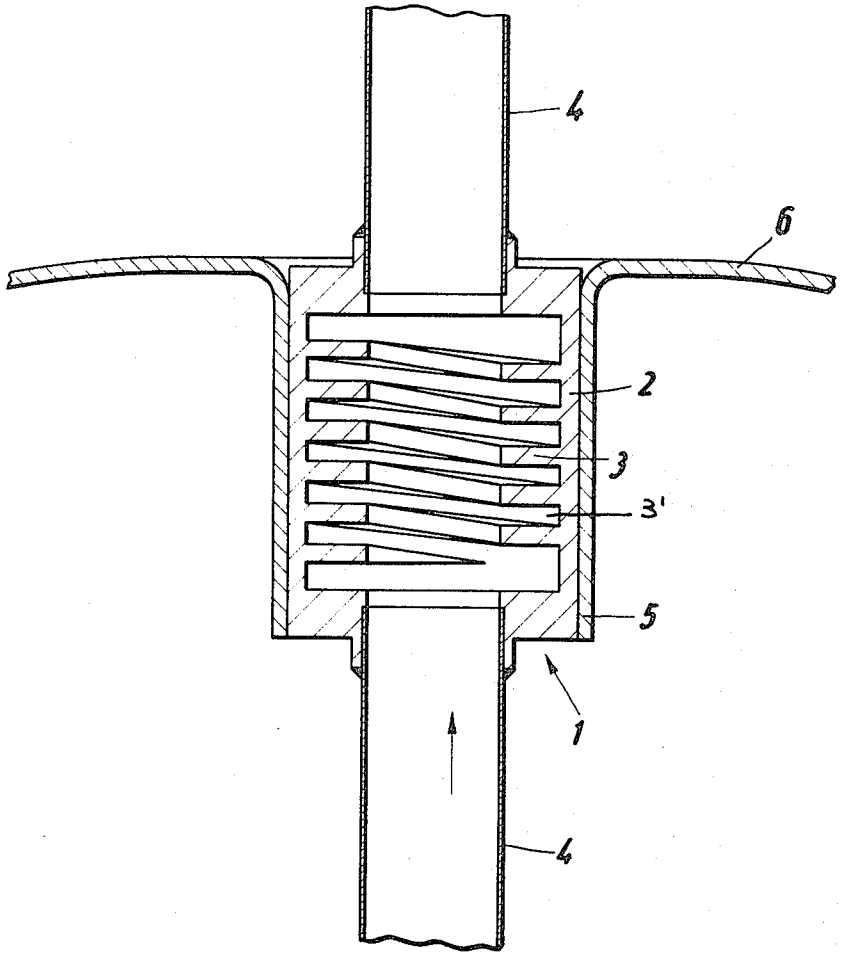
Nov. 10, 1970 G. KLING ET AL 3,538,714

LOW TEMPERATURE LIQUID STORAGE DEVICES

Filed Feb. 12, 1969 3 Sheets-Sheet 1

Fig. 1



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Nov. 10, 1970 G. KLING ET AL 3,538,714

LOW TEMPERATURE LIQUID STORAGE DEVICES

Filed Feb. 12, 1969 3 Sheets-Sheet 2

Fig. 2

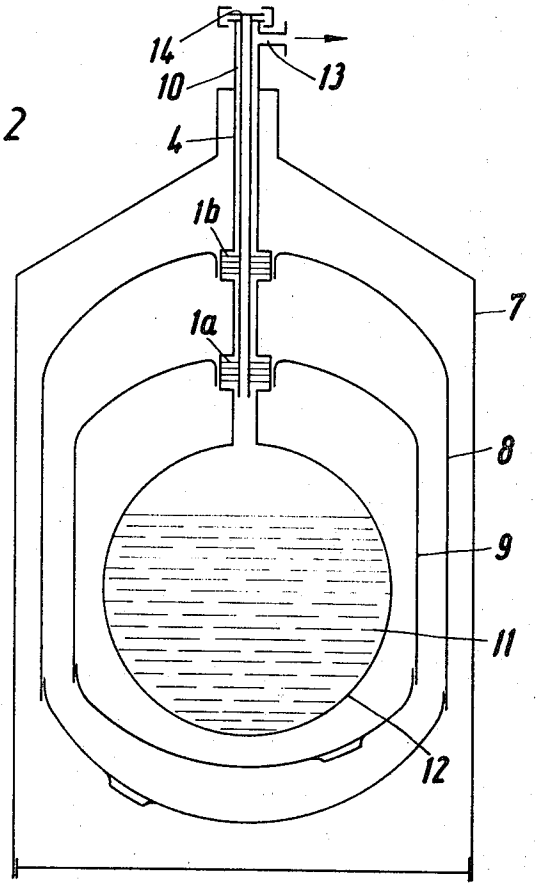
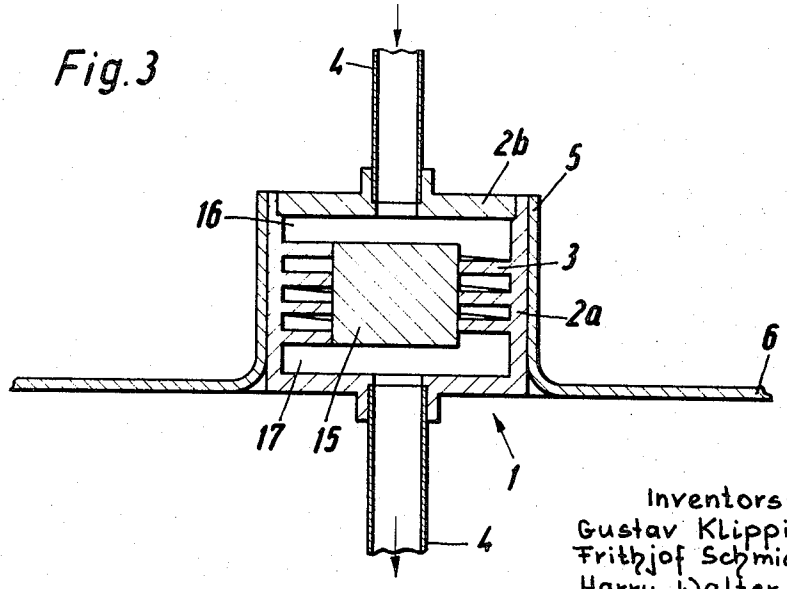


Fig. 3



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LOW TEMPERATURE LIQUID STORAGE DEVICES

Filed Feb. 12, 1969 3 Sheets-Sheet 3

Fig.4

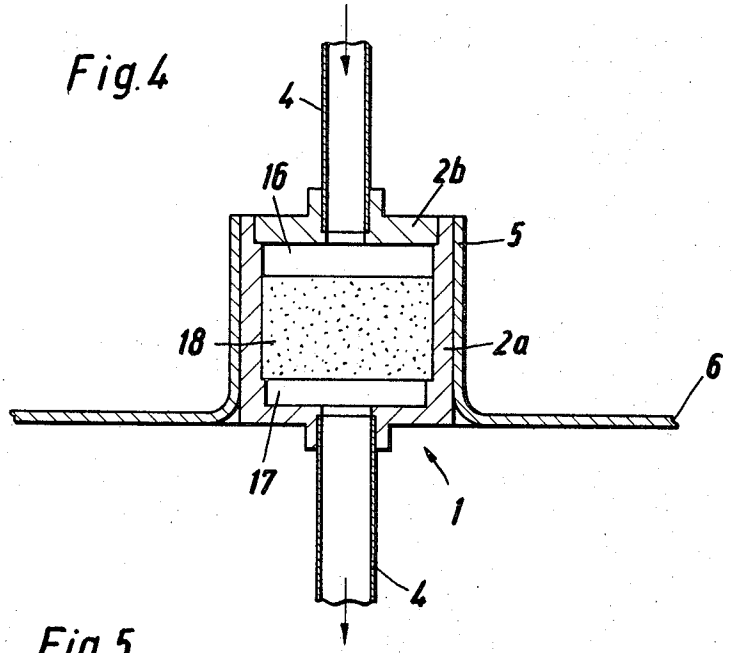
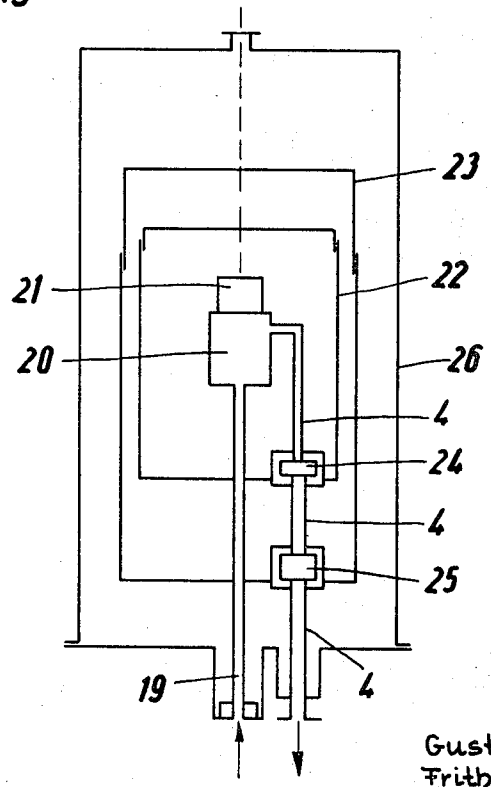


Fig.5



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LOW TEMPERATURE LIQUID STORAGE DEVICES

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Claims priority, application Germany, Feb. 13, 1968, 1,601,908
Int. Cl. F17c 13/00
U.S. Cl. 62—54 8 Claims

ABSTRACT OF THE DISCLOSURE

In low temperature liquid storage apparatus including an inner container connected to a waste gas pipe and surrounded by radiation shields which are to be cooled by their heat conductive connection to the pipe, heat exchange elements connected in series in the pipe to be traversed by the gas flowing through the pipe and defining a gas flow path whose cross-sectional area is greater than that of the pipe, the outer surface of each element contacting one radiation shield to define the surface via which heat is transferred from the shield.

BACKGROUND OF THE INVENTION

The present invention relates to the cooling of radiation shields in vessels and apparatus containing low-boiling liquids as coolants, and particularly to the cooling of radiation shields by establishing a heat-conducting connection with portions of the waste gas line of such apparatus.

Storage vessels for liquid helium are known in which a vacuum-insulated inner container is enclosed by a plurality of protective shields. The shields are supported by the neck tube of the container and are cooled via their metallic connection with this tube; such cooling being effected by utilizing the heat absorbing capacity of the evaporated gas. This idea is described, for example, in the following:

A. A. Balla, E. Donth, "Experimental Technique in Physics" XIII (1965) pages 184–190, VEB Deutscher Verlag der Wissenschaf-Leipzig; O. P. Anashkin, I. B. Danilov, V. G. Krvenko, "Cryogenics" 6 (1966) pages 106–107, Heywood-Temple, Industrial Publications Ltd., London; German published patent application No. 1,230,-048; V. E. Keilin, "Cryogenics" 7 (1967) pages 3 to 6, FIG. 1.

These known arrangements exhibit the drawback of not fully utilizing the heat absorbing capabiilty of the exhaust, or waste, gases, particularly in the case of a large supply of gas, primarily because the heat transfer rate between the exhaust gas line and the radiation shields remains quite low. It has also been disclosed, in German Pat. No. 1,151,264, to conduct the exhaust gases from a continuous-flow cryostat through a helically wound pipe which encloses the evaporator body to form a radiation shield. Such an arrangement results in a substantial improvement in the degree of utilization of the heat absorbing capacity of the exhaust gases. But it also gives rise to an undesirable increase in the flow resistance presented by the exhaust gas line.

SUMMARY OF THE INVENTION

It is a primary object of the present invention to overcome these drawbacks and difficulties.

Another object of the invention is to substantially improve the efficiency of the cooling action effected by the waste gas.

Still another object of the invention is to provide a more efficient heat exchange between the associated radiation shields and the waste gas.

Still another object of the invention is to provide an improved heat exchange without increasing the flow resistance of the waste gas line.

These and other objects are achieved by the provision of an improved heat exchange element in combination with apparatus for storing a low temperature liquid. This apparatus includes a container for such liquid, a waste gas pipe connected to the container and communicating with the interior thereof, and a radiation shield surrounding the container and connected to the pipe in a heat conductive manner for permitting at least part of the shield to be cooled. The heat exchange element according to the invention is connected in series in the pipe to be traversed by the gas flowing through the pipe, the element presenting a gas flow path whose cross-sectional area is greater than that of the gas flow path defined by the pipe and having an outer surface contacting the shield and defining the surface via which heat is transferred from the shield.

Thus, the present invention provides a device for cooling radiation shields in which favorable heat transfer conditions are created and which can be manufactured, installed and disassembled in a simple manner. Moreover, heat exchange elements according to the invention do not create any noticeable increase in the gas flow resistance of the waste gas pipe.

Heat exchange elements according to the invention are highly advantageous because, even when the waste gas pipe is relatively short, these elements serve to substantially enlarge the effective heat exchange area, which results in a corresponding increase in the rate at which heat can be exchanged with the radiation shields.

In preferred embodiments of the invention, the heat exchanger is constructed so that its gas flow region is provided with gas conduits formed in a heat conductive material and presenting a gas flow region which is symmetrical with respect to the longitudinal axis of the exchanger. Preferably, the interior of the exchanger has the form of a helical conduit.

According to one form of construction of embodiments of the invention, the unobstructed cross section of the heat exchanger gas flow region, which is in the form of a cylinder defining the inner boundary of the conduit, has a cross-sectional area equal to, and coaxial with, the cross-sectionl area of the interior of the waste gas pipe.

The dimensioning of the heat exchanger to cause it to have an unobstructed cross section which is equal to that of the waste gas pipe is advantageous because it assures that standardized siphons can be inserted through both the pipe and the heat exchanger.

According to a further form of construction of embodiments of the invention, there is also provided a further pipe which extends through the heat exchanger and partially through the waste gas pipe, the further pipe having a smaller cross-sectional area than the waste gas pipe so that the two pipes define an annular gas flow path, and being connected to the helical conduit which has an unobstructed cross section of smaller diameter than the cross section of the waste gas pipe. The provision of this further pipe assures that there will be a clear passage for the insertion of probes, siphons, samples, etc., and furthermore all of the waste gas is forced to pass the helical gas conduit even if no probe or something else is inserted.

In those cases when it is not necessary to provide the capability of permitting instruments to be inserted through the waste gas pipe, it might prove desirable to plug the unobstructed central region of the heat exchanger so as to force all of the waste gas to traverse the helical gas

conduit. This can be accomplished by means of a solid plug of heat conducting material which is axially coextensive with the helical conduit.

In other forms of construction according to the invention, the heat exchange element can be constituted by a sintered metal packing disposed within a hollow jacket and extending across the entire cross-sectional area of the hollow region defined by the jacket, the packing being dimensioned to cause the jacket to also present a gas distribution chamber at each end of the packing. Arrangements of this type are highly advantageous because they permit optimum heat exchange conditions to be achieved.

In further accordance with the invention, the radiation shields which are to be cooled are formed with a socket-type sleeve into which a heat exchanger according to the invention can be tightly inserted in such a manner as to cause the outer surface of the heat exchanger to be in close heat-exchanging contact with the socket. This arrangement substantially simplifies installation of the heat exchanger and permits excellent heat transfer conditions to be established.

In further accordance with the invention, when a plurality of heat exchangers are inserted along the length of the waste gas pipe, it might prove advantageous to dimension the individual lengths of the waste gas pipe and the individual heat exchangers so as to provide a progressive increase in the cross-sectional area of the gas flow path in the direction of gas flow. This compensates for the tendency of the waste gas to expand each time it is heated and thus maintains the flow resistance of the waste gas line at a low value.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of one embodiment of a heat exchanger according to the invention.

FIG. 2 is a simplified pictorial illustration of a storage vessel constructed according to the invention.

FIG. 3 is a view similar to that of FIG. 1 of another embodiment of the invention.

FIG. 4 is a view similar to that of FIG. 1 of still another embodiment of the invention.

FIG. 5 is a view similar to that of FIG. 2 of a continuous-flow cryostat constructed according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the embodiment shown in FIG. 1, the heat exchanger **1** consists of a cylindrical hollow body **2** whose inner wall is formed to create a helical, heat-conductive gas conduit **3** which, it should be noted, does not extend along the entire length of the inner wall, and which defines a gas flow channel **3'**. The heat exchanger **1** is made, for example, of copper and is interposed as an intermediate piece in the thin-walled waste gas pipe **4** made of a material having a low thermal conductivity and high structural strength, one such material being refined steel.

A radiation shield **6** provided with an integral plug-type sleeve **5** is connected to the outside of the heat exchanger **1** in such a way that the entire external surface of the heat exchanger **1** is in good heat exchange contact with the radiation shield **6**.

The unobstructed cross section of the heat exchanger **1**, which is a cylindrical region defining the inner boundary of channel **3'** corresponds with the cross section of the waste gas pipe **4**, so that, for example, a siphon, or probe, or the like, can pass through the heat exchanger **1** for insertion into the inner container. After a siphon whose diameter is somewhat smaller than the diameter of the waste gas pipe **4** has been inserted, an annular gap results between the siphon jacket pipe and the pipe **4**, this gap being interrupted by heat exchanger **1**, and it is through this gap that the waste gas flows. If no siphon were inserted, the full cross section of the gas pipe **4** would be available for the flow of exhaust gas.

FIG. 2 shows a variant of the heat exchanger illustrated in FIG. 1 in association with a storage can **7** having two radiation shields **8** and **9** surrounding an inner vessel **12** containing a coolant **11**. There are two heat exchangers **1***a*, **1***b* each having the form of a hollow body presenting a helical gas conduit as shown in FIG. 1. However, the heat exchangers are here of smaller unobstructed cross section than in FIG. 1 and are traversed by an inner pipe **10** which is connected to the inner boundary of the gas conduits **3**.

The inner pipe **10** extends from below the heat exchanger **1***a*, which is connected to the innermost shield **9**, to the outer end of the gas pipe **4**, pipe **4** here constituting the neck tube of inner vessel **12**, and is enclosed by the waste gas pipe **4**. Between the inner pipe **10** and the gas pipe **4** there is thus created an annular gap which is interrupted by the two heat exchangers **1***a* and **1***b* and through which the waste gas flows toward the waste gas discharge connection **13**.

This embodiment presents the advantage that the waste gas will be fed through a narrow annular gap even when no siphon is present and that the entire mass of waste gas is forced to flow substantially through the helical conduits of the heat exchangers **1***a* and **1***b*. Upon removal of a siphon, the upper end of inner pipe **10** is closed by a cover or stopper **14**.

This arrangement is of particular interest when large amounts of waste gas develop, for example in storage vessels having large capacities.

FIG. 3 shows another embodiment of the heat exchanger according to the invention which is advantageously employed in those cases where nothing need be inserted through the waste gas pipe. The free cylindrical region enclosed by, and defining the inner boundary of, the helical gas conduit **3** is here closed off by a permanently inserted solid heat-conducting plug **15** which extends over the entire length of the helical conduit. At the gas inlet side of the heat exchanger there is provided a gas distribution chamber **17** within the heat exchanger. A similar chamber **16** is provided at the gas outlet side. This embodiment also serves to cause the entire mass of waste gas to flow through the heat exchanger helical conduit.

FIG. 4 shows an embodiment of the heat exchanger in which a sintered-metal packing **18** is inserted in a closed cylindrical hollow body, made of two parts **2***a* and **2***b*, to serve as the heat-exchange element. In this embodiment optimum heat exchange-conditions can be realized since, as is known, sintered-metal bodies present a very large internal surface and good thermal conductivity. Appropriate sintered-metal packings could also be used in the embodiment illustrated in FIG. 2. Materials suited for the sintered-metal packing are copper, silver, aluminum, bronze and the like.

FIG. 5 is a schematic representation of a continuous-flow cryostat in which heat exchangers of the type illustrated in FIG. 4 are used. The evaporator cooling head **20**, supplied with coolant through a feed line **19**, holds a probe **21** and is enclosed on all sides by two radiation shields **22** and **23**. The radiation shields **22** and **23** are in heat-conductive communication with the heat exchangers **24** and **25**, respectively, disposed in series with the waste gas pipe **4** of evaporator **20**. The entire apparatus is enclosed in an evacuatable housing **26**. The heat exchangers illustrated in FIGS. 3 and 4 are the most advantageous embodiments to be employed in this apparatus.

Such a continuous-flow cryostat is distinguished by a particularly simple construction. The exhaust gas pipe may be constructed of sections having progressively increasing cross-sectional areas corresponding to the decreasing density of the gas, thus keeping the flow resistance of the waste gas pipe at a low value. Moreover,

suitable dimensioning of the heat exchangers permits a truly complete utilizatiton of the heat absorbing capacity of the gas to be achieved.

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

We claim:

1. In combination with apparatus for storing a low temperature liquid and including a container for such liquid, a waste gas pipe connected to the container and communicating with the interior thereof, and a radiation shield surrounding the container and connected to the pipe in a heat conductive manner for permitting at least part of the shield to be cooled, the improvement comprising: a heat exchange element connected in series in said pipe to be traversed by the gas flowing through said pipe, said element being a hollow body whose cross-sectional area is greater than that of the gas flow path defined by said pipe and having an outer wall contacting said shield and defining the surface via which heat is transferred from said shield; and gas flow directing means disposed in said hollow body adjacent said outer wall and constructed for deflecting at least that part of the gas flowing adjacent the inner surface of said outer wall to cause such gas to follow a flow path through said element which is longer than the axial length of said element.

2. An arrangement as defined in claim 1 wherein said directing means comprise at least one heat-conductive gas conduit which defines the gas flow path and wherein said element is symmetrical with respect to its longitudinal axis.

3. An arrangement as defined in claim 2 wherein there is a single helical gas conduit.

4. An arrangement defined in claim 3 wherein the inner boundary of said gas conduit defines a hollow cylindrical region and having a cross section which is equal to, and coaxial with, the internal cross section of said waste gas pipe.

5. An arrangement as defined in claim 3 wherein the inner boundary of said conduit defines a hollow cylindrical region, and said element comprises a solid plug of heat conductive material completely filling said hollow cylindrical region and coextensive with said helical conduit.

6. An arrangement as defined in claim 2 further comprising an inner pipe passing completely through said heat exchanger and at least partially through said waste gas pipe, the external diameter of said inner pipe being less than the internal diameter of said waste gas pipe and said inner pipe and waste gas pipe defining between them an annular gas flow region, and said inner pipe being connected to the inner boundary surface of said heat exchanger having an unobstructed cross section of less than the internal diameter of said waste gas pipe.

7. An arrangement as defined in claim 1 wherein said radiation shield is formed with an integral hollow sleeve in which said heat exchange element is tightly inserted.

8. An arrangement as defined in claim 1 wherein there are a plurality of heat exchange elements connected in series in said pipe and dividing said pipe into a plurality of sections, the internal cross-sectitonal areas of said pipe sections and said heat exchange elements increasing progressively in the direction of waste gas flow.

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ALBERT W. DAVIS, JR., Primary Examiner

U.S. Cl. X.R.

165—146, 164, 179; 220—9, 14

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,538,714 Dated November 10th, 1970

Inventor(s) Gustav Klipping, Frithjof Schmidt and Harry Walte

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

In the heading of drawing sheets 1, 2 and 3, respectively, change the patentee's name to --G. Klipping et al--.
Column 1, line 50, change "capabiilty" to --capability--.
Column 5, line 2, change "utilizatiton" to --utilization--.
Column 6, line 23, change "sectitonal" to --sectional--.

SIGNED AND SEALED FEB 9 1971

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents