Feb. 7, 1967 H. WALTER 3,302,419

VACUUM JACKET SIPHON FOR CRYOGENIC FLUIDS

Filed May 14, 1965 3 Sheets-Sheet 1

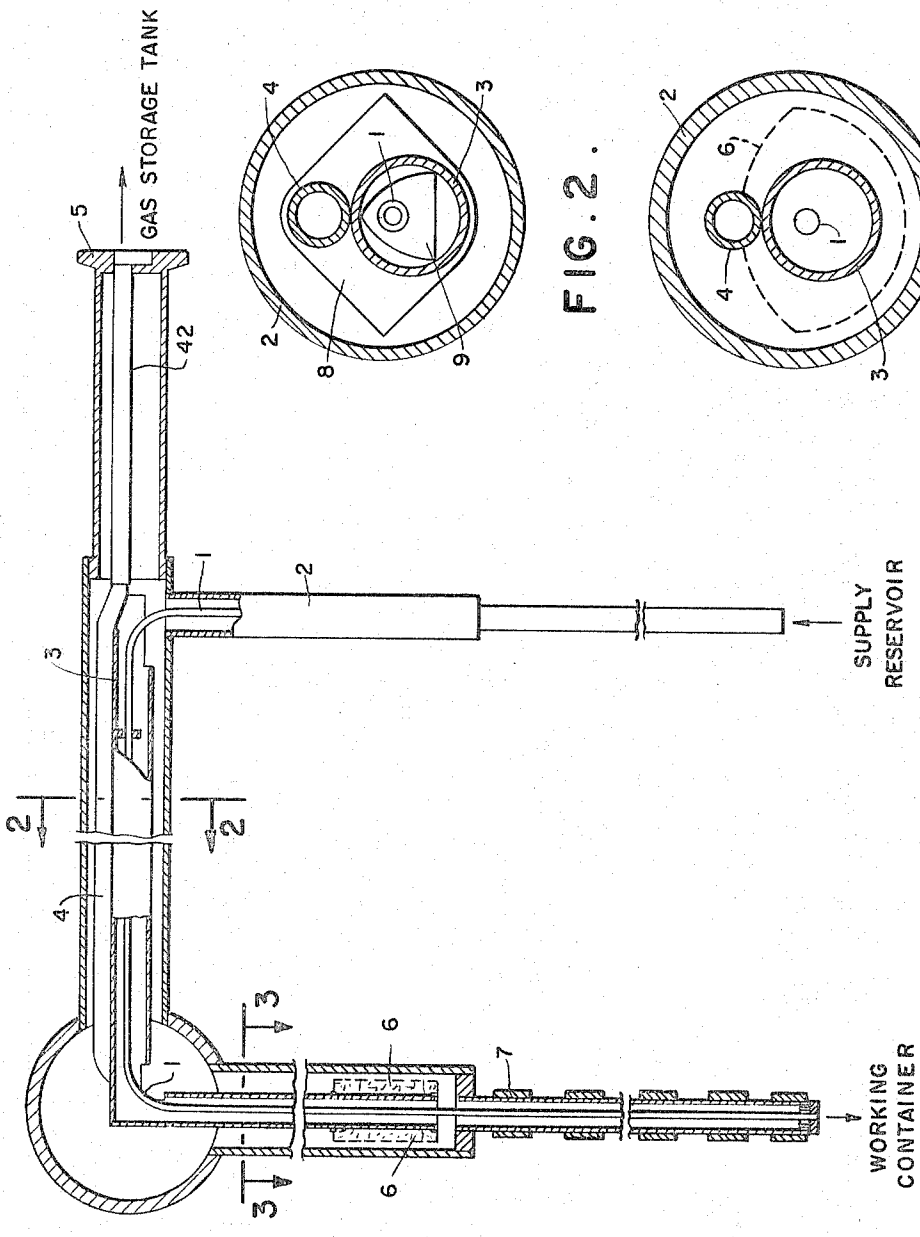


FIG. 1.

FIG. 2.

FIG. 3.

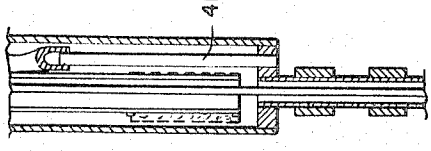


FIG. 1a.

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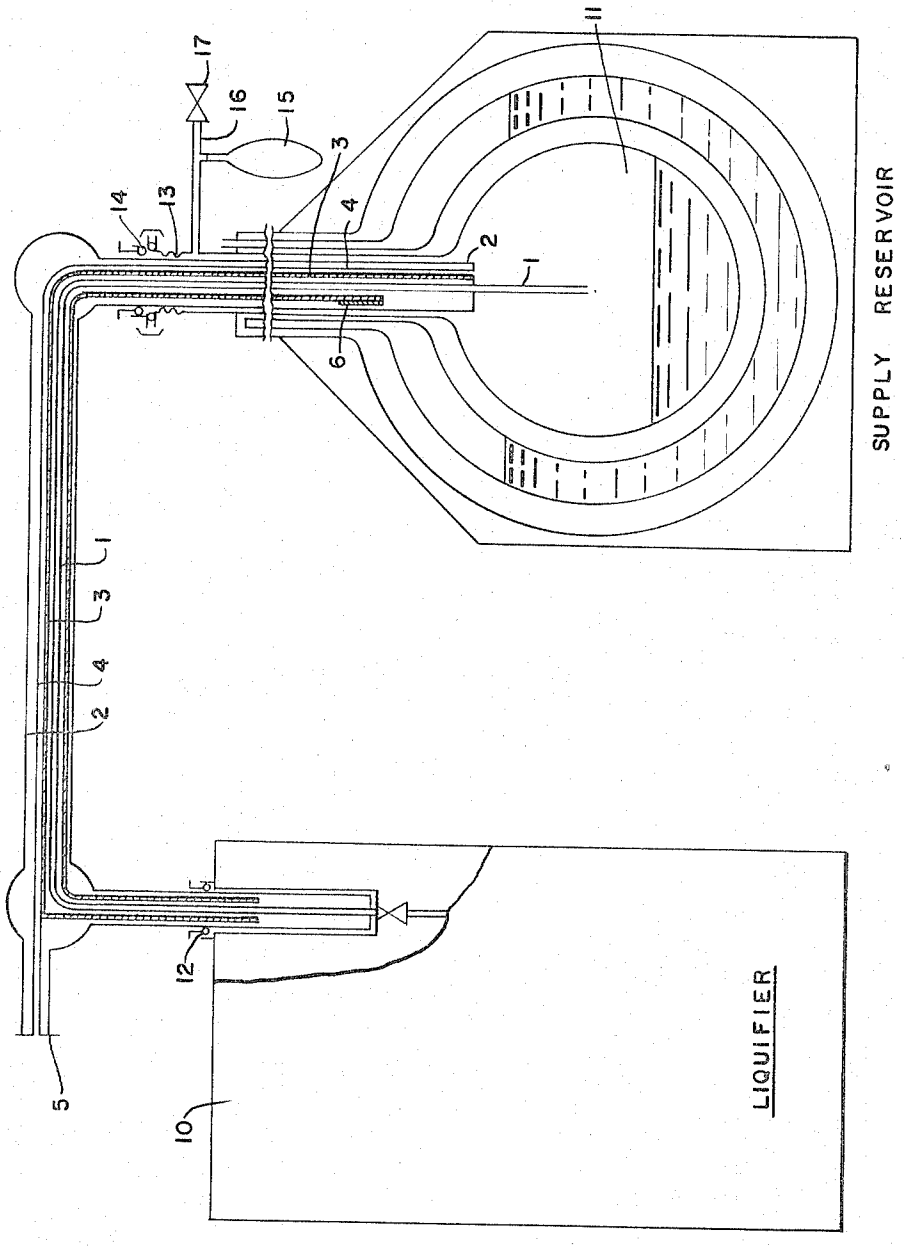


FIG. 4.

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VACUUM JACKET SIPHON FOR CRYOGENIC FLUIDS

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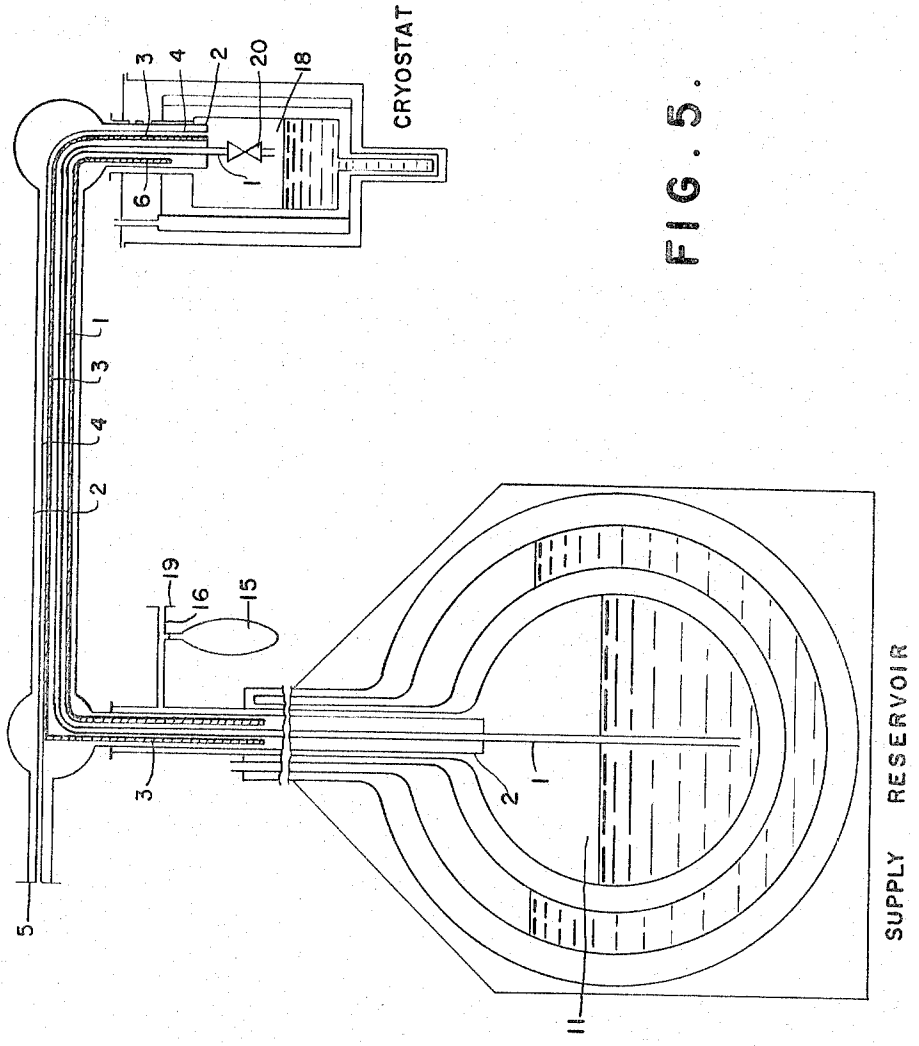


FIG. 5.

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3,302,419

VACUUM JACKET SIPHON FOR CRYOGENIC FLUIDS

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7 Claims. (Cl. 62—55)

The present invention relates to a vacuum jacket siphon for transporting liquids having low boiling points, and particularly to such a siphon designed to minimize heat flow across it.

In handling low-temperature-boiling liquids such as nitrogen, hydrogen and helium, the liquids are often transferred from a liquefier to a supply reservoir, and from there into a working container, by means of vacuum jacket siphons. Some heat, however, is transferred to the liquid-conducting inner tube or channel of the siphon by radiation, causing evaporation losses. Such losses can be considerable, for instance when large quantities of a liquid refrigerant are transferred, or if the refrigerant is being continuously transferred, as in the case of a continuous flow cryostat, especially when helium is used, because it has a low heat of vaporization. As the costs of liquefying helium are very high, the heat transferred to the liquid-conducting inner channel of a vacuum jacket siphon has to be kept as low as possible.

The amount of heat radiated to the channel can be decreased by polishing the surfaces of the vacuum jacket tube and the inner tube forming the channel which surfaces face each other, or by installing a highly insulating material, such as superinsulation, in the evacuated space between them. Both methods decrease radiation to some degree, but neither is good enough for many practical applications. The superinsulations have the disadvantage that they decrease the vacuum to an intolerable extent by outgassing.

It has also been suggested that the channel for the liquid helium be cooled itself, by liquid nitrogen. In this case the evacuated space forming the jacket of the siphon might be filled with a porous insulating material, and the vacuum jacket tube cooled by an exteriorly located heat exchanger through which liquid nitrogen flows. This method has the disadvantage that a second refrigerant would be needed to cool the siphon. Furthermore, the vacuum jacket siphon itself would have to be surrounded by a thick insulation layer to prevent icing on the outside of the jacket. The siphon thus becomes so big and unwieldy that it can not be used for many applications.

It is therefore an object of the present invention to provide a vacuum jacket siphon which overcomes the above-mentioned disadvantages, resulting in a highly insulating siphon.

It is a further object of the present invention to provide a vacuum jacket siphon wherein a radiation shield is provided within the vacuum jacket, which shield is cooled by exhaust gas from a working container.

These objects as well as others are achieved in a vacuum jacket siphon according to the invention for use in conjunction with a working container from which exhaust gas may be drawn, such siphon including a channel through which a low-boiling-point liquid may flow, a vacuum jacket surrounding the channel, a radiation shield disposed between the channel and the outer wall of the vacuum jacket and surrounding the channel for shielding the latter from thermal radiation, and a heat exchanger in thermal contact with the radiation shield for conducting a flow of such exhaust gas to absorb heat from the radiation shield. The radiation shield is insulated from the channel, and may be a copper tube polished on its exterior. The heat exchange element may be a copper tube provided at each end with a segment, or section, of low heat conductivity, and may be soldered along its entire working length to the radiation shield.

Additional objects and advantages of the present invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a vertical cross-sectional view through a vacuum siphon with a radiation shield cooled by exhaust gas.

FIGURE 1*a* is a sectional view of part of the device shown in FIGURE 1, shown rotated by about 90°.

FIGURE 2 is a horizontal cross section through the vacuum jacket siphon taken along line 2—2 in FIGURE 1.

FIGURE 3 is a horizontal cross section through the siphon taken along line 3—3 in FIGURE 1.

FIGURE 4 is a schematic cross-sectional view of a siphon with a radiation shield cooled by exhaust gas, which siphon serves as a connection between a liquefier and a reservoir.

FIGURE 5 is a schematic cross-sectional view of a siphon with a radiation shield cooled by exhaust gas, which siphon serves as a connection between a supply reservoir and a cryostat.

As can be seen from FIGURE 1, the siphon includes a liquid-conducting inner channel 1 which is surrounded along its entire length by a vacuum jacket 2, portions of which are tapered and one portion of which is enlarged to form a socket. The channel 1 in that part of the siphon extending from the supply reservoir (or the siphon coupling) is surrounded by a radiation shield 3 within the vacuum jacket 2. A heat exchanger tube 4 made of material such as copper which has a relatively high heat conductivity, is soldered to the radiation shield tube 3 along about its entire length. Only the end sections 41 and 42 of the heat exchanger tube 4 are made of a material that has a low heat conductivity such as a high grade steel. These end sections (one of which (41) appears in the partial sectional view of FIGURE 1*a*, showing the siphon rotated by about 90°) are not in direct thermal communication with the radiation shield tube 3. This prevents heat from being transferred to radiation shield 3 through end section 42, which is joined by flange 5 to an exhaust gas pipe (not shown) leading to a regenerating system. It also prevents heat transfer to the working container through end section 41, which is connected to a working container (not shown). A sieve 6 containing activated charcoal is placed at that end of the radiation shield 3 adjacent the working container, which end is the coldest. The gaskets 7 mounted on the narrow length of the vacuum jacket 2 on the side near the working container, assure that the refrigerant flowing into the working container passes through the working container (which may be e.g. a continuous flow cryostat) before entering the heat exchanger tube

4 and does not flow into the heat exchanger 4 directly from the inner channel 1, by-passing the working container in a "short circuit."

The relating positions of the tubes 1, 2, 3 and 4 can be seen from cross sections 2—2 and 3—3 of FIGURES 2 and 3, respectively. Section 2—2 shows the differently shaped spacers 8 and 9, which consist of thin super-refined steel plates. These spacers support and hold tubes 1 through 4 in the positions shown. One thus obtains a sufficiently stable arrangement of the tubes inside one another, and at the same time prevents heat transfer among the tubes where this is not desired. Cross section 3—3 also shows the sieve 6. Each reference numeral refers to the same structural element in all figures of the drawings.

The embodiment shown schematically in FIGURE 4 is a siphon with a radiation jacket that is cooled by exhaust gas, which siphon connects the liquefier 10 and the supply reservoir 11. Supply reservoir 11 is provided with an elastic connector section 13, to which the siphon, extending from the liquefier, is joined by means of a ring-type threaded connector 14. Normally the supply reservoir 11 is connected to the exhaust gas tube of a regenerating system (not shown), which tube leads to the gas container, via exhaust gas tube 16, with which a rubber bulb 15 communicates. When the siphon is cooled with exhaust gas, this tube has to be shut off by valve 17.

The schematic of FIGURE 5 shows a further embodiment of a gas-cooled siphon, which siphon serves for continuous transfer of refrigerant into a cryostat containing a refrigerant bath boiling under reduced pressure, especially a helium bath. In this case, one end of the siphon is sealed air-tightly into the liquid refrigerant supply reservoir 11, and the other end is connected into the cryostat 18 by conventional sealing means (not shown). The exhaust gas tube 16 from the supply reservoir 11 may be connected to a gas container (not shown) via flange 19. The siphon is cooled by the cold gas that accumulates in the cryostat 18. In order to have the refrigerant bath (e.g. helium) in the cryostat boil under lowered pressure, the accumulated gas has to be pumped out. Then, as is known, the temperature of the bath can be decreased below the normal boiling point temperature. The heat interchanger 4 of the siphon must in this case be connected via flange 5 to a vacuum pump (not shown). The heat exchanger 4 must consequently be dimensioned in such a way that the required low pressure can be produced over the liquid bath in cryostat 18. The liquid-conducting inner channel 1 of the siphon is here provided with a valve 20 that can be externally operated. This valve is positioned on the outlet side of the siphon, i.e., on the side that opens into the cryostat, and allows transfer of the liquid refrigerant taken from supply reservoir 11 at the normal boiilng temperature, into cryostat 18 under expansion, thereby causing cooling.

The use of a siphon cooled by exhaust gas provides substantial advantages in the case where liquid baths boiling under lowered pressure are continuously refillled. As evaporation of the refrigerant in the siphon is substantially reduced by cooling the siphon, the liquid that reaches the exponsion valve contains less gas then in the case of a conventional vacuum jacket siphon. When refilling the cryostat under lowered pressure with liquids through the expansion valve, the gas content of the liquid reaching the expansion valve is important in regard to the economic advantages of the method. If the gas content is too high, the separation of gas and liquid after expansion is rendered more difficult.

A cooled radiation protection tube as has been described, provided in the vacuum jacket of a siphon, surrounding the liquid-conducting inner channel, considerably decreases the evaporation losses involved in the transfer of liquid refrigerants. This becomes obvious when one compares the amount of heat reaching the inner tube by radiation through a conventional vacuum jacket tube, with that transmitted by the cooled radiation shield tube of the invention, as shown in the following table.

	Temperature of the inner tube, ° K.	Temperature of the vacuum jacket, ° K.	Heat transmitted by radiation (Q), kcal./hr.	$Q_B/Q_A \cdot 100$, percent
Conventional vacuum siphon jacket	4.2	293	0.219	100
Vacuum siphon with cooled radiation protection shield (as shown in Figures 2 and 3).	4.2	100	$2.92 \cdot 10^{-3}$	1.33
	4.2	70	$0.7 \cdot 10^{-3}$	0.3

Comparison of heat transmitted by radiation in a prior art device and in the invention, wherein the emissivities were $\epsilon_{Cu}=0.3$; $\epsilon_{brass\ dull}=0.25$, and siphons one meter long were used.

As has been shown, the radiation shield tube can be cooled in a rational way, by utilizing the relatively high refrigeration capacity of the gaseous refrigerant that evaporates out of whatever working chamber is used. The heat exchanger element must be designed to prevent heat from flowing to the refrigerant supply reservoir through the heat-exchanger. This can be done by providing sections at the ends of the working length of the heat-exchanger which are made of material with a low heat conductivity, as described above with respect to an illustrative embodiment.

In many cases, especially in the production of low temperatures by continuous flow cryostats, the supply reservoir for the liquid refrigerant is equipped with a siphon, which is left in the reservoir and which is provided with a shut-off valve and a coupling. The connection siphons attached to the various working containers can be coupled in via this coupling. In such a case it is not possible to insert activated charcoal into the vacuum jackets of the working container siphons, near the supply reservoir, in order to improve the vacuum. On the contrary, in this case the activated charcoal would function as an undesired heat bridge between the vacuum jacket (which is here not disposed in liquid helium, but in the coupling, so that it is warm) and the liquid-conducting inner channel.

As shown with respect to the above-described embodiment, in order to be able to equip such a siphon with activated charcoal, the latter may be provided in a sieve-like container, which can be positioned either on the liquid-conducting inner channel or, where this is not possible, at the coldest place within the radiation shield.

A vacuum siphon such as that described, with a radiation shield cooled by exhaust gas, has the advantage that it allows very little heat to be radiated to the liquid-conducting inner channel, compared to conventional devices. This reduces the amount of liquid refrigerant required for any given application, achieving a reduction in refrigeration costs, especially in the case of helium, which costs about $20.00 per liter of liquid. Cooling the radiation jacket by means of the cold gas that exhausts from the working container represents a step forward from cooling of the vacuum jacket by means of an auxiliary refrigerant. The expense and trouble of storing and handling the auxiliary refrigerant is also eliminated. The production of a vacuum-tight siphon with a cooled radiation shield is no more difficult than production of a conventional siphon, so that the vacuum-retention characteristics and quality of the conventional siphon are preserved by the invention.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to

be comprehended within the meaning and range of equivalents of the appended claims.

What is claimed is:

1. A vacuum jacket siphon for liquids having low boiling points for use in conjunction with a working container from which an exhaust gas may be drawn, said siphon comprising, in combination:

means forming a channel for such liquids;

means forming a vacuum jacket about said channel means so as to provide an evacuated chamber therebetween;

radiation shield means disposed in the evacuated chamber between said channel means and said vacuum jacket means and surrounding said channel means for shielding the latter from radiation; and

heat exchange means in thermal contact with the radiation shield means for conducting a flow of such exhaust gas therethrough to absorb heat from the radiation shield means.

2. A siphon as defined in claim 1, wherein said radiation shield means is a copper tube having a polished exterior surface.

3. A siphon as defined in claim 1, wherein said exhaust gas conducting means is a highly heat conductive tube provided with a section of low heat conductivity on each end for inhibiting heat transfer to and from said tube across said sections.

4. A siphon as defined in claim 3 wherein said tube is copper.

5. A siphon as defined in claim 3 wherein said heat conductive tube extends in thermal contact with the radiation shield means along substantially the entire length of the latter.

6. A siphon as defined in claim 5 wherein a solder joint bonds the heat conductive tube to the radiation shield means along their common extent.

7. A method of transferring a liquid having a low boiling point so as to minimize heat transfer thereto, in conjunction with a working container to which such liquid is ultimately transferred, said method including the steps of:

forming an evacuated zone about a conduit through which such liquid passes;

preventing heat radiation from entering the immediate vicinity of said conduit by trapping it in said zone; and

removing the trapped heat by directing exhaust gas from such working container along a portion of said zone to absorb and carry away any heat which would otherwise be radiated to the liquid in the conduit.

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