

Astro-E2 Magnesium Diboride High Current Leads.....	952
J. S. Panek, J. G. Tuttle, V. Marrero, S. Mustafi, R. Edmonds, A. Gray, and S. Riall	

PART B

HELIUM II PHENOMENA

Critical Velocities for He II.....	961
H. A. Snyder	
Variation of Subcooled Film Boiling State in He II with the Pressure.....	968
M. Nozawa, N. Kimura, M. Murakami, and I. Yamamoto	
Measurements of He II Thermal Counterflow Using PIV Technique.....	976
T. Zhang and S. W. Van Sciver	
Heat Transfer through Porous Media in the Counterflow Regime of He II.....	983
R. Maekawa and B. Baudouy	
Transient Heat Transport in Subcooled He II Associated with JT Effect.....	991
R. Maekawa, A. Iwamoto, and S. Hamaguchi	
Steady State Heat Transport in a Channel Containing He II at High Pressures up to 1.5 MPa	999
A. Sato, M. Maeda, and Y. Kamioka	
Heat Transport Characteristics of He II Channels with the Fountain Effect	1007
K. Suemasu, M. Takahashi, and T. Okamura	
Numerical Analysis on Heat Transfer from a Flat Plate at One End of a Rectangular Duct with an Orifice Filled with Pressurized He II.....	1015
K. Fujita, H. Tatsumoto, Y. Shirai, and M. Shiotsu	
Critical Heat Flux on a Flat Plate Located at the Middle of a Duct in Forced Flow of Pressurized He II	1023
T. Okamura, M. Saeki, K. Hata, K. Hama, Y. Shirai, and M. Shiotsu	
Experimental Study of Heat Transfer from Stainless Steel Foil in He II during Film Boiling State	1031
P. Zhang and M. Murakami	
Numerical Study on Characteristics of a Pre-Cooling He II Heat Exchanger.....	1039
Y. Ueno, T. Okamura, and A. Sato	
Thermo-Mechanical Pumps for Superfluid Helium.....	1047
G. Kaiser, B. Schumann, R. Stangl, A. Binneberg, and E. Wobst	
Temperature and Pressure Measurements and Visualization of He II Cavitation Flow through Venturi Channel	1052
T. Ishii, M. Murakami, and K. Harada	
Numerical Simulation of Cavitating Flow of Liquid Helium in a Vertical Converging-Diverging Nozzle	1060
J. Ishimoto and K. Kamijo	

Lambda Front Propagation in the Superfluid Helium Contained in the External Auxiliary Bus-Bar Line of the LHC	1068
O. Capatina, A. Poncet, and B. Skoczen	

FLUID DYNAMICS, HEAT TRANSFER, AND THERMODYNAMICS

Design and Operating Characteristics of a Cryogenic Nitrogen Thermosyphon.....	1079
R. Christie, D. Robinson, and D. Plachta	
Natural Convection of Subcooled Liquid Nitrogen in a Vertical Cavity.....	1091
Y. S. Choi, S. W. Van Sciver, and H.-M. Chang	
Basic Study on Two-Phase Flow Characteristics of Slush Nitrogen in a Pipe.....	1099
J. Ishimoto, R. Ohno, H. Yanagi, A. Machida, M. Ikeuchi, K. Hattori, and A. Ito	
Heat Transfer near Critical Condition in Two-Phase He I	
Thermosiphon Flow at Low Vapor Quality.....	1107
B. Baudouy	
A Heat Exchanger between Forced Flow Helium Gas at 14 to 18 K and Liquid Hydrogen at 20 K Circulated by Natural Convection.....	1115
M. A. Green, S. Ishimoto, W. Lau, and S. Yang	
Thermal Conductivity Measurements of Subcooled Oxygen below 80 K.....	1123
T. Kucukomeroglu, D. Celik, and S. W. Van Sciver	
Experimental Study on the Superheat Limit of Liquid Mixture of Argon and Oxygen	1130
K. Nishigaki, M. Takeda, H. Ohta, and T. Akazawa	
Computational Fluid Dynamic Modeling of Pressure Drop through Wire Mesh Screen Regenerators.....	1138
S. A. Yarbrough, B. A. Flake, and A. Razani	
Working Fluid State Properties Measurements in Medium and High Frequency Cryocoolers.....	1146
T. P. Roberts and P. V. Desai	
Study of Random Wire Type Regenerators for Stirling Cryocoolers	1154
S. Jeong, K. Nam, and S. Choi	

CRYOGENICS AT ZERO G

Liquid Hydrogen Zero-Boiloff Testing and Analysis for Long-Term Orbital Storage	1163
L. J. Hastings, A. Hedayat, C. B. Bryant, and R. H. Flachbart	
Test Data Analysis of a Spray Bar Zero-Gravity Liquid Hydrogen Vent System for Upper Stages.....	1171
A. Hedayat, J. W. Bailey, L. J. Hastings, and R. H. Flachbart	

Microgravity Cryogenic Boiling Heat Transfer with Application to ZBO and Pipe Chilldown.....	1179
J. N. Chung, W. Shyy, K. Yuan, T. Chen, and C. Carvalho	
Trade-Off between Thermal Link Solutions for the Cryosystem Cryocooler On-Board the International Space Station	1187
T. Trollier, A. Ravex, C. Aubry, A. Seidel, H. Stephan, L. De Parolis, A. Sirbi, and R. Kujala	

CRYOCOOLER PROGRAMS OVERVIEWS

NASA Space Cryocooler Programs — A 2003 Overview	1197
R. G. Ross, Jr., R. F. Boyle, and P. Kittel	
Air Force Research Laboratory Cryocooler Technology Development.....	1205
T. M. Davis, D. A. Smith, and R. M. Easton	
Space Tracking and Surveillance System (STSS) Cryogenic Technology Efforts and Needs.....	1213
I. L. Kolb, D. G. T. Curran, and C. S. Lee	
Air Force Research Laboratory Spacecraft Cryocooler Endurance Evaluation Update: 2000–2002.....	1221
E. Oliver, S. A. Yarbrough, N. S. Abhyankar, and B. J. Tomlinson	

CRYOCOOLER RELIABILITY

Performance Degradation of Cryocoolers for Space Applications.....	1231
N. Abhyankar, T. Roberts, T. Davis, and B. J. Tomlinson	
Methods for Accelerated Life Evaluation of Long-Life Cryocoolers.....	1239
G. R. Pruitt, T. M. Davis, and B. A. Ross	
Reliability Growth of Tactical Coolers at CMC Electronics Cincinnati: 1/5-Watt Cooler Test Report.....	1252
D. T. Kuo and T. D. Lody	

STIRLING CRYOCOOLERS

High Capacity Staged Pulse Tube Cooler	1263
C. Jaco, T. Nguyen, R. Colbert, T. Pietrzak, C. K. Chan, and E. Tward	
Inertance Tubes Optimization for kW-Class Pulse Tubes.....	1269
L. O. Schunk, J. M. Pfotenhauer, G. F. Nellis, R. Radebaugh, and E. Luo	
Performance Characterization of the TRW 95 K High Efficiency Cryocooler	1277
S. A. Yarbrough, N. Abhyankar, B. J. Tomlinson, and T. M. Davis	
Raytheon Stirling/Pulse Tube Two-Stage (RSP2) Cryocooler Advancements	1285
A .T. Finch, K. D. Price, and C. S. Kirkconnell	

Performance of the AIRS Pulse Tube Coolers and Instrument — A First Year in Space.....	1293
R. G. Ross, Jr. and J. I. Rodriguez	
An Experimental Set-Up for Large-Scale Pulse Tube Refrigeration.....	1301
D. W. J. Willems, V. Backx, and A. K. De Jonge	
Design and Operation of a 4 kW Linear Motor Driven Pulse Tube Cryocooler	1309
J. H. Zia	
Design of a Miniature Pulse Tube Cryocooler for Space Applications	1318
T. Trollier, A. Ravex, I. Charles, L. Duband, J. Mullié, P. Bruins, T. Benschop, and M. Linder	
Miniature Pulse Tube Cooler	1326
E. Tward, T. Nguyen, J. Godden, and G. Toma	
Progress in Development of a Miniature Pulse Tube Cooler for Space Applications	1330
A. S. Gibson, R. Hunt, I. Charles, L. Duband, M. R. Crook, A. H. Orlowska, T. W. Bradshaw, and M. Linder	
Development of the Miniature Pulse Tube Cryocooler	1339
N. Matsumoto, Y. Yasukawa, K. Ohshima, K. Toyama, Y. Tsukahara, T. Kamoshita, and T. Takeuchi	
Two Stage Pulse Tube Cooler for Space Applications	1347
T. Nguyen, R. Orsini, G. Toma, T. Pietrzak, and E. Tward	
An Experimental Study for the Coaxial Inertance Tube Pulse Tube Cryocooler	1353
S. J. Park, Y. J. Hong, H. B. Kim, Y. H. Kim, and K. B. Lee	
Development of a Light Weight Pulse-Tube Cryocooler	1360
Y. Hiratsuka, H. Morishita, and T. Nomura	
Low-Cost Cryocoolers for the Allen Telescope Array	1367
J. B. Lugten, R. Radebaugh, and M. A. Lewis	
Experimental Characterisation of a Pulse Tube Cryocooler for Ground Applications.....	1373
I. Charles, L. Duband, J.-Y. Martin, J. C. Mullié, and P. C. Bruins	
Design and Development of an Orifice/Inertance Pulse Tube Cryocooler Using a Linear Compressor	1380
K. G. Narayankhedkar and B. S. Gawali	
Low Thermal Mass Liners for Pulse Tubes	1388
M. P. Mitchell and D. Fabris	
Basic Limitations on the Performance of Stirling Cryocoolers	1396
P. C. T. de Boer	
The Development of the Cryotel™ Family of Coolers	1404
R. Unger and D. Keiter	
Dynamic Counterbalancing of a Pneumatically Driven Expander of a Split Stirling Linear Cryogenic Cooler	1412
A. M. Veprik, S. V. Riabzev, and N. Pundak	
6 W Full-Flexure-Bearing Stirling Cryocooler for the Cryosystem Program	1420
A. A. J. Benschop, P. C. Bruins, J. C. Mullié, M. Meijers, H. Helmonds, and T. Trollier	

Development of Two-Stage Stirling Cycle Cooler for ASTRO-F	1428
K. Narasaki, S. Tsunematsu, K. Ootsuka, M. Kyoya, T. Matsumoto, H. Murakami, and T. Nakagawa	
Analysis of the Serial Production Measurements Made on the Thales Cryogenics Integral Lightweight Cryocooler RM2-Xi.....	1436
J. M. Cauquil, J. Y. Martin, T. Benschop, and P. C. Bruins	

PULSE TUBE — G-M TYPE

Developments on GM-Type Pulse Tube Cryorefrigerators with Large Cooling Power	1445
T. Köttig, A. Waldauf, M. Thürk, and P. Seidel	
Analysis of Loss Mechanisms in G-M Type Pulse Tube Refrigerators	1451
J. H. Baik, G. F. Nellis, and J. M. Pfotenhauer	
Development of a High-Power Coaxial Pulse Tube Refrigerator for a Liquid Xenon Calorimeter	1459
T. Haruyama, K. Kasami, H. Inoue, S. Mihara, and Y. Matsubara	
A Helium Recondenser Using 4 K Pulse Tube Cryocooler	1467
C. Wang and P. E. Gifford	
Experimental Studies of Convection in a Single Stage Pulse Tube Refrigerator	1474
S. Kasthurirengan, S. Jacob, R. Karunanithi, U. Behera, and D. S. Nadig	

PULSE TUBE JT AND HEAT EXCHANGER MODELING AND PERFORMANCE ISSUES

Inertance Tube Models and Their Experimental Verification	1485
E. Luo, R. Radebaugh, and M. Lewis	
Modeling Pulse Tube Cryocoolers with CFD	1493
B. Flake and A. Razani	
Simulation of Thermodynamics Aspects about Pulse Tube Refrigerator.....	1500
Y. Hozumi, M. Shiraishi, and M. Murakami	
Exergy Flow in Pulse Tube Refrigerators and Their Performance Evaluation Based on Exergy Analysis	1508
A. Razani, B. Flake, and S. Yarbrough	
Comparison of Entropy Generation Rates in Various Multi-Stage Stirling-Class Cryocooler Configurations	1519
C. S. Kirkconnell, J. P. Harvey, and P. V. Desai	
A Power-Efficiency Diagram for Performance Evaluation of Cryocoolers	1527
A. Razani, B. Flake, S. Yarbrough, and N. S. Abhyankar	
Space Cryogenic Systems Model and Capabilities.....	1536
R. A. Franck and D. G. Glaister	

Performance of Pulse Tube Refrigerators for a Wide Temperature Range	1546
Y. Fujisawa, M. Shiraishi, K. Yasuno, and M. Murakami	
SABER on Orbit Performance Evaluation and Lessons Learned.....	1552
S. M. Jensen and J. C. Batty	
Reduction of Secondary Flow in Inclined Orifice Pulse Tubes by Addition of DC Flow	1560
M. Shiraishi, Y. Fujisawa, M. Murakami, and A. Nanako	
Comparative Exergetic Analysis of Joule–Thomson Liquefiers.....	1568
M. Chorowski	
Performance of a Throttle Cycle Refrigerator with Nitrogen–Hydrocarbon and Argon–Hydrocarbon Mixtures	1576
G. Venkatarathnam, P. Senthil Kumar, and S. Srinivasa Murthy	
Development of Recuperator for 4 K Pulse Tube Refrigerators Operating at Opposite Phases.....	1584
J. Jung and S. Jeong	
Assembly Methods for Etched Foil Regenerators	1592
M. P. Mitchell	
Performance of Gd-Tb Oxysulfide Ceramic Regenerator Material for G-M Cryocoolers	1598
T. Numazawa, K. Kamiya, T. Satoh, H. Nozawa, and T. Yanagitani	
 BRAYTON, COLLINS, SORPTION CRYOCOOLERS	
Subkelvin Mechanical Coolers	1607
S. Triqueneaux, A. Ravex, and P. Hernandez	
20 K Continuous Cycle Sorption Coolers for the Planck Flight Mission	1613
P. Bhandari, M. Prina, R. C. Bowman, C. Paine, D. Pearson, and A. Nash	
Design and Performance of a Charcoal Filter for the Planck Sorption Cooler.....	1621
C. G. Paine	
Development of a Novel Brayton-Cycle Cryocooler and Key Component Technologies	1627
S. J. Nieczkoski and R. A. Mohling	
35 K Turbo-Brayton Cryocooler Technology	1635
M. V. Zagarola, A. J. Dietz, W. L. Swift, and T. M. Davis	
Initial Test Results from a 6 K–10 K Turbo-Brayton Cryocooler for Space Applications	1643
W. L. Swift, M. V. Zagarola, J. J. Breedlove, J. A. McCormick, and H. Sixsmith	
Floating Piston Expander Development for a Small-Scale Collins Type 10 K Cryocooler for Space Applications	1650
C. L. Hannon, J. Gerstmann, B. J. Krass, M. J. Traum, J. G. Brisson, and J. L. Smith, Jr.	

JT AND THERMOACOUSTIC CRYOCOOLERS

Maximizing Run Time of a Fixed Orifice Joule–Thomson Cryocooler	1661
B.-Z. Maytal	
Idealized Closed Form Performance Modeling of a Closed Cycle	
Joule–Thomson Cryocooler	1669
B.-Z. Maytal	
Properties of Gas Mixtures and Their Use in Mixed-Refrigerant	
Joule–Thomson Refrigerators	1677
E. Luo, M. Gong, J. Wu, and Y. Zhou	
Investigations of Acoustics and Heat Transfer Characteristics of	
Thermoacoustic Driven Pulse Tube Refrigerators	1687
E. Bretagne, M.-X. François, and H. Ishikawa	
Hydrogen/Oxygen Propellant Densifier Thermoacoustic Stirling	
Heat Engine	1696
C. T. Nguyen, A. J. Yeckley, D. J. Schieb, and M. S. Haberbusch	
Hydrogen/Oxygen Propellant Densifier Using a Two-Stage Pulse	
Tube Cryocooler	1703
C. Nguyen, A. Yeckley, A. Culler, M. Haberbusch, and R. Radebaugh	

MAGNETIC REFRIGERATION

Demagnetizing Effects in Active Magnetic Regenerators	1713
A. Rowe, O. Peksoy, and J. Barclay	
An Overview of Operating Experience Using the AMR	
Test Apparatus	1721
A. Rowe, A. Tura, M.-A. Richard, R. Chahine, and J. Barclay	
Design of a Miniature Adiabatic Demagnetization Refrigerator	1729
J.-M. Duval, B. M. Cain, and P. T. Timbie	
Space Engineering Model Cryogen Free ADR for Future ESA	
Space Missions	1737
I. D. Hepburn, C. Brockley-Blatt, P. Coker, E. Crofts, B. Winter,	
S. Milward, R. Stafford-Allen, R. Hunt, M. Brownhill, N. Rando, and	
M. Linder	
A Portable, Cryogen-Free Ultra-Low Temperature Cooling System	
Using a Continuous ADR	1746
P. J. Shirron, M. J. DiPirro, M. Jirmanus, Z. Zhao, and B. Shields	
Passive Superconducting Shielding: Experimental Results and	
Computer Models	1754
B. A. Warner and K. Kamiya	

HYBRID CYCLE CRYOCOOLERS

Ball Aerospace Long Life, Low Temperature Space Cryocoolers	1763
D. S. Glaister, W. Gully, E. Marquardt, and R. Stack	

Development of a Rectifying Interface for a Hybrid Pulse-Tube / Reverse-Brayton Cryocooler	1771
A. K. Diab, G. F. Nellis, J. R. Maddocks, and S. Yarbrough	
Performance Investigations of a 4 to 10 K Long-Life Mechanical Cryocooler	1779
W. J. Gully, D. Glaister, and E. Marquardt	
Development of Cryogenic System for SMILES	1785
K. Narasaki, S. Tsunematsu, S. Yajima, A. Okabayashi, J. Inatani, K. Kikuchi, R. Satoh, T. Manabe, and M. Seta	

TERRESTRIAL APPLICATIONS OF CRYOCOOLERS

Technical and Economical Demands on 25 K–77 K Refrigerators for Future HTS-Series Products in Power Engineering	1797
B. Gromoll	
A Single-Stage Pulse Tube Cryocooler for Horizontally Cooling HTS MRI Probe	1805
C. Wang and P. E. Gifford	
Gifford McMahon Machine Used for Precooling of Two Superconducting Cavities at ESRF	1812
M. Rossat, P. Bredy, J. Jacob, F. Torrecillas, D. Boilot, and E. Bruas	
An Efficient Cooling Loop for Connecting Cryocooler to a Helium Reservoir	1818
C. E. Taylor, S. R. Abbott, D. Leitner, M. Leitner, and C. M. Lyneis	
4.5 K Cooling System for a Cryogenically Cooled Probe for a 920 MHz NMR	1826
H. Yokota, T. Okamura, Y. Ohtani, T. Kuriyama, M. Takahashi, T. Horiuchi, J. Kikuchi, S. Yokoyama, and H. Maeda	
Survey of Cooling Options for Application in a Low-T_c SQUID System for Fetal Magnetocardiography	1834
A. P. Rijpma, S. Uzunbajakau, H. J. M. ter Brake, M. J. Peters, and H. Rogalla	

NOVEL CONCEPTS OR DEVICES

The First Demonstration of an Optical Refrigerator	1845
G. L. Mills, J. A. Turner-Valle, and M. I. Buchwald	
Optical Solid State Cooling within a Laser	1853
M. Stone, B. Heeg, A. Khizhnyak, and P. A. DeBarber	
HF Cryogenic Low Noise Amplifier	1861
T. Trollier, A. Ravex, and D. Butin	
Low Thermal Loss Cryogenic Transfer Line with Magnetic Suspension	1869
Q.-S. Shu, G. Cheng, K. Yu, J. R. Hull, J. A. Demko, C. P. Britcher, J. E. Fesmire, and S. D. Augustynowicz	

Novel Cryogenic Heaters: Sputter Deposited Cermet Materials with Low Temperature Coefficients of Resistivity.....	1877
C. J. Yeager, S. S. Courts, and L. Chapin	
Cryogenic Freeze Plug Using Alternative Fluid	1883
D. A. Lobmeyer and Z. F. Nagy	
Cryogenic Magnetostrictive Materials and Devices.....	1891
C. H. Joshi, A. Mavanur, C.-Y. Tai, Z.-X. Han, A. J. Rodenbush, and Y. Wong	
Losses of Superconductor Journal Bearing.....	1899
Y. H. Han, J. R. Hull, S. C. Han, N. H. Jeong, J. M. Oh, and T. H. Sung	
Superfluid Vortex Cooler	1906
I. A. Tanaeva, U. Lindemann, N. Jiang, A. T. A. M. de Waele, and G. Thummes	
Development of Advanced Tools for Cryogenic Integration	1914
D. C. Bugby, B. C. Marland, C. J. Stouffer, and E. J. Kroliczek	
Investigation for Magnetic Separation of Oxygen from Supercritical Air Near the Maxcondentherm Point	1923
A. Nakano and M. Shiraishi	
Author Index	A1
Subject Index	S1