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FLEXIBLE HEAT-CONDUCTING MOUNT

Filed Aug. 24, 1966

2 Sheets-Sheet 1

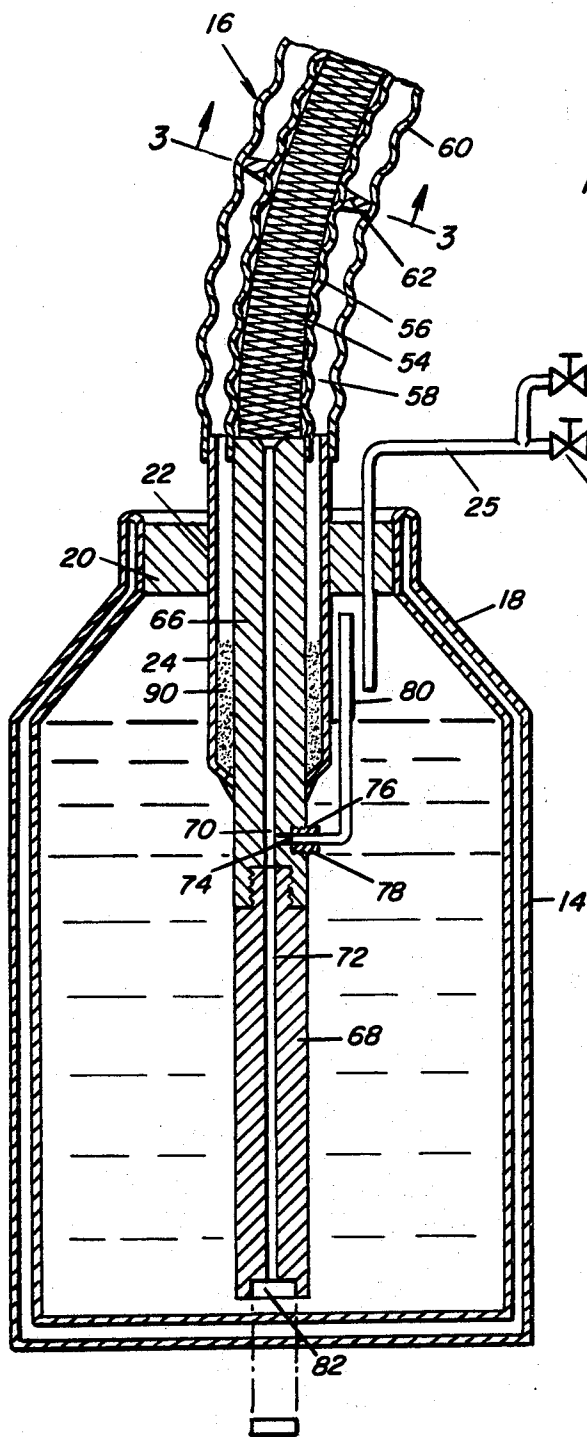


Fig. 1

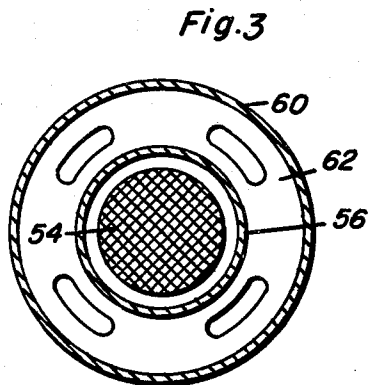


Fig. 3

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2 Sheets-Sheet 2

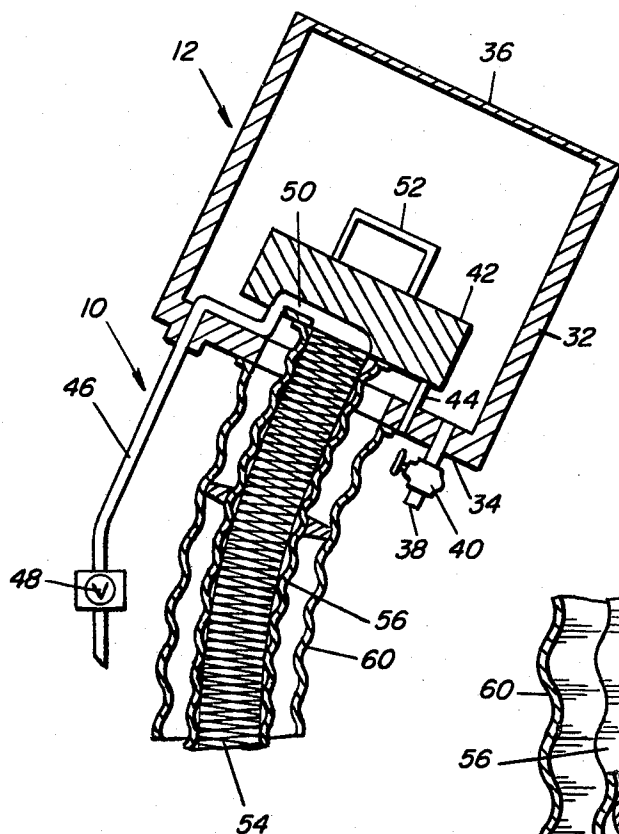


Fig. 2

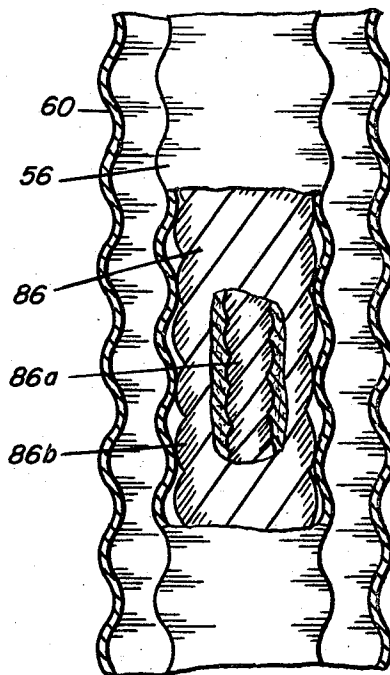


Fig. 4

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FLEXIBLE HEAT-CONDUCTING MOUNT
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ABSTRACT OF THE DISCLOSURE

A cryogenic system comprising a reservoir containing a liquefied gas cryogenic coolant, a mounting block to support an object to be cooled, an elongated linkage being flexible at least in part having one end in thermal contact with the contents of the reservoir and the other end connected to the mounting block, said linkage including a solid thermal conductor extending from the mounting block to the reservoir for extracting substantial amounts of heat from the block and delivering by solid thermal conduction the extracted heat to the coolant, said conductor being one of a metallic braidlike member arranged to generally fill its periphery along its length and a metallic cable of at least two twisted strands.

The present invention relates to cryogenic systems and more particularly to a system for cooling a metallic cooling block upon which a device or sample can be mounted which system includes an elongated flexible linkage between a source of cooling medium and the metallic block.

With the advent of improved cryogenic and solid state radiation detection techniques, there has arisen a need in the art for more versatile and efficient systems for cooling the conducting mounting platforms used for a variety of purposes. Known systems include coupling extensions with hollow coolant delivery tubes surrounded by insulating chambers. But the rate of coolant delivery is difficult to control and sealing problems are commonly experienced.

In brief, the present invention includes a new and improved elongated flexible linkage between a reservoir of liquefied gas such as nitrogen or the like and a conducting mounting block upon which the device or sample to be cooled is supported. The linkage includes a flexible metallic thermal conductor connected to remove by conduction heat from the mounting block.

In one herein disclosed embodiment a flexible inner tube surrounds the central conductor and a flexible outer tube spaced from the inner tube forms an insulation space to reduce to a minimum heat transfer with the ambient. The conductor may be of any design suitable to provide good heat conduction and, if desired, a path for coolant delivery. Examples of the conductor disclosed herein are a flexible braided member and alternately a multi-strand cable.

Another feature of the invention is the provision of a rigid metallic rod extending into the fluid medium within the reservoir, said rod defining a conduit feeding the lower end of the conductor within the inner flexible tube. The reservoir is pressure sealed and the inherent boil-off or addition of pressurized gas fed into the reservoir creates a driving pressure which forces coolant liquid and/or gas up the conductor and inner tube to the mounting block.

Thus the invention can operate in a purely conductive mode in which the difficult problems of coolant delivery control and sealing are avoided. In addition, the invention has versatility over conventional systems by virtue of the additional cooling made possible by coolant delivery up through the inner tube to the mounting block. As will become apparent with the following detailed description, the apparatus of the present invention is capa-

ble of several different modes of operation or combinations thereof.

It is therefore an object of the present invention to provide a new and improved flexible linkage between a reservoir of cooling fluid and a metallic mounting block.

It is a further object of the present invention to provide linkage of the type described which comprises an elongated flexible thermal conductor connected to lower the mounting block temperature by conduction.

It is another object of the present invention to provide a flexible linkage of the type described which includes a flexible conductor and an inner flexible tube fitted about said conductor and a flexible outer tube spaced from the inner tube to define therewith an insulation space, said conductor and inner tube cooperating to provide a conduction path and a coolant delivery path.

It is still another object of the present invention to provide a system of the type described which includes a rigid rod extending partially into the fluid medium and being connected at its end to the lower end of the flexible conductor and inner tube, said rod defining a central bore for carrying fluid medium up to the base of the conductor and defining a side port for conveying coolant vapors to the central bore and upward to the conductor.

Other and further objects of the present invention will become apparent with the following detailed description when taken in view of the appended drawings in which:

FIGURE 1 is a vertical section with parts broken away of the reservoir and part of the flexible linkage of one embodiment of the present invention;

FIGURE 2 is a vertical section of the upper or free end of the flexible linkage of FIGURE 1 as connected to the mounting block within an evacuated chamber;

FIGURE 3 is a transverse sectional view of the linkage taken along line 3-3 of FIGURE 1; and

FIGURE 4 is a vertical section with parts broken away of part of an alternate embodiment of the flexible linkage.

With reference to FIGURES 1-3, the system generally indicated as 10 which according to the present invention includes a vacuum chamber 12 housing the device or sample to be cooled, a reservoir of cooling medium 14 and an elongated flexible linkage 16 connected from reservoir 14 to vacuum chamber 12 and serving to take heat away from the components within chamber 12 in the manner described below. When the system is in use and liquefied gas partially fills reservoir 14, the reservoir cannot be conveniently nor safely moved about. Consequently, the flexible nature of linkage 16 permits movement and orientation of chamber 12 independently of the relatively fixed position of reservoir 14. This capability is important in radiation detection systems where chamber 12 can be moved to the sample or snaked through shielding to take a reading which would otherwise be inaccessible to a solid state detector rigidly fixed to its associated reservoir.

A preferred reservoir 14 comprises a Dewar vessel 18 having a pressure seal 20 closing the upper end thereof. Seal 20 is provided with a central aperture 22, which closes fluid-tight above a rigid insulating shell 24 the function of which is more fully described below. Another line 25 communicates with the upper portion of the Dewar vessel interior through seal 20 and is fluid-tight therewith. Line 25 communicates with a pressure release valve 26 and to a pressure source through cut-off valve 30.

Dewar vessel 18 is provided with conventional means (not shown) for feeding the liquefied medium to the interior thereof. The fluid medium includes liquefied gas, the most common of which is liquefied nitrogen, however, other gases such as helium or hydrogen can be used.

Chamber 12 includes a housing 32 having a base 34 and, in the case of solid state radiation detectors, a for-

ward thin metallic window 36 made of aluminum or beryllium permitting penetration of low energy gamma radiation but preserving the vacuum within housing 32. Nozzle 38 having a cut-off valve 40 communicates with the interior of housing 32 and is adapted to receive a conventional mechanism for reducing the pressure within the housing. A cooling block 42 is mounted within housing 32 by means of posts 44 made of high thermal resistant material to prevent heat loss. An exhaust tube 46 fitted to an automatic solenoid or motor operated control valve 48 extends through base plate 34 into housing 32 and communicates with a conduit 50 defined in the cooling block 42. The sample or device to be cooled, generally indicated as 52, is mounted on the forward face of the cooling block 42. The control valve 48 and exhaust tube 46 is one example of means for controlling the delivery rate of fluid medium to the cooling block 42 as described below.

The elongated flexible linkage 16 includes a conductor having any suitable configuration. One embodiment is in the form of an elongated flexible metallic braid 54 made of a material with good heat conducting properties such as copper or the like. This column of braided material is wound with high density to afford good heat conduction and so that there is at least some degree of porosity between the strands thereof to convey the coolant. It is preferred but not essential that the solid braid occupy 75-85% of the volume within tube 56. Covering the braid is a continuous inner bellows tube 56 which forms the outer boundary of the conduit through which the coolant transfers. Tube 56 may be of good or poor thermal conductive material as desired. In addition, inner bellows tube 56 forms the inner boundary of an insulation space 58 defined by an elongated flexible outer bellows tube 60 held in space relationship with inner bellows tube 56 by a number of insulating circular spacers 62. The lower end of outer bellows tube 60 is secured to the upper end of shell 24.

It should be understood the inner tube 56 may be eliminated if the system is to only operate in a pure conduction mode. Further, it is not essential that tubes 56 and 60 be of metallic bellows construction so long as the tubes have good flexible characteristics at low temperatures. Insulation space 58 communicates with the interior of housing 32 so that space 58 is evacuated to further decrease heat transfer efficiency of the flexible linkage 16 with the ambient. To permit evacuation of all areas of space 58 spacers 62 are provided with openings 64.

The upper end of bellows tube 56 is welded or otherwise rigidly attached to the back face of cooling block 42 and in sealed communication with conduit 50. In order to enhance heat conduction, the upper ends of braid 54 are in contact with surfaces of block 42.

At their lower ends the flexible braid 54 and surrounding inner bellows tube 56 are thermally connected to a rigid metallic rod 66 formed of low thermal resistant material such as copper or the like. Rod 66 is concentric with and spaced from shell 24 with the exception of the bottom of the shell being welded to the rod at a point above the lowermost limit of the rod. Getter material 90 within shell 24 and about rod 66 assists in establishing a low linkage and housing pressure. A rigid extension rod 68 of desired length is threaded to the bottom of rod 66 by means of a heat conducting threaded joint and may be used with correspondingly deep vessels. Cylindrical bores 70 and 72 extend through the length of conducting rod 66 and extension arm 68. In the case of a purely conductive system, the rods can be solid throughout. An access port 74 is defined within rod 66 just above the threaded joint. Access port 74 communicates with bore 70. Port 74 is counter bored at 76 allowing the seating of either a bushing or a cap seal. Thus, a breather tube 80 having its upper end near the upper portion of vessel 18 and its lower end fitted with bushings 78 may be fitted to communicate with bore 70. The lower terminus

of bore 72 is also counterbored at 82 to receive a cap seal (not shown).

In operation, liquid coolant partially fills the vessel 18. Tube 80 and bushing 78 are removed and a cap seal inserted in counterbore 76. Liquid coolant is forced up through bores 70 and 72 to the metal braid 54 within inner bellows tube 56 under action of normal boil-off pressure or introduction of pressurized gas through line 25. Relief valve 26 prevents excess pressure build-up in Dewar 18. The porosity of the braid allows liquefied gas and the cold vapors therefrom to move up the braid toward cooling block 42. The rate of coolant transfer is controlled by valve 48, the automatic opening and closing of which controls the rate of exhaust of liquid coolant and/or vapors. Because arm 68, rod 66 and braid 54 are of low thermal resistant materials, heat conduction through these members from block 42 toward reservoir 14 increases the efficiency and rapidity of the primary cooling function. The block 42 is further cooled by passage of the liquid and vapor through conduit 50 within the block. It is preferred that conduit 50 have as large a surface area within block 42 as possible. Heat transfer from the interior of tube 56 with the ambient is held to a minimum by virtue of the evacuated housing 32 and evacuated space 58 extending the entire length of the exposed linkage 16.

As an alternate method of cooling, counterbore 82 can be plugged and vapor tube 80 with bushings 78 installed to communicate with bore 70. This arrangement results in conductive cooling as described plus additional cooling due to the forcing of coolant vapor through tube 80, up bore 70, up the porous flexible braid 54 to cooling block 42 in the manner described.

Yet another mode of operation comprises the opening of counterbore 82 and installation of tube 80 so that both liquid and vapor are forced up through braid 54 to the cooling block 42.

A pure conduction mode of operation can be used with both bores 76 and 82 plugged.

It will be appreciated that the evaporation or boil-off rate of the cooling medium can be affected to provide the necessary pressure to force the coolant in the manner described without the use of an external pressure source. The flow rate of liquefied gas and vapor therefrom up the porous braid will be controlled by the internal self-generating vapor pressure within the Dewar and the control valve 48.

An alternate construction of linkage 16 illustrated in FIG. 4 includes a central conductor in the form of a multi-strand flexible cable 86 which may have any number of strand layers. For purposes of illustration, a central core 86a and one layer 86b of strands are shown. Each strand is helically wound around the others and has a circular or any other suitable cross section. The strands of cable 86 define a plurality of coolant delivery conduits by virtue of the helical spaces between the strands and the spaces between the outermost strands and the inner walls of bellows tube 56. Thus, the solid strands provide flexibility and good heat conduction and at the same time define conduits for coolant delivery.

Thus, there has been described a new and improved system for efficiency and rapidly cooling a metallic cooling block by several alternate modes of operation and in which the rate of cooling is efficiently controlled. Because of the conductive cooling factor, less coolant consumption per unit time is required during the coolant rising modes than in the case with conventional systems. It should be understood that various modifications can be made to the herein disclosed example of the present invention without departing from the spirit and scope thereof.

What is claimed is:

1. In a cryogenic system having a liquefied gas containing vessel, a mounting block, and an elongated flexible linkage therebetween, the method of cooling the mounting block comprising cooling the block by removing heat

from the block, conducting the heat through the linkage by solid thermal conduction toward the liquefied gas in the vessel.

2. A cryogenic system comprising a reservoir containing a liquefied gas cryogenic coolant, a mounting block to support an object to be cooled, an elongated linkage being flexible at least in part having one end in thermal contact with the contents of the reservoir and the other end connected to the mounting block, said linkage including a solid thermal conductor extending from the mounting block to the reservoir for extracting substantial amounts of heat from the block and delivering by solid thermal conduction the extracted heat to the coolant, said conductor being one of a metallic braidlike member arranged to generally fill its periphery along its length and a metallic cable of at least two twisted strands.

3. The system of claim 2 wherein the linkage includes a flexible tube having an inner wall disposed about the conductor and operatively coupled to the reservoir and block for conveying fluid coolant therein for delivery to said block to further cool the same, parts of said tube being in contact with the solid conductor at spaced locations along the length thereof.

4. A system as set forth in claim 3 wherein the reservoir includes a sealed vessel, a rod having one end contacting the conductor and connected to the tube, said rod extending into the vessel, said rod provided with a bore establishing communication from the vessel interior to the tube, said rod formed of good thermal conducting material.

5. A system as set forth in claim 4 wherein said linkage further includes flexible outer tube means generally coaxial with and spaced from the first mentioned tube to define therewith an insulation space, spacers of thermal insulating material held on one of the first mentioned tube and outer tube means to prevent one tube from contacting the other, said first-mentioned tube and outer tube means formed of material of high thermal impedance and said outer tube means having one end fixed relative said vessel and its other end fixed relative said mounting block but free relative said vessel.

6. A system as set forth in claim 5 wherein the free end

of said outer tube means comprises a housing within which the mounting block is supported, said exhaust tube extending through said housing to the ambient, valve means provided on said housing to permit evacuation of the housing and insulation space, the other end of the outer tube means including an insulating shell member spaced from and about the rod but having one part sealed with a part of the rod within the vessel, said shell member extending through to the outside of the vessel, said outer tube means further including an outer flexible tube sealed with and connected from the exposed end of the shell member to the walls of the housing, said inner tube and said outer tube being of corrugated construction.

7. A system as set forth in claim 4 wherein the coolant comprises one of the group consisting of liquid nitrogen and liquid helium and the coolant partially fills the vessel, the boil-off vapors thereof pressurizing the vessel to assist the forcing of coolant through the bore, through the first mentioned tube, the mounting block and the exhaust tube, means provided on the exhaust tube for regulating the coolant exhaust rate and coolant delivery rate.

8. A system as set forth in claim 7 wherein the bore communicates with a zone of the vessel normally containing liquid coolant.

9. A system as set forth in claim 7 wherein the rod includes an upper part and a threaded lower part, a conduction tube removably connected in communication with a zone of the vessel normally containing vapor coolant and a port in the rod feeding the bore, and the lower part having a port in communication with liquid coolant feeding the bore, and means for selectively closing said ports.

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