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Kadi et al.

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[54] **FLEXIBLE CRYOGENIC LIQUID TRANSFER SYSTEM AND IMPROVED SUPPORT MEANS THEREFOR**

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[52] **U.S. Cl.** **62/55,** 138/112, 138/114, 285/DIG. 5

[51] **Int. Cl.**.....**F25d 25/10**

[58] **Field of Search** 62/45, 52, 55, 514; 138/112, 138/114, 148, 149; 285/DIG. 5

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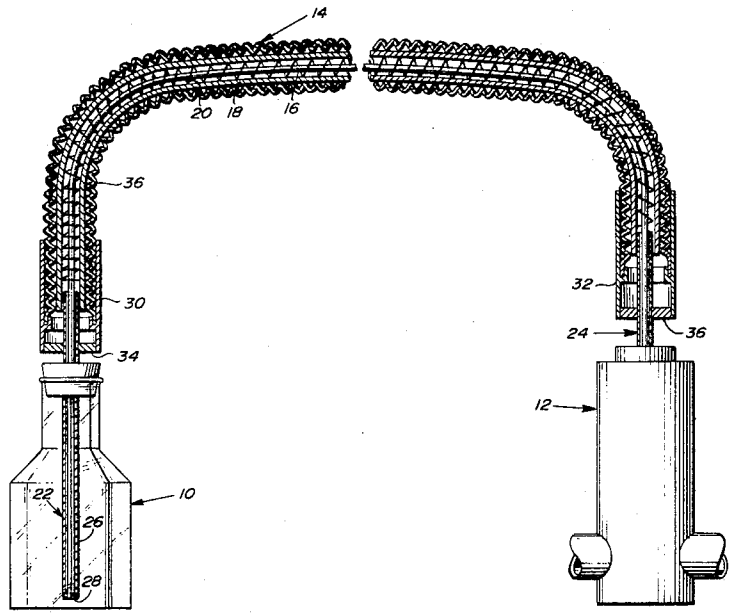
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[57] **ABSTRACT**

A flexible cryogenic fluid transfer system wherein the fluid conduit is held in spaced relation to the outer flexible hose by an improved support system. The support system is characterized in that a hollow support member surrounding the fluid conduit is provided with a plurality of helicly disposed slotted apertures on its surface. A continuous filament is wrapped around the support member and those portions of the filament in the slotted apertures serve to position and hold the inner fluid conduit.

9 Claims, 7 Drawing Figures



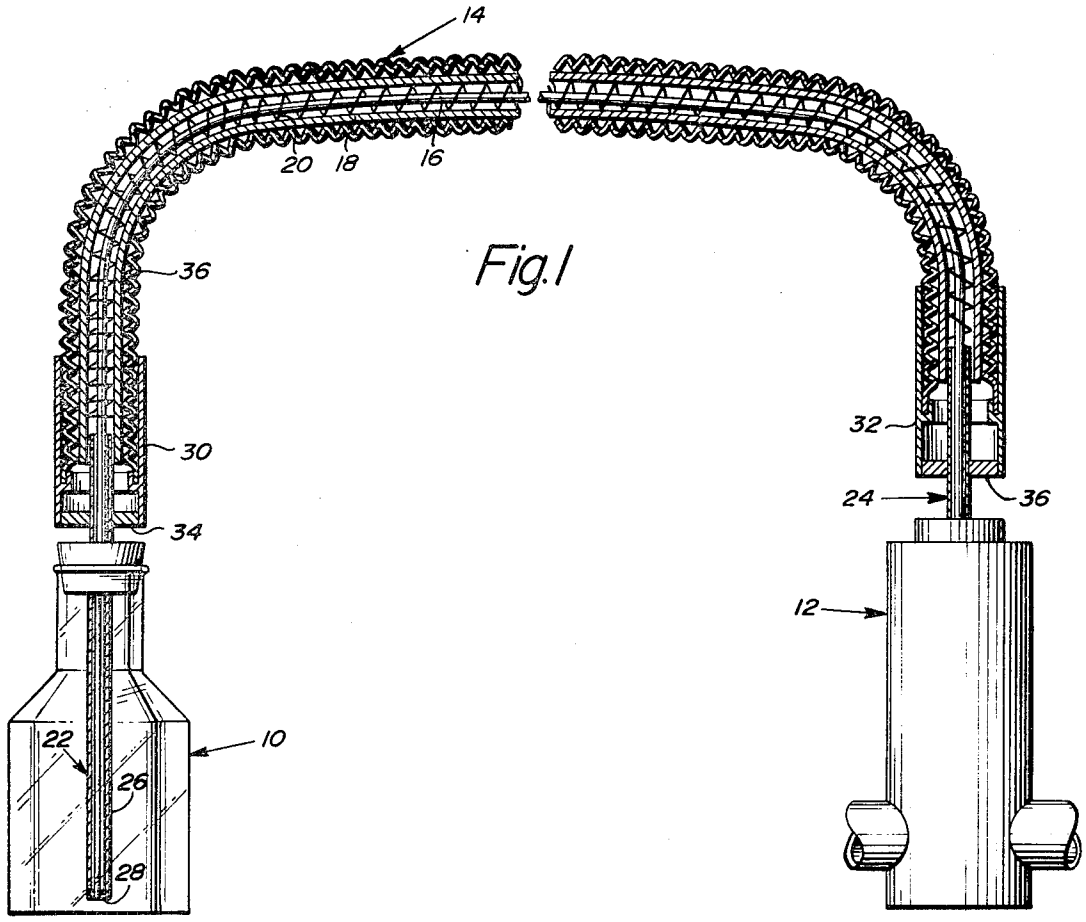


Fig. 1

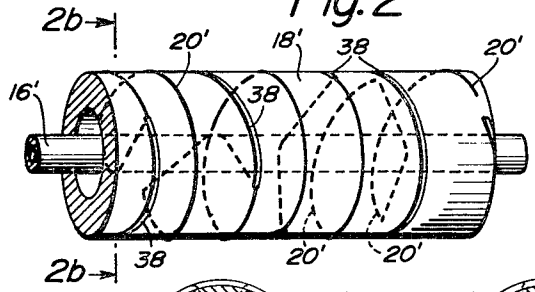


Fig. 2

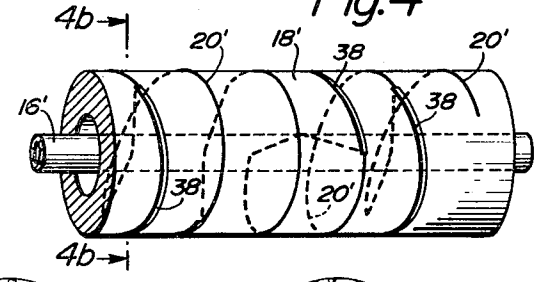


Fig. 4

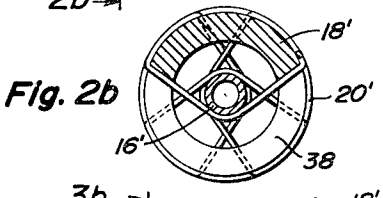


Fig. 2b

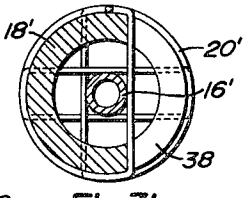


Fig. 3b

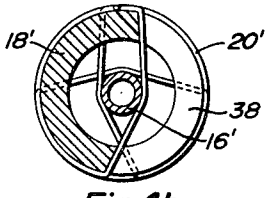


Fig. 4b

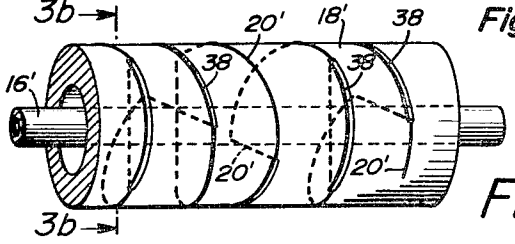


Fig. 3

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FLEXIBLE CRYOGENIC LIQUID TRANSFER SYSTEM AND IMPROVED SUPPORT MEANS THEREFOR

BACKGROUND OF THE INVENTION

This invention pertains to liquid cryogen transfer systems such as are used to transport a liquid cryogen from a storage dewar to a remote point of use. Such devices are used to transport the liquid cryogen from a supply dewar to cryo-surgical devices, analytical instruments, smaller dewars, and the like.

In prior art cryogenic transfer systems it has been difficult to make such a transfer system flexible and prevent large heat influx to the liquid cryogen thereby increasing the liquid cryogen loss due to vaporization. In making the system flexible it has been found necessary to maintain the tube or conduit through which the cryogen flows in a spaced relationship to the outer covering of the transfer system in order to prevent heat influx by moving the cryogen transfer tube closer to one side of the outer covering. If in fact the fluid conduit or tube contacts the outer covering this causes heat influx by conduction. Problems common to prior art flexible transfer lines are relatively high heat conduction losses through solid spacers (supports) and prolonged cooldown time of these spacers.

Prior art flexible transfer systems were of necessity very complex in design and difficult to manufacture because of the required insulation and positioning of the central transfer tube.

SUMMARY OF THE INVENTION

In order to avoid the above-mentioned problems and to provide an improved cryogen fluid transfer system, it has been discovered that when the cryogen transfer tube is supported within a hollow support member that has been provided with slotted apertures disposed on its surface in a helical pattern and a filament is continuously wound around the support member and allowed to enter the slotted apertures the central cryogen transfer tube is supported centrally of the support member and if the support is twisted or bent the cryogen transfer maintains its position in the central location.

It has also been found that when the support apparatus is incorporated into a liquid cryogen transfer system that it permits rapid cooldown of the entire system. The improved support means also allows for more positive positioning of multi-layer insulation around the cryogen transfer tube if such insulation is desired.

Therefore, it is the primary object of this invention to provide an improved method for supporting an elongated object in spaced relation to and within a complimentary hollow elongated object.

It is a further object of this invention to provide an improved method for supporting a cryogen transfer tube within a surrounding insulated jacket.

It is yet another object of this invention to provide an improved flexible cryogen transfer system.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a cross-sectional view (partially schematic) of a liquid cryogen transfer system according to the present invention.

FIG. **2***a* is a perspective view of the one embodiment of the support system according to the present invention.

FIG. **2***b* is a section taken along the line **2***b*—**2***b* of FIG. **2***a*.

FIG. **3***a* is a perspective view of a second embodiment of a support system according to the present invention.

FIG. **3***b* is a section taken along the line **3***b*—**3***b* of FIG. **3***a*.

FIG. **4***a* is a perspective view of another embodiment of the support system according to the present invention.

FIG. **4***b* is a section taken along the line **4***b*—**4***b* of FIG. **4***a*.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Shown in FIG. **1** is a fluid cryogen transfer system according to the present invention for transporting a fluid such as liquid helium or a liquid hydrogen from a storage dewar **10** to a cryogenic refrigerator **12**. The cryogenic refrigerator **12** can be those commonly used for cooling in an infra red spectrophotometer or the like found in the research laboratory.

The transfer system is shown generally as **14** consisting of the actual liquid transfer tube **16** which is supported by a combination of a support conduit **18** and continuously wound filament **20** as will be hereinafter more fully explained. The extreme ends of the conduit **16** that enter the dewar **10** and the refrigerator **12** are provided with bayonet ends **22** and **24** respectively. The bayonet end **22** comprises a sleeve **26** and end closure **28**. The bayonet ends **22,24** are fitted in adapter sleeves **30,32** through end caps **34** and **36** respectively. The adapters **30**, **32** are in turn fitted with a flexible outer hose covering **36** which is fastened to the adapters **30**, **32** respectively. The outer hose **36**, adapters **30**, **32**, bayonet ends **22**, **24** are assembled in vacuum relation so that the inner space defined by the adapters **30** and the interior portion of flexible hose **36** can be evacuated to further insulate the central conduit **16** from the atmosphere.

Between the support member **18** and the transfer tube **16** there may be provided what is known as superinsulation. Superinsulation is taken to mean a multilayer insulation generally comprising a metallic layer on top of a very thin synthetic sheet material. It is also possible that the outer surface of transfer tube can be plated with a low emissivity material such as gold or aluminum.

While the outer hose **36** is preferably a flexible corrugated metal it can be fabricated from other materials used for transfer systems.

The liquid transfer tube **16** is preferably made of a chromium nickel stainless steel. If the transfer tube is to be used in a permanent or semi-permanent application it is preferable that the tubing be in the annealed condition so as to minimize stresses on the support matrix when the transfer system is in use.

If the transfer system is to be used for varying purposes then it is preferred that the stainless tubing be slightly work-hardened to promote flexibility.

In operation the transfer system functions to transport the liquid cryogen similar to prior art systems with

the important advantage of having a rapid cooldown time. This characteristic is due to the low thermal mass of the material which is in good thermal contact with the central transfer tube **16**. The thermal mass consists of a thin-walled transfer tube **16**, the super-insulation and those portions of the support matrix filament **20**.

Referring to FIG. **2***a* and **2***b* there is shown in more detail one embodiment of the support system as employed in the transfer system **14** of FIG. **1**. The central transfer tube **16'** is disposed within the support member **18'**. On the circumference of support member **18'** there is disposed a plurality of slotted apertures **38**. The apertures **38** extend along the circumference of the support member **18'** and for their length pierce the wall of the support member **18'**. The apertures **38** are spaced around the circumference of the support member **18'** so that they begin and end at different locations along the outside surface of support member **18'** and define a generally quadrant shaped aperture in the wall of the support member **18'**. A continuous filament **20'** is then wound in a helical pattern around the supported member **18** and allowed to enter the apertures **38** as they appear on the surface of support member **18'**. In this way, as is shown in ghost lines, the filament **20'** supports the transfer tube **16'** within the center of the support member **18**. This is more readily shown in FIG. **2***b*.

By controlling the depth and width of the apertures **38**, it is possible to achieve different support configurations for the central tube **16'**. This is shown more clearly in FIGS. **3***a*, **3***b*, and **4***a* and **4***b* wherein different support configurations are shown.

The support system as shown is effective because the load-carrying capacity of any filament shaped material is greater in tension than in compression. It is also known that, in terms of heat transfer through a support member used in a liquid cryogen transfer system, the cross-sectional area and consequently the conduction of heat can be significantly reduced. Therefore, when a material possessing both high-strength and low terminal conductivity is used with a tensile support design as is shown above it is possible to minimize heat transfer. The fiber-support material is preferably a multistrand synthetic polyester or a synthetic monofilament strand and is wrapped around a flexible, low outgasing rate, tubing material such as polytetrafluoroethylene or polyethylene. These materials function together so that when the entire assembled transfer tube is bent the flexibility of the system is achieved. It is also possible to use a flexible corrugated metal tube as the support member.

In actual fabrication it is preferred to position the transfer tube **16** within the support member **18** and then proceed to wind the filament **20** in a helical pattern around the support member **18**. As the filament is being wound, the slotted incisions previously made in the support member allow the filament to be positioned for supporting the transfer tube **16**.

It is also possible that the continuous filament could be threaded through a plurality of discrete holes in the support member **18**. However, this is a more complicated fabrication technique.

For convenience it has been shown that the support member **18** is cylindrical. It is possible with this invention to use other shapes for support member **18** as long as they have a hollow bore that is complimentary to the transfer tube being supported.

While it is preferred that filament **20** be a continuous strand it is within the scope of the invention to use individual lengths of the filament disposed in an aperture and fastened to support member **18** as by tying or bonding thereto.

It is also possible to support a plurality of transfer tubes of uniform or non-uniform outside surface configuration with the support system of the present invention.

After assembling the transfer system the entire system is evacuated to provide increased insulation for the transfer tube.

As has been shown the support means of the present invention minimizes the heat influx and consequently insures greater thermal efficiency of the system.

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

We Claim:

1. A means for supporting an elongated object in spaced relationship to and within a hollow elongated object comprising:

a plurality of slotted apertures in said hollow elongated object disposed substantially perpendicular to the axis of said hollow elongated object, said apertures being spaced one from the other, each of said apertures beginning and ending in the outside surface of the hollow elongate object at a different location than the adjacent apertures;

a filament wrapped around said hollow elongated object and disposed in said apertures;

whereby said elongated object is held within and in spaced relationship to said hollow elongated object.

2. A support system according to claim **1** wherein the apertures extend no deeper than one-half the cross-section of said hollow elongated object.

3. A support system according to claim **1** wherein the apertures are disposed in a helical relationship to the axis of the hollow elongated object.

4. A support system according to claim **1** wherein the hollow elongate object has a shape complimentary to the shape of the elongated object being supported.

5. A support system according to claim **1** wherein the apertures are of equal depth from the outside surface of said hollow elongate object.

6. A flexible cryogenic liquid transfer system for transferring a liquid cryogen from a storage dewar to an apparatus to receive the cryogen and be cooled thereby comprising in combination:

a liquid transfer conduit;

disposed around and in fluid tight relation to a portion of either end of said transfer conduit, means for engaging receiving means on the storage dewar on one end and on the apparatus to be cooled on the other end to hold the transfer conduit in fluid tight relation therebetween;

surrounding a portion of each of said first mentioned means and the transfer conduit therebetween a jacket;

disposed within a substantial portion of said jacket and spaced apart from said transfer conduit a length of flexible tubing;

a plurality of slotted apertures in said tubing disposed substantially perpendicular to the axis of said flexible tubing, said apertures being equally spaced one from the other, each aperture beginning and ending in the outside surface of said flexible tubing at a different location than the beginning and ending of the adjacent apertures;

a filament wrapped around said flexible tubing and disposed in said apertures to support said transfer conduit in spaced relation to the hollow tubing.

7. A cryogenic transfer system according to claim 6 wherein the transfer conduit is held in vacuum-tight relationship to said first mentioned means and said jacket.

8. A transfer system according to claim 6 wherein the jacket is a flexible hose, the tubing is of a flexible synthetic material, and the filament is continuously wrapped around the tubing.

9. A transfer system according to claim 8 wherein the apertures in the flexible tubing extend no deeper than one-half the cross-section of the tubing.

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