

Contents

Government Cryocooler Development and Test Programs	1
Military Space Cryogenic Cooling Requirements for the 21st Century	1
<i>T.M. Davis and B.J. Tomlinson, Kirtland AFB, NM; and J.D. Ledbetter, Mission Research Corp., Albuquerque, NM</i>	
Status of Programs for the DoD Family of Linear Drive Cryogenic Coolers for Weapon Systems	11
<i>W.E. Salazar, US Army Night Vision, Fort Belvoir, VA</i>	
Air Force Research Laboratory Cryocooler Characterization and Endurance Update	17
<i>B.J. Tomlinson, C.H. Yoneshige, AFRL, Kirtland AFB, NM; and N.S. Abhyankar, Dynacs Engin., Albuquerque, NM</i>	
Air Force Research Laboratory Cryocooler Reliability Initiatives	27
<i>S. Blankenship and T.L. Fountain, Georgia Inst. of Tech., Atlanta, GA; and T.M. Davis and B.J. Tomlinson, AFRL, Kirtland AFB, NM</i>	
Space Stirling Cryocooler Developments	35
Protoflight Spacecraft Cryocooler Performance Results	35
<i>K. Price, Raytheon, El Segundo, CA; and J. Reilly, N. Abhyankar, and B.J. Tomlinson, AFRL, Kirtland AFB, NM</i>	
Characterization of Raytheon's 60 K 2 W Protoflight Spacecraft Cryocooler	45
<i>N.S. Abhyankar, Dynacs Engin., Albuquerque, NM; and C.H. Yoneshige, B.J. Tomlinson, and J. Reilly, AFRL, Kirtland AFB, NM</i>	
The Development of a 10K Closed Cycle Stirling Cooler for Space Use	55
<i>G. Baker, D. Féger, and A. Little, Astrium, Stevenage, UK; A.H. Orlowska, T. Bradshaw, and M. Crook, RAL, Chilian, UK; B.J. Tomlinson, AFRL, Kirtland AFB, NM; and A. Sargeant, Cubic Appl. Inc., Lacey, WA</i>	
Development of a 12K Stirling Cycle Precooler for a 6 K Hybrid Cooler System	63
<i>W.J. Gully, D.S. Glaister, and D.W. Simmons, Ball Aerospace, Boulder, CO</i>	
Thermodynamic Optimization of Multi-Stage Cryocoolers	69
<i>C.S. Kirkconnell and K.D. Price, Raytheon, El Segundo, CA</i>	

Long-Life Tactical and Commercial Stirling Coolers	79
The Advent of Low-Cost Cryocoolers	79
<i>R.Z. Unger, R.B. Wiseman, and M.R. Hummon, Sunpower, Inc., Athens, OH</i>	
Performance and Reliability Improvements in a Low-Cost Stirling Cycle Cryocooler	87
<i>M. Hanes, Superconductor Tech. Inc., Santa Barbara, CA</i>	
Development of a Long-Life Stirling Cryocooler	97
<i>Y. Ikuta, Y. Suzuki, K. Kanao, and N. Watanabe, Sumitomo Heavy Indus., Hiratsuka, Kanagawa, Japan</i>	
Flexure Springs Applied to Low-Cost Linear Drive Cryocoolers	103
<i>R.M. Rawlings and S. Miskimins, DRS Infrared Tech., Dallas, TX</i>	
High Reliability Coolers under Development at Signaal-USFA	111
<i>M. Meijers, A.A.J. Benschop, and J.C. Mullié, Signaal-USFA, Eindhoven, The Netherlands</i>	
Long-Life Commercial Pulse Tube Coolers	119
Development of a Long-Life Stirling Pulse Tube Cryocooler for Superconducting Filter Subsystems	119
<i>Y. Hiratsuka, Daikin Indus., Osaka, Japan; K. Murayama, Y. Maeda, F. Imai, and K.Y. Kang, Daikin Envir. Lab, Tsukuba, Japan; and Y. Matsubara, Nihon Univ., Funabashi, Japan</i>	
Development of a 5 W at 65 K Air-Cooled Pulse Tube Cryocooler	125
<i>S-Y Kim, J-J Park, S-T Kim, W-S Chung, and H-K Lee, LG Electronics Inc., Seoul, Korea</i>	
Space Pulse Tube Cryocooler Developments	131
TES FPC Flight Pulse Tube Cooler System	131
<i>J. Raab, S. Abedzadeh, R. Colbert, J. Godden, D. Harvey, and C. Jaco, TRW, Redondo Beach, CA</i>	
The AIM Space Cryocooler Program	139
<i>I. Rühlich, H. Korf, and Th. Wiedmann, AEG Infrarot-Module, Heilbronn, Germany</i>	
Miniature Pulse Tube Cryocooler for Space Applications	145
<i>T.C. Nast, P.J. Champagne, V. Kotsubo, J. Olson, A. Collaco, and B. Evtimov, Lockheed Martin ATC, Palo Alto, CA; T. Renna, Lockheed Martin Communications, Newtown, PA; and R. Clappier, Clappier Consulting, Discovery Bay, CA</i>	
Gamma-Ray Pulse Tube Cooler Development and Testing	155
<i>R.G. Ross, Jr., D.L. Johnson, and A. Metzger, JPL, Pasadena, CA; V. Kotsubo, B. Evtimov, J. Olson, and T. Nast, Lockheed-Martin ATC, Palo Alto, CA; and R.M. Rawlings, DRS Infrared Tech., Dallas, TX</i>	
High Efficiency Pulse Tube Cooler	163
<i>E. Tward, C.K. Chan, J. Raab, T. Nguyen, and R. Colbert, TRW, Redondo Beach, CA; and T. Davis, AFRL, Kirtland AFB, NM</i>	

High Performance Flight Cryocooler Compressor	169
<i>P.B. Bailey and M.W. Dadd, Oxford Univ., Oxford, UK; N. Hill and C.F. Cheuk, Hymatic Engin. Co., Redditch, UK; and J. Raab and E. Tward, TRW, Redondo Beach, CA</i>	
Vibration Reduction in Balanced Linear Compressors	175
<i>M.W. Dadd., P.B. Bailey, and G. Davey, Oxford Univ., Oxford, UK; and T. Davis and B.J. Tomlinson, AFRL, Kirtland AFB, NM</i>	
95K High Efficiency Cryocooler Program	183
<i>K. Price, Raytheon, El Segundo, CA; and V. Urbancek, AFRL, Kirtland AFB, NM</i>	
Design and Test of the NIST/Lockheed Martin Miniature Pulse Tube Flight Cryocooler	189
<i>P.E. Bradley and R. Radebaugh, NIST, Boulder, CO; J.H. Xiao, Johnson and Johnson, Somerville, NJ; and D.R. Ladner, Lockheed Martin Astronautics, Denver, CO</i>	
Low-Cost Pulse Tube Liquefier for In-Situ Resource Utilization	199
<i>C.M. Martin and J.L. Martin, Mesoscopic Devices, Broomfield, CO</i>	
GM-Type Pulse Tube Coolers for Low Temperatures	205
Performance Characteristics of a 4 K Pulse Tube in Current Applications	205
<i>C. Wang and P.E. Gifford, Cryomech, Inc., Syracuse, NY</i>	
Experimental Study of a 4K Pulse Tube Cryocooler	213
<i>S. Fujimoto, T. Kurihara, T. Oodo, Y.M. Kang, Daikin Ltd., Tsukuba, Japan; T. Numazawa, Nat. Res. Inst. for Metals, Tsukuba, Japan; and Y. Matsubara, Nihon Univ., Chiba, Japan</i>	
GM-Type Two-Stage Pulse Tube Cooler with High Efficiency	221
<i>A. Hofmann, Karlsruhe Inst. for Tech. Physics, Karlsruhe, Germany; H. Pan and L. Oeltrich, Univ. of Karlsruhe, Karlsruhe, Germany</i>	
Developments on Single and Double Stage GM Type Pulse Tube Cryorefrigerators	229
<i>J.M Poncet, A. Ravex, and I. Charles, CEA/DRFMC/Service des Basses Temperatures, Grenoble, France</i>	
30 - 50 K Single Stage Pulse Tube Refrigerator for HTS Applications	235
<i>J. Yuan, J. Maguire, A. Sidi-Yekhlief, and P. Winn, American Superconductor Co., Westborough, MA</i>	
Two-Stage 4K Pulse Tube Refrigerator	243
<i>S. Zhu, M. Ichikawa, M. Nogawa, and T. Inoue, Aisin Seiki Co., Ltd., Kariya, Aichi, Japan</i>	
Compressor-Specific Design of a Single Stage Pulse Tube Refrigerator	249
<i>J.M. Pfothenhauer and J.H. Baik, Univ. of Wisconsin, Madison, WI</i>	
Hybrid Cryocoolers Using Pulse Tubes	259
A Novel Multi-Stage Expander Concept	259
<i>C.S. Kirkconnell, K.D. Price, M.C. Barr, and J.T. Russo, Raytheon, El Segundo, CA</i>	

Numerical Study of a New Type of 4K GM/PT Hybrid Refrigerator	265
<i>L. Liu, L. Gong, J. Liang, and L. Zhang, Cryogenic Lab, Chinese Acad. of Sci., Beijing, China</i>	
Thermally Actuated ³He Pulse Tube Cooler	273
<i>Y. Matsubara, H. Kobayashi, and S.L. Zhou, Atomic Energy Res. Inst., Nihon Univ., Chiba, Japan</i>	
Investigation of Helium and Nitrogen Mixtures in a Pulse Tube Refrigerator	281
<i>Z.H. Gan and G.B. Chen, Zhejiang Univ., Hangzhou, China; and G. Thummes and C. Heiden, Univ. of Giessen, Giessen, Germany</i>	
Pulse Tube Refrigeration with a Combined Cooling and Freezing Cycle for HTSC Devices	291
<i>G. Chen, Z. Gan, L. Qiu and J. Yu, Zhejiang Univ., Hangzhou, China</i>	
Experimental Investigation of a Pulse Tube Refrigerator Driven by a Thermoacoustic Prime Mover	301
<i>L.M. Qiu, G.B. Chen, N. Jiang, Y.L. Jiang, and J.P. Yu, Zhejiang Univ., Hangzhou, China</i>	
Design, Development, and Operation of a Thermo-Acoustic Refrigerator Cooling to below -60°C	309
<i>M.E.H. Tijani, J. Zeegers, and A.T.A.M. de Waele, Eindhoven Univ. of Tech., Eindhoven, The Netherlands</i>	
Pulse Tube Analysis and Experimental Measurements	317
Design of a Miniature Pulse Tube Refrigerator	317
<i>A. Halouane, French Inst. of Petroleum, Rueil-Malmaison, France; and J-C. Marechal and Y. Simon, Ecole Normale Supérieure, Paris, France</i>	
Investigation of a Single Stage Four-Valve Pulse Tube Refrigerator for High Cooling Power	327
<i>T. Schmauder, A. Waldauf, M. Thürk, R. Wagner, and P. Seidel, Univ. of Jena, Jena, Germany</i>	
Analysis and Experimental Research of a Multi-Bypass Version Pulse Tube Refrigerator	337
<i>L.W. Yang, J.T. Liang and Y. Zhou, Chinese Academy of Sciences, Beijing, China</i>	
Experimental Study of the Heat Transfer in Pulse Tubes	345
<i>S. Jeong, K. Nam and M.G. Kim, Korea Adv. Inst. of Sci. and Tech., Taejon, Korea; and H.-M. Chang and E.S. Jeong, Hong Ik Univ., Seoul, Korea</i>	
Shuttle Loss in Pulse Tubes	353
<i>L. W. Yang, Chinese Academy of Sciences, Beijing, China</i>	
Numerical Study of Gas Dynamics Inside of a Pulse Tube Refrigerator	363
<i>Y. Hozumi, Chiyoda Corp., Yokohama, Japan; M. Murakami, Univ. of Tsukuba, Tsukuba, Japan; and M. Shiraiishi, ME Lab, MITI, Tsukuba, Japan</i>	

Visualization of DC Gas Flows in a Double-Inlet Pulse Tube Refrigerator with a Second Orifice Valve	371
<i>M. Shiraishi and A. Nakano, ME Lab, MITI, Tsukuba, Japan; K. Takamatsu and M. Murakami, Univ. of Tsukuba, Tsukuba, Japan; T. Iida, NASDA, Tsukuba, Japan; and Y. Hozumi, Chiyoda Corp., Yokohama, Japan</i>	
GM Refrigerator Developments	381
A Gifford-McMahon Cycle Cryocooler below 2K	381
<i>T. Satoh, Sumitomo Heavy Ind., Kanagawa, Japan; A. Onishi, Sumitomo Heavy Ind., Tokyo, Japan; I. Umehara, Y. Adachi, and K. Sato, Yokohama Nat 'l Univ., Yokohama, Japan; and E.J. Minehara, FEL Lab, Japan Atomic Energy Res. Inst., Naka, Japan</i>	
High Efficiency, Single-Stage GM Cryorefrigerators Optimized for 20 to 40K	387
<i>C. Wang and P.E. Gifford, Cryomech, Inc., Syracuse, NY</i>	
Remote Cooling with a G-M Cryocooler by Use of Cold Electro-magnetic Valves Driving an External Flow Loop	393
<i>K.M. Ceridon and J.L. Smith, Jr., MIT, Cambridge, MA</i>	
Optimum Intermediate Temperatures of Two-Stage Gifford-McMahon Type Coolers	401
<i>T.C. Chuang, Raytheon-RCSE, Philadelphia, PA; S. Yoshida, Taiyo Toyo Sanso, Co., Kawasaki, Japan; and T.H.K. Frederking, UCLA, Los Angeles, CA</i>	
Regenerator Analysis and Materials Developments	409
Regenerator Behavior with Heat Input or Removal at Intermediate Temperatures	409
<i>R. Radebaugh, E.D. Marquardt, J. Gary, and A. O'Gallagher, NIST, Boulder, CO</i>	
Measurement of Heat Conduction through Metal Spheres	419
<i>M.A. Lewis and R. Radebaugh, NIST, Boulder, CO</i>	
Innovative Technology for Low Temperature Regenerators	427
<i>L. Tuchinsky and R. Loutfy, MER Corp., Tucson, AZ; and B.J. Tomlinson, AFRL, Kirtland AFB, NM</i>	
Ductile, High Heat Capacity, Magnetic Regenerator Alloys for the 10 to 80 K Temperature Range	433
<i>K.A. Gschneidner, Jr., A.O. Pecharsky, and V.K. Pecharsky, Ames Lab, Iowa State Univ., Ames, IA</i>	
Low Temperature Properties of HoSb, DySb, and GdSb	443
<i>H. Nakane and S. Yamazaki, Kogakuin Univ., Tokyo, Japan; H. Fujishiro, Iwate Univ., Morioka, Japan; T. Yamaguchi and S. Yoshizawa, Meisei Univ., Tokyo, Japan; T. Numazawa, Nat. Res. Inst. for Metal, Tsukuba, Japan; and M. Okamura, Toshiba Corp., Yokohama, Japan</i>	
Manufacturing Considerations for Rare Earth Powders Used in Cryocooler and Magnetic Refrigerator Applications	449
<i>S.A. Miller, J.D. Nicholson, Starmet Corp., Concord, MA; and K.A. Gschneidner, Jr., A.O. Pecharsky, and V.K. Pecharsky, Ames Laboratory, Iowa State Univ., Ames, IA</i>	
Magnetothermal Properties of Polycrystalline Gd₂In	457
<i>M.I. Ilyn and A.M. Tishin, Moscow State Univ., Moscow Russia; K.A. Gschneidner, Jr., V.K. Pecharsky, and A.O. Pecharsky, Ames Labs, Iowa State Univ., Ames, IA</i>	

New Regenerator Material for Sub-4 K Cryocoolers 465
T. Numazawa, O. Arai and A. Sato, Tsukuba Magnet Lab, Nat. Res. Inst. for Metals, Tsukuba, Japan; S. Fujimoto, T. Oodo, and Y.M. Rang, Daikin, Ltd., Tsukuba, Japan; and T. Yanagitani, Konoshima Chemical Co., Kagawa, Japan

New Regenerator Materials for Use in Pulse Tube Coolers 475
A. Kashani and B.P.M. Helvensteijn, Atlas Scientific, Sunnyvale, CA, P. Kittel, NASA/ARC, Moffett Field, CA; and K.A. Gschneidner, Jr., V.K. Pecharsky, and A.O. Pecharsky, Ames Labs, Iowa State Univ., Ames, IA

Turbo-Brayton Cryocooler Developments 481

Advanced Developments for Low Temperature Turbo-Brayton Cryocoolers 481
J.A. McCormick, G.F. Nellis, H. Sixsmith, M.V. Zagarola, M.G. Izenson and W.L. Swift, Creare, Hanover, NH; and J.A. Gibbon, NASA/GSFC, Greenbelt, MD

Life and Reliability Characteristics of Turbo-Brayton Coolers 489
J.J. Breedlove, M.V. Zagarola, G.F. Nellis, F.X. Dolan, and W.L. Swift, Creare, Hanover, NH; and J.A. Gibbon, NASA/GSFC, Greenbelt, MD

A Flexible Turbo-Brayton Cryocooler Model 499
P.L. Whitehouse, NASA/GSFC, Greenbelt, MD; and G.F. Nellis and M.V. Zagarola, Creare, Inc., Hanover, NH

J-T and Throttle-Cycle Cryocooler Developments 505

A 10 K Cryocooler for Space Applications 505
D.S. Glaister, W.J. Gully, G.P. Wright and D.W. Simmons, Ball Aerospace, Boulder, CO; and B.J. Tomlinson, AFRL, Kirtland AFB, NM

Modern Trends in Designing Small-Scale Throttle-Cycle Coolers Operating with Mixed Refrigerants 513
M. Boiarski and A. Khatri, IGC-APD Cryogenics, Allentown, PA; O. Podcherniaev, IGC-Polycold Sys., San Rafael, CA; and V. Kovalenko, Moscow Power Engin. Inst., Moscow, Russia

Thermodynamic Analysis of an Mixed-Refrigerant Auto-Cascade J-T Cryocooler with Distributed Heat Load 523
M.Q. Gong, E.C. Luo, J.T. Liang, Y. Zhou, and J.F. Wu, Chinese Academy of Sciences, Beijing, China

Sorption Cryocooler Developments 531

PLANCK Sorption Cooler Initial Compressor Element Performance Tests 531
C.G. Paine, R.C. Bowman Jr., D. Pearson, M.E. Schmelzel, P. Bhandari, and L.A. Wade, JPL, Pasadena, CA

Sizing and Dynamic Performance Prediction Tools for 20 K Hydrogen Sorption Cryocoolers 541
P. Bhandari, M. Prina, R.C. Bowman and L.A. Wade, JPL, Pasadena, CA; and M. Ahart, Princeton Univ., Princeton, NJ

165 K Microcooler Operating with a Sorption Compressor and a Micromachined Cold Stage	551
<i>J.F. Burger, H.J. Holland, J.H. Seppenwoolde, J.W. Berenschot, H.J.M. ter Brake, J.G.E. Gardeniens, M. Elwenspoek and H. Rogalla, Univ. of Twente, Enschede, The Netherlands</i>	
Sub-Kelvin Refrigerator Developments	561
Double Stage Helium Sorption Coolers	561
<i>L. Duband, CEA/DRFMC/Service des Basses Températures, Grenoble, France</i>	
Sub-Kelvin Sorption Coolers for Space Application	567
<i>L. Duband, CEA/DRFMC, Grenoble, France; B. Collaudin, ESTEC, Noordwijk, The Netherlands; and P. Jamotton, Centre Spatial de Liège, Belgium</i>	
Closed-Cycle Cooling of Infrared Detectors to 0.25 K for the Polatron	577
<i>R.S. Bhatia, J.J. Bock, V.V. Hristov, W.C. Jones, A.E. Lange, J. Leong, P.V. Mason, B.J. Philhour and G. Sirbi, Caltech, Pasadena, CA; S.E. Church and B.G. Keating, Stanford Univ., Standford, CA; J.G. Glenn, Univ. of Colorado, Boulder, CO; S.T. Chase, Chase Research Ltd., Sheffield, UK; and P.A.R. Ade and C.V. Haynes, QMW College, London, UK</i>	
A Continuous Adiabatic Demagnetization Refrigerator for Use with Mechanical Coolers	587
<i>P. Shirron, E. Canavan, M. DiPirro, M. Jackson, J. Panek and J. Tuttle, NASA/GSFC, Greenbelt, MD; and N. Abbondante, M. Grabowski and M. Hirsch, Worcester Polytechnic Institute, Worcester, MA</i>	
Reaching 96 mK by a Pulse-Tube Precooled Adiabatic Demagnetization Refrigerator	597
<i>G. Thummes and M. Theiß, Inst. of Applied Physics, Giessen, Germany; and M. Bühler and J. Höhne, CSP GmbH, Ismaning, Germany</i>	
Dissipation in Metal Welded Bellows and Its Consequences for Sub-Kelvin Refrigerators	605
<i>C.L. Phillips and J.G. Brisson, MIT, Cambridge, MA</i>	
Optical Refrigeration Developments	613
Design and Predicted Performance of an Optical Cryocooler for a Focal Plane Application	613
<i>G.L. Mills, A.J. Mord and P.A. Slaymaker, Ball Aerospace, Boulder, CO</i>	
Optical Refrigeration Using Anti-Stokes Fluorescence from Molecular Dyes	621
<i>G. Rumbles, B. Heeg, and J.L. Lloyd (née Clark), Imperial College, London, UK; P.A. DeBarber, MetroLaser, Inc., Irvine, CA; and B.J. Tomlinson, AFRL, Kirtland AFB, NM</i>	
Solid-State Optical Cooler Developments	631
<i>B.C. Edwards, J.E. Anderson, and R.I. Epstein, Los Alamos Nat'l Lab, Los Alamos, NM; and C. W. Hoyt and M. Sheik-Bahae, Univ. of New Mexico, Albuquerque, NM</i>	
Cryocooler Reliability Investigations and Analyses	637
Cryocooler Reliability and Redundancy Considerations for Long-Life Space Missions	637
<i>R.G. Ross, Jr., JPL, Pasadena, CA</i>	

Space Cryocooler Contamination Lessons Learned and Recommended Control Procedures	649
<i>S. Castles, NASA/GSFC, Greenbelt, MD; K.D. Price, Raytheon, El Segundo, CA; D.S. Glaister and W.J. Gully, Ball Aerospace, Boulder, CO; J. Reilly, AFRL, Kirtland AFB, NM; and T. Nast and V. Kotsubo, Lockheed-Martin, Palo Alto, CA</i>	
Cryocooler Contamination Study: Temperature Dependence of Outgassing	659
<i>S.W.K. Yuan and D.T. Kuo, BAE Systems, Sylmar, CA</i>	
BAE's Life Test Results on Various Linear Coolers and Their Correlation with a First Order Life Estimation Method	665
<i>D.T. Kuo, T.D. Lody and S.W.K. Yuan, BAE Systems, Sylmar, CA</i>	
Initial Observations from the Disassembly and Inspection of the TRW 3503 and Creare SSRB	673
<i>B.J. Tomlinson and C.H. Yoneshige, AFRL, Kirtland AFB, NM; and M.L. Martin, Dynacs Engin., Albuquerque, NM</i>	
Cryocooler Integration Technologies and Materials	681
Cryogenic Material Properties Database	681
<i>E.D. Marquardt, J.P. Le, and R. Radebaugh, NIST, Boulder, CO</i>	
Experimental Results on the Thermal Contact Conductance of Ag-Filled Epoxied Junctions at Cryogenic Temperatures	689
<i>Z. Wang, A. Devpura, and P.E. Phelan, Arizona State Univ., Tempe, AZ</i>	
A Fail-Safe Experiment Stand for Cryocooler Characterization	699
<i>C.H. Yoneshige, J.P. Kallman, G. Lybarger, AFRL, Kirtland AFB, NM; and N.S. Abhyankar and M.L. Martin, Dynacs Engin., Albuquerque, NM</i>	
Development and Testing of a Gimbal Thermal Transport System	707
<i>D. Bugby, B. Marland, and C. Stouffer, Swales Aerospace, Beltsville, MD; and B. Tomlinson and T. Davis, AFRL, Kirtland AFB, NM</i>	
Cryocooler Interface System	719
<i>G.S. Willen, Tech. Applications, Inc., Boulder, CO; and B.J. Thomlinson, AFRL, Kirtland AFB, NM</i>	
Development and Testing of a High Performance Cryogenic Thermal Switch	729
<i>B. Marland, D. Bugby, and C. Stouffer, Swales Aerospace, Beltsville, MD; and B. Tomlinson and T. Davis, AFRL, Kirtland AFB, NM</i>	
Thermally Conductive Vibration Isolation System for Cryocoolers	739
<i>G.S. Willen, Tech. Appl., Inc., Boulder, CO; and E.M. Flint, CSA Engin., Mountain View, CA</i>	
Advanced Cryogenic Integration and Cooling Technology for Space-Based Long Term Cryogen Storage	749
<i>B.J. Tomlinson and T.M. Davis, AFRL, Kirtland AFB, NM; and J.D. Ledbetter, Mission Research Corp., Albuquerque, NM</i>	

Space Cryocooler Applications 759

MOPITT On-Orbit Stirling Cycle Cooler Performance 759

G.S. Mand and J.R. Drummond, Univ. of Toronto, Toronto, Canada; and D. Henry and J. Hackett, COM DEV Inter., Cambridge, Ontario, Canada

HIRDLS Instrument Flight Cryocooler Subsystem Integration and Acceptance Testing 769

W.C. Kiehl, D.J. Berry, D.S. Glaister, J. Richards, and R.G. Stack, Ball Aerospace, Boulder, CO

Low-Temperature, Low-Vibration Cryocooler for Next Generation Space Telescope Instruments 775

R.L. Oonk, D.S. Glaister, W.J. Gully and M.D. Lieber, Ball Aerospace, Boulder, CO

Commercial Cryocooler Applications 783

Considerations in Applying Open Cycle J-T Cryostats to Cryosurgery 783

R.C. Longworth, IGC-APD Cryogenics, Allentown, PA

Interference Characterization of Cryocoolers for a High-Tc SQUID-Based Fetal Heart Monitor 793

A.P. Rijpm, M.R. Bangma, H.A. Reincke, E. de Vries, H.J. Holland, H.J.M. ter Brake and H. Rogalla, Univ. of Twente, Enschede, The Netherlands

Vapor Precooling in a Pulse Tube Liquefier 803

E.D. Marquardt, R. Radebaugh, and A.P. Peskin, NIST, Boulder, CO

Terrestrial Applications of Zero-Boil-Off Cryogen Storage 809

L.J. Salerno and P. Kittel, NASA/ARC, Moffett Field, CA; J. Gaby, NASA/GRC, Cleveland, OH; R. Johnson, NASA/KSC, FL; and E.D. Marquardt, NIST, Boulder, CO

Indexes 817

Proceedings Index 817

Author Index 819

Subject Index 821