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NASA TECH BRIEF

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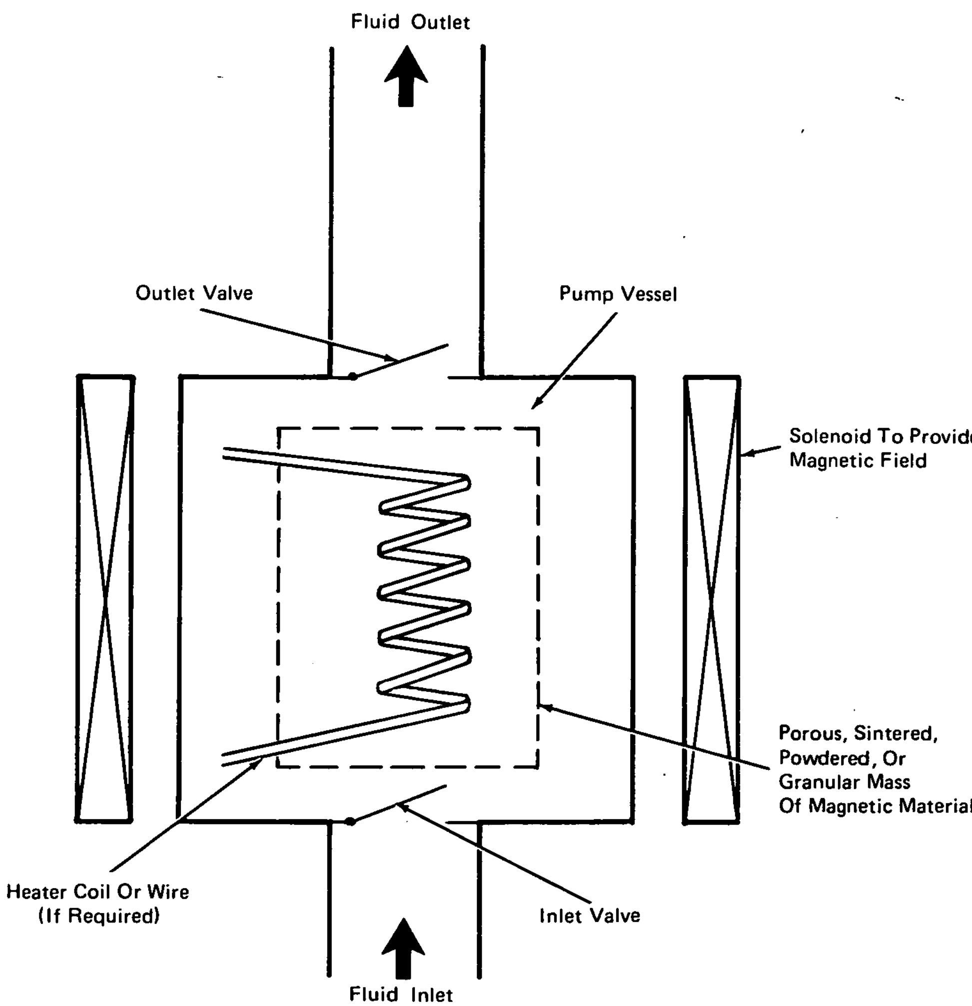
Magnetocaloric Pump

A unique pump has been designed to pump very cold liquids and gases such as helium, neon and nitrogen. Pumping is achieved by use of the magnetocaloric effect. Adiabatic magnetization and demagnetization are used to alternately heat and cool a slug of the pumped fluid contained in a closed chamber. This alternate heating and cooling causes the fluid to alternately expand and contract. Unidirectional inlet and outlet valves in the chamber alternately open and close to produce a pulsating flow of fluid.



Schematic Of Magnetocaloric Pump

(continued overleaf)

Conventionally, cold fluids are pumped by mechanical pumps, diffusion pumps, and various other types of cyclic and acyclic sorption pumps. Mechanical and diffusion pumps can cause contamination of the pumped fluid with oil or other substances, and many such pumps can operate only at or above room temperature. In contrast, the magnetocaloric pump (see figure) does not contaminate the pumped fluid, and it can operate at or near the boiling point of a fluid. It is, in fact, at the boiling point (saturated conditions) where the magnetocaloric pump is expected to be the most effective. The cyclic nature of the magnetocaloric pump permits indefinite operation, which in many applications would be an advantage over acyclic or one-shot cryopumps.

The pumping chamber contains a porous mass of magnetic material and has unidirectional input and output valves. In operation, the magnetic material is magnetized by an electromagnet. To start up, using a magnetic material having a positive magnetocaloric effect, the magnetic material is magnetized. The pump is primed and cooled to the same temperature as the fluid to be pumped by drawing the cold fluid through the pump until the temperatures equalize. The outlet valve is closed, and the magnetic field is decreased. This causes the fluid in the pump to contract and the reduced pressure draws in more fluid through the inlet valve. In cases where cold gases are being pumped, condensation may occur at this point of the cycle. The inlet valve is now closed, and the magnetic field is increased, causing the fluid to expand. At the right moment, the outlet valve opens, and the expanding fluid is expelled. Alternately, for a magnetic material having a negative magnetocaloric effect, the magnetization/demagnetization cycle is reversed.

To increase flow rate, it may be desirable to add additional heat to the chamber during the pumping cycle.

This pumping principle has been demonstrated with a 4-cm diameter pumping chamber. Saturated helium gas at 3 to 4 K was pumped with a magnet varying from 1.5 to 6.0 teslas of magnetic flux intensity and cycled once every 15 to 20 seconds. Pressure differences between inlet and outlet of 470 mm Hg with no flow and 110 mm Hg with flow have been created by the pump in initial tests. Analysis indicates that with optimum design, a pressure difference of more than 740 mm Hg should be possible. This would permit the pump to create superfluid conditions in a vessel of liquid helium by dropping the vapor pressure below 38 mm Hg.

Notes:

1. The following documentation may be obtained from:
   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)

   Reference: NASA TM-X-52983 (N71-20943), The Practical Use of Magnetic Cooling
2. Technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B73-10124

Patent status:

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