A publication of the International Cryocooler Conference

CRYOCOOLERS 12

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Pasadena, California

Kluwer Academic/Plenum Publishers
New York, Boston, Dordrecht, London, Moscow

Proceedings of the 12th International Cryocooler Conference, held June 18–20, 2002
in Cambridge, Massachusetts

ISBN 978-0-306-47714-0

233 Spring Street, New York, N.Y. 10013

http://www.wkap.nl/

10 9 8 7 6 5 4 3 2 1

A C.I.P. record for this book is available from the Library of Congress

Preface

The last two years have witnessed a continuation in the breakthrough shift toward pulse tube cryocoolers for long-life, high-reliability cryocooler applications. One class of pulse tubes that has reached maturity is referred to as "Stirling type" because they are based on the linear Oxford Stirling-cooler type compressor; these generally provide cooling in the 30 to 100 K temperature range and operate at frequencies from 30 to 60 Hz. The other type of pulse tube cooler making great advances is the so-called "Gifford-McMahon type." Pulse tube coolers of this type use a G-M type compressor and lower frequency operation to achieve temperatures in the 2 to 10 K temperature range. Nearly a third of this proceedings covers these new developments in the pulse tube arena.

Complementing the work on low-temperature pulse tubes is substantial continued progress on rare earth regenerator materials and Gifford-McMahon coolers. These technologies continue to make great progress in opening up the 2 - 4 K market. Also in the commercial sector, continued interest is being shown in the development of long-life, low-cost cryocoolers for the emerging high temperature superconductor electronics market, particularly the cellular telephone base-station market. At higher temperature levels, closed-cycle J-T or throttle-cycle refrigerators are taking advantage of mixed refrigerant gases to achieve low-cost cryocooler systems in the 65 to 80 K temperature range. Tactical Stirling cryocoolers, the mainstay of the defense industry, continue to find application in cost-constrained commercial applications and space missions; the significant development here is the cost-effective incorporation of Oxford-like flexure spring piston supports so as to achieve an extended-life, low-cost product.

The objective of *Cryocoolers 12* is to archive these latest developments and performance measurements by drawing upon the work of the leading international experts in the field of cryocoolers. In particular, this book is based on their contributions at the 12th International Cryocooler Conference, which was held in Cambridge, Massachusetts, on June 18-20, 2002. The program of this conference consisted of 120 papers; of these, 105 are published here. Although this is the twelfth meeting of the conference, which has met every two years since 1980, the authors' works have only been made available to the public in hardcover book form since 1994. This book is thus the fifth volume in this new series of hardcover texts for users and developers of cryocoolers.

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, and application and integration experience, is included under specific index entries. Contributing organizations are also listed in the Subject Index to assist in finding the work of a known institution, laboratory, or manufacturer. To aide those attempting to locate a particular contributor's work, a separate Author Index is provided, listing all authors and coauthors.

Prior to 1994, proceedings of the International Cryocooler Conference were published 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.

The content of *Cryocoolers 12* is organized into 20 chapters, starting first with an introductory chapter providing summaries of major government cryocooler development and test programs. The next several chapters address cryocooler technologies organized by type of cooler, starting with regenerative coolers; these include Stirling cryocoolers, pulse tube cryocoolers, Gifford-McMahon cryocoolers, thermoacoustic refrigerators, and associated regenerator research. Next, recuperative cryocoolers including Brayton, Joule-Thomson, and sorption cryocoolers are covered. The technology-specific chapters end with a chapter on unique sub-Kelvin and optical refrigerators. The last three chapters of the book deal with cryocooler integration technologies and experience to date in a number of representative space and commercial applications. 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 is making major advances in a number of fields.

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