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R. P. SKINNER

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COOLING HEAD FOR SMALL CHAMBERS

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Fig. 1.

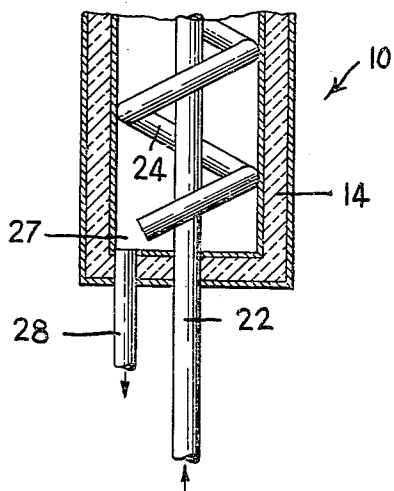
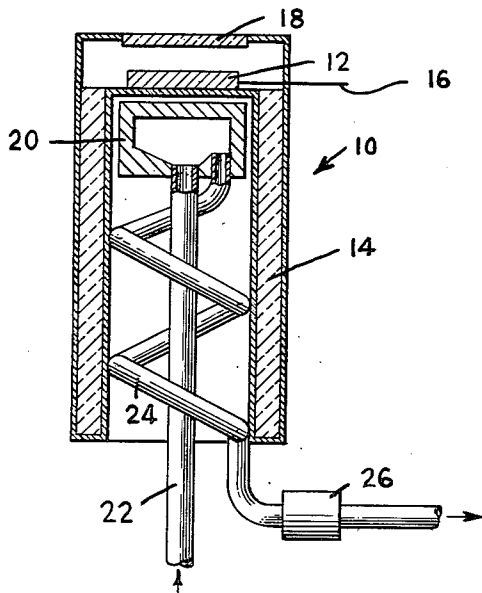


Fig. 2.

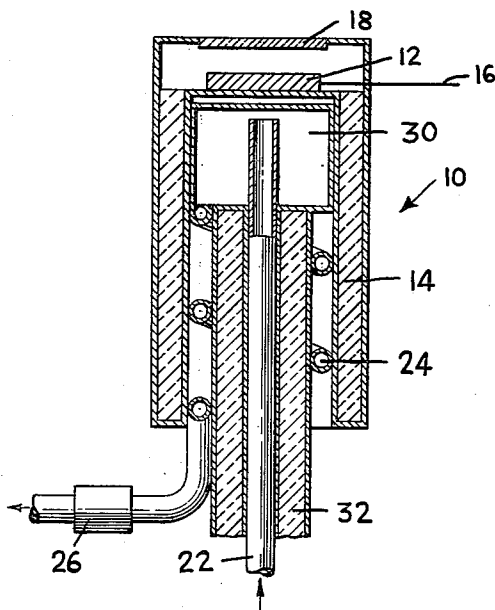


Fig. 3.

INVENTOR.
RANSOM P. SKINNER

BY *R. R. Schumacher, Jr.*
ATTORNEY

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COOLING HEAD FOR SMALL CHAMBERS

Ransom P. Skinner, Indianapolis, Ind., assignor to Union Carbide Corporation, a corporation of New York

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This invention relates to an improved cooling head for supplying liquid refrigerant in close proximity to an object or a small chamber which is to be cooled. More particularly it relates to such an apparatus for storing small quantities of liquid refrigerant and vaporizing same at a point separated from the principal liquid refrigerant storage container by means of a refrigerant supply line.

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. Therefore, a considerable effort has been expended by the industry to produce apparatus which effectively cools an infra-red sensing element to about liquid nitrogen temperature and which also does not use prohibitive amounts of the liquid refrigerant. Some of the sensing elements are mounted on a "scanning" device which moves up, down, and sideways in order to cover the greatest possible "searching area." Most of the prior art cooling devices were not successful for use in such a "scanning" device since they rely primarily on gravity feed of the liquid and became ineffective when the device was positioned upward. Complex labyrinth means have previously been tried in order to prevent the liquid from draining away from the sensing elements on vertical operation, but these have not been completely satisfactory.

It is accordingly a primary object of this invention to provide an improved cooling head for supplying refrigeration to a small chamber.

It is a further object to provide such a cooling head which will function at a point separated by means of a liquid supply line from the principal liquid refrigerant storage container wherein the refrigerant is preferably stored under pressure.

It is a still further object to provide such a cooling head which will remain functional as it is moved through different orientations.

Other objects of the invention will be apparent from the accompanying description and drawings in which:

FIG. 1 is a side elevation partly in cross-section of a cooling head according to the invention.

FIG. 2 is a side elevation partially in cross-section of the lower portion of another embodiment of the cooling head of FIG. 1; and

FIG. 3 is a side elevation in cross-section of a preferred embodiment of a cooling head according to the invention.

The objects of this invention are accomplished in general by providing an improved cooling head for supplying a low temperature liquid refrigerant in close proximity to an infra-red detection cell or similar small area object to be cooled, said object mounted at or adjacent to one end of an elongated chamber such as a hollow double walled insulated container having an open and a closed end. Said cooling head comprises a relatively small liquid refrigerant receptacle positioned internally of and at one end of the elongated chamber

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in proximity to said cell or like object. A central liquid refrigerant supply line leads to the receptacle and a helical refrigerant outlet line which makes at least one complete turn around the inlet line leads from the receptacle out through the opposite end of the chamber, the coils of such outlet line being positioned in close proximity to the side walls of the chamber.

As exemplified by the apparatus shown in the accompanying FIG. 1, the invention comprises a cooling head intended for operation within an elongated chamber such as a vacuum insulated container 10 with provision for mounting an infra-red detection cell 12 in the portion of the insulation space 14 containing no additional insulating material. This is to prevent frosting of the cold detection cell which would occur if it were in contact with the atmosphere. It is also to provide insulation for the cell so as to help maintain it at the desirable low temperature. Electrical leads 16 from the cell are introduced through the container wall in a convenient leak-free fashion. A portion of the container outer wall in proximity to the cell is provided with a window 18 fabricated from material which has a high infra-red transmission such as sapphire. Receptacle 20 is mounted near the detection cell 12 and is used to store small quantities of liquid refrigerant. A liquid refrigerant, such as liquid nitrogen, is introduced to the receptacle through central supply line 22 and refrigerant vapors leave through outlet helical line 24. This particular configuration is quite useful when the device is moved to various positions and especially when it is in a vertical position. In this latter situation, the helical path creates a resistance to flow of liquid and prevents the liquid from rapidly draining from the receptacle. In addition, the helical outlet line is positioned near the container walls so that heat exchange between the refrigerant vapors and heat leaking through and along the container wall can recover a portion of the refrigeration in the outlet vapors. This heat exchange will also vaporize any liquid that happens to flow into the helical line, thus allowing only vapor to be discharged through the outlet line. The helical outlet also provides a low temperature zone surrounding the inlet supply line so as to minimize undesirable heat inleak to such inlet line. This combination maintains the zone in proximity to the liquid nitrogen receptacle substantially at liquid nitrogen temperature. Flow of liquid into line 22 is governed by a controller 26 in the gaseous outlet line 24. Such a controller would normally comprise a valve operated by a temperature sensitive control apparatus.

With such a cooling head, the principal liquid refrigerant container may be located at a remote point, being connected to the cooling head through refrigerant supply line 22. Pressure for supplying the liquid refrigerant to the head is normally developed by vaporization of refrigerant in the principal storage container due to heat inleak which is bound to occur even under the most ideal conditions.

An alternative form of this apparatus is shown in FIG. 2 wherein the gas from line 24 is used to purge the elongated chamber to prevent introduction of air into the chamber. In this embodiment the cooling head and the elongated chamber, such as the double walled insulated container 10, are made as an integral unit wherein the container is closed at what is shown as the lower end in the figures. A discontinuity 27 is provided in exhaust line 24 whereby the refrigerant gas will circulate through the inside of the container 10 before it flows out through the outlet line 28. This air leakage in ap-

paratus of the type shown in FIG. 1 can present a serious problem because it will deposit undue amounts of frost along the outer surfaces of lines 22 and 24 as well as cause an undue loss of refrigeration. The sensing element for control of liquid in line 22 can be positioned in the gas stream leaving the container through outlet line 28.

A preferred form of the apparatus is shown in FIG. 3. Inlet line 22 is separately vacuum insulated at 32 and coil 24 is wound around the insulation outer wall. This additional vacuum insulation reduces heat leak to the interior of the container 10 and also reduces refrigerant losses within the inlet line 22. In this embodiment the receptacle 30 has a somewhat different configuration than that of FIG. 1. Inlet line 22 also preferably extends through one end of receptacle 30 and terminates near the opposite end.

As an example of the use of the apparatus of the present invention, a model was constructed of the type shown in FIG. 3 wherein the vacuum insulated container 10 used with the cooling head was three inches long and 1/2 inch in diameter. The central supply line and helical outlet line were constructed from 1/32 inch diameter stainless steel tubing. The outer shell of the vacuum insulated supply line was 0.134-in. O.D. Liquid nitrogen temperature was continuously maintained at the receptacle with a liquid nitrogen consumption of only 0.03 pound per hour.

With the apparatus of the present invention it is possible to supply refrigeration to such devices as infra-red detection apparatus, masers (microwave-amplification by secondary emission radiation) and the like at remote locations where it is mechanically impossible or undesirable to locate the liquid refrigerant container close to the device to be cooled. While liquid nitrogen has been disclosed as a preferred refrigerant, others such as liquid hydrogen and liquid helium could be used.

Although certain preferred embodiments of the invention have been shown and described, it is to be understood that certain modifications and substitutions could be made by a person skilled in the art without departing from the spirit and scope thereof.

What is claimed is:

1. Apparatus for cooling small objects which comprises a thermally-insulated container having inner and outer walls which define an insulating space therebetween so constructed and arranged to receive a small object at an end thereof; a closed receptacle positioned in the container adjacent the inner wall in indirect heat exchange relation with said small object; a liquid refrigerant inlet conduit extending through said container into said closed receptacle; refrigerant flow-restricting means comprising a vapor exhaust conduit providing gaseous communication with the interior of said closed receptacle and extending out of said closed receptacle through said container in the form of a helix so as to provide flow resistance to the exhaust of liquid phase of the refrigerant conducted into said closed receptacle through the inlet conduit.

2. Apparatus for cooling infra-red detection means which comprises a cylindrical, thermally-insulated container having inner and outer walls which define an insulating space therebetween, such container having an open and a closed end and said insulating space being so constructed and arranged to receive said infra-red detection means at the closed end of said container; a closed receptacle adapted for insertion and mounting in the container adjacent the closed end in indirect heat exchange relation with said infra-red detection means; an inlet conduit for liquid refrigerant extending axially into said container and providing fluid communication with the interior of said closed receptacle, such inlet conduit entering said closed receptacle at a surface opposite the receptacle surface adjacent the container closed end; fluid flow-restricting means comprising a vapor

exhaust conduit providing at least gaseous communication with the interior of said closed receptacle, such exhaust conduit entering said closed receptacle at a surface adjacent the container closed end and extending through said container in the form of a helix axially positioned about said inlet conduit so as to provide flow resistance to the exhaust of liquid phase of the refrigerant conducted into said closed receptacle through the inlet conduit.

3. An apparatus as set forth in claim 2 wherein a tubular insulating medium is interposed between the inlet line and the helical outlet line and wherein the inlet line extends into the chamber and terminates adjacent a side thereof opposite from that where it entered.

4. A refrigerating apparatus for cooling small areas which comprises an elongated hollow, cylindrical, double walled closed container wherein the small area to be cooled is located in one end of the container, a member defining a chamber located within the container adjacent the area to be cooled for storing small quantities of liquid refrigerant and vaporizing same, an inlet line entering through the other end of the container extending axially there through connecting with said chamber, liquid flow-restricting means comprising a helical exhaust line also entering the container through said other end and extending around the periphery of the interior of the container and connecting with the chamber, and wherein there is a discontinuity in the helical exhaust line within the container for purging air which may leak into said container.

5. A cooling head for efficiently supplying low temperature refrigeration to a relatively small area which comprises a relatively small liquid refrigerant receptacle capable of being positioned within and adjacent to one end of an elongated chamber, said end of the chamber providing the relatively small area to be cooled by vaporization of the liquid refrigerant within the receptacle; a substantially straight liquid refrigerant inlet line connected to one surface of the refrigerant receptacle and passing substantially along the longitudinal axis of the cooling head; and liquid flow restricting means comprising a helical refrigerant vapor exhaust line connected to the same surface of the receptacle and passing around the inlet line wherein the axis of the resulting helix is substantially concurrent with the axis of the inlet line, said helical exhaust line providing a flow resistance path to prevent liquid refrigerant from easily leaving the receptacle and also providing means to minimize undesirable heat leak to the liquid refrigerant in the inlet line and receptacle and wherein the exterior dimension of the helical exhaust line with respect to the longitudinal axis of the cooling head is substantially the same as that of the receptacle with respect to said longitudinal axis.

6. A cooling head for efficiently supplying low temperature refrigeration to a relatively small area which comprises a relatively small liquid refrigerant receptacle capable of being positioned within and adjacent to one end of an elongated chamber, said end of the chamber providing the relatively small area to be cooled by vaporization of the liquid refrigerant within the receptacle; a substantially straight liquid refrigerant inlet line connected to the refrigerant receptacle and passing substantially along the longitudinal axis of the cooling head, said inlet line passes through one surface of the receptacle and terminates near the opposite surface interiorly thereof, a substantial portion of the inlet line extending beyond the receptacle being surrounded by an outer shell having an evacuated insulation space between the line and shell; and liquid flow-restricting means comprising a helical refrigerant vapor exhaust line connected to the same surface of the receptacle as the inlet line and passing around the outer shell of the vacuum insulated inlet line wherein the axis of the resulting helix is substantially concurrent with the axis of the inlet line, said helical exhaust line provides a flow resistance path to prevent

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liquid refrigerant from easily leaving the receptacle and also provides means to minimize undesirable heat inleak to the liquid refrigerant in the inlet line and receptacle.

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