WHAT ARE MICRO MINIATURE REFRIGERATORS OR JOULE THOMSON REFRIGERATORS?

Micro Miniature Refrigerators are small, cryogenic refrigerators (Refer to Figure 1.) that derive their cooling power from the Joule-Thomson expansion of a high pressure gas. This effect is amplified by using the cooled gas to pre-cool incoming gas in a counter-current heat exchanger. Temperatures down to 70 K can be achieved in devices a little larger than a matchbox in size. Typically the cold stage is a ceramic pad 14 mm x 10 mm in size supplied with a temperature sensor and resistive heater.

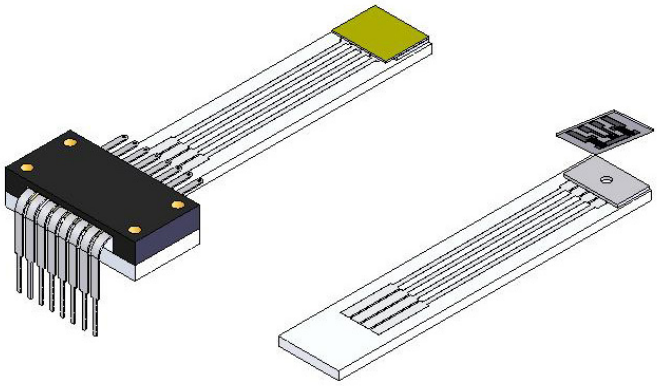

FIGURE 1. The Joule Thomson Micro Miniature Refrigerator.

THE JOULE-THOMSON EFFECT

When a non-ideal gas expands from a high pressure to a low pressure, there is a temperature change, as long as no other work is being done by the gas. The ratio of the temperature change to the pressure change is known as the Joule-Thomson Coefficient. When the ratio is positive, a drop in pressure means a drop in temperature.

The expansion of air from a very high pressure to atmospheric pressure can be used to cool the air to the point of liquefaction. High-pressure gas is passed down a counter-current heat exchanger (Refer to Figure 2.). The gas expands through a capillary section and cools by the Joule-Thomson Effect. Cooled gas is then passed back up the heat exchanger to pre-cool the next cycle of incoming gas. The new cycle of incoming gas is cooler than first cycle, so it cools to even lower temperatures. The cycles repeat until liquefaction.

▶ **NOTE**

The liquefaction of a gas only occurs under vacuum of 8 milliTorr or better.

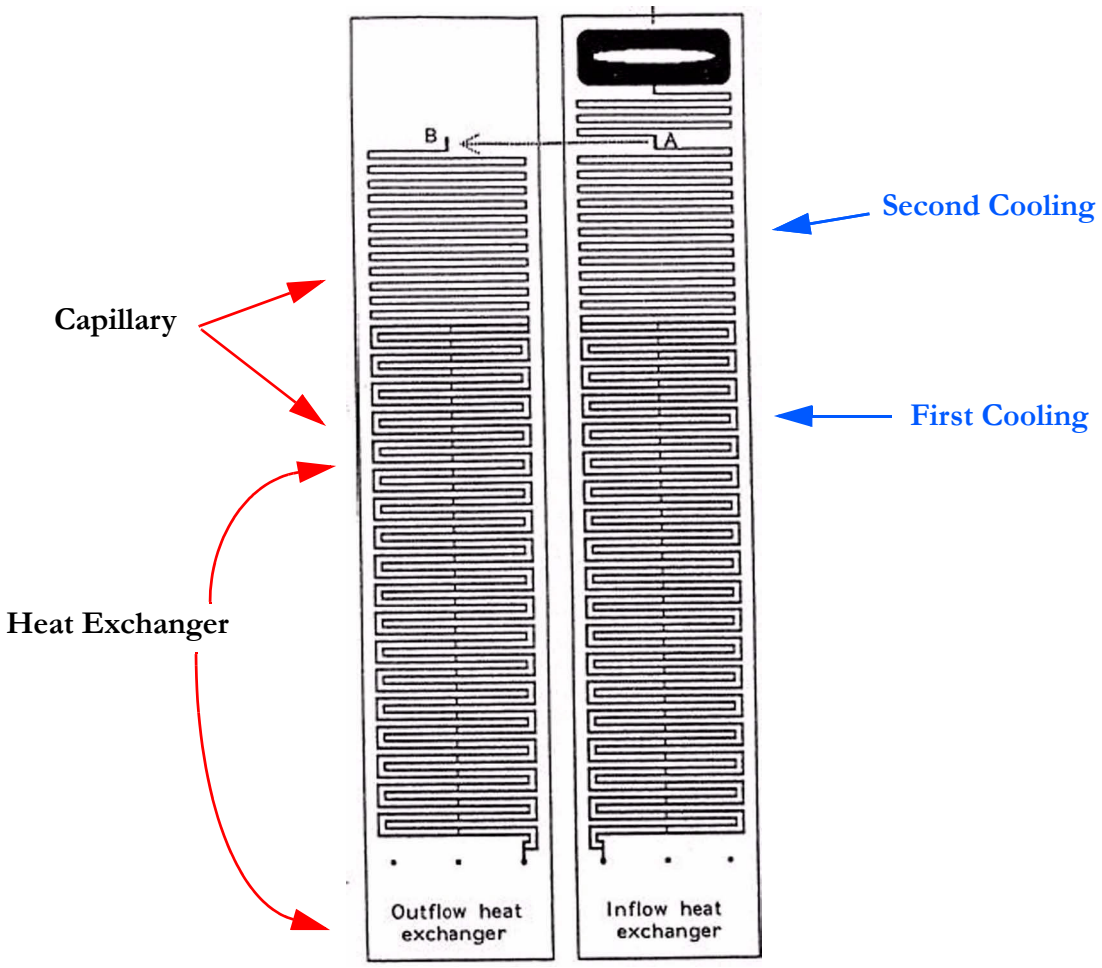

FIGURE 2. The heat exchangers found in a Joule Thomson refrigerator.

With the general concept of cooling in mind, gas typically enters into the Joule Thomson refrigerator at a pressure of at least 1800 psi (Refer to Figure 3.). As the high pressure gas goes through the capillary channels in the glass, the first pressure drop is encountered (A). This first pressure drop gives a cooling of between 2 and 3 degrees. The second pressure drop gives another 4 to 5 degrees of cooling (B). At this point in the cycle, roughly 80 percent of the gas is returned to pre-cool the next incoming gas (C). The gas then exits the refrigerator at a final pressure of less than 10 psi. When the gas has cooled enough, there is a low temperature reservoir if liquefied gas found at the end of the refrigerator (D), directly under the cold pad.

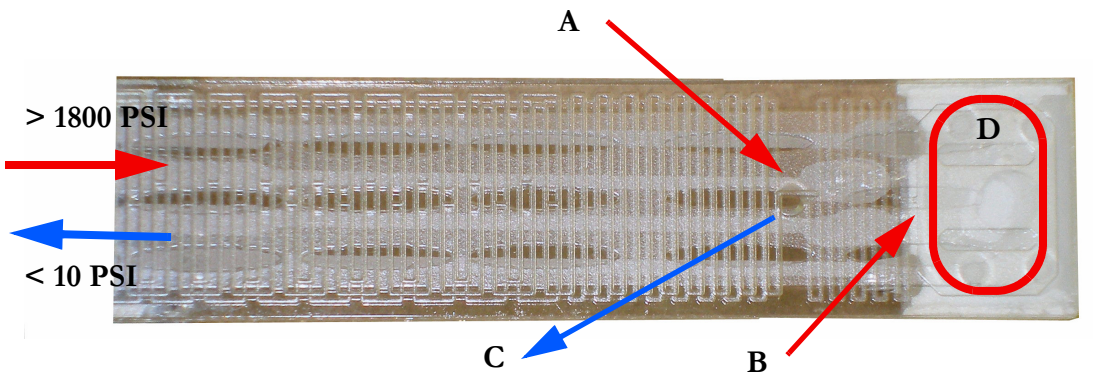

FIGURE 3. The channels in the Joule Thomson refrigerator channel the high pressure gas.

For further information on the fabrication of these refrigerators, please refer to W.A. Little, Review of Scientific Instruments 55, 661 (1984).

THE REFRIGERATION SYSTEM COMPONENTS

The cryogenic system consists of:

- Pure high-pressure gas (greater than 1800 psi)
- Gas Regulator
- Filter/Dryer Apparatus
- Refrigerator
- Temperature controller
- Vacuum Chamber
- Vacuum Pump

ADVANTAGES OF A JOULE THOMSON MICRO MINIATURE SYSTEM:

The advantages of such micro miniature refrigerators for scientific applications are:

- Fast cool-down and warm-up. < 20 min.
- Precise Temperature control ± 0.1 K
- Absence of mechanical, acoustic, or electrical noise
- Small size
- Wide range of operation - 70 K to 730 K
- Low cost of operation - $0.50/ hour
- No maintenance required

These refrigerators have been widely used for applications in chemistry, physics, and materials science. Refrigerators have been tailored for use for:

- optical microscopy
- electron microscopy
- optical transmission spectroscopy
- X-Ray diffraction
- Raman and fluorescence work

These refrigerators have been optimized for use with low temperature microprobes for studies of semiconductor devices, and for studies of the physical properties of semiconductors and semimetals.

FURTHER QUESTIONS

If you have further questions, please do not hesitate to contact MMR Technologies, Inc.:

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