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DUAL TUBE REGENERATIVE CRYOSTAT

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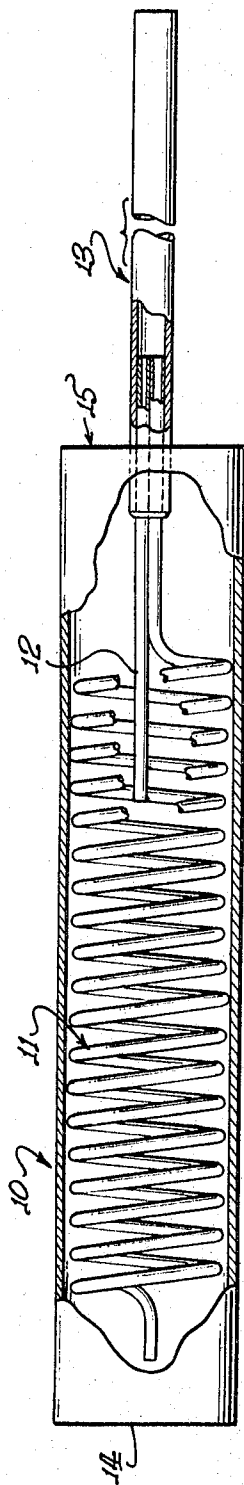


Fig. 1

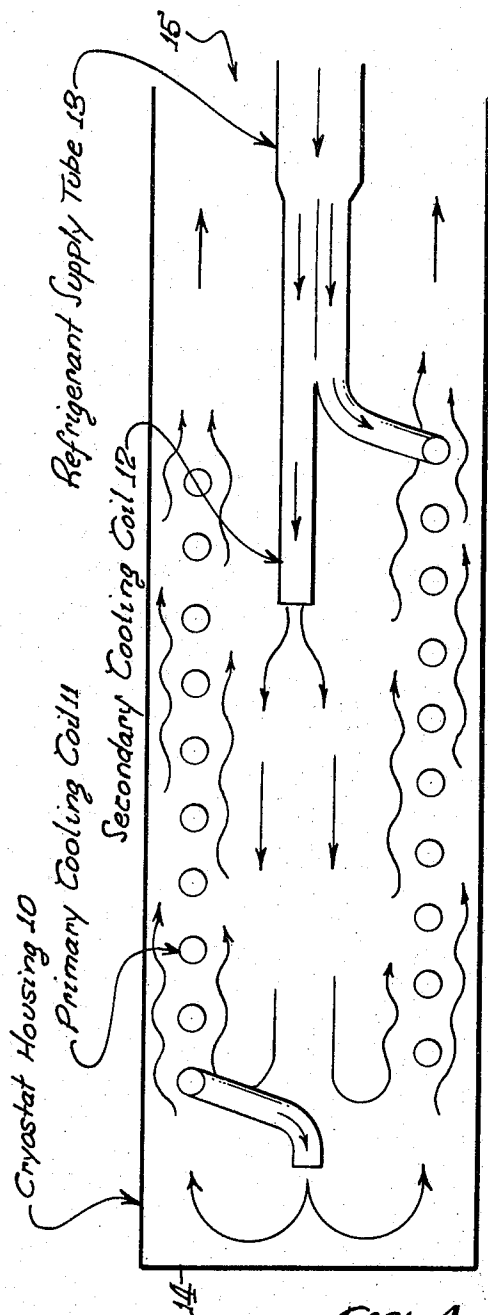


Fig. 2

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DUAL TUBE REGENERATIVE CRYOSTAT

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ABSTRACT OF THE DISCLOSURE

Broadly, the disclosure relates to a regenerative cryostat of the Joule-Thomson type wherein a cryostat fluid is passed through a primary unfinned coil arrangement to a nozzle where it is expanded into the gas phase, the expanded gas being passed back over the coil to effect precooling of the fluid. The structure includes an auxiliary or secondary jet comprising a short unfinned tube or coil extending into the center of the primary coil. The expanding exhaust from the secondary cooling coil acts to control or channel the entire exhaust flow over the primary cooling coil to provide for a more efficient heat transfer.

This invention relates to Joule-Thomson effect cooling apparatus, particularly to a Joule-Thomson effect cooling system providing fast initial cool-down to reduce temperatures of radiation sensing devices, and more particularly to such apparatus which utilizes dual unfinned tubes, thus simplifying the construction and expense thereof.

Radiation sensing devices, such as infrared detectors, are being utilized for a variety of purposes, especially by the military, and provide a detector of requisite sensitivity, namely, one having optimum spectral response and capable of detecting small temperature differences, requiring that the detector cell be maintained at cryogenic temperatures. One common method of accomplishing this low temperature is by expanding a pressurized refrigerant in the vicinity of the cell and returning the cool expanded refrigerant in regenerative heat exchange with the incoming refrigerant to cool the refrigerant before or during expansion and thereby attain a greater Joule-Thomson effect. Joule-Thomson effect cooling devices are capable of producing temperatures as low as about -200° C. for a single stage unit or about -269° C. for multistage systems.

Various types of Joule-Thomson effect cooling devices commonly known as cryostats have been developed. These known prior art devices utilize finned tube coils, heat conductive elements, and/or a plurality of different coolants to enhance the cooling capabilities thereof.

The cryostat of this invention differs from the existing cryostats in two respects: (1) bare tube coils are used instead of the conventional finned tube coils, and (2) a secondary jet of refrigerant gas is utilized to channel the entire exhaust flow over the cooling coils to provide efficient heat transfer. While cryostats exist that utilize a secondary flow of refrigerant, this secondary flow is of a different (secondary) refrigerant and not of the same type of coolant. This secondary flow is also unique in that precooling (regeneration) is enhanced by the location of the secondary nozzle. Thus the principle of secondary flow for this invention is entirely unique with respect to existing cryostats.

The advantages of the inventive cryostat over existing cryostats are simplicity and cost. The technique of a secondary jet to channel the exhaust gas flow makes this bare tube cryostat compatible performance-wise with more complex and most costly finned tube cryostats; and in addition, miniature bare tube cryostats can be produced for less than about one-tenth the cost of existing devices.

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Therefore, it is an object of this invention to provide an improved Joule-Thomson effect cooling system providing fast initial cool-down by the use of a secondary tube arrangement.

Another object of the invention is to provide a simple, bare tube, low cost cryostat for cooling electronic and photoelectric components to cryogenic temperatures.

Another object of the invention is to provide a simple, low cost cryostat which utilizes unfinned tubes and a secondary jet.

Other objects of the invention will become readily apparent from the following description and accompanying drawings wherein:

FIG. 1 is a view partially broken away and partially in cross section of an embodiment of the invention; and

FIG. 2 is a schematic diagram of the gas flow of the FIG. 1 device.

Referring now to the drawings, the cryostat illustrated in FIG. 1 consists of four major components; housing 10, primary cooling coil 11, secondary cooling tube or coil 12, and refrigerant supply tube 13. The cryostat housing 10 defines a cylindrical chamber which confines the expanded refrigerant. While not shown, a detector cell or other device to be cooled will be located in the forward end 14 of housing 10. The exhaust from coils 11 and 12 discharges from the aft end 15 of housing 10. End 15 may be open or provided with a discharge orifice and conduit. The primary cooling coil 11 and the secondary cooling coil or tube 12 are constructed from standard high pressure tubing. Coil 11 is wound in the form of a helix and serves as a heat exchanger. Coil 12 may actually be a straight tube or a short coil positioned partially within and centrally of coil 11 and serves to enhance the regeneration (cooling) of the high pressure incoming refrigerant. The refrigerant supply tube 13 furnishes refrigerant to both coils 11 and 12 from a point of high pressure supply (not shown). The ends of coils 11 and 12 are sealed within supply tube 13 to prevent leakage therearound.

In operation, as shown in FIG. 2, high pressure refrigerant from the source enters the cryostat through the supply tube 13. A portion of the refrigerant passes through the primary cooling coil 11 and expands into the forward end 14 of housing 10. The remainder of the refrigerant passes through the secondary cooling coil or tube 12 and expands into the housing 10 forward of the aft end 15. The primary coil 11 acts as a heat exchanger and the warm high pressure gas passing through is cooled by the flow of cold expanded gas leaving the cryostat. This occurs, as known in the art, since expansion of high pressure gas through a nozzle produces a throttling process, whereby the temperature of the gas decreases as the pressure is lowered. As the incoming high pressure gas or refrigerant is cooled, the expansion takes place from a lower and lower temperature until liquefaction occurs. The efficiency of the cryostat is directly dependent upon the rate of heat exchange between the warm supply gas and the cold exhaust gas. As the refrigerant discharges from the secondary coil or tube 12, it is expanded and the temperature thereof reduced due to the expansion thereof. This cool refrigerant from coil or tube 12 serves to additionally cool the incoming refrigerant in the primary coil 11 and provides additional turbulence at the center of the device (see FIG. 2) which acts to channel the entire exhaust flow over the primary cooling coil 11 to provide for a more efficient heat transfer. The expanded refrigerant from both coils exhausts through the aft end 15 of the housing 10. The exhausted refrigerant may be discharged or recovered depending on the type of system within which the cryostat is utilized.

Due to the secondary coil or tube of the cryostat, bare tube coils for the primary coil 11 becomes feasible thus

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eliminating the need for finned tube coils presently employed and their related cost.

The cryostat of this invention is especially adaptable to miniaturization and the cooling of electronic or photoelectric elements as well as many applications associated with liquefaction of gases. In addition, this concept of the secondary jet may be applied to many heat exchanger designs and applications not associated with cryogenics.

It has thus been shown that this invention provides a simple, bare tube, low cost cryostat which is compatible performance-wise with more complex and costly cryostats.

Although a particular embodiment of the invention has been illustrated and described, modifications will become apparent to those skilled in the art, and it is intended to cover in the appended claims all such modifications as come within the true spirit and scope of the invention.

What we claim is:

1. A cryogenic device comprising: a housing having an opening in at least one end thereof, a coiled tubing defining a heat exchanger positioned at least partially in said housing, said coiled tubing being without cooling fins and having one end terminating near one end of said housing and the other end of said tubing terminating in a fluid supply conduit, unfinned tubing means positioned substantially centrally within only a portion of said coiled tubing, one end of said tubing means terminating in said fluid supply conduit, and the other end of said tubing

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means terminating a substantial distance from said one end of said coiled tubing and adapted to discharge fluid from said fluid supply conduit into a central portion of said coil tubing, whereby additional turbulence at the central portion of said coiled tubing is produced which acts to channel fluid exhausting from said coiled tubing and from said unfinned tubing means over said coiled tubing thus providing more efficient heat transfer.

2. The device defined in claim 1, wherein said tubing means is a substantially straight tube.

3. The device defined in claim 1 additionally including means for preventing leakage between said fluid supply conduit, said coiled tubing, and said tubing means.

4. The device defined in claim 1, wherein said housing is substantially annular.

5. The device defined in claim 4, wherein said opening in said one end of said housing extends across the entire end thereof.

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