# United States Patent

[11] 3,565,118

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[21] Appl. No. **747,284**
[22] Filed **July 24, 1968**
[45] Patented **Feb. 23, 1971**

[54] **THERMAL INSULATION FOR FLUID STORAGE CONTAINERS**
**9 Claims, 3 Drawing Figs.**

[52] U.S. Cl. **138/112;** 138/148; 138/149; 220/9
[51] **Int. Cl.** **F16l 9/18**
[50] **Field of Search** 138/111, 112, 113, 114, 148, 149; 220/15; 161/241, 242

[56] **References Cited**

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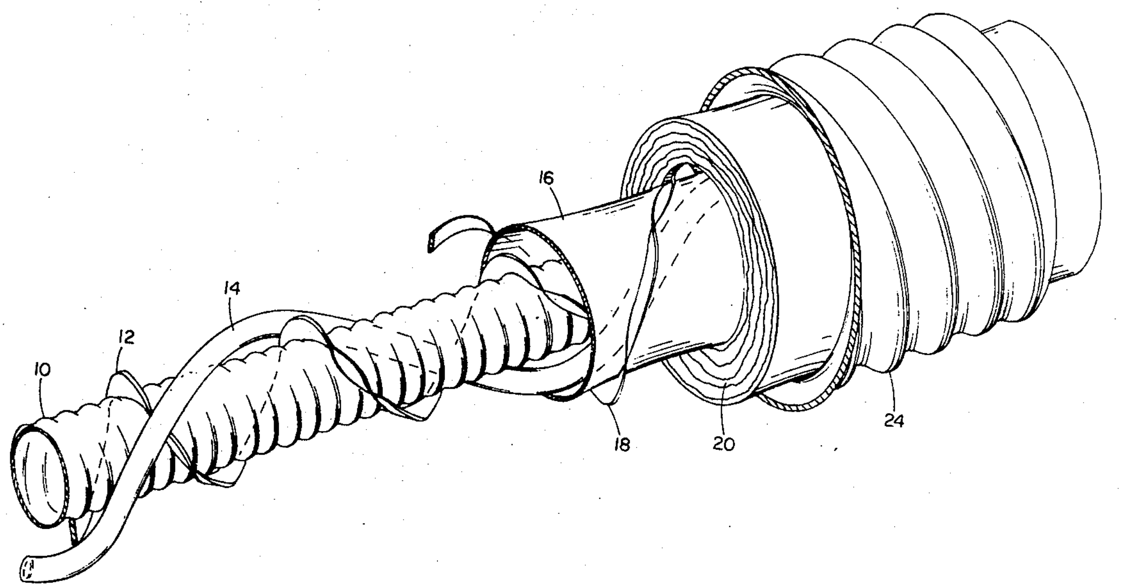
**ABSTRACT:** Insulation for fluid storage chambers includes a hollow vacuum-tight tube or sets of tubes surrounding the chamber and spaced from the chamber and from each other by thermal insulating spacer means, each tube, or set of tubes, being in contact with a heat-conductive layer extending circumferentially with or without helical windings and spaced convolutions, around the chamber, and separated from one another and from the chamber by thermal insulating spacer means.



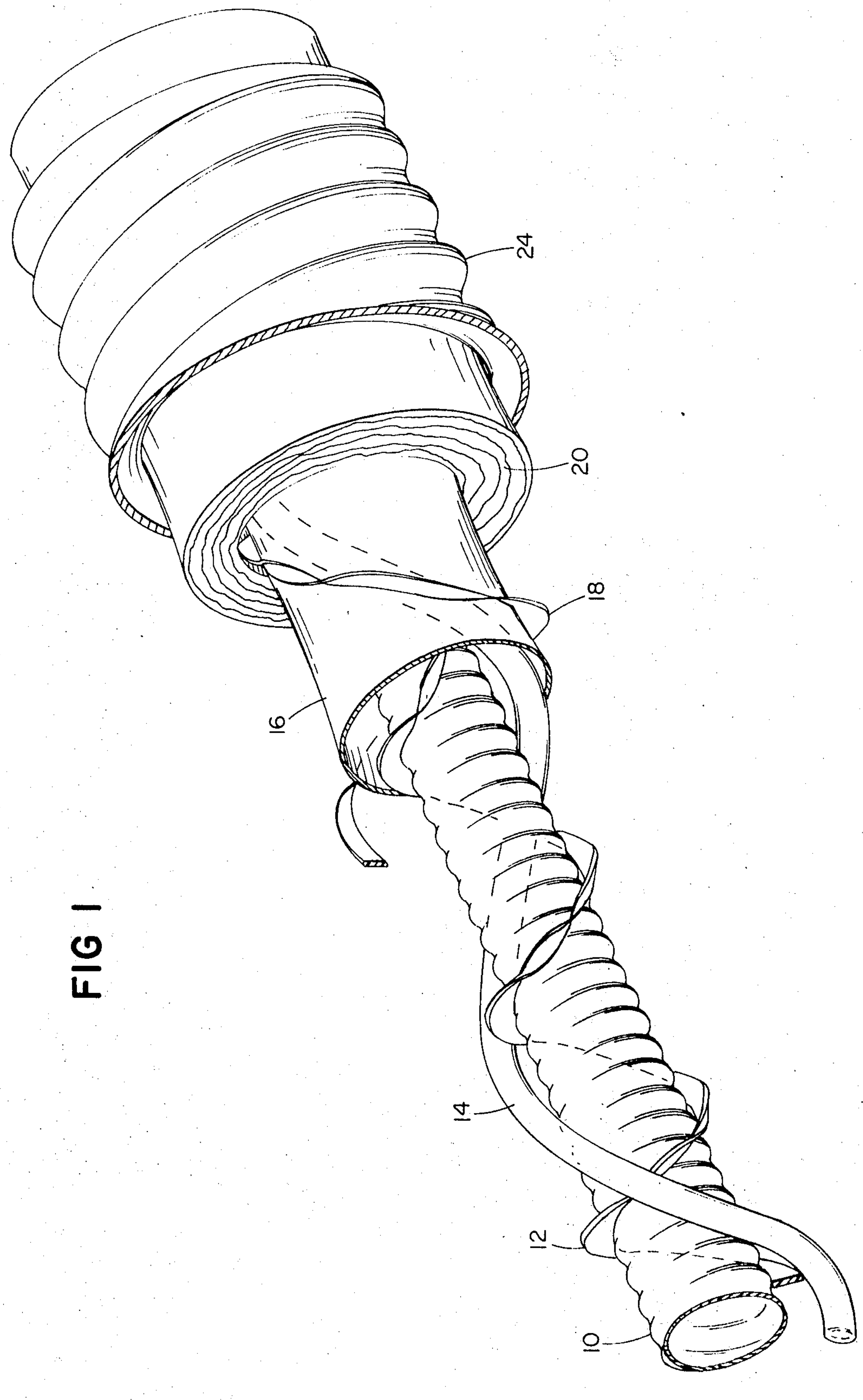
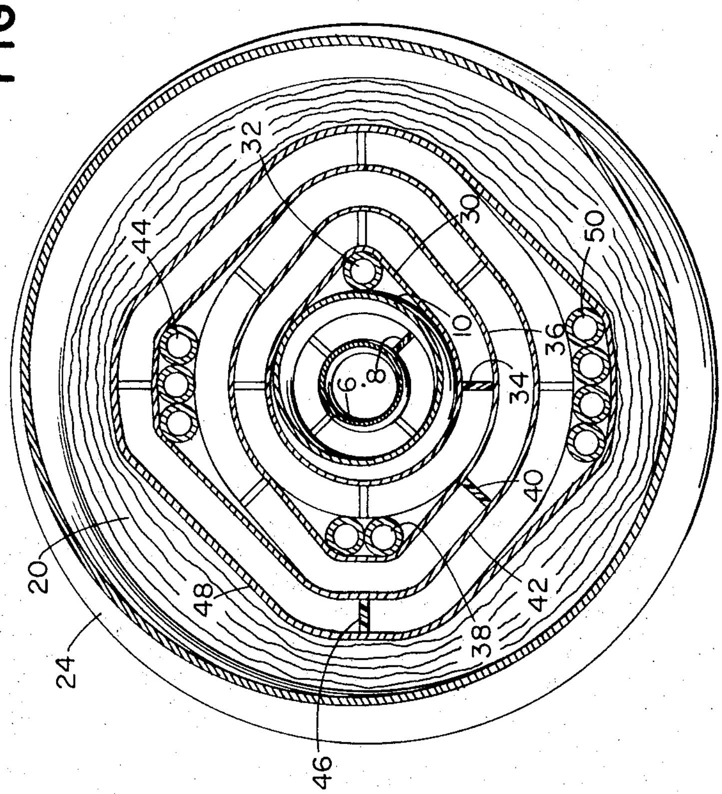



FIG I

FIG 3



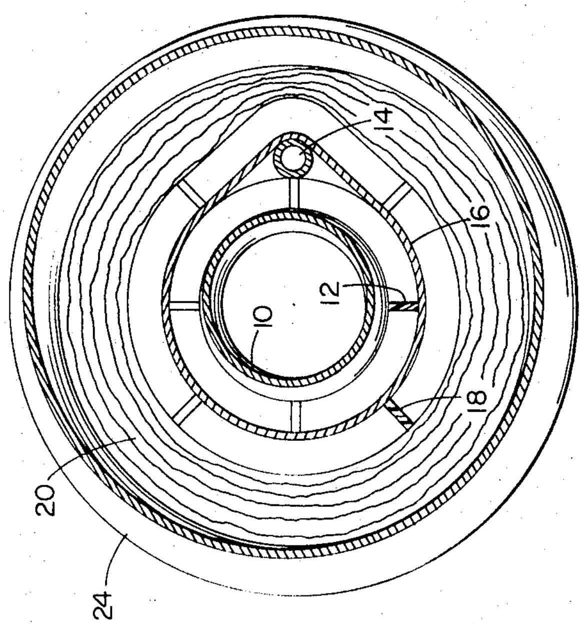




FIG 2

## THERMAL INSULATION FOR FLUID STORAGE CONTAINERS

This invention relates to thermal insulation of cryogenic fluid storage containers including transfer lines and has for an object the provision of insulating structures which diminish the heat leak rate from such containers, though the structures and operation herein described may also be applied to the reduction of heat leakage to or from any stored or flowing fluid.

To this end the invention contemplates surrounding an enclosure in the form of a chamber or conduit with insulation which, in the case of cryogenic fluids, includes one or more hollow cooling tubes which may, if the container is a semiflexible tube, be corrugated and spirally wound about the container so as not to eliminate flexibility. The hollow cooling tube or tubes are formed of thermally conductive material and are in contact with thin thermally conductive and preferably radiation reflective sheet material which extends around the container with interposed spacer means for restricting radial heat conduction, thereby establishing a relatively stable temperature differential between the container and the surrounding thermally conductive sheet.

Further stages of hollow cooling tubes may lie radially outwardly, each insulated from the next innermost stage of hollow cooling tubes and each contacting a separate surrounding thermally conductive sheet.

One basic embodiment of the invention and a typical more complicated embodiment of the invention are shown in the accompanying drawings, wherein:

FIG. 1 is a perspective view of the basic embodiment of the invention with successive layers cut away for illustration purposes.

FIG. 2 is a cross-sectional view of the complete assembly shown in FIG. 1; and

FIG. 3 is a cross-sectional view of a different embodiment of the invention.

FIG. 1 shows an inner corrugated vacuum-tight metal tube **10** around which is helically wrapped a spacer **12** which may be a plastic or metal ribbon or may be a ribbon of fibrous insulating material such as disclosed in an application filed simultaneously herewith, SER. No. 747,134. Helically wound around the inner tube **10** and spaced therefrom by the spacer **12** is a hollow metallic vacuum-tight tube **14** which, though shown uncorrugated in the drawing, may be corrugated if desired. The pitch of the tube **14** is much greater than that of the spacer **12**.

Wrapped around the spacer means **12** is also a 100 percent coverage of a heat radiation reflective material such as a metal foil **16** which is heat conductive and contacts the metallic tube **14**.

Further spacer means **18** is wound in an opposite direction from the spacer **12** and may be of like material. Around the spacer means **18** are layers of insulation material **20**, the whole being surrounded by a corrugated vacuum-tight outer tube **24**.

The insulation material **20** may be of the type disclosed in U. S. Pat. Nos. 3,009,600; 3,265,236; and 3,236,406, comprising alternate layers of fibrous material and heat-reflective sheet material.

The annular space between the vacuum-tight tubes **10** and **24** is evacuated except for the volume occupied by the tube **14**.

In use, it is contemplated that the inner tube **10** may, as in a transfer line, carry a cryogenic fluid such as helium at a temperature well below 80° K. with or without an electrical conductor, and the tube **14** may carry a cryogenic fluid such as nitrogen at a temperature between the temperatures of tube **10** and of tube **24**, the heat conductive layer **16** acting to stabilize the intermediate temperature circumferentially.

Alternatively, the tube **14** may have connections at the outflow end of tube **10** so as to carry cryogenic fluid bled from the inner tube **10** counter flow-wise back through the tube **14**.

In the embodiment shown in cross section in FIG. 3, there are multiple sets of surrounding hollow tubes, each set of tubes being in contact with a circumferentially extending layer of heat conductive material, such as metal foil, thus providing a plurality of separate and insulated temperature stages radially of the coaxial tubing.

Thus an inner vacuum-tight tube **6** is surrounded by a helically wound spacer means **8**, and the tube **10**, like the tube **10** in FIG. **1**, which may or may not be vacuum-tight, furnishes further mechanical support. Tube **10** is surrounded by a heat conductive layer **30** which encloses a single helically wound hollow vacuum-tight tube **32**. A spacer means **34** is then spirally wound in one direction around the conductive layer **30** to space therefrom a circumferentially extending thermally conductive layer **36** which encloses and is in contact with a pair of vacuum-tight tubes **38**. This is followed radially outward by a spacer ribbon **40** wound spirally in the opposite direction around the conductive layer **36** and spacing outwardly therefrom a third conductive layer **42** which encloses and is in contact with a set of three vacuum-tight tubes **44**.

Further spacer means **46** then separate outwardly a last layer of conductive material **48** which encloses a set of four spirally wound hollow vacuum-tight tubes **50** and the last layer is similar to the layer **20** in the embodiment of FIGS. **1** and **2**; the entire assembly being enclosed in the outer vacuum-tight corrugated tube **24**.

Any of the sets of tubes may be further supported by contacting rigid coaxial corrugated tubing similar to the arrangement of **10**, **32** and **30** or other rigidifying structure at the greater radii of the other set of tubes.

It is contemplated that cooling fluid may be circulated in one direction down tube **32**, back in the other direction through tubes **38** then in reverse flow through tubes **44**, and finally back through the set of four tubes **50**, the increased number of tubes taking care of expansion of the fluid as it heats. As in the case of FIG. **1**, if desired, the input feed to inner tube **32** may be a bleed off from the fluid within the inner central container **6**. Or, any of the sets of tubes may be supplied from a separate refrigeration source, alone or in combination, permitting use of different cryogenic fluid in different stages.

No matter how connected, the intention is to carry off heat longitudinally via the fluid flowing in each set of cooling tubes, thereby reducing the temperature of each conductive layer which in turn materially reduces the overall heat leakage to or from fluid in central tube **6**.

The diameters and number of cooling tubes may vary in the same or different stages depending upon the temperature, the fluid used and the length, to give optimum performance.

It is contemplated that the annular spaces between vacuum-tight coaxial tubes not occupied by cooling tubes will be evacuated separately; or, if any intermediate coaxial tube is not vacuum-tight may be evacuated together, in which case the intermediate coaxial tube or tubes may be perforated.

While the conductive layer **16** in FIGS. **1** and **2** gives 100 percent coverage, where there are multiple conductive layers as in FIG. 3, only the outer one needs to have 100 percent coverage and be heat reflective and the inner conductive layers may then be helically wound with spaced convolutions with only partial coverage. 100 percent coverage can be attained either with a wrap or an abutting or overlapping helical winding.

While the container storage of this invention is particularly efficient in the case of cryogenic fluids, it can be used for controlling heat leakage to and from fluids having higher boiling points including methane and fluorocarbons.

I claim:

**1**. An insulated container comprising:
- a vacuum-tight inner enclosure;
- a vacuum-tight outer enclosure;
- a thermally conductive hollow tube extending axially of said container between said inner and outer enclosures;
- said tube being in contact with an associated layer of thermally conductive material extending circumferentially about said inner enclosure;

circumferentially extending spacing means of thermal insulating material radially separating said layer of thermally conductive material from said inner enclosure; and

whereby fluid flowing in said hollow tube tends to establish a substantially stable equilibrium temperature for said conductive layer by absorbing and removing heat leakage via conduction through said conductive layer and tube.

**2.** A container as claimed in claim **1** having a plurality of said hollow tubes, each tube being in contact with an associated layer of thermally conductive material contacting that tube and each such tube and associated layer being separated from other tubes and their associated layers by thermal insulating material.

**3.** An insulated container for cryogenic fluids having:

a central enclosure;

an outer enclosure;

a series of circumferentially extending layers of thermally conductive material extending around said central enclosure;

spacing means between said thermally conductive layers for holding said layers in radially spaced relation; and

at least one hollow tube of thermally conductive material extending axially of said central enclosure in contact with one of said layers of thermally conductive material but radially spaced from said central enclosure.

**4.** A container as claimed in claim **3** wherein there are at least three of said hollow tubes and more of said tubes contact the outermost conductive layer than contact any other layer of



conductive material inside of said outermost layer.

**5.** A container as claimed in claim **3** wherein there are a plurality of said hollow tubes and the number of said tubes contacting successive circumferentially extending layers increases in number progressively from the innermost layer to the outermost layer.

**6.** A container as claimed in claim **3** wherein at least some of said spacer means are constituted of thermal insulating material.

**7.** A container as claimed in claim **3** wherein the innermost spacer means is a spirally wound ribbon.

**8.** Semiflexible cryogenic transfer tubing comprising:

inner and outer corrugated coaxial vacuum-tight tubes and successively overlying layers of the following materials in the following sequence between said inner and outer tubes;

helically wound spacer means having spaced convolutions;

a helically wound hollow heat conductive tube;

a heat conductive film in heat conductive contact with said helically wound tube;

helically wound spacer means having spaced convolutions layed with a pitch opposite to that of said first named spacer means; and

a layer of fibrous insulation.

**9.** A transfer tubing as claimed in claim **8** also having heat reflective foil insulation adjacent to said layer of fibrous insulation.

UNITED STATES PATENT OFFICE

# CERTIFICATE OF CORRECTION

Patent No. 3,565,118 Dated February 23, 1971

Inventor(s) Thornton Stearns

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Caption:

Change "Thronton" to --Thornton--;

Add as assignee Vacuum Barrier Corporation of Woburn, Massachusetts, a corporation of Delaware

Col. 2, line 75, after "enclosure;" delete ";" and insert --,and--;

Col. 3, line 3, after "enclosure;" delete --; and--.

Signed and sealed this 6th day of July 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents