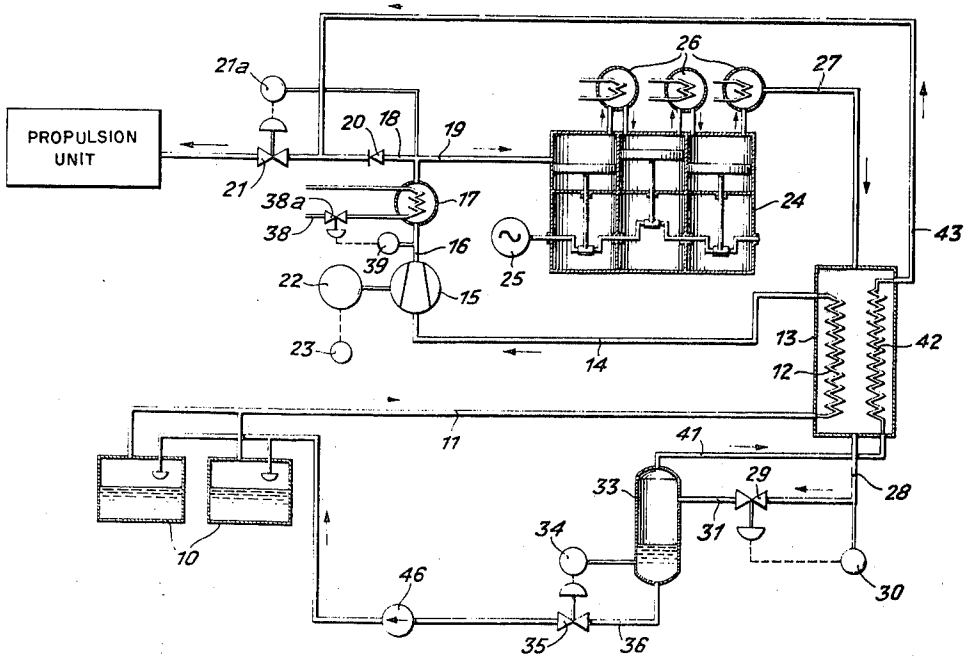
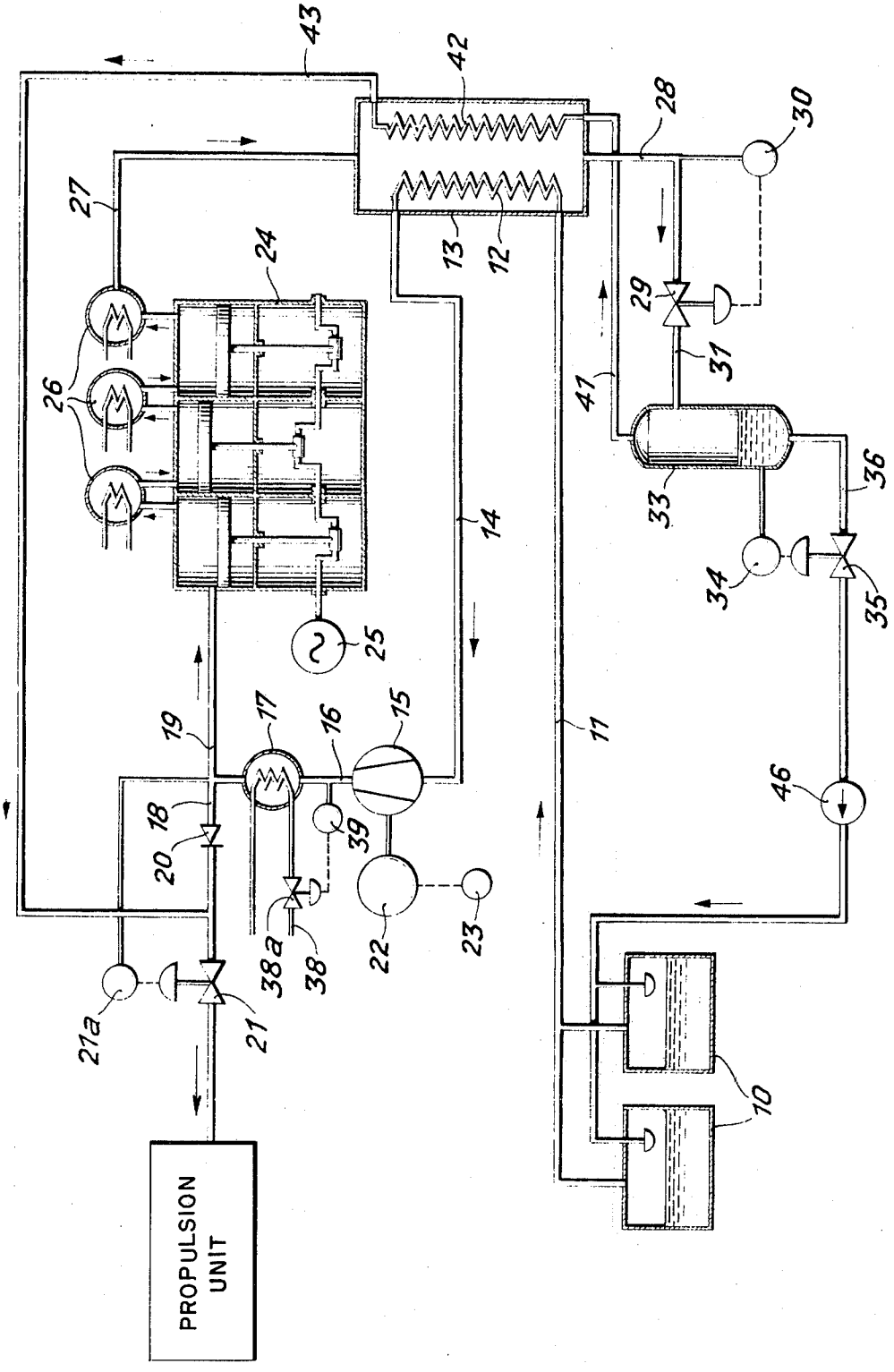
[57] **ABSTRACT**

The vaporized gas is first heated and then compressed. Thereafter, the gas is divided into two component flows with one component flow being sent to the ship's propulsion plant as a source of fuel. The second component flow is then further compressed and cooled in heat exchange relation with the continued flow of vaporized gas from the gas tanks. The cooled gas is then liquified and returned to the gas tanks.

9 Claims, 1 Drawing Figure




PROPULSION UNIT

PROCESS AND APPARATUS FOR TREATING AND UTILIZING VAPORIZED GAS IN A SHIP FOR TRANSPORTING LIQUIFIED GAS

This invention relates to a process and apparatus for treating and utilizing vaporized gas from a liquified gas tank of a ship for transporting liquified combustible gas.

As is known, the liquified gas transported in tankers and ships vaporizes or evaporates to some extent during travel due to the presence of heat even in the best insulated vessels. In order to accept this fact, proposals have been made to burn these gaseous products as fuel in a combustion device forming a part of the propulsion unit of the ship.

However, it has been found that the quantity of gas required to power the propulsion unit of a ship of normal size at normal speeds is less than the quantity of gas arising from vaporization.

Accordingly, it is an object of the invention to provide a proces and apparatus which can economically reduce vaporization losses by re-liquifying some of the gases.

It is another object of the invention to use the heat which is drawn off during re-liquifaction to heat the gas vaporized in the liquified gas tanks before this gas is compressed to a pressure suitable for the propulsion unit.

It is another object of the invention to re-liquify some of the boil-off or vaporized gas from a liquified gas tank in order to reduce the economic loss due to vaporization of the liquified gas cargo.

Briefly, the invention provides a process in which a flow of vaporized gas is drawn off at least one tank, compressed and divided into two component flows. One component flow is then fed as a fuel to the propulsion unit of a ship, for example, to a combustion device such as a piston engine, marine boiler or gas turbine plant. The other component flow is further compressed and passed in heat exchange relation with the continued flow of vaporized gas from the tank to heat the flow of vaporized gas prior to initial compression and to cool the gas component flow. The cooled gas component flow is then reduced in pressure and fed back to the gas tank in at least partly liquified form. In this way, it is possible to use the low temperature of the full gas flow drawn off the tanks to cool the second gas component flow over the entire temperature range covered during cooling and, at least, partial liquifaction of this component flow.

The invention also provides an apparatus which includes means for drawing off the flow of vaporized gas from a gas tank, a first compressor to compress the full flow and a first branch line to deliver one component flow to the propulsion unit. Also, a second compressor is used to receive and compress the second component flow and a heat exchanger is used to effect the heat exchange between the full flow and the second component flow. A pressure reducing means is also connected to the heat exchanger and the tank to deliver the at least partly liquified gas back to the tank.

Due to the compression of the full flow in the first compressor, the second compressor does not need to operate at low suction temperatures but instead can operate at temperatures above 0°C.

These and other objects and advantages of the invention will become more apparent from the following detailed description and appended claims taken in conjunction with the accompanying drawing in which:

The drawing illustrates a schematic view of a ship employing an apparatus according to the invention.

Referring to the drawing, a ship such as a liquified combustible gas tanker has a propulsion unit (not shown) and a plurality of liquified gas tanks **10**, only two of which are shown for simplicity. A means, such as a line **11**, is connected to each tank **10** to draw off a flow of gas, for example, methane or natural gas vaporized in each at a temperature, for example, of −150°C and approximately at atmospheric pressure. The line **11** is connected to a cooling passage **12** in a heat exchanger **13** to deliver the flow of vaporized gas to the passage **12** for heating, for example, to 10°C in a manner as described below. A line **14** extends from the exit end of the passage **12** to a compressor **15** to deliver the heated flow for compression purposes. A delivery line **16** extends from the compressor **15** through an aftercooler **17** and divides into two branch lines **18**, 19. One line **18** conveys one component flow of the gas after cooling in the aftercooler **17** to a combustion device (not shown) of the propulsion unit (not shown), e.g. a combustion chamber of a steam generator. The line **18** is provided with a non-return valve **20** and a pressure regulating valve **21** which maintains the pressure in the line **18** at a predetermined value by means of a controller **21***a*.

The compressor **15** has a drive motor **22** whose speed is controlled by a controller **23** according to the pressure in the line **11**. The conditions are such that when the pressure rises in the line **11** due to the vaporization of gas in the tanks **10** the speed is increased and vice versa.

The branch line **19** carries a second gas component flow into a second compressor **24** formed by a three-stage piston machine driven by a diagrammatically indicated electric motor **25**. Coolers **26** are also provided between the various stages and where the gas component flow leaves the last stage.

A line **27** connects the outflow of the compressor **24** to the heat exchanger **13** so that the component flow of compressed gas comes into heat exchange relation with the continued flow of vaporized gas from the tanks **10** and is cooled. A pressure reducing means including a line **28** and a pressure reducing valve **29** e.g. an expansion valve is connected to the heat exchanger **13** to receive the cooled component flow. The pressure reducing valve **29** is operated by a controller **30** so as to maintain the desired pressure in the line **28**. As shown, the valve **29** communicates via a line **31** with a separator **33** which has a conventional level regulating means **34** for operating a valve **35** in an exit line **36** to a pump **46**. The pump **46** serves to feed the liquified gas back to the tanks **10**.

The separator **33** is connected by a line **41** to another cooling passage **42** in the heat exchanger **13** so that volatile gas constituents, particularly nitrogen, can be drawn off along the line **41** and used to cool the gas component flow passing through the heat exchanger during liquification. These constituents then flow along a line **43** into the line **18**, where they are added to the component intended for combustion.

As shown, the aftercooler **17** is connected by a line **38** to a source of coolant, for example, cooling water for cooling the gas flow through the line **16**. Also, a regulating valve **38***a* is disposed in the line **38** and is oper-

ated via a controller **39** in accordance with temperature variations in the compressed gas in the line **16** so that a rise in temperature is followed by increased cooling and vice versa.

The process of treating and utilizing the vaporized gas resides in drawing off the gas from the tanks **10** via the line **11** into the heat exchanger **13.** After heating, for example, to 10°C, the gas flows along the line **14** into the compressor **15** and is compressed to a pressure of approximately 2 atmospheres absolute and heated to about 60°C. After cooling to about 40°C in the after-cooler **17,** one component flow of gas is conveyed via the line **18** at the same pressure to the furnace (not shown) of a steam generator which produces steam for the turbines which propel the ship.

The other gas component flow passes via the line **19** into the compressor **24** and is compressed, for example, to about 42 atmospheres absolute and at a temperature of, for example, 40°C. The gas then flows along the line **27** into the zone of the heat exchanger containing the cooling passage **12** and is cooled, for example, to −120°C. The gas so cooled is discharged from the heat exchanger **13** along the line **28** to the pressure reducing valve **29,** where the pressure is reduced to 2 atmospheres absolute, that is, to the delivery pressure of the first compressor **15.**

From the pressure reducing valve **29,** the gas, now at least partly liquified, flows along the line **31** into the separator **33** and collects in the lower part of the separator **33.** The re-liquified portion of the gas is then returned to the tanks **10** via the line **36** by means of the pump **46.**

This invention is not restricted to the embodiment illustrated. On the contrary, the gas component flow intended for combustion, instead of going to a boiler furnace, can be fed to a diesel engine at a pressure of, for example, eight atmospheres absolute or to a gas turbine plant used to propel the ship. According to another alternative, the pressure reducing valve **29** is used to reduce the pressure to that in the tanks **10** directly, omitting the separation of volatile gases.

Further, the invention provides an apparatus which is of simple construction and which uses equipment on which no complicated demands need be made.

What is claimed is:

1. A process of treating and utilizing vaporized gas from a liquified gas tank of a ship for transporting liquified combustible gas comprising the steps of

drawing off a flow of vaporized gas from at least one gas tank;

compressing said flow of vaporized gas;

dividing the compressed flow of gas into at least two component flows;

feeding one of said gas component flows to a propulsion unit of the ship;

compressing a second of said gas component flows;

passing said compressed second gas component flow into heat exchange relation with a continued flow of said flow of vaporized gas to heat said continued flow of vaporized gas prior to compressing of said continued flow of vaporized gas; and

thereafter reducing the pressure of said second gas component flow and feeding a liquid part of the reduced pressure gas component flow to at least one gas tank.

2. A process as set forth in claim **1** which further comprises the step of cooling said flow of compressed gas prior to dividing into said component flows.

3. A process as set forth in claim **1** wherein the full flow of said vaporized gas from one tank is compressed to a pressure demanded by the propulsion unit.

4. A process as set forth in claim **1** which further comprises the step of separating volatile constituents from said reduced pressure gas component flow.

5. A process as set forth in claim **4** wherein said step of reducing the pressure of said second gas component flow includes expanding said second gas component flow to a pressure corresponding to a delivery pressure of said vaporized gas from the tank and wherein the separated volatile constituents pass in heat exchange relation with said flow of vaporized gas and are added to said one gas component flow.

6. An apparatus for treating and utilizing vaporized gas from a liquified gas tank of a ship for transporting liquified combustible gas comprising

at least one gas tank;

means for drawing off a flow of vaporized gas from said tank;

a first compressor connected to said for drawing off means for compressing the flow of vaporized gas;

a first branch line connected to said compressor to deliver one component flow of the compressed gas flow to a propulsion unit of the ship;

a second compressor connected to said first compressor to receive and compress a second component flow of the compressed gas flow from said first compressor;

a heat exchanger connected with said means and to said second compressor to receive the flow of vaporized gas from said tank and the flow of the compressed second gas component flow from said second compressor in heat exchange relation to heat the flow of vaporized gas and cool the second gas component flow; and

a pressure reducing means connected to said heat exchanger and said tank to deliver the second gas component flow to said tank in at least partly liquified form.

7. An apparatus as set forth in claim **6** which further comprises a second branch line between said first compressor and said second compressor to convey the second gas component therebetween.

8. An apparatus as set forth in claim **6** which further comprises an after-cooler downstream of said first compressor for cooling the compressed flow of vaporized gas.

9. An apparatus as set forth in claim **6** which further comprises a separator connected to said heat exchanger to receive the cooled second gas component flow, a cooling passage in said heat exchanger, a line between said separator and said cooling passage for passing separated volatile gas constituents from the second gas component flow through said cooling passage, a line between said cooling passage and said first branch line to deliver the volatile gas constituents thereto and a line between said separator and said gas tank to deliver liquified gas thereto.

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