United States Patent

Foster-Pegg

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[54] GAS LIQUIFACTION

[72] Inventor: **Richard W. Foster-Pegg**, Warren, Pa.

[73] Assignee: **Struthers Energy Systems, Inc.**

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[52] **U.S. Cl.** **62/5**

[51] **Int. Cl.** **F25b 9/02**

[58] **Field of Search** 62/5

[56] **References Cited**

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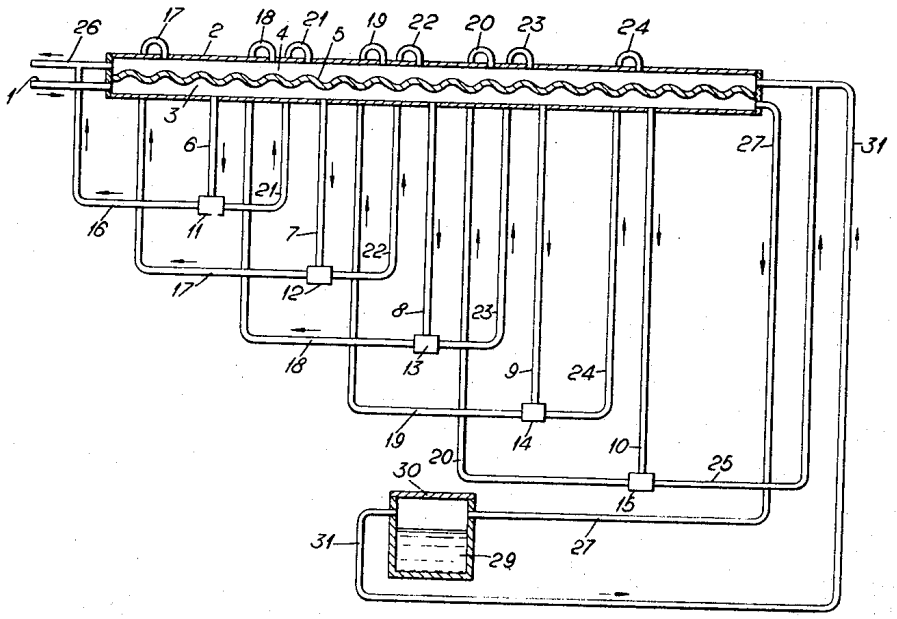
Primary Examiner—William J. Wye

Attorney—William A. Drucker

[57] **ABSTRACT**

A gas under pressure enters a single counter-flow heat exchanger haVing a high pressure entrance side and a low pressure exhaust side, the gas from the high pressure side being connected in parallel to a number of Ranque tubes in which the gas expands. The hot and cold streams from the tubes are connected along the length of the low pressure side of the heat exchanger to progressively cool gas in the high pressure side until a small percentage of the gas can be flashed to liquid for storage.

3 Claims, 2 Drawing Figures



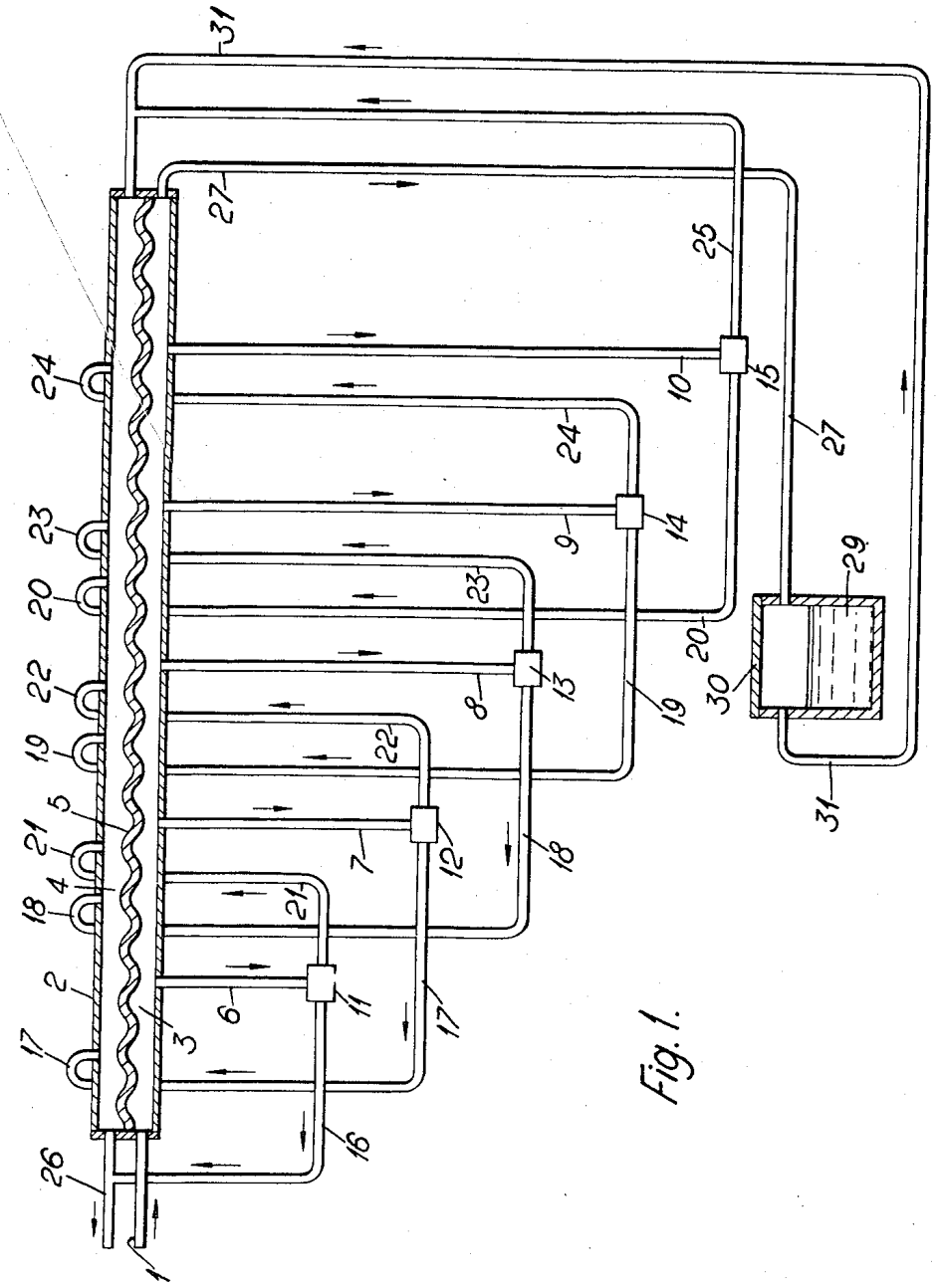

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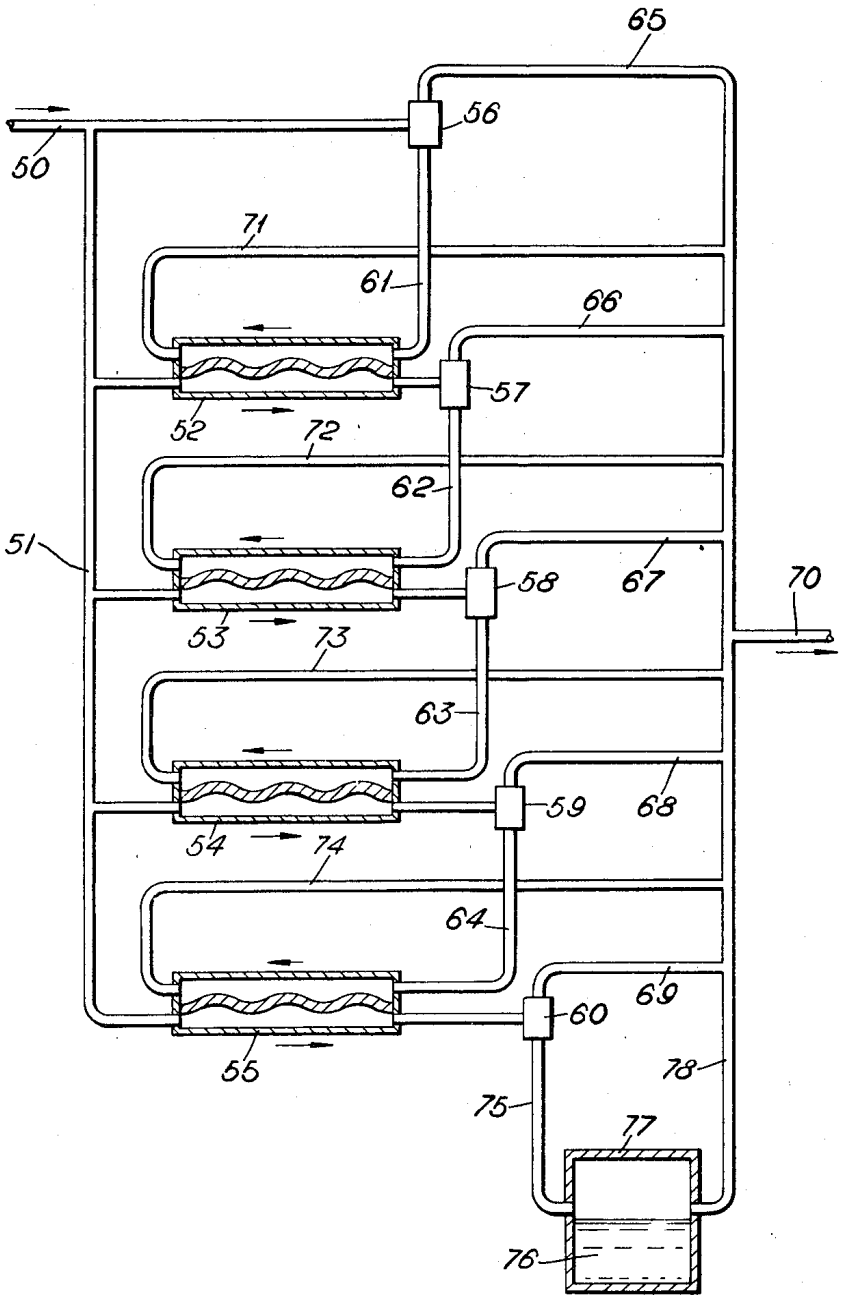
Fig. 1.

Fig. 2.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GAS LIQUIFACTION

BACKGROUND OF THE INVENTION

Natural gas is frequently expanded from pipeline pressure to a lower pressure for distribution. At the same time, it is often desired to store liquified natural gas for use at periods of high demand. This is sometimes accomplished by absorbing work from the gas as it expands to a lower pressure and thus extracting heat to cool the gas. This system conventionally requires rotating turbo machinery which requires skilled operation, is costly, and is difficult to maintain.

SUMMARY OF THE INVENTION

Accordingly to this invention, the rotating equipment is replaced by a single heat exchanger and a number of static Ranque tubes. A gas at a given temperature expending through these tubes exhausts in two streams, one at a higher temperature and one at a lower temperature. Depending on the initial temperature and pressure of the natural gas or other gas being treated, it is indicated that, according to this invention, 1 percent or more of a gas may be liquified. If the gas is at a sufficiently high pressure, it may be expanded in series through a number of Ranque tubes with each tube being connected to the cold stream of the tube before it. Since the pressures required for series expansion of natural gas are prohibitive, a heat exhanger is employed with an inlet high pressure side and an outlet low pressure side. Progressively cooler gases from both the high and low temperature streams of each Ranque tube exhaust at suitable locations along the low pressure outlet side of the heat exchanger to progressively cool counter-flowing gas in the inlet side of the heat exchanger. Progressively colder gases are tapped from the inlet side of the heat exchanger to the Ranque tubes. At the end of the heat exchanger, a quantity of the gas is sufficiently cooled to be flashed to a liquid.

It is possible to replace the single heat exchanger with a number of heat exchangers. A single high pressure feed line would then be connected in parallel to a number of Ranque tubes with a heat exchanger using the cold stream from each tube to cool the inlet stream to the following tube.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram of a preferred embodiment of this invention; and

FIG. 2 is a schematic diagram of another embodiment of this invention using a plurality of heat exchangers.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, natural gas or the like, which is to be cooled by expansion, flows from inlet pipe **1** into heat exchanger **2** having a high inlet pressure side **3** separated from a low pressure exhaust side **4** by a heat conducting wall **5**. Progressively cooled gas flowing to the right as shown in side **3** is tapped off the pipes **6–10** to the Ranque tubes **11–15**.

The hot stream from tube **11** passes through pipe **16** to the low pressure exhaust or outlet pipe **26**. The hot streams from tubes **12–15** pass respectively, through the pipes **17–20** to the low pressure outlet side **4** of heat exchanger **2**. The cold streams from the tubes **11–15** pass, respectively, through the pipes **21–25** to the outlet side **4** of heat exchanger **2**. Pipes **17–25** lead into the exhaust side **4** of the heat exchanger **2** at suitable locations to progressively cool gas in the inlet side **3**. The gases in exhaust side **4** flow to the left as shown counter to the direction of flow of the gases in the inlet side **3**. Sufficiently cooled gas is drawn from the end of the inlet side **3** of the heat exchanger **2** through pipe **27** to be partially flashed into liquid **29** in tank **30**. Low pressure cooled gases pass from tank **30** through pipe **31** to the exhaust side of heat exchanger **2**.

As one example of this invention natural gas at 150 psig and 70° F. or 530° R. flows from inlet pipe **1** into side **3** to be cooled and withdrawn through pipes **6–10** at temperatures of 496° R., 414° R, 347° R., 293° F., and 246° R., respectively. The hot streams from tubes **11–15** flow through pipes **16–20** at temperatures of 610° R., 510° R., 427° R., 360° R., and 302° R., respectively. The cold streams from tubes **11–15** flow through pipes **21–25** at temperatures of 407° R., 340° R., 285° R., 240° R., and 202° R., respectively. The pipes **17–25** leading gas into the heat exchanger **2** at appropriate locations along the length of side **4** cool gas flowing from side **3** through pipe **27** to 204° R. so that this gas may be flashed into liquid in tank **30**. The gas leaving through pipe **26** is at 16 psig. It is to be noted that pipe **7**, which has gas flowing into it at 414° R. is to the right of pipe **21** which introduces a cooling gas at 407° R. into heat exchanger **2** to cool the gas entering pipe **7**. Thus the temperature in heat exchanger **2** having counter-flow therein, decreases to the right as shown and the pipes enter and leave it accordingly. About 1 percent of the natural gas treated in this manner may be liquified at the given temperatures and pressures.

FIG. **2** shows a modification of this invention in which a gas from pipe **50** at a high pressure is piped in parallel through pipe **51** and the heat exchangers **52–55** to the Ranque tubes **56–60**, respectively. Pipes **61–64** lead the cold stream from the tubes **56–59** to the heat exchangers **52–55** respectively. Hot streams from the tubes **56–60** flow through pipes **65–69** to an outlet **70**. Warmed gases from heat exchangers **52–55** flow through pipes **71–74** to outlet **70**. Gases from the cold stream of tube **60** flow through pipe **75** to be flashed to liquid **76** in tank **77**. Gases from tank **77** may be flashed to liquid **76** in tank **77**. Gases from tank **77** may pass through pipe **78** to the outlet **70**. It is to be noted that relatively cold gases in pipes **66–69** and pipe **78** may be passed to a portion of a heat exchanger to help cool inlet gases and improve the efficiency of this embodiment of the invention.

While all pipes and heat exchangers are shown as being of uniform size, these would be scaled according to the required flow therethrough and the degree of heat exchange surface required.

What is claimed is:

1. Apparatus for flashing a small percent of a gas into a liquid on expansion of the gas from a higher to a lower pressure, the apparatus comprising, in combination,

a. a number of Ranque tubes connected in parallel to the gas at higher pressure allowing the gas to expand therein,

b. a hot and a cold outlet pipe from each Ranque-Hilsch tube,

c. counterflow heat exchanger means having at least one high pressure inlet cooling side and at least one low pressure outlet heating side, said cold outlet pipes conducting progressively colder gas to the at least one heating side of said heat exchanger means to greatly cool a small portion of the gas in said at least one inlet side, and

d. means flashing sufficiently cooled gas from said at least one inlet side into a liquid.

2. The combination according to claim **1** wherein said heat exchanger means has a single high pressure cooling inlet side, a single low pressure heating side, and a heat conducting wall separating said high and low pressure sides, said Ranque tubes having inlet pipes connected along progressively colder portions of said inlet side of said heat exchanger means, said hot and cold outlet pipes leading to said outlet side opposite higher temperature portions of said inlet side to sufficiently cool a percentage of said gas in said inlet side to be flashed into liquid in said means flashing gas into a liquid.

3. The combination according to claim **1** wherein said heat exchanger means comprises a plurality of heat exchangers having inlet cooling sides and outlet heating sides, said inlet sides being connected in parallel to gas at a high pressure, cooled gas from said inlet sides passing to said Ranque-Hilsch tubes for expansion therein, each of said cold outlet pipes leading to a progressively colder heat exchanger, a final one of said heat exchangers having an outlet side connected to a Ranque tube having a cold outlet pipe from which gas is flashed into liquid in said means flashing gas into a liquid, and

with the addition of a common low pressure outlet, said outlet sides of said heat exchangers and said hot outlet pipes from said Ranque tubes being connected to said common low pressure outlet.

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