Phase 2 Project Summary

(no proprietary data)

Firm: Creare Incorporated
Contract Number: NNX08CA24C
Project Title: Lightweight Magnetic Cooler With a Reversible Circulator

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Identification and Significance of Innovation:

A critical need for NASA's future space exploration is the capability to provide multi-year cooling for low-noise detector systems in the temperature range from 4 K to subkelvin. There are no commercially available cryocoolers that can provide efficient, low-capacity cooling in this temperature range. The innovation is to develop a highly efficient, lightweight space magnetic cooler that can continuously provide remote/distributed cooling at temperatures in the range of 2 K with a heat sink at about 15 K. The magnetic cooler uses an innovative cryogenic circulator that enables a lightweight magnetic cooler to operate at a high cycle frequency to achieve a large cooling capacity. The ability to provide remote/distributed cooling not only allows flexible integration with a payload(s) and spacecraft, but also reduces the mass of the magnetic shields needed.

Technical Objectives and Work Plan:

The goal was to develop one of the most critical component technologies for an AMRR, the reversible cryogenic circulator. The circulator design is based on Creare's space-proven micro-turbomachinery technology, which features non-contacting, self-acting gas bearings and clearance seals. These features result in long-life and vibration-free operation.

We designed, built, and tested a circulator module. More specifically, we first characterized the performance of the gas bearings at low pressures in a brassboard facility. Then we fabricated a complete circulator module (one-half of a complete two-way circulator). Next, we measured the circulator performance at low temperatures and low pressures under forward and reverse flow conditions. Finally, we updated the design and performance prediction of the circulator and the AMRR system.

Technical Accomplishments:

We demonstrated that the circulator module can operate at very high speeds under the challenging conditions of 80 K and 0.2 bar. The low operating pressure is the key to enabling the AMRR to achieve a low cooling temperature of about 2 K. We showed that the circulator module can achieve the pressure rise needed for an AMRR system. We also demonstrated that the module's operation is efficient. Based on its performance data, the predicted AMRR COP can reach about 36% of a Carnot Cycle.

NASA Application(s):

The AMRR system will enable NASA to carry out future science missions that use cryogenic infrared, gamma ray, and X-ray detectors. It will be especially useful for missions that require multiple detectors spaced at a distance from one another. Potential missions include the

International X-Ray Observatory (IXO) and the Single Aperture Far-Infrared observatory (SAFIR).

Non-NASA Commercial Application(s):

The military applications for the proposed magnetic cooler include cooling systems on space-based surveillance, missile detection, and missile tracking systems. Scientific applications include cooling systems for material microanalysis using X-ray microcalorimeter spectrometers, cryogenic particle detectors, and biomolecule mass spectrometry using superconducting tunnel junction detectors. The cryogenic circulator itself has many cryogenic thermal management applications.

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