

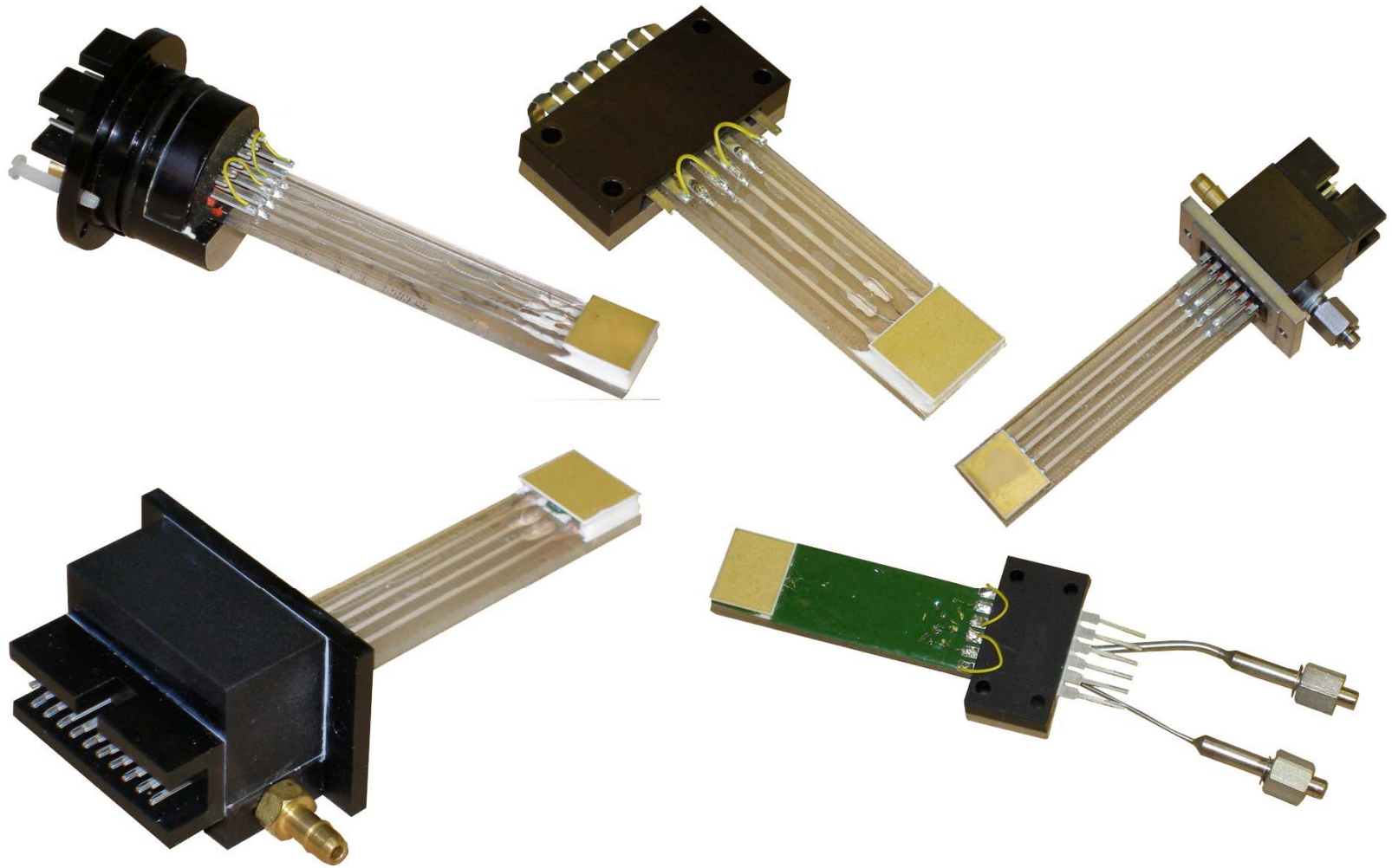
# Joule-Thomson Refrigerators

Micro-Miniature Refrigerators



**MMR Technologies, Inc**

# The Joule-Thomson Refrigerators

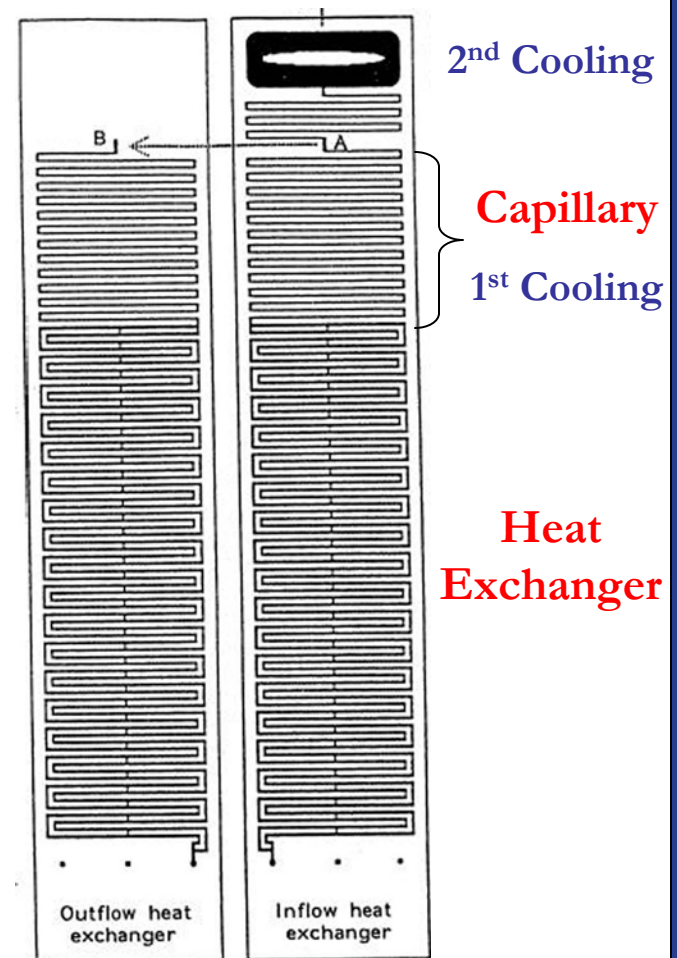


# The Joule-Thomson Effect

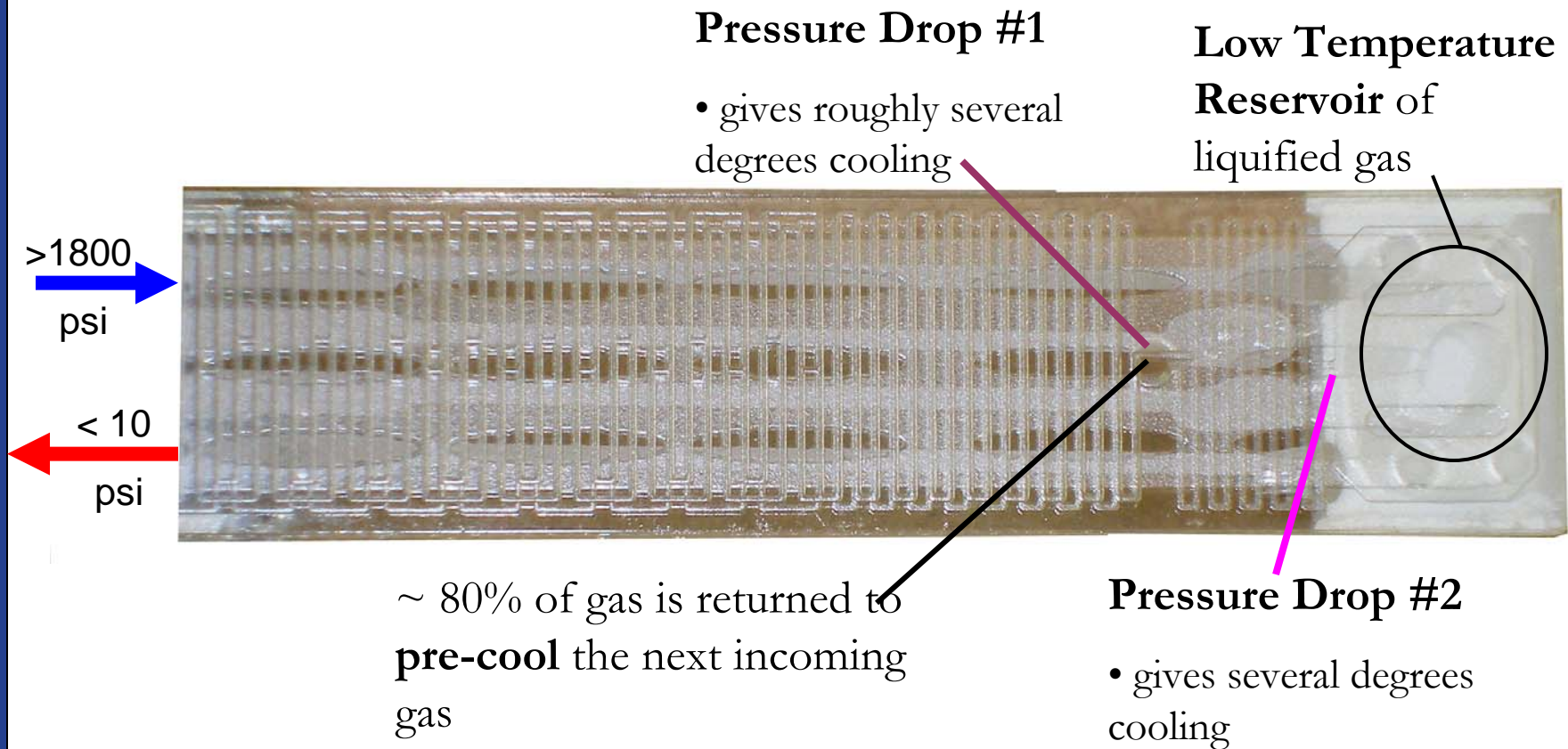
- When a non-ideal gas expands from a high pressure to a low pressure, there is a temperature change, as long as no other work is being done by the gas
  - Ratio of the temperature change to the pressure change is known as the Joule-Thomson Coefficient
  - When the ratio is positive, a drop in pressure means a drop in temperature
- Expansion of air from a very high pressure to atmospheric pressure can be used to cool the air to the point of liquefaction

# How Does a J-T Refrigerator Work?

- High-pressure gas is passed down a counter-current heat exchanger
  - The gas expands through a capillary section and cools by the Joule-Thomson Effect
- Cooled gas is passed back up the heat exchanger to pre-cool the next cycle of incoming gas
- New cycle of incoming gas is cooler than first cycle, so it cools to even lower temperatures
- Cycles repeat until liquefaction (only occurs under vacuum of 8 milliTorr or better)



# Structure of a J-T Refrigerator



# Components in a J-T Temperature Control System

- Pure high-pressure gas (greater than 1800 psi)
- Filter/Dryer Apparatus
  - This is required to prevent the condensation of impurities in the refrigerator.
- Refrigerator
- Temperature controller
  - The gas mechanism only provides cooling – there is a temperature sensor and a heater built into a Joule-Thomson Refrigerator to provide heating and accurate temperature control.

# Possible Temperature Ranges

## Kelvin Scale

- 70 K to 580 K
- 80 K to 580 K
- 70 K to 730 K
- 80 K to 730 K
- 300 K to 730 K

## Centigrade Scale

- - 200 °C to 305 °C
- - 190 °C to 305 °C
- - 200 °C to 455 °C
- - 190 °C to 455 °C
- 25 °C to 455 °C

$$K = °C + 273$$

# General J-T Refrigerator Specs

- Temperature Range: available between 70K and 730 K
  - Temperature Stability: +/- 1.5 K
- Cooling Capacity (at 85K): 250 mW with N<sub>2</sub>(g)
- Possible Gases: Nitrogen, Argon
- Inlet Gas Pressure: 1800 psi
- Sample Size: 1 cm x 1 cm
- Vacuum Pressure Required: 8 milliTorr or better
- Weight of Stage: 10 g to 60 g (dependent on stage)
- Dimensions of Stage: 35 mm x 100 mm (dependent on stage)
- Stage Materials:
  - Refrigerator: Glass
  - Temperature Sensor: Platinum Resistor Thermal Device
  - Sample Stage Material: Al<sub>2</sub>O<sub>3</sub>