

A publication of the International Cryocooler Conference

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# **CRYOCOOLERS 8**

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## Preface

The last few years have witnessed a substantial maturing of long life Stirling-cycle cryocoolers built upon the heritage of the flexure-bearing cryocoolers from Oxford University, and have seen the emergence of mature pulse tube cryocoolers competing head-to-head with the Stirling cryocoolers. Hydrogen sorption cryocoolers, Gifford-McMahon cryocoolers with rare earth regenerators, and helium Joule-Thomson cryocoolers have also made tremendous progress in opening up applications in the 4 K to 10 K temperature range. Tactical Stirling cryocoolers, now commonplace in the defense industry, are finding application in a number of cost-constrained commercial applications and space missions, and are achieving ever longer lives as they move to linear-drive, clearance-seal compressors.

Building on this expanding availability of commercially viable cryocoolers, numerous new applications are being enabled; many of these involve infrared imaging systems, and high-temperature superconductors in the medical and communications fields. The vibration sensitivity of many of the infrared and medical imaging applications has led to the recognition that cryocooler-generated vibration and EMI is a critical performance parameter for these applications. In response, advanced closed-loop active vibration control systems have been developed and are being delivered to their first users. Application experiments, designed to explore, troubleshoot and resolve product integration issues, are occurring on an ever widening front, particularly in the fields of infrared imaging and spectroscopy, gamma-ray spectroscopy, and high-temperature superconductor applications. An important lesson is that integrating cryogenic systems requires care and thoughtfulness in a broad range of engineering and scientific disciplines.

This book draws upon the work of many of the international experts in the field of cryocoolers, and is based on their contributions at the 8th International Cryocooler Conference, held in Vail, Colorado, in June 1994. The program of this conference consisted of 107 papers. Of these, 93 are published here in *Cryocoolers 8*. Although this is the eighth meeting of the conference, which has met every two years since 1980, this is the first time the authors' works have been made available to the public in hardcover book form. As such, this book is the first volume of what we hope will be a series of professional texts for users and developers of cryocoolers. Previous proceedings of the International Cryocooler Conference have been published over the years as informal reports by the particular government organization sponsoring the conference -- typically a different organization for each conference. A listing of previous conference proceedings is presented in the Proceedings Index, at the rear of this book. Most of the previous proceedings were printed in limited quantity and are out of print at this time.

Because this book is designed to be an archival reference for users of cryocoolers as much as for developers of cryocoolers, extra effort has been made to provide a thorough Subject Index that covers the referenced cryocoolers by type and manufacturer's name, as well as by the scientific or engineering subject matter. Extensive referencing of test and measurement data is included in the Subject Index under a wide variety of performance topics. Examples include refrigeration performance data, complete cryocooler characterization test data, vibration and EMI

measurements, and qualification and life test experience. Application and integration experience is also highlighted by specific index entries. To aide those attempting to locate a particular contributor's work, a separate Author Index is also provided, listing all authors and co-authors. Contributing organizations are listed in the Subject Index to assist in finding the work of a known institution, laboratory, or cryocooler manufacturer.

The content of the book is organized into 14 chapters by cryocooler type, starting with Stirling cryocoolers, pulse tube cryocoolers, and their associated drive electronics. Next, Brayton, Joule-Thomson and sorption cryocoolers are covered in a progression of lowering temperatures. Low-temperature regenerators for Gifford-McMahon cryocoolers and magnetic refrigerators in the 4 to 10 K range are covered next. The last three chapters deal with cryocooler integration technologies and experience to date in a number of representative applications. These applications are divided by temperature into those in the 2-20 K range, and those in the 50-100 K range. The articles in these last three chapters contain a wealth of information for the potential user of cryocoolers, as well as for the developer.

It is hoped that this book will serve as a valuable source of reference to all those faced with the challenges of taking advantage of the enabling physics of cryogenics temperatures. The expanding availability of low-cost, reliable cryocoolers has the potential of making major advances in a number of fields.

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