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CRYOGENIC LIQUID TRANSFER TUBE, METHODS OF CONSTRUCTING TUBE AND OF TRANSFERRING LIQUID

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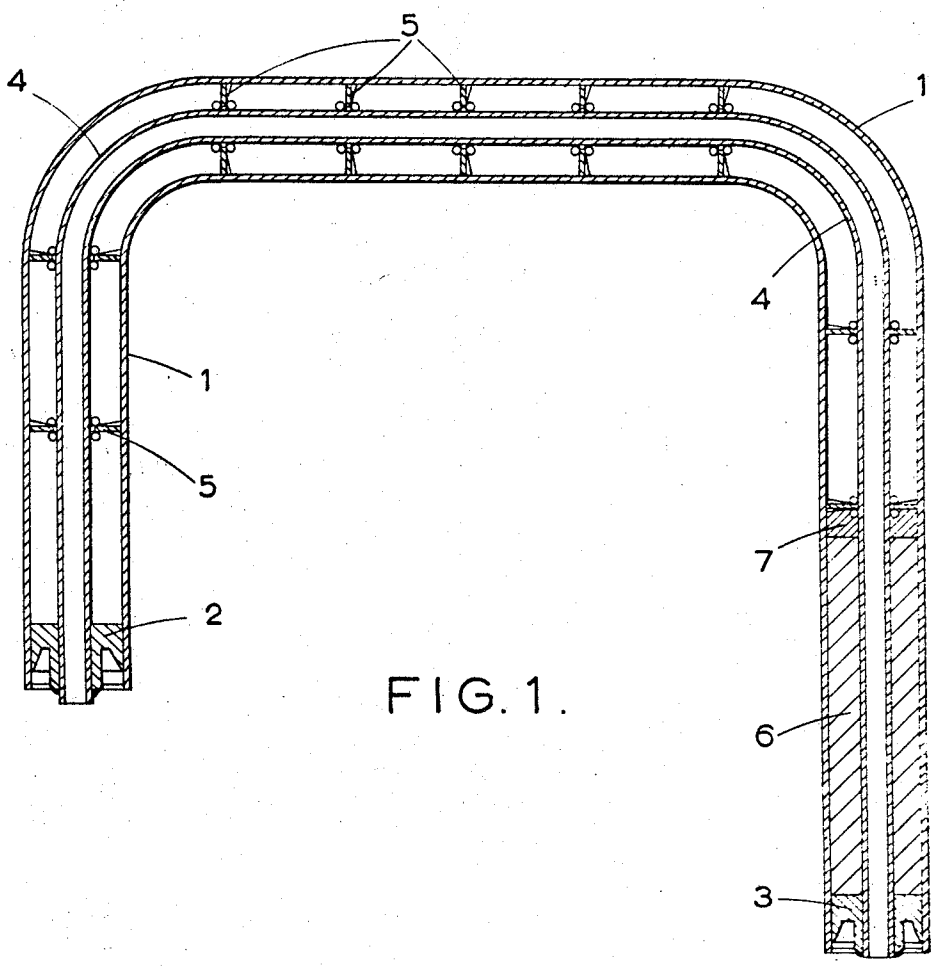


FIG. 1.

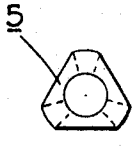


FIG. 2.

INVENTORS
NORMAN K. WRIGHT
MAURICE E. KITE
BY Frank K. Iriani
AGENT

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CRYOGENIC LIQUID TRANSFER TUBE, METHODS OF CONSTRUCTING TUBE AND OF TRANSFERRING LIQUID

Norman K. Wright, Horsham, and Maurice E. Kite, Smallfield, England, assignors, by mesne assignments, to U.S. Philips Corporation, New York, N.Y., a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

A cryogenic-liquid transfer tube is formed of concentric inner and outer tubes which define between them an annular space, the tubes being joined at their adjacent ends to thereby seal the ends of the annular space and within the space is disposed a quantity of gas-adsorbent material and a quantity of condensable gas such as argon. During operation of the transfer tube the argon is cooled and liquefied, thereby producing a vacuum in the annular space which then functions as a heat insulator. During inoperation such as when a blockage of solid gas or water occurs in the inner tube, the outer tube is heatable to vaporize the argon which then fills the annular space such that heat can be transferred through the space to melt said blockage.

The invention relates to a cryogenic liquid transfer tube and to its construction. Transfer tubes for use when transferring a liquified gas, such as helium, from a storage Dewar vessel to a smaller flask in which it is required, are well known. They generally consist of a U-shaped tube comprising two stainless steel leg portions and a bridging section which is surrounded coaxially by a larger stainless steel tube sealed to the two leg portions. The space between the stainless steel tubes may be evacuated through a valve in the outer tube or may be evacuated and sealed during manufacture. The vacuum in the coaxial section prevents excessive heat loss during transfer of liquid through the tube.

Occasionally the inner tube becomes blocked by gas or water solidifying and forming a plug in the bridging section. When this occurs it is difficult to remedy and the inner tube has to be heated to melt the plug. If the coaxial portion of the transfer tube is fitted with a vacuum valve this can be released and air admitted so that heat can now be transmitted to the inner tube via the air in the coaxial portion. However, if the vacuum in the coaxial portion cannot be removed then the plug has to be heated by conduction along the inner tube.

It is an object of the invention to provide a transfer tube which mitigates the above disadvantage and which is also easily constructed. It is a further object of the invention to provide a cryogenic liquid transfer tube comprising an outer tube and an inner tube, said inner tube being coaxially positioned within said outer tube, said tubes being each sealed at one of its ends, a quantity of molecular sieve material or other gas adsorbent material in the space between said inner and outer tubes forming a sealed spaced in the area between said molecular sieve material and the sealed ends of said tubes, said sealed space containing a gas which liquifies at the operating temperature of said transfer tube, said gas being liquified in said molecular sieve material to thereby produce a vacuum in said sealed space when said transfer tube is operative and a substantially normal atmospheric pressure in said sealed space when said transfer tube is inoperative.

The gas may be argon and the molecular sieve material finely divided carbon. Preferably the inner and outer tubes are made of stainless steel which are sealed with the aid of stainless steel plugs and argon arc welded together. Spacers may be provided between the inner and outer tubes and care should be taken to prevent the tubes touching, other than at their ends, during use.

According to a further aspect of the invention there is provided a method of manufacturing a cryogenic liquid transfer tube comprising the steps of filling part of the space between a stainless steel outer tube and a coaxially spaced stainless steel inner tube with a molecular sieve material, causing argon gas to flow through said space to reactivate said molecular sieve material, sealing the inner and outer tubes together at said argon gas outlet end, and sealing the inner and outer tubes at said other end so as to trap within said sealed space between said coaxially arranged tubes the molecular sieve material and argon gas at substantially atmospheric pressure. The molecular sieve material is preferably finely divided charcoal screened to No. 10 mesh.

A cryogenic liquid transfer tube and method of manufacturing same will now be described, by way of example, with reference to the accompanying diagrammatic drawings in which:

FIGURE 1 is a cross section elevation view of the transfer tube;

FIGURE 2 is a plan view of a spacer for the transfer tube.

Referring now to the drawing the gas transfer tube comprises an outer tube **1** of stainless steel welded at its ends by means of two stainless steel plugs **2** and **3** to an inner tube **4** of stainless steel. In the sealed space between the outer tube **1** and the inner tube **4** is a number of stainless steel spacers **5**, one of which is shown in plan view, in FIGURE 2, these help to maintain the tubes **1** and **4** in a substantially coaxial relationship. The space between the coaxial tubes **1** and **4** also includes argon gas and in section **6** a quantity of granulated charcoal. The charcoal in section **6** is trapped between a plug **7** of glass and wool and the plug **3**.

A particular embodiment of such a liquid transfer tube as described above was constructed as follows, referring also to the drawing. The transfer tube consisted of two tubes of stabilized stainless steel 18–8T1 (EN58B). Each tube is approximately 0.018 inch thick and 109 inches long and the external diameters of the inner and outer tubes are 0.157 and 0.375 inch respectively. A number of substantially triangular shaped spacers, as shown in FIGURE 2, are provided with corrugated and rounded apices so as to increase their rigidity. The spacers are held on the inner tube **4** between a pair of circlips (not shown). The inner tube **4** provided with the spacers **5** in inserted in the outer tube **1**. The tubes are bent to the desired shape with a bridging section of 27 inches connected by 2.5 inches radius bends to two leg portions of 33 and 44 inches respectively. The shaping is achieved by filling the space between the tubes with water, which is then frozen by blowing liquid nitrogen through the inner tube. The ice prevents the tubes from collapsing as they are bent to shape. The ice is then melted and the tubes dried out.

A plug **7** of glass wool backed by 40 mesh gauze (EN58B) is now inserted through an open end into the space between the tubes **1** and **4** in one leg of the now U-shaped tubes. The plug is tamped down onto the first spacer in this leg and the space between the end of the tubes and the plug **7** is filled with finely divided charcoal.

The outer tube **1** is wrapped with electrical heating tape and the temperature of the tubes is maintained between

350° C. and 450° C., preferably at 400° C. The tubes are connected to an argon gas supply and argon is passed through the charcoal for a sufficient time to reactivate it. The argon is blown through the charcoal while the plug **2** is inserted in position. The outer tube **1** is then argon arc welded to the plug **2**. The tubes are then held in a jig so that the inner tube **4** can be pushed into the outer tube and held during welding to the plug **2** so that when the tubes are cooled, any difference in the amounts they contract will not cause the inner and outer tubes to come into direct contact at the bends.

When the plug **2** is welded to both the inner and outer tubes the argon supply is disconnected and the plug **3** inserted. The plug **3** is now argon arc welded in a manner similar to the plug **2** so that the space between the tubes **1** and **4** is now hermetically sealed and contains activated charcoal and argon. The heating tape is now removed. The plugs **2** and **3** are preferably machined from 0.5 inch stainless steel sheet so that the grain is across the bore. This helps to prevent porosity at the welds.

In operation the transfer tube is inserted between a Dewar flask, in which the liquid gas is required, and a storage Dewar containing, say liquid helium or hydrogen, the leg containing the charcoal being inserted into the storage Dewar. The argon gas in the space between the tubes **1** and **4** liquifies in the charcoal which acts as a molecular sieve. As the argon liquifies a vacuum is formed in the space between the tubes and so the inner tube **4** is effectively thermally insulated from the outer tube **1**. If a blockage of solidified gas or water occurs in the inner tube **4** this can be easily dissipated by firstly removing the tube from the Dewar flasks and allowing the leg portion of the transfer tube containing the charcoal to warm up. This brings the pressure in the space between the tubes **1** and **4** back to substantially atmospheric pressure and heat from the outer tube can be easily transmitted via the argon gas to the inner tube to melt the blockage.

If it is desired to extend either leg of the transfer tube, the end may be threaded or some other form of coupling provided so that the inner tube extends beyond the coaxial section. However, care should be taken to ensure that when the leg containing the carbon is inserted in the storage Dewar flask the carbon containing portion of the leg is in good thermal contact with the liquid gas so that the vacuum between the coaxial tubes is formed quickly.

It has been found that a higher transfer flow rate is achieved with the transfer tube according to the invention than with the known tubes.

What is claimed is:

1. A method of manufacturing a cryogenic liquid transfer apparatus comprising the steps:

(a) fixedly disposing an inner tube within an outer tube to define therebetween an annular space;

(b) disposing gas-adsorbent material in a portion of the annular space;

(c) flowing a condensable gas through said material to reactivate the material;

(d) disposing said gas at substantially atmospheric pressure in said space; and

(e) joining the ends of the inner and outer tubes to seal the annular space, the gas being (i) condensable when the inner tube is at an operating temperature established by the flow of cryogenic liquid therethrough, and (ii) adsorbable in said material thereby establishing a partial vacuum in said space.

2. A method as defined in claim **1** comprising the additional steps (following step a):

(a') filling said annular space with water;

(b') flowing liquid nitrogen through the inner tube to freeze said water;

(c') bending said tubes to a desired shape; and

(d') removing said ice by melting same.

3. In a method for transferring a cryogenic liquid through an inner tube of an apparatus having outer and inner tubes and a sealed annular space therebetween, the improvement in combination therewith for removing a blockage of frozen liquid in said inner tube, comprising the steps:

(a) (prior to the flowing said liquid through said inner tube) disposing in said space (1) a quantity of gas adsorbing material and (2) a quantity of condensable gas at substantially atmospheric pressure,

(b) flowing said liquid through the inner tube thereby (1) cooling and condensing the gas, and (2) adsorbing the gas in said material with a vacuum being established in the annular space, and

(c) removing a blockage of frozen liquid when it develops in said inner tube, by (1) applying heat to the exterior of the outer tube; (2) conducting said heat into said annular space and into the adsorbed condensed gas therein, thereby vaporizing said gas which then becomes situated at substantially atmospheric pressure in said space thus eliminating the vacuum, and (3) conducting said heat through said vaporized gas to the inner tube, to thereby melt and remove said blockage of frozen liquid therein.

4. A tubular apparatus for transferring a cryogenic liquid and for overcoming a blockage in the apparatus of frozen cryogenic or other liquid comprising:

(a) an outer tube;

(b) an inner tube fixedly positioned within the outer tube to define an annular space therebetween;

(c) means joining the adjacent ends of the tubes and thereby sealing the ends of the annular space;

(d) a quantity of gas-adsorbent material disposed in said sealed annular space; and

(e) a quantity of condensable gas disposed in said annular space, the gas being condensed and substantially adsorbed by said material at the operating temperature of the apparatus when cryogenic liquid is transferred therethrough thereby producing a vacuum in said space, the gas (when the apparatus is inoperative and at a temperature above said operating temperature) (i) being vaporized and situated at substantially normal atmospheric pressure and (ii) being substantially conductive of heat from the outer tube to the inner tube to melt said blockage in the inner tube.

5. Apparatus as defined in claim **4** wherein said gas-adsorbent material is finely divided carbon.

6. Apparatus as defined in claim **4** wherein said gas-adsorbent material is a molecular sieve.

7. Apparatus as defined in claim **4** wherein said gas in the annular space is substantially argon.

8. Appartus as defined in claim **4** further comprising a gas-permeable plug fixedly positioned in said annular space and spaced from one sealed end thereof thereby defining a pocket, the gas-adsorbent material being located and retained in that pocket.

9. Apparatus as defined in claim **8** wherein said gas-permeable plug is formed of glass-wool.

10. Apparatus as defined in claim **4** wherein said inner and outer tubes are generally coaxial, said tubes and means joining their ends are stainless steel and are argon-arc-welded together.

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LLOYD L. KING, *Primary Examiner.*