



## Advances in Cryogenic Engineering Materials

*Advances In  
Cryogenic  
Engineering  
Vol 19*

*Downloaded  
from  
[blog.gmrcyru.edu](http://blog.gmrcyru.edu)  
by guest*

---

### **TYRONE HAYNES**

---

*Advances in Cryogenic Engineering* Springer Science & Business Media The 1959 Cryogenic Engineering Conference Committee is pleased to present the papers of the 1959 Cryogenic Engineering Conference. We are fortunate to have had the University of California at Berkeley, Ca!., as our host for the fifth national meeting of this kind. The move to the West Coast for this past Cryogenic Engineering Conference was prompted in part by the large concentration of missile activities which are to be found there. Recognition of cryogenic operations and techniques in the missile field is given in many of the included papers. The University of California was certainly well suited for such a meeting as this because it was here that much early work was done in cryogenics. This pioneering in cryogenics is still evident today in the operation of the 72-in. bubble chamber at the Lawrence Radiation Laboratory. The Cryogenic

Engineering Conference salutes the missile industry and the cryogenic pioneers of yesterday and today at the University of California. Special thanks must go to Dr. D. N. Lyon from the Low-Temperature Laboratory of the University of California, who as chairman of the 1959 Cryogenic Engineering Conference Committee has worked tirelessly to increase the stature of this conference. vii  
ACKNOWLEDGMENT The Cryogenic Engineering Conference Committee is deeply grateful for the continued support and interest of the following organizations who made the 1959 Cryogenic Engineering Conference possible. Aerojet-General Corporation A. D. Little, Inc.

#### **Advances in Cryogenic Engineering Materials**

Springer Science & Business Media The Third International Cryogenic Materials Conference (ICMC) was held in Madison, Wisconsin, in conjunction with the Cryogenic Engineering Conference (CEC) in August 1979. The University of Wisconsin hosted the two

conferences in an excellent manner and deserves special recognition and praise. The synergism produced by conducting the two conferences simultaneously continues to be strong. Materials remain a demanding challenge and, in some cases, an obstacle to effective application of cryogenic technology. The association of materials specialists and cryogenic engineers every other year centers their attention on the most needed areas of research. The present ICMC Board met during the conference and elected two new members, E. W. Collings (U. S.) and D. Evans (England). The board voted to conduct two smaller, special-topic conferences in 1980. These are Filamentary A15 Superconductors, which was held at Brookhaven National Laboratories, Upton, New York in May 1980, and Fundamentals of Nonmetallics and Composites at Low Temperatures, held in Geneva, Switzerland in August 1980. The 1981 CEC/ICMC will be held August 10 through 14 in San Diego, California.

Advances in Cryogenic Engineering Springer Science & Business Media

The National Bureau of Standards Boulder Laboratories at Boulder, Colorado once again served as the host for the 1972 Cryogenic Engineering Conference. For the Cryogenic Engineering Conference it was like coming home, for it was at the NBS Boulder Laboratories that the Cryogenic Engineering Conference was first conceived and held in 1954 in connection with the dedication of the NBS Boulder Laboratories by President Dwight D. Eisenhower. The Cryogenic Engineering Conference is grateful for the continuing support that the National Bureau of Standards has given over the years, and which was expanded on July 1, 1971 when the NBS Boulder Laboratories assumed the secretariat function of the Conference from the National Academy of Sciences. Because of common interests in heat transfer, the 1972 Cryogenic Engineering Conference worked with the 13th National Heat Transfer Conference to develop a joint program in heat transfer. A majority of the papers presented in

this cooperative effort are included in Volume 18 of the Advances in Cryogenic Engineering through the kind permission of the 13th National Heat Transfer Conference and are accordingly acknowledged.

Advances in Cryogenic Engineering Springer Science & Business Media

The 1960 Cryogenic Engineering Conference Committee is pleased to present the papers of the 1960 Cryogenic Engineering Conference. Discussion of the papers, wherever available, has also been included to make the papers more valuable and interesting to the reader. This annual meeting once again has been held in Boulder, Colorado. Many delegates will recall that similar meetings were held in Boulder in 1954, 1956 and 1957. However, this year, because of the continued growth of this conference, the National Bureau of Standards Boulder Laboratories was joined by the College of Engineering of the University of Colorado in hosting this sixth national conference. The Cryogenic Engineering Conference Committee is happy to acknowledge the help of an Editorial

Committee which contributed valuable assistance in the difficult and thankless task of screening the preliminary papers and also reviewing the final drafts. This committee headed by R. B. Jacobs, who also served as chairman for the Conference Committee, consisted of R. W. Arnett, D. B. Chelton, R. J. Corruccini, T. M. Flynn, R. H. Kropschot, R. M. McClintock, A. F. Schmidt, L. E. Scott and W. A. Wilson.

*Advances in Cryogenic Engineering* Springer Science & Business Media

1971 marked the first year since 1956 that the annual Cryogenic Engineering Conference was not held. Instead, the Cryogenic Engineering Conference gave its full support to the XIII International Congress of Refrigeration by working with Commissions I and II of the International Institute of Refrigeration to organize the cryogenic sessions for these two commissions. All of the papers presented at the International Congress of Refrigeration will be published by the IIR as part of the proceedings of that meeting. Even though no Cryogenic Engineering Conference

was held in 1971, it became quite evident to the Conference Board that there were sufficient advances in cryogenic engineering to warrant the publication of Volume 17 of the *Advances in Cryogenic Engineering*. Volume 17 presents the advances in this important field by bringing together in one volume some of the significant papers that have been presented at various technical meetings across the country during the latter half of 1970 and the first part of 1971. In addition, several authoritative review papers have been prepared by invitation of the Cryogenic Engineering Conference Board.

*Advances in Cryogenic Engineering Materials*

Springer Science & Business Media

The 1987 joint Cryogenic Engineering

Conference/International Cryogenic Materials

Conference was held at the Pheasant Run Resort,

St. Charles, Illinois from June 14 to 18. Fermi

National Accelerator

Laboratory, located a few kilometers from Pheasant

Run, was the host for this conference. There is a

great deal of cryogenic research and

development underway at

Fermilab and many applications of cryogenic materials and systems are in routine, daily use at the Tevatron. The technical program for the joint conference had over 300 invited and contributed papers from many different countries. The CEC board and I have tried to dramatically shorten the publication time of this volume of *Advances in Cryogenic Engineering*. In order to help meet the goal of the February publication, I asked the reviewers to complete their reviews before leaving Pheasant Run, after the conference. I would like to thank all of the reviewers for their prompt and thoughtful reviews. I very much appreciate the authors following the prescribed format and responding quickly to my requests for revisions.

*Advances in Cryogenic Engineering Vol. 6*

Springer Science & Business Media

Readership includes engineers, scientists and students working in all areas of cryogenics and superconductivity as well as those working in areas that use cryogenics as an enabling technology (e.g. High Energy Physics, Astronomy, Space exploration, Materials

science and Fusion energy) As this is an archival volume of cryogenic research it should be included in the collections of all major University and research libraries as well as libraries maintained by National Labs and research centers. The information in these proceedings will be of interest to both US and foreign researchers and engineers. This conference is the principal North American Conference on cryogenic engineering. It is attended by scientists and engineers from all over the world. The papers published here have been fully refereed and cover all aspects of cryogenic engineering including: refrigeration, superconductivity, cryocoolers, air liquefaction, heat and mass transfer, insulation systems, cryostat design and space cryogenics.

***Advances in Cryogenic Engineering Vol. 4***

Springer Science & Business Media

The Hyatt Regency Hotel, Columbus, Ohio was the

venue for the 1995

Cryogenic Engineering

Conference. The meeting

was held jointly with the

International Cryogenic

Materials Conference. Jim

Peeples, of CVI, Inc., was conference chairman. Columbus is the home of the Battelle Memorial Institute, a pioneer in cryogenic materials development; the home of CVI, Inc., and Lake Shore Cryotronics, Inc., two leading manufacturers of cryogenic equipment; and it is the home of Ohio State University, where research on liquid helium has long been conducted. The program consisted of 315 CEC papers, nearly the same number as for CEC-91. This was the second largest number of papers ever submitted to the CEC. Of these, 252 papers are published here, in Volume 41 of *Advances in Cryogenic Engineering*. Once again the volume is published in two books. This volume includes a number of photographs taken during the awards lunch on July 20, 1995. Photographs have often been taken during the conferences, but they have never been used. The pictures are of the awardees, the conference chairs, and the organizers. They are distributed through out the books on pages that would otherwise have been blank. The pictures can be found on the following pages: 28, 232, 334, 536, 640, 826, 990,

1032, 1202, 1462, 1682, 1888, and 1994. *Advances in Cryogenic Engineering* Springer Science & Business Media The 1989 Cryogenic Engineering Conference, meeting jointly with the International Cryogenic Materials Conference, was held on the campus of the University of California, Los Angeles from July 24 to 28. Professor T.H.K. Frederking was the conference chairman. The Conference had previously met at U.C.L.A. in 1962 and 1969. A special symposium, "A Half Century of Superfluid Helium," was a significant part of the program of CEC-89. We were especially fortunate to have Professor Jack Allen of the University of St. Andrews, Scotland present at the Conference; his paper, "Early Superfluidity in Cambridge, 1936 to 1939," was a delightful, often humorous account of the early experimental work with superfluid helium. Professors V.L. Ginzburg and J.L. Olesen could not be present for the Symposium, but provided papers which are published in these proceedings. The late Bill Fairbank, responding graciously to a last-

minute invitation from Professor Frederking, presented a wonderful account of superfluid research in the United States in the post-war years.

### **Advances in Cryogenic Engineering Vol. 1**

Springer Science & Business Media Proceedings of the Tenth International Cryogenic Materials Conference (ICMC) held in Albuquerque, New Mexico, July 12-16, 1993. *Advances in Cryogenic Engineering* Springer Science & Business Media The Cryogenic Engineering Conference celebrated its Silver Anniversary at the 1979 Conference held at Madison, Wisconsin. For many it provided an opportunity to reminisce about the first Cryogenic Engineering Conference convened at the National Bureau of Standards in Boulder, Colorado and also about the many following conferences and advances that had been reported at these conferences. It is difficult to realize that the first Cryogenic Engineering Conference was held before the advent of multilayer insulation, the space age, large-scale LNG Operations and superconductivity

applications. The evolution of these activities has been carefully recorded in past volumes of the *Advances in Cryogenic Engineering*. Once again, the Cryogenic Engineering Conference is happy to have had the International Cryogenic Materials Conference cohost this meeting at the University of Wisconsin. Collaboration between these two conferences has proven to be mutually beneficial by providing the cryogenic engineer with an in-depth exposure to materials properties, selection, and utilization to complement the exposure to new applications and design concepts. The papers presented at this joint conference as part of the International Cryogenic Materials Conference will be published as Volume 26 of the *Advances in Cryogenic Engineering*. [Advances in Cryogenic Engineering Springer](#)

The 1999 Joint Cryogenic Engineering Conference (CEC) and International Cryogenic Materials Conference (ICMC) were held in Montreal, Quebec, Canada from July 12th to July 16th. The joint conference theme was "Cryogenics into the Next Millennium". The total

conference attendance was 797 with participation from 28 countries. As with previous joint CEC and ICMC Conferences, the participants were able to benefit from the joint conference's coverage of cryogenic applications and materials and their interactions. The conference format of plenary, oral and poster presentations, and an extensive commercial exhibit, the largest in CEC-ICMC history, aimed to promote this synergy. The addition of short courses, workshops, and a discussion meeting enabled participants to focus on some of their specialties. The technical tour, organized by Suzanne Gendron, was of Hydro-Quebec's research institute laboratories near Montreal. In keeping with the conference venue the entertainment theme was Jazz, culminating in the performance of Vic Vogel and his Jazz Big Band at the conference banquet. This 1999 ICMC Conference was chaired by Julian Cave of IREQ - Institut de recherche d'Hydro-Quebec, and the Program Chair and Vice-Chair were Michael Green of the Lawrence Berkeley National Laboratory and Balu Balachandran of the Argonne National

Laboratory respectively. We especially appreciate the contributions of both the CEC and ICMC Boards and the conference managers, Centennial Conferences, under the supervision of Paula Pair and Kim Bass, in making this conference a success. [Advances in Cryogenic Engineering Springer Science & Business Media](#)

The Fifth International Cryogenic Materials Conference (ICMC) was held in Colorado Springs, Colorado in collaboration with the Cryogenic Engineering Conference (CEC) on August 15-19, 1983. The growth and success of the joint conferences is a result of their complementary program and close cooperation. Materials remain a challenge in the application of cryogenic technology and sometimes, as in the case of superconductors, are the driving force for the technology. The association of materials and cryogenic engineers increases their awareness of recent research in their respective fields and influences the course of future research and applications. Many contributed to the success of the 1983 conference: E. W. Collings of Battelle Memorial Institute was the

ICMC Conference Chairman; M. Suenaga of Brookhaven National Laboratories, the ICMC Program Chairman; and L. L. Sparks of the National Bureau of Standards, the ICMC Local Arrangements Chairman. J. M. Wells and A. I. Braginski of Westinghouse R & D Center, G. Hartwig of the Nuclear Research Center of Karlsruhe, and K. T. Hartwig of the University of Wisconsin assisted the Program Chairman in metallic metals, superconducting materials, nonmetallic materials, and cryo physical properties, respectively. Excellent conference management was provided by Centennial Conferences. We especially thank M. Stieg, who coordinated the preparation of the papers for this volume. The CEC Board, especially their conference chairman, C. D. Henning of Lawrence Livermore National Laboratories, contributed very substantially to conference planning and implementation.

**Advances in Cryogenic Engineering** Springer Support from the National Science Foundation has made it possible for the tenth annual Cryogenic Engineering Conference,

hosted by the University of Pennsylvania and capably directed by K. R. Atkins and his staff, to emphasize the major international advances in cryogenic engineering. This specific emphasis resulted in a final program of over one hundred papers and has made it necessary to publish the proceedings of the conference in two volumes. The first volume will be similar in nature to previous volumes in this series, while the second volume will feature the international aspect of the conference program. The latter volume, because of this distinction, will be entitled *International Advances in Cryogenic Engineering*. As in the past, the Cryogenic Engineering Conference Committee gratefully acknowledges the assistance of all the dedicated workers in the cryogenic field who have contributed their time in reviewing the preliminary papers for the program and the final manuscripts for this volume. Since the list of participants in this thankless task numbers well over one hundred, any attempt to acknowledge their individual contributions in the limited space available would be

practically impossible. **Advances in Cryogenic Engineering** Springer Science & Business Media The 1965 Cryogenic Engineering Conference, in presenting the papers of its eleventh annual meeting takes this opportunity to gratefully acknowledge the assistance of Rice University and, in particular, R. Kobayashi and his staff for serving as hosts for this conference. This meeting, because of its proximity to the NASA Manned Spacecraft Center, has recognized the impact of the space age on the cryogenic field and has, therefore, attempted to emphasize this aspect of cryogenics to a greater degree than in past conferences. The highlight of this conference has been the presentation of the highest Cryogenic Engineering Conference award-The Samuel C. Collins Award-to its first recipient, Dr. Samuel C. Collins. This award, set up in his name, has recognized the outstanding contributions that Dr. S. C. Collins, retired Professor of Mechanical Engineering at the Massachusetts Institute of Technology, has made in the field of helium liquefaction. His

significant advances in various phases of cryogenics have been recognized internationally by numerous organizations. High on this list has been the tribute which was bestowed on him by the Kamerlingh-Onnes Laboratory in Leiden in awarding him the first Kamerlingh-Onnes gold medal to an American in 1958. The Cryogenic Engineering Conference, in addition to recognizing his pioneering work in helium liquefaction by the presentation of the Samuel C. Collins Award, also dedicates this volume of the *Advances in Cryogenic Engineering* to him.

**Advances in Cryogenic Engineering** Springer

"Since 1954 *Advances in Cryogenic Engineering* has been the archival publication of papers presented at the biennial CEC/ICMC conferences. *Advances in Cryogenic Engineering* resides throughout the world in the libraries of most institutions that conduct research and development in cryogenic engineering and applied superconductivity. The publication includes invited, unsolicited, and government-sponsored research papers in the

research areas of superconductors and structural materials for cryogenic applications. All of the papers published must (1) be presented at the conference, (2) pass the review process, and (3) report previously unpublished theoretical studies, reviews, or measurements of material properties at low temperatures." Victoria A. Bardos, Managing Editor *ADVANCES IN CRYOGENIC ENGINEERING- VOL 13- PROCEEDINGS OF THE 1967 CRYOGENIC ENGINEERING CONFERENCE*. Springer Science & Business Media  
The 1985 joint Cryogenic Engineering/International Cryogenic Materials Conference was held on the campus of the Massachusetts Institute of Technology, Cambridge, Massachusetts. About 350 papers were presented at the joint conference on a wide variety of topics in cryogenic science and engineering. This volume of *Advances in Cryogenic Engineering*, the thirty-first in the series which began in 1954, contains most of the papers which were presented at the 1985 Cryogenic Engineering Conference. Each paper was rigorously peer reviewed to maintain the international

reputation of *Advances* as the premier archival publication in the field of cryoscience, engineering, and technology. All the papers published in Volume 31 contain an abstract. A copy of the book will be sent to all major abstracting services, which should improve retrieval of the information contained in the published papers. I would like to thank the authors and those who served as reviewers. I especially appreciate the assistance of my colleague M. E. Stone who edited some of the papers for this volume. Terry Gutierrez was invaluable in preparing the manuscripts for publication, and I thank her. xvii DEDICATION Dr. Samuel C. Collins, Professor Emeritus of the Massachusetts Institute of Technology, internationally known as the father of practical helium liquefiers and founder of the MIT Cryogenic Engineering Laboratory, died on June 19, 1984, in George Washington University Hospital, Washington, DC. [Advances in Cryogenic Engineering - Proceedings \[Vol 1-\]](#). Springer Science & Business Media  
The First International Cryogenic Materials



Conference (ICMC) provided a new forum for the presentation of low-temperature materials research. The conference, held in conjunction with the 1975 Cryogenic Engineering Conference, provided materials research personnel with excellent exposure to current developments in the cryogenics field and beneficial interactions with designers of cryogenic systems. Because of the large response to a late call for papers, the enthusiasm and encouragement at the meeting, and the wide spectrum and high quality of papers, the Second International Cryogenic Materials Conference is being planned along with the 1977 Cryogenic Engineering Conference for Boulder, Colorado, in the summer of 1977. The success of the First International Cryogenic Materials Conference was certainly in large measure due to the excellent hospitality of our Canadian hosts, the Royal Military College of Canada and Queen's University in Kingston, Ontario. In particular, the efforts of A. C. Leonard and his staff ensured an excellent conference and a pleasant and memorable visit to Canada. The Cryogenic

Engineering Conference Board was both generous and skillful in helping to initiate this new conference and their guidance and acceptance is gratefully acknowledged. The Cryogenic Engineering Conference program chairman, M. J. Hiza, greatly facilitated the interaction for the two conferences and provided valuable assistance in generating a workable program. The proceedings of the 1975 Cryogenic Engineering Conference are published as Volume 21 of the *Advances in Cryogenic Engineering* and include many papers indicating innovative use of new cryogenic materials properties data. [Advances in Cryogenic Engineering Vol. 3](#) Springer Colorado Springs, Colorado, spectacularly located at the foot of Pike's Peak, was the site of the joint 1983 Cryogenic Engineering Conference - International Cryogenic Materials Conference. Over 300 papers were presented at the two conferences on a variety of cryogenic science and engineering topics. Volume 29 of *Advances in Cryogenic Engineering* contains 116 of the papers presented

at the 1983 Cryogenic Engineering Conference. Each paper was comprehensively peer reviewed to maintain the international reputation of the series as the premier archival medium in the field of cryotechnology. I would like to thank both authors and reviewers for their assistance in the preparation of this volume. R. W. Fast, Editor xvii DEDICATION The cryogenic engineering community was saddened to learn of the death of A. Clark Leonard of the Royal Military College of Canada, Kingston, Ontario, on November 24, 1983. Professor Leonard was born in Prince Albert, Saskatchewan, Canada, in February, 1922. Following service in the RCAF during World War II he received his B.M.E. degree at the University of Saskatchewan. While serving with the Canadian forces in Korea, he was awarded membership in the Order of the British Empire. He received his M.S. and Ph.D. degrees in Mechanical Engineering at the University of Michigan.

**Advances in Cryogenic Engineering Vol. 9**  
American Institute of Physics  
Proceedings of the 1991 Cryogenic Engineering

Conference held in Huntsville, Alabama, June 11-14, 1991.

Related with Advances In Cryogenic Engineering Vol 19:

- Otc Final Exam Schedule : [click here](#)