A publication of the International Cryocooler Conference

CRYOCOOLERS 13

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Springer

Proceedings of the 13th International Cryocooler Conference,
held March 29–April 1, 2004 in New Orleans, Louisiana

ISSN: 1570-2235
ISBN: 0-387-23901-4

Printed on acid-free paper.

Printed in the United States of America.

9 8 7 6 5 4 3 2 1 SPIN 11335245

springeronline.com

Preface

The last two years have witnessed a continuation in the breakthrough shift toward pulse tube cryocoolers for long-life, high-reliability cryocooler applications. New this year are papers describing the development of very large pulse tube cryocoolers to provide up to 1500 watts of cooling for industrial applications such as cooling the superconducting magnets of Mag-lev trains, cooling superconducting cables for the power industry, and liquefying natural gas. Pulse tube coolers can be driven by several competing compressor technologies. One class of pulse tube coolers 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. A second type of pulse tube cooler is the so-called "Gifford-McMahon type." Pulse tube coolers of this type use a G-M type compressor and lower frequency operation (~1 Hz) to achieve temperatures in the 2 to 10 K temperature range. The third type of pulse tube cooler is driven by a thermoacoustic oscillator, a heat engine that functions well in remote environments where electricity is not readily available. All three types are described, and in total, nearly half of this proceedings covers new developments in the pulse tube arena.

Complementing the work on low-temperature pulse tube and Gifford-McMahon cryocoolers is substantial continued progress on rare earth regenerator materials. These technologies continue to make great progress in opening up the 2 - 10 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 take 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 13* 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 13th International Cryocooler Conference that was held in New Orleans, Louisiana, on March 29 - April 1, 2004. The program of this conference consisted of 123 papers; of these, 88 are published here. Although this is the thirteenth 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 sixth volume in this new series of hardcover texts on 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 13* is organized into 15 chapters, starting with papers describing the development of a new class of space cryocoolers to provide cooling in the 4-18 K temperature range. 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 Joule-Thomson, and sorption cryocoolers are covered. The technology-specific chapters end with a chapter on unique sub-Kelvin, magnetic, 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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