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INFRA-RED DETECTION APPARATUS

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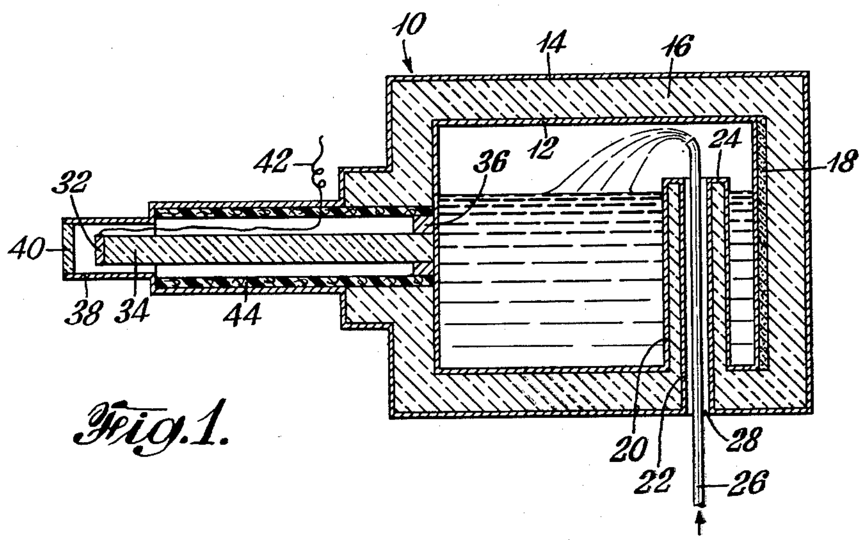


Fig. 1.

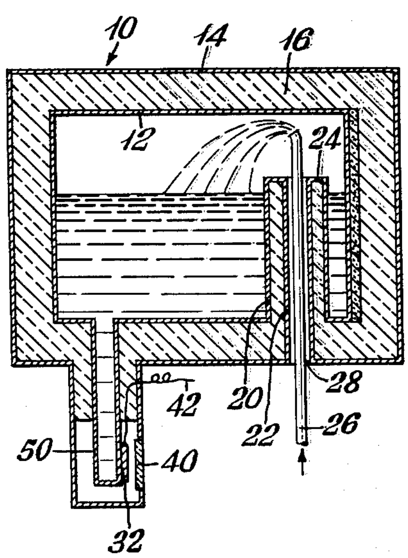


Fig. 2.

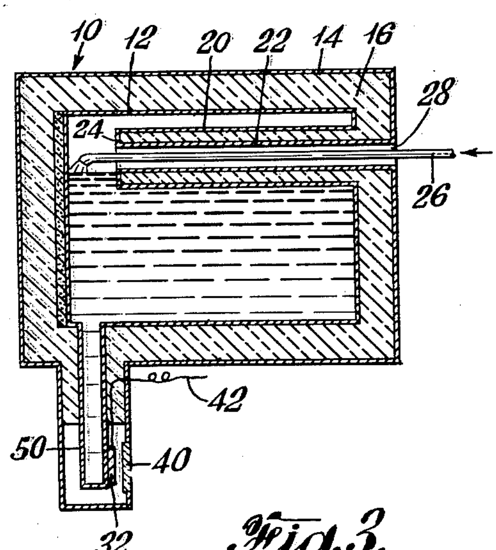


Fig. 3.

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# INFRA-RED DETECTION APPARATUS

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This invention relates to an improved refrigerated mounting means for an infra-red detection cell utilizing cryogenic liquids. More particularly it relates to such a means having improved filling and venting means for the refrigerant liquids.

Infra-red sensing apparatus is quite useful for detecting the location of objects by the infra-red or heat waves radiating from the object. The homing mechanism on certain air-to-air missiles, for example, is operated by means of such a sensing apparatus. It has been found that the infra-red detection cell is most effective when maintained at an extremely low temperature, such as the temperature of liquid nitrogen, hydrogen or helium. Therefore a considerable effort has been expended by the industry to produce apparatus which effectively cools an infra-red sensing element to such low temperatures and which also does not use prohibitive amounts of the liquid refrigerant.

In such apparatus weight and size are very critical factors, hence it is of paramount importance to achieve maximum efficiency in the refrigeration system so that a minimum of refrigerant will be necessary to maintain proper operating temperature conditions. Previously available apparatus has utilized rather crude filling and venting means in the form of a filler hole in the top of the container with a vented stopper therefor. This crude filling and venting system permits considerable heat leak into the refrigerant storage container with attendant vaporization and loss of refrigerant. When working with refrigerants, like liquid nitrogen, where temperatures approach absolute zero even such small paths for heat transfer cause very great difficulty.

It is accordingly a primary object of this invention to provide a refrigerated mounting means for an infra-red detection cell having improved thermal efficiency.

It is a further object to provide such an apparatus having improved filling and venting means.

Other objects and advantages will be apparent from the description and drawings in which:

FIG. 1 is a cross-sectional view of a preferred embodiment of refrigerated mounting means for an infra-red detection cell according to the invention,

FIG. 2 is a cross-sectional view of another embodiment of the invention and

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

The objects of the invention are accomplished in general by a novel unit which stores low temperature refrigerant and supplies refrigeration to an infra-red detection cell and which has improved filling and venting means. The apparatus consists of inner and outer vessels forming a double-walled container employing vacuum space insulation and preferably opacified-vacuum insulation between the walls. An insulated double-walled tube extends inward from an outer wall of the container into the inner vessel and terminates near the opposite wall of the inner vessel. A removable filling line for liquid refrigerant can be readily inserted into the tube for charging the inner vessel. Vapors from the refrigerant are vented out through the tube around the filling line. In a preferred modification of the present invention, the combination filling and vent tube is positioned at the bottom of the container, and an extension projects from the side of the container to provide a means for mounting the infra-red



detection device and also to provide a means of keeping it cold.

The invention will now be described in more detail with respect to the accompanying figures. In the embodiment of FIG. 1 the container **10** is formed from an inner vessel **12** and an outer vessel **14**, both preferably constructed of brass, aluminum, or aluminum alloys. The space between the vessels is under a vacuum pressure and preferably contains an opacified insulating jacket **16** and gas adsorbent material **18** communicating with the opacified insulation to maintain the space under a vacuum.

Inner concentric extension tubes **20** and **22** of inner vessel **12** and outer vessel **14** respectively are joined at point **24** to form a double-walled insulated tube extending inward from one wall of the container to a point adjacent the opposite wall of the inner vessel. A filling line **26** is inserted through this tube to charge the inner vessel with liquid refrigerant, such as liquid nitrogen. The filling line **26** is designed to discharge the refrigerant at an angle so that the refrigerant does not flow back down through the bottom filling and vent tube. Vapors from the refrigerant can be vented out through the filling and vent tube around the filling line **26**. Once the inner vessel has received a desired amount of refrigerant, the filling line is withdrawn and a stopper (not shown) is placed into the outlet **28** of the filling tube. This further reduces heat inleak along the filling and vent tube. This stopper will have a vent opening to allow the escape of vapors from the inner vessel. A porous plug might also be used. The particular filling and vent means of this invention has the unique advantage of allowing the use of a long combination fill and vent tube without extending the overall dimensions of the container. The relatively long insulated filling tube provides a high resistance to heat flow from the outer vessel to the inner vessel. Also, part of the refrigeration in the vapors leaving the container can be recovered by heat exchange along the walls of the filling tube.

The double-walled filling and vent tube is so located within the container that when the container is in its normal position, no liquid refrigerant will be present within the opening. Thus, under pressure due to vaporization build-up within the container, the liquid refrigerant will not be forced out through the filling and vent tube. Positioning this combination tube in the bottom or sides of the container accomplishes this result.

It should be noted that the particular improved filling and vent tube and its combination with a filling line described herein is not limited to use with infra-red detection cell cooling systems. These improvements are quite useful for other cryogenic apparatus wherein size of the container must be minimized and a desirably long filling tube heat path is required. Such improvement is especially useful for containers having storage capacity less than about 50 liters.

An extension **30** located on the side of container **10** provides a means for mounting an infra-red detection cell **32** and a means for keeping the cell cold. This extension consists of a solid rod **34** of material having high thermal conductivity and low coefficient of thermal expansion, such as sapphire. It is positioned in thermal contact with inner vessel **12** and is supported as a cantilever beam by ring **36** attached to or a part of inner vessel **12**. Infra-red detection cell **32** is mounted in thermal contact with the unsupported end of rod **34**. This rod **34** is surrounded by extension **38** of outer vessel **14** to enable this portion of the container to have vacuum type insulation. Mounting the infra-red detection cell 32 in an evacuated space prevents it from being hampered in its operation by frost accumulation which could occur if it were exposed directly to the atmosphere. Also the refrigeration loss is reduced. The use of solid rod **34** to conduct refrigeration to the detection cell has the additional advantage of reducing the noise level in the detection circuit. Such high noise level caused by boiling liquid was undesirably present in prior art systems wherein the liquid refrigerant was positioned near the cell. A window **40** fabricated from sapphire, for example, is positioned in the end of extension **38** to form an area of high infrared transmission to enable the detection cell to operate at maximum efficiency. Electrical connection **42** to cell **32** can be introduced to the vacuum space at any convenient position. When any opacified material is employed in the evacuated insulation space to increase insulation efficiency, it is understood that this material should not be positioned between the detection cell and the transmission window. This can be achieved in several convenient fashions. For example, if a foil and fiber glass wrapped insulation combination is employed in the evacuated space, the foil and fibers are terminated before blocking the window.

It has been found that the distance between the cell **32** and the end of extension **38** is quite critical in order to satisfy the optical requirements of the system. In order to maintain this distance as constant as possible, the inner vessel **12** is supported at one end by a hollow plastic spacing member **44** positioned between inner vessel **12** and extension **38** of outer vessel **14** and attached to both vessels **12** and **14** by adhesive. Member **44** should have a thermal coefficient of expansion similar to that of rod **30**. In this manner when rod **30** contracts due to cooling caused by refrigerant in the container, spacing member **44** will also contract an equal overall amount. This will force the rod **30** toward window **40** and thus maintain distance between **32** and window **40** substantially constant. When sapphire is used for rod **30**, spacing member **44** is preferably constructed from phenol-formaldehyde resins reinforced with fabric or paper. The other end of inner vessel **12** is supported by the tubes **20** and **22** forming the bottom filling tube.

An alternate form of the invention which is useful for containers employing a different apparatus for mounting the infra-red detection cell is shown in FIG. 2. In this embodiment the cell **32** is mounted against the inner wall of a hollow extension **50** in the bottom of inner vessel **12** into which liquid refrigerant passes.

Still another form of the invention is shown in FIG. 3 whereby the filling and vent means enter from the side of the container. In this modification the problem of liquid refrigerant flowing out through the vent annular passage is substantially eliminated.

Similar reference numerals have been used in all of the figures to denote similar parts for the sake of clarity.

In some missile configurations bottom filling of the refrigeration container is highly desirable. The present invention, especially in the form shown by FIGS. 1 and 2, is believed to be the only system presently known that can be conveniently used in such bottom-filling situations.

A device of the type shown in FIG. 1 having an overall length of about 5 inches and about 2½ inches wide successfully maintained desired operating temperature at the infra-red detection cell for 6 to 7 hours without refilling. This provides adequate operating life for an infra-red detection cell cooling system on a missile. Tube **22** was about 3/16-inch O.D. with 0.006 in. wall thickness and tube **20** was about ⅜-inch O.D. with 0.010 in. wall thickness. These small tubes in combination with fill line **26** having a maximum O.D. of about ⅛-inch provided a path of high resistance to heat inleak.

The term "vacuum" as used herein is intended to apply to subatmospheric pressure conditions not substantially greater than 1000 microns of mercury, and preferably below 100 microns of mercury absolute. The term "opacified insulation" as used herein refers to a two-component insulating system comprising a low heat conductive, radiation-permeable material such as silica or fiber glass and a radiant heat impervious material such as copper or aluminum flakes or foil which is capable of reducing the passage of infra-red radiation rays without significantly increasing the thermal conductivity of the insulating system.

Adsorbent **18**, either in powder or pellet form, is preferably used in the insulation jacket to remove by adsorption any gas which may leak into the jacket space. This is important since no provision is made in these relatively small storage containers for re-evacuation of the insulating jacket. In particular, zeolitic molecular sieves having pores of at least about 5 Ångstrom units in size, are preferred as the adsorbent since they have extremely high adsorptive capacity at the temperature and pressure conditions existing in the insulating jacket and are chemically inert toward any gases which might leak into the insulating jacket. However, other adsorbents such as silica gel, activated alumina and activated charcoal may also be used if so desired. Alternatively active metal "getters" that function by chemically combining with inleaking and residual air may be used.

As may be seen from the above description and example the refrigerated infra-red detection cell mounting means of the present invention gives very satisfactory results in terms of thermal efficiency and operating life for a given charge of refrigerant. While certain preferred embodiments of the invention have been shown and described it is to be understood that certain modifications could be made by a person skilled in the art without departing from the spirit and scope thereof.

What is claimed is:

1. Apparatus comprising an inner liquefied-gas storage vessel; an outer protective shell surrounding the vessel and spaced therefrom to form an evacuable insulation space therebetween; inner vessel refrigerant filling and venting means extending into the apparatus and terminating adjacent an inner surface of said vessel within the normal vapor space thereof, such means comprising a double-walled conduit; an elongated outwardly-extending member appended to the outer shell and constructed and arranged such that a small object may be positioned within the outer end thereof; and elongated heat transfer means positioned within the member and spaced from the walls thereof for refrigerating such object whereby sensible heat is conducted from said object to the refrigerant in said vessel.

2. Apparatus according to claim 1 wherein the member depends from said outer shell; and wherein the interior of said heat transfer means is in liquid communication with the interior of said vessel and comprises liquefied gas in thermal contact with said object.

3. Apparatus according to claim 1 wherein said elongated heat transfer means comprises a solid rod of thermally conductive material in thermal contact with said object and said vessel.

4. Apparatus according to claim 3 wherein said object is an infra-red detecting cell which is affixed to the outer end of the rod; and wherein an infra-red radiation transparent window is positioned in the end of said member adjacent said object; and wherein at least the inner longitudinal portion of said member comprises a material having substantially the same overall coefficient of thermal contraction as said rod, such inner portion being so constructed and arranged to maintain said object in substantial alignment with the adjacent window when in operation.

5. Apparatus according to claim 1 wherein said member and said heat transfer means comprise two spaced concentric outwardly-extending conduits gas-tightly connected to said outer shell and vessel respectively, and are constructed and arranged such that the space between such concentric extended conduits is in gaseous communication with said evacuable insulation space; and wherein said object is positioned within said space.

6. Apparatus according to claim 1 wherein the vessel

filling and venting means comprises two spaced concentric inwardly-extending conduits gas-tightly connected to said outer shell and vessel, respectively, and is constructed and arranged such that the space between such concentric extended conduits is in gaseous communication with said evacuable insulation space; and wherein the interior of such means is adapted to receive an insertable liquid filling conduit of a size such that an annular vapor vent passage is provided between the interior of such means and the liquid filling conduit.

7. Apparatus comprising an inner liquefied gas storage vessel; an outer protective shell surrounding the vessel and spaced therefrom to form an evacuable insulation space therebetween; inner vessel filling and venting means extending into the apparatus and terminating adjacent an inner surface of said vessel within the normal vapor space thereof, such means comprising two spaced concentric inwardly-extending conduits gas-tightly connected to said outer shell and vessel, respectively, which are constructed and arranged such that the space between such concentric extended conduits is in gaseous communication with said evacuable insulation space, the interior of such means being adapted to receive an insertable liquid filling conduit of a size such that an annular vapor vent passage is provided between the interior of such means and the liquid filling conduit; an elongated outwardly-extending member comprising two spaced concentric conduits gas tightly connected to said outer shell and vessel, respectively, such member being constructed and arranged such that the space between the concentric conduits provides gas communication with said evacuable insulation space, and such member being further constructed and arranged such that an infra-red detecting cell may be positioned within the outer end of said space; an infra-red radiation transparent window positioned in the end of said member adjacent said infra-red detecting cell; and heat transfer means positioned within said member for refrigerating said infra-red detecting cell whereby sensible heat is conducted from the cell into said vessel.

8. Apparatus comprising an inner liquefied-gas storage



vessel; an outer protective shell surrounding the vessel and spaced therefrom to form an evacuable insulation space therebetween; inner vessel filling and venting means; an elongated outwardly-extending member appended to the outer shell and constructed and arranged such that an infra-red detecting cell may be positioned within the outer end thereof; an infra-red radiation transparent window positioned in the end of such member adjacent said infra-red detecting cell; an elongated rod composed of thermally conductive material positioned within said member and spaced from the walls thereof for refrigerating said infra-red detecting cell whereby sensible heat is conducted from said infra-red detecting cell to the refrigerant in said vessel; and a material having substantially the same overall coefficient of thermal contraction as said rod comprising at least the inner longitudinal portion of said member, such inner portion being so constructed and arranged to maintain said infra-red detecting cell in substantial alignment with the adjacent window when in operation.

9. Apparatus according to claim 8 wherein said rod is constructed of sapphire and said material comprising the inner longitudinal portion of said member is constructed of a reinforced phenol-formaldehyde resin.

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