Dec. 18, 1962 J. C. ALLEN 3,068,657

METHOD FOR THE TRANSPORTATION AND MAINTENANCE OF A NORMALLY GASEOUS HYDROCARBON IN SOLUTION WITH A LIQUID HYDROCARBON

Filed July 24, 1959

3 Sheets-Sheet 1

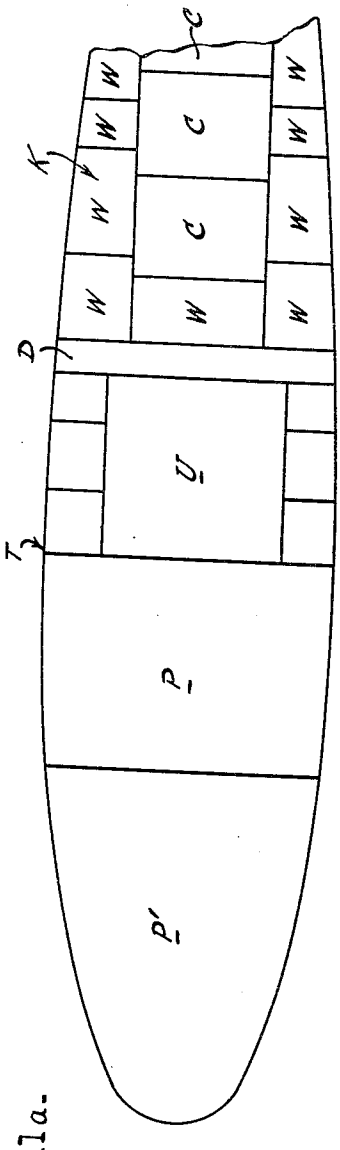



Fig. 1a.

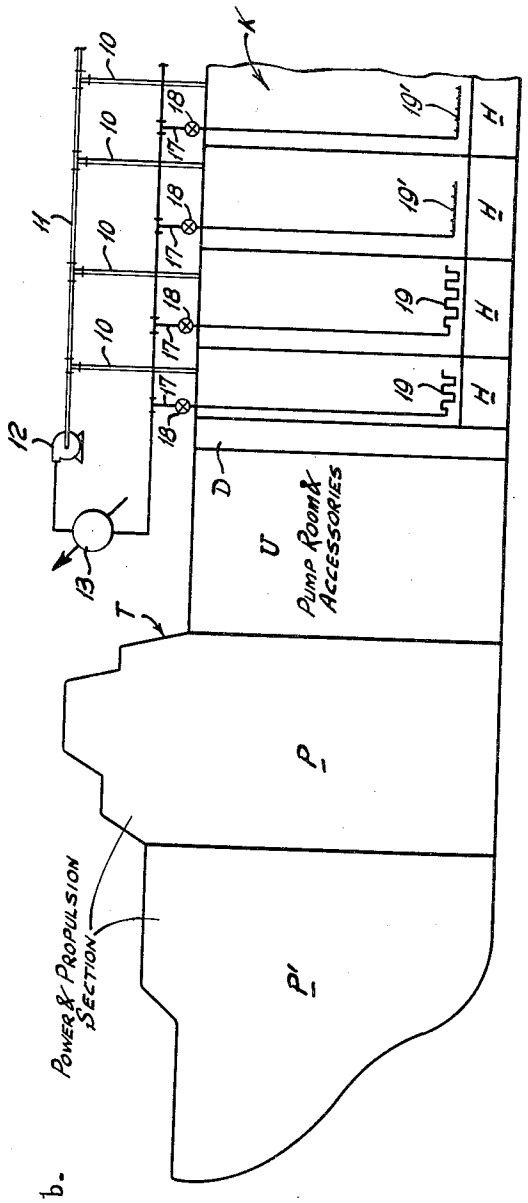



Fig. 1b.

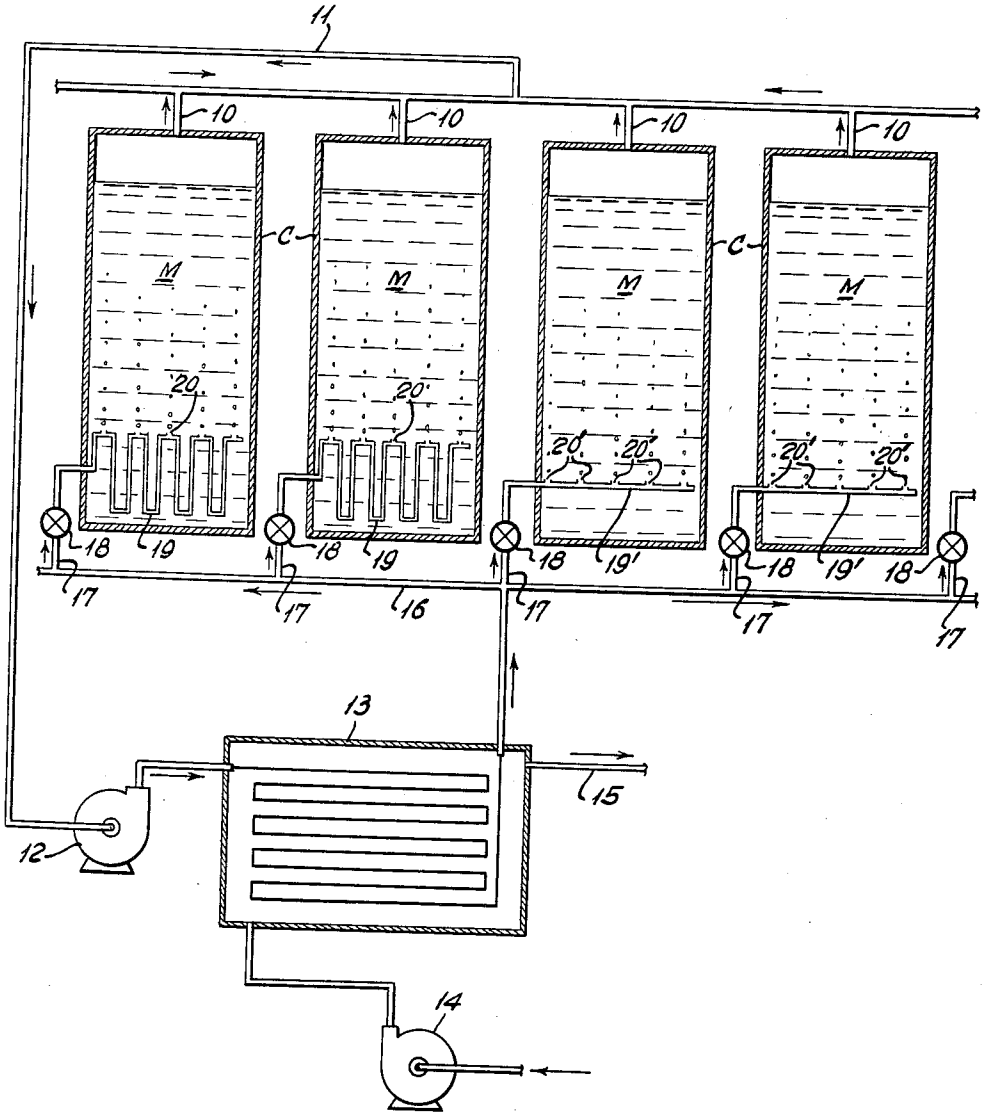
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Fig. 2.



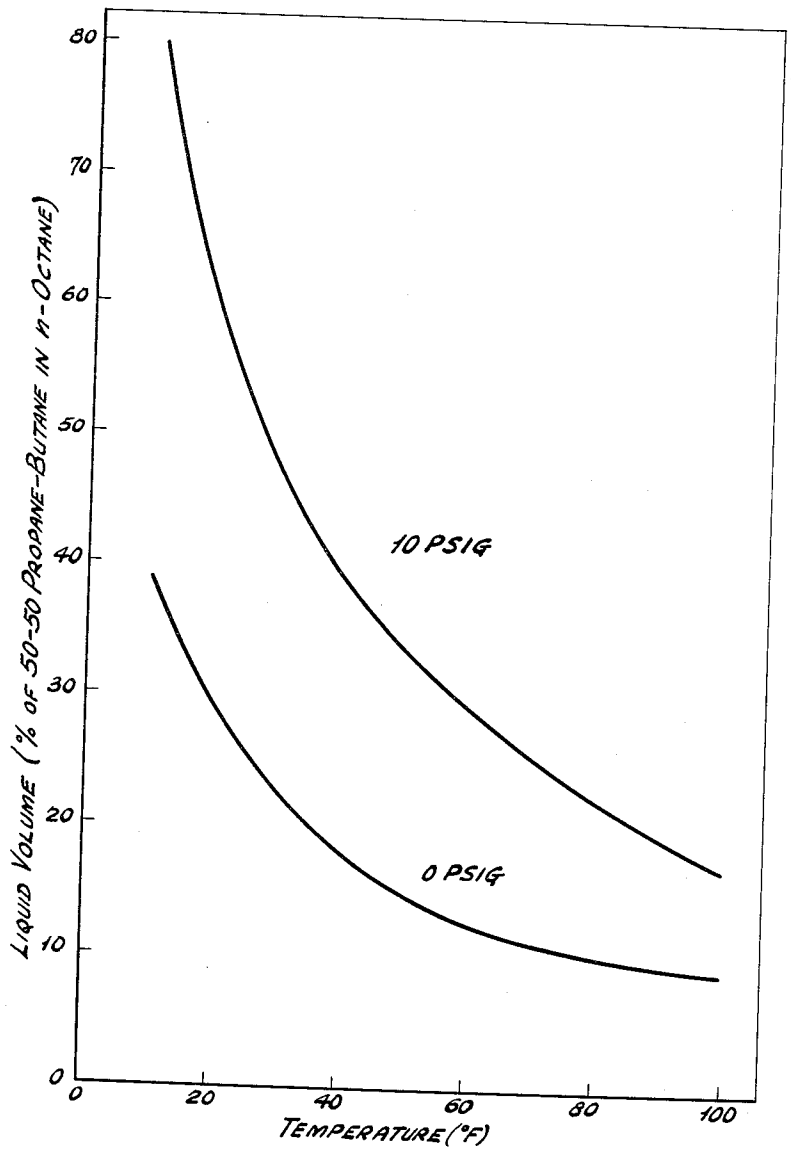
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Fig. 3.



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# METHOD FOR THE TRANSPORTATION AND MAINTENANCE OF A NORMALLY GASEOUS HYDROCARBON IN SOLUTION WITH A LIQUID HYDROCARBON

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1 Claim. (Cl. 62—48)

This invention relates generally to the maintenance of a normally gaseous hydrocarbon in solution with a liquid hydrocarbon and, in one specific aspect, is concerned with a method for the transport of a gaseous hydrocarbon, such as propane or some other petroleum gas, while dissolved in a liquid hydrocarbon, such as crude oil or refined liquid petroleum products, at reduced temperatures.

Among the problems encountered in petroleum production and especially in foreign producing operations is that of the release of large quantities of petroleum gases, which include the butanes, propane, ethane and methane. Not only are these gases suitable for use in petrochemical production and for fuel purposes, but also they are a valuable source, with but slight processing, for the enrichment of manufactured gas to be used for heating purposes. In domestic oil field production, the transportation of petroleum gases to the points of utilization is largely by means of pipelines.

The shipment of liquefied petroleum gases for considerable distances is feasible in containers which are built to withstand elevated pressures. However, the cost of manufacture of such containers, due to the amount and quality of material required, as well as the expense of transportation of the heavy containers, restrict shipment to localized regions. At the same time, because of the maximum allowable metal wall thickness permitted without stress relief, the size of such containers is limited.

Other means for transporting liquefied petroleum gases at low temperature and at substantially atmospheric pressure, include the use of insulated tanks mounted on barges or in vessels, the tanks being considerably larger than the pressurized containers and employing balsa wood for insulation. Because of the amount of such insulation required, the usable dimensions of the tank container are reduced considerably. In addition, there is the danger of low temperature embrittlement of carbon steel tank walls which might occur, should the insulation drop off. In the absence of the use of high cost alloy steels for constructing the tanks, the shipment of liquefied petroleum gases is restricted by safety standards to the relatively heavier petroleum gases, such as the butanes and propane, which have the higher boiling points.

Among potentially prolific world sources of petroleum gases are those of the Middle East and of the South American oil fields adjoining the Caribbean Sea. In these regions, the production of petroleum gases could be lavish, but since they cannot be exploited fully, either by further processing or by shipment through pipelines to areas where such could be accomplished, they are, in the case of a natural gas reservoir, not produced, and in the case of solution gas from oil reservoirs, conservation regulations prevent its exhaust to the atmosphere as waste. If such petroleum gases should become available economically to energy-deficient areas, the deficiency in energy requirements would be reduced.

In the shipment of liquefied petroleum gases, problems arise as to the transportation and storage of these gases at their atmospheric boiling points and the installation of containers for holding them at their low liquid temperatures. While it is known to transport and store



liquefied gases, such as nitrogen and oxygen, in Dewar type containers of spaced inner and outer receptacles, the problems encountered in the construction of such type containers for the shipment of the amounts of liquefied petroleum gases required to justify their economical transportation prevents the use of the same.

Accordingly, it is an object of the present invention to provide for a more efficient and economical maintenance of a normally gaseous hydrocarbon dissolved in a liquid hydrocarbon.

Still another object of the present invention is to provide an improved apparatus for the transportation of a normally gaseous hydrocarbon dissolved in a liquid hydrocarbon.

And another object of the present invention is to provide for an improved method for the transportation and maintenance of a liquefied petroleum gas in solution with a liquid hydrocarbon.

These and other objects, advantages and features of the present invention will become apparent from the following description of the invention and by reference to the accompanying drawings wherein:

FIG. 1*a* is a diagrammatic plan view of part of a tanker for use in the transportation of a solution of a normally gaseous hydrocarbon dissolved in a liquid hydrocarbon;

FIG. 1*b* is a elevation view of the tanker of FIG. 1*a* and showing part of the installation used for maintaining the solution at low temperature;

FIG. 2 is a diagram of the auto-refrigeration recycle structure used in the practice of this invention; and

FIG. 3 is a graph showing solubility curves as a function of temperature of a normally gaseous hydrocarbon mixture dissolved in a liquid hydrocarbon.

The objects of my invention are achieved by the use of an auto-refrigeration recycle for maintaining at low temperature a solution of a normally gaseous hydrocarbon with a liquid hydrocarbon.

Referring to the drawings, FIGS. 1*a* and 1*b* disclose the aft portion of a tanker, indicated generally at T, with the power and propulsion sections indicated respectively as P and P', the pump room including accessories such as the refrigeration unit and adjoining fuel oil wing tanks being located in the section indicated at U, and the cargo tankage for crude petroleum and refined products in a forward section of the tanker, indicated generally at K, and the coffer dam structure, separating the cargo tankage from the remainder of the ship being indicated at the section at D. The cargo tankage consists of center tanks indicated at C, wing tanks, indicated at W and the double hull, indicated at H.

While all parts of the cargo tankage are suitable for the carriage of crude petroleum and petroleum products, for more efficient practice of the invention, it is preferable to provide the center tanks at C with the mixture of the normally gaseous hydrocarbon dissolved in the liquid hydrocarbon. In this manner, the surrounding exterior tanks serve to insulate the outer walls of the tanker from the low temperature of the refrigerated solution.

Referring to FIG. 2, there is disclosed diagrammatically a number of center tanks C holding a solution M of liquefied petroleum gas, e.g. propane and/or butane, and liquid hydrocarbon. As the solution absorbs heat, there is a continuous evolution of the petroleum gas, which is drawn off through the headers **10** to a manifold **11** leading to a compressor **12**, where it is pressurized for passage through a condenser **13**, where it is liquefied, the condenser being cooled, e.g. by sea water, in a conventional manner, the intake pump for the coolant being at **14** and the outlet at **15**. The liquefied petroleum gas, under high pressure, is directed to manifold **16**, to which

are joined the take-offs 17 leading to individual expansion valves 18, which are connected to evaporator coils indicated at 19 and located adjacent the bottom of the center tanks C, or alternately connected to a distributor indicated as 19'. As the liquefied gas passes through the expansion valves, and its pressure is reduced, it changes from liquid to gaseous state and cools the solution. Each of the coils 19 has at least one bleed valve, as at 20 (and alternatively the distributor has orifices 20') for release of the expanded gases into the solution. In this manner, the auto-refrigeration cycle maintains the temperature of the solution at a low level and liquefied petroleum gas is added to and kept in solution. While the liquefied petroleum gas and liquid hydrocarbon solution may be kept at atmospheric pressure, Coast Guard regulations permit grade A cargo carriers to operate at a pressure below 10# gauge.

FIG. 3 presents solubility curves showing the great increase in solubilities of a 50–50 propane-butane mixture in normal octane as the temperature of the solution is reduced. Octane is taken as representative of the average properties of a liquid hydrocarbon. These curves at atmospheric and 10# gauge pressures indicate an approximate 300 percent increase in solubilities as the ambient temperature of the solution is lowered from about 80° F. to about 20° F.

Thus, there has been shown and described a method for the maintenance and transportation of a normally gaseous hydrocarbon dissolved in a liquid hydrocarbon at low temperature and at about atmospheric pressure.

Obviously, many modifications and variations of the invention as hereinbefore set forth may be made without departing from the spirit and scope thereof, and therefore only such limitations should be imposed as are indicated in the the appended claim.



I claim:

The method of transporting a normally gaseous hydrocarbon at substantially atmospheric pressure and at reduced temperature comprising the solution of said normally gaseous hydrocarbon in a normally liquid hydrocarbon and the maintenance of the resulting solution at a reduced temperature by auto-refrigeration comprising the drawing off of gaseous hydrocarbon evolved from said resulting solution, compressing the drawn off evolved gaseous hydrocarbon to liquefaction, and passing the liquefied gaseous hydrocarbon in heat exchange relationship with said solution by bleeding off said liquefied gaseous hydrocarbon into said solution for dissolution therein whereby a reduced temperature is obtained to maintain said gaseous hydrocarbon in solution in said liquid hydrocarbon, said liquid hydrocarbon being chosen from the class comprising crude petroleum and petroleum products.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 541,462 | Suckert | June 25, 1895 |
| 1,444,665 | Crommett | Feb. 6, 1923 |
| 1,986,959 | Davenport | Jan. 8, 1935 |
| 2,231,500 | Harlow | Feb. 11, 1941 |
| 2,277,138 | Newton | Mar. 24, 1942 |
| 2,290,839 | White | July 21, 1942 |
| 2,535,148 | Martin | Dec. 26, 1950 |
| 2,550,886 | Thompson | May 1, 1951 |
| 2,933,902 | Howard | Apr. 26, 1960 |
| 2,959,928 | Maker | Nov. 15, 1960 |