LIQUID CRYOGEN TRANSFER SYSTEM


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ABSTRACT

A system for transferring a cryogenic liquid from a storage vessel to a remote point of use at a constant temperature, pressure and flow rate wherein the transfer tube is jacketed with a second tube along substantially its entire length and these tubes are enclosed in an evacuated jacket. Use of a nozzle in the second tube entry end causes the liquid entering the jacket to decrease in pressure and temperature thereby subcooling the liquid in the transfer tube to prevent said liquid from boiling. The jacketing fluid absorbs heat entering the transfer system from the atmosphere. Included in the system as accessories are an adaptor for attaching the system to the storage vessel in pressure tight relationship and flow control on the delivery end of the system.

8 Claims, 3 Drawing Figures
LIQUID CRYOGEN TRANSFER SYSTEM

BACKGROUND OF THE INVENTION

This invention pertains to liquid cryogen transfer systems for transferring a liquid cryogen from a storage vessel to a remote point of use. U. S. Pat. No. 3,433,028 and 3,364,689 are examples of cryogenic transfer lines that are known in the art. Transfer lines such as this are produced in smaller diameter versions for use in transferring a liquid cryogen, e.g., helium, from a storage dewar to a remote point of use such as instruments and the like used for infrared spectroscopy.

In building a transfer system for use with instruments requiring a liquid cryogen for cooling it is desirable to deliver the liquid to the point of use at a very low flow rate but with a constant flow rate. In the past this has been extremely difficult because the cryogen vaporizes resulting in what is known as "vapor binding" in the transfer line. This "vapor binding" results from the gas bubbles having a greater volume than the liquid thus forming a temporary block in the transfer line. This causes pressure to build up in the line to the point where the liquid is actually forced back into the storage dewar. At the delivery end of the transfer line the fluid is delivered in spurts with accompanying pressure and temperature cycling. The "vapor binding" results from heat leaking into the transfer line from the atmosphere and has been found with systems employing vacuum and solid type insulation between the actual liquid transfer tube and the outer jacket.

SUMMARY OF THE INVENTION

In order to avoid the above described problems, and to, in general, provide an improved transfer system it has been discovered that if the liquid cryogen is caused to flow in a separate conduit surrounding the actual cryogen transfer conduit of the system for substantially the length of the transfer conduit that this second source of cryogen acts as a shield fluid to the initial transfer conduit absorbing heat and preventing "vapor binding" in the transfer line. The second conduit surrounding the transfer conduit is provided with a nozzle in the end that is disposed in the source of liquid cryogen to provide for a pressure and temperature drop in the shield gas as it flows along the outer surface of the transfer conduit thereby subcooling the liquid in the center transfer conduit and preventing boiling thereof. The fluid in the annular space around the transfer conduit absorbs the energy radiated and conducted to the transfer line and evaporates as it proceeds from the supply end to the delivery end of the transfer system. The shield gas conduit is then vented outwardly of the covering jacket of the transfer system. It has also been found that the transfer system can be coupled to the source of the liquid cryogen by a special adaptor so that the normal boiling off of the cryogen in the storage vessel causes pressurization of the liquid cryogen to aid in steady state flow. It has also been found that a needle valve at the delivery end can be used to control the flow of the liquid cryogen and a heat exchanger in combination with the needle valve can be used to provide multiposition orientation of the delivery end of the transfer system.

Therefore it is the primary object of this invention to provide an improved liquid cryogen transfer system.

It is another object of this invention to provide a liquid cryogen transfer system that employs the liquid cryogen as a shield gas to prevent vaporization of the cryogen in the transfer tube.

It is still another object of this invention to provide a liquid cryogen transfer system that can be used in combination with self-pressurization of the storage vessel and metered flow at the delivery end of the transfer system.

It is yet another object of this invention to provide a cryogen transfer system wherein the actual transfer tube can be of small diameter to make the entire transfer system flexible.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a cross sectional schematic diagram of the transfer system according to the present invention shown in operating position on a cryogenic storage vessel.

FIG. 2 is a section taken along line 2—2 of FIG. 1.

FIG. 3 is an enlarged schematic of the delivery end of the cryogenic transfer system shown in conjunction with the needle valve and heat exchanger system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 there is shown a cryogenic transfer system 10 disposed with a cryogenic storage vessel 12 such as commonly referred to as a dewar wherein there is a quantity of cryogenic fluid 14.

The transfer system comprises a central transfer tube 16 that is disposed within the cryogenic fluid 14 and which actually transfers the cryogen from the dewar 12 to the remote point of use (not shown). Surrounding the transfer tube 16 is a complimentary tube 18 spaced apart from the tube 16 and held in fluid tight relation thereto. At the lower end 20, which is also referred to as the supply end of the cryogen transfer system, there is a nozzle 22. The tube 18 extends for almost the entire length of the actual cryogen transfer tube 16. At the delivery end 24 of the surrounding tube 18 there is a return conduit 26 which returns toward the supply end 20 of the conduit 18 and then exits outwardly of the jacket 28 through a suitable fitting 30. The entire system is covered by the jacket 28 which is in vacuum tight relationship to the inner conduits. The jacket 28 can be rigid but it also can be fabricated from flexible metallic coverings as are well known. The flexible metallic covering is preferred especially if the entire transfer line is to be flexible which can be accomplished by using small diameter conduits for the transfer tube 16 and the shield gas tube 18 and return tube 26. The end of transfer tube or conduit 16 that projects through the upper end 29 of jacket 28 contains a nozzle 31. A preferred method of achieving a flexible transfer system is disclosed in U.S. Pat. application Ser. No. 106,167 filed Jan. 13, 1971 and owned by the assignee of the present application.

The transfer system 10 is disposed in dewar 12 by means of a dewar adaptor 32. The dewar adaptor 32 includes a housing 34 which communicates with the neck 36 of dewar 12 and is held in fluid tight relation therewith. Included within housing 34 is sealing means 38 including O-ring sealing devices 40 as are well known in the art. Included with housing 34 is a conduit 42 and a pressure release valve 46 to prevent over pressurization of the system.
In operation the dewar is fitted with the adaptor 32 and the transfer system 10 thereby enabling the vaporizing cryogen in the dewar to increase the pressure inside the dewar and force liquid into both tubes 16 and 18. The nozzle 31 in conduit 16 is included to assure that the cryogenic fluid in conduit 16 remains at the pressure inside dewar 12, thereby maintaining its boiling point above the boiling point of the cryogenic fluid in tube 18. As the cryogen enters tube 18 through nozzle 22 it drops in both temperature and pressure. The net effect of this drop in temperature and pressure is to subcool the liquid in tube 16 and thus prevent that liquid from boiling. For example at a dewar pressure of 2.5 psig liquid helium would have a boiling temperature of 4.4°K. At essentially atmospheric pressure (inside tube 18) the helium has a boiling temperature of 4.2°K. The liquid flowing in the annulus defined by tubes 16 and 18 also absorbs any energy radiated or conducted to the transfer line by evaporating the liquid as it proceeds from the supply end 22 to delivery end 24 of conduit 18. The liquid plus vapor is then conducted by a conduit 26 outwardly of the vacuum jacket 28 through the fitting 30. Because the cryogen flowing in the annulus defined by conduits 16 and 18 intercepts all heat leaking into the transfer line it is referred to as a shield gas conduit. The shield gas flow is a non-steady flow as a result of this heat input. However, if sufficient shield gas flow is present so that it is in a saturated state as it is vented through port 30 the cryogen flowing in conduit 16 will be subcooled and will be pure liquid.

With the device of FIG. 1 and 2 it is possible to achieve a steady flow of cryogenic liquid in the transfer line at a very low flow rate. Because the liquid is delivered in a saturated or subcooled state the size of a vacuum pump required to get to sub-atmospheric saturation pressure in the vessel to which the liquid is delivered is minimized. The fact that small cryogen transfer tubes can be used minimizes heat leak and allows for the system to be made flexible so that it can be readily bent into a variety of positions. The shield gas requirement is small thus enabling the transfer efficiency for the overall system to be very high. Another benefit arises from the fact that the small transfer tubes having small thermal mass make the cooldown time very minimal.

There is shown in FIG. 3 a CRYO-TIP refrigerator 44 which receives the transfer system 10 by means of an adaptor 46 from which the conduit 16' and 18' project toward the end of refrigerator 44 through a suitable refrigeration body 48. Conduits 16' and 18' are the delivery end counterparts of conduits 16 and 18 of FIG. 1. The projecting end 45 of the transfer system terminates at a needle valve 50 which serves to control the flow of the liquid cryogen. The needle valve 50 has a valve member 52 that can be adjusted by means of adjusting nut 54 at the top of the refrigerator body 48. The refrigerator body 48 includes suitable heaters to raise the temperature of the venting gas as it is conducted outwardly of the system through vent 60, lead through ports 58, and vacuum connector 62 for evacuating the system.

At the needle valve 50 end of the refrigerator there is a sample holder 64 which contains a suitably threaded aperture 66 and a heater 68 for warming the delivered cryogen. Between the needle valve 50 and the specimen holder 64 there is a heat exchanger 70. The heat exchanger 70 serves to transfer the heat from the sample holder to the cryogenic fluid. Because the cryogenic fluid is forced through the exchanger the tip can operate in any orientation. The heat transfer is counter flow, thus it is possible to have the liquid enter from the needle valve and be warmed to a high temperature as it flows through the heat exchanger. For example, if liquid helium is being used, it flows from the needle valve 52 as a saturated liquid at 4.2° Kelvin and can then be warmed to 300° Kelvin as it flows through the heat exchanger. The refrigerator 44 contains the necessary ports 71 for venting the warmed cryogenic fluid from the entire system through vent 60. The refrigerator 44 is shown inserted in a receptacle 73, such as an instrument adaptor or the like, by known sealing means to assure a pressure-tight fit.

Referring back to FIG. 2 there is shown an insulating layer 27 surrounding conduits 16, 18, and 26. This layer can be a multi-layer insulation such as synthetic sheet material with a metalized coating. The insulation extends to the delivery end of the system and is disposed around conduit 16', 18' and 26' of FIG. 3.

Having thus described my invention the following is desired to be secured by Letters Patent of the United States.

1. A cryogenic transfer system for transferring a liquid cryogen from a storage container to a remote point of use with the liquid being delivered at constant temperature pressure and flow rate comprising:
   a liquid transfer conduit having a first end disposed in a source of liquid cryogen and a second end with a nozzle therein for delivering the liquid cryogen to a point of use;
   surrounding said liquid transfer conduit in spaced relation thereto a second conduit, said second conduit extending for substantially the length of said liquid transfer conduit;
   a nozzle on one end of said second conduit the end containing the nozzle disposed within the liquid inventory of the source of liquid cryogen;
   surrounding said second conduit containing said liquid transfer conduit and in spaced relationship thereto an outer jacket, said outer jacket being in vacuum tight relationship to said transfer and second conduits;
   means for venting said second conduit outwardly of said jacket; and
   means for connecting said transfer system in pressure tight relationship to said cryogen storage container.

2. A cryogenic transfer system according to claim 1 wherein there is included valve means to vary the flow of liquid cryogen at the delivery end of the system.

3. A cryogenic transfer system according to claim 1 wherein the means for venting said second conduit includes a separate conduit for returning said second conduit flow to a point near the cryogen storage end of the system for venting.

4. A cryogenic transfer system according to claim 1 wherein there is provided a multilayer insulation surrounding said conduits.

5. A cryogenic transfer system comprising a first liquid cryogen transfer conduit having a supply end disposed in a cryogen supply vessel and a
delivery end for providing cryogen at a point of use;
a nozzle in the delivery end of the liquid cryogen transfer conduit;
a second conduit spaced apart from said first conduit and concentric therewith for substantially the length of said first conduit;
said second conduit being in fluid tight relation to the first conduit and including a nozzle at the end adjacent the supply end of the first conduit;
a jacket surrounding a substantial length of the first and second conduits and forming a vacuum tight closure around the conduits;
a third conduit extending from the delivery end of the second conduit to a point near the supply end of the second conduit and outwardly of the jacket to form a vent;
an adaptor to fix the system to a cryogen supply vessel in pressure tight relation thereto; and means for metering the flow of liquid cryogen at the supply end of the system.
6. A system according to claim 5 wherein the metering includes a variable needle valve attached to the supply end of the system.
7. A system according to claim 6 including a heat exchanger on the delivery end of the system.
8. A system according to claim 7 wherein the heat exchanger is disposed between the needle valve and means for supporting an object to be cooled by the cryogen, the object supporting means including a control heater in contact with the heat exchanger.

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