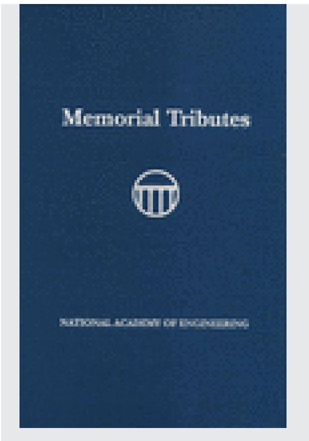

Memorial Tributes Volume 19

DETAILS

352 pages | 6 x 9 | HARDBACK | ISBN 978-0-309-37720-1

AUTHORS

National Academy of Engineering

Memorial Tributes

NATIONAL ACADEMY OF ENGINEERING

NATIONAL ACADEMY OF ENGINEERING
OF THE
UNITED STATES OF AMERICA

Memorial Tributes

Volume 19

THE NATIONAL ACADEMIES PRESS
WASHINGTON, DC 2015

International Standard Book Number-13: 978-0-309-37720-1

International Standard Book Number-10: 0-309-37720-X

Additional copies of this publication are available from:

The National Academies Press
500 Fifth Street NW, Keck 360
Washington, DC 20001

(800) 624-6242 or (202) 334-3313

www.nap.edu

Printed in the United States of America

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FOREWORD

THIS IS THE NINETEENTH VOLUME in the *Memorial Tributes* series compiled by the National Academy of Engineering as a personal remembrance of the lives and outstanding achievements of its members and foreign members. These volumes are intended to stand as an enduring record of the many contributions of engineers and engineering to the benefit of humankind. In most cases, the authors of the tributes are contemporaries or colleagues who had personal knowledge of the interests and the engineering accomplishments of the deceased.

Through its members and foreign members,* the Academy carries out the responsibilities for which it was established in 1964. Under the charter of the National Academy of Sciences, the National Academy of Engineering was formed as a parallel organization of outstanding engineers. Members are elected by their peers on the basis of significant contributions to engineering theory and practice and to the literature of engineering or on the basis of demonstrated exceptional accomplishments in the pioneering of new and developing fields of technology. The National Academies of Sciences, Engineering, and Medicine share a responsibility to advise the federal

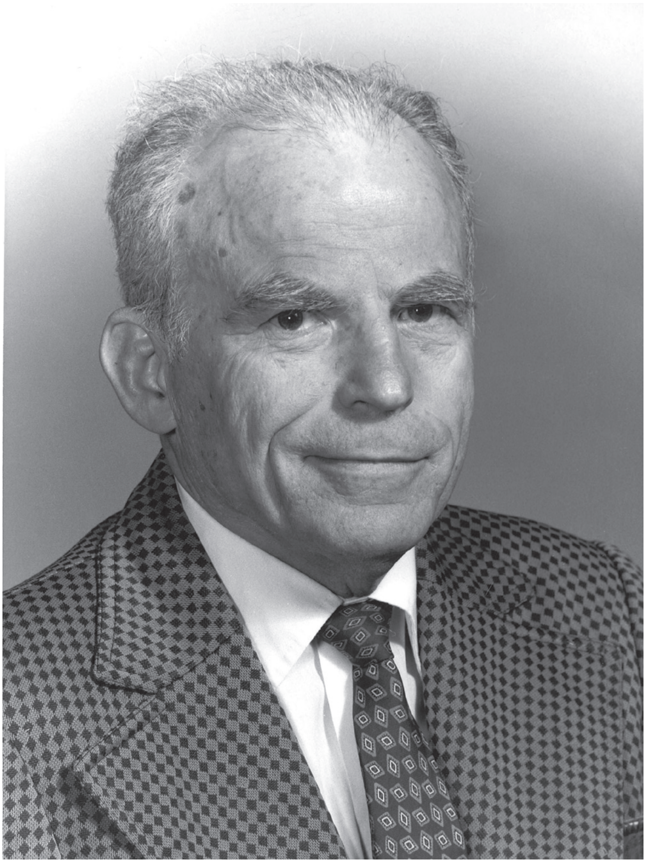
* Until May 2014 foreign members were known as foreign associates.

government on matters of science and technology. The expertise and credibility that the National Academy of Engineering brings to that task stem directly from the abilities, interests, and achievements of our members and foreign members, our colleagues and friends, whose special gifts we remember in these pages.

Thomas F. Budinger
Home Secretary

Memorial Tributes

NATIONAL ACADEMY OF ENGINEERING



Arthur Paul Adamson

ARTHUR P. ADAMSON

1919–2014

Elected in 1980

"Creativity, inventiveness, and engineering in the design and development of aircraft gas turbine and other engineering apparatus."

BY M.J. BENZAKEIN

ARTHUR PAUL ADAMSON died at age 95 on May 3, 2014, in Philadelphia. He leaves behind a unique legacy at General Electric and in the world of aviation.

Art was born March 14, 1919, and raised in rural Kansas, where he was educated in a one-room schoolhouse. Engines and machinery were part of his life since his boyhood on a farm in Coffeyville, Kansas. He said he never had a doubt that he would become a mechanical engineer. "Farm boys always know a lot about machinery," he said. "I like airplanes in particular. The engines are more fun than anything else."

It wasn't long before he succumbed to the call. After high school, he spent two years at a junior college in Coffeyville before packing his bags in 1939 and heading for Los Angeles. He moved in with his aunt and enrolled in the University of Southern California's mechanical engineering program, supporting himself with summer jobs in an aircraft plant and a part-time job in the engineering school's mechanical engineering lab. Sydney Duncan became his favorite professor; Thomas ("Pop") Taylor Eyre, then chair of the Mechanical Engineering Department, was his inspiration. He graduated at the top of his class in 1941.

He joined GE a month after graduation and spent his early years working on rocket and jet engine programs in

Philadelphia and then Schenectady. He also enrolled in GE's advanced technical training program, which allowed him to move into technical leadership positions. This was the beginning of his four-decade career at General Electric, where he left a remarkable, long-lasting legacy.

In the late 1950s he became a technical leader on GE's lift fan program and manager of the J85 engine program. He took a young Brian Rowe under his wing, and Rowe recalled him as "probably the most intelligent person working" at GE Aviation.

When the US Army awarded the GE12 demonstrator program in 1967, Art led the team on the radically efficient design. This led to a production contract in 1972, and the GE12 became the first version of the T700 helicopter program—still going strong with more than 15,000 engines in service. He also helped develop the TF34 family of turbofan engines used in the Navy's antisubmarine aircraft, the Warthog, and in regional commercial passenger jets.

In 1955 he moved to Evendale, Ohio, a suburb of Cincinnati, to oversee rocket engine development. In 1959, while the country scrambled to catch up with Sputnik-era launch capabilities, he became chief engineer of the Vanguard rocket engine program. A successful launch powered the first satellite into an Earth-orbiting trajectory on 24,000 pounds of thrust.

"His creative genius led to several aircraft engine programs," said USC classmate and fellow GE engineer Robert Hoffman, a resident of Redwood City, California. "One of them was the XV-5A lift fan for vertical launch, high-speed helicopters. That was a very rewarding program and a great vehicle to see take off."

In 1967 GE Aviation was determined to reenter the large commercial engine market in a big way. The company turned to Art to lead the initial CF6 engine development effort, based heavily on the TF39 military engine. Rowe soon led the CF6 project and worked closely with his engineering mentor, leading to the successful launch of the initial CF6-6 on the DC-10.

But the CF6 really came into its own with the higher-thrust CF6-50. And again Art Adamson played a central role: he created the design concept that enabled the CF6-50 to grow in thrust while keeping the turbine temperatures manageable. As Rowe later said, the CF6-50 would not have been possible without Art and his design team.

In the 1980s Art led the design team that created GE's ultra-high-bypass unducted fan (UDF) engine and became the "father of the UDF." The engine was a revolutionary concept that addressed the needs for low fuel consumption in the industry. Art's team designed this new propulsion system in cooperation with SNECMA of France. The team demonstrated its performance in flight tests on the Boeing 727-100 and MD 80 aircraft. When fuel prices dropped, interest in the fuel-efficient UDF engine waned and the unique engine never entered airline service. The concept, however, is being revived today in advanced studies at NASA and in the Clean Sky program in Europe.

Art's technology innovations on the program were extraordinary. For example, without the composite fan blades developed on the UDF, it is unlikely that the GE90 ultra-high-bypass ratio engine for the Boeing 777 airplane would have seen the light of day. He and his team were awarded the Collier Trophy for their achievements.

Art retired from GE in the late 1980s but continued for many years as a consultant. In 1989 he was inducted into GE Aviation's Propulsion Hall of Fame.

Few engineers have influenced the jet propulsion industry as Art Adamson. And he enjoyed more than most sharing his creativity and wisdom with those around him. His years as a consultant at GE were invaluable. He participated in "technical circuses," which are technical reviews of newly developed products; his comments were few and to the point. When Art spoke, we all listened.

Through the years, he received some of the most prestigious aviation industry awards around: GE's Charles P. Steinmetz Award for "concepts in developing electric motors, guided missile autopilots, electronic controls, rocket propulsion systems, and the CF6, T700, and CF34 jet engines"; GE's Perry T. Egbert Jr. Memorial Award "for outstanding creativity in the development of the CF6-50 Commercial Jet Engine"; and SAE's Franklin W. Kolk Air Transportation Progress Award for service to aviation (1985). He was elected to the National Academy of Engineering in 1980, a recognition that he highly deserved.

Art had multiple interests when he was not working; he was a devoted husband and father as well as an avid downhill skier, tennis player, world traveler, wood carver, and prolific reader. He was married for 59 years to the late Florence (Smith) Adamson, of Schenectady, and is survived by son David Adamson, daughter Judith Adamson, five grandchildren, two great-grandchildren, brother Charles Adamson, and five nephews and five nieces.

He will be greatly missed.

LEO R. BEARD

1917–2009

Elected in 1975

"Leadership in statistical applications and system analyses in hydrologic design and operation."

BY JOSEPH F. MALINA JR. AND RANDALL J. CHARENEAU
SUBMITTED BY THE NAE HOME SECRETARY

LEO ROY BEARD, civil engineering professor emeritus, died in Austin, Texas, on March 21, 2009, at the age of 91.

He was born in West Baden, Indiana, on April 6, 1917. His family moved to San Gabriel, California, in 1922, where he grew up with five siblings. He attended parochial schools, Alhambra High School, Pasadena Junior College, and California Institute of Technology, from which he graduated with a BS in civil engineering in 1939. Also that year he married Marian Jeanette Wagar, with whom he had three children.

Roy Beard had an illustrious career with the US Army Corps of Engineers from 1939 to 1972, and retired as founding director of the Corps's Hydrologic Engineering Center in Davis, California. He was known for his pioneering work on the application of statistics to hydrologic engineering. After his retirement he joined the University of Texas at Austin as lecturer and was appointed professor of civil engineering in 1976. He served as director of the Center for Research in Water Resources from 1972 until his retirement from UT in 1981; he was designated professor emeritus of civil engineering on

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This memorial resolution is reproduced with the permission of the Office of General Faculty and Faculty Council at the University of Texas at Austin and was originally prepared in August 2009.

September 1, 1987. He subsequently joined the engineering consulting firm of Espey Huston and Associates.

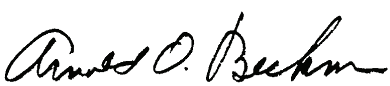
Professor Beard lectured at universities and professional organizations throughout the world. He was a visiting professor at the University of California, Berkeley and Utah State University and lectured at the University of California, Davis. He was a member of the American Geophysical Union (AGU), International Association of Hydrologic Sciences, American Association for the Advancement of Science, and International Water Resources Association; a fellow and honorary member of the American Society of Civil Engineers (ASCE); and honorary member of the American Waterworks Association. He served as chair of the ASCE Water Resources Planning and Management Division, president of the AGU Section of Hydrology, editor in chief of *Water International*, and managing editor of the *International Journal of Hydrology*.

His many contributions to civil engineering were recognized by a number of important awards and designations. In 1975 he was elected to the National Academy of Engineering. In 2001 he received the Lifetime Achievement Award from the ASCE Environmental and Water Resources Institute for "a lifelong and eminent contribution to the environment and water resources engineering disciplines through practice, research, and public service." He was designated an honorary diplomate of the American Academy of Water Resources Engineers in 2005, and in 2007 he received the ASCE Ven Te Chow Award "for advancing knowledge in hydrologic engineering in systems techniques for reservoir regulation, statistical methods for streamflow frequency analysis, flood hydrograph computation, and the development of computer based methods for hydrologic computations."

Marian died in 1973, and in 1974 Roy married Marjorie Pierce Wood of Austin. He is survived by her; his sister Margaret (Peggy) Nougier of Laguna Beach; his daughter Patricia Huntzicker of Portland, Oregon; his son Thomas Beard of Reno, Nevada; and his son James Beard of Hurricane, Utah; by Marjorie's daughters Patricia Fowler and Ann Bonner of Richland Springs, Texas, Kay DeVaux of Hot Springs, Arkansas, and son Thomas Wood of Austin, as well as 22 of his and Marj's grandchildren and 6 great-grandchildren.

Professor Beard said:

> Don't cry for me. There could hardly be a better life than that which mine has been. Starting with wonderful parents and three older siblings (later two younger siblings), I have been blessed with an abundant and happy life, including two wonderful marriages, three children of my own, four step-children, and so many friends, including professional associates throughout the world. The world has been full of good for me. My cup runneth over a thousandfold!



ARNOLD O. BECKMAN

1900–2004

Elected in 1967

"Invention and development of precision instruments."

BY TOM EVERHART

ARNOLD ORVILLE BECKMAN, scientist, inventor, founder of Beckman Instruments, and philanthropist, died in La Jolla on May 18, 2004, at the age of 104.

He was born on April 10, 1900, the oldest of four children (three boys and a girl) in Cullom, Illinois, a village of 500 individuals. His father was the local blacksmith, and Arnold grew up fascinated with mechanisms, devising some of his own during his youth. He read avidly and when he was 9, after finishing many of the family books, he found a copy of Steele's *Fourteen Weeks in Chemistry*. He began to read, and fell under its spell, a spell that was to last a lifetime. He soon had his own chemistry lab, using ingredients readily available from the druggist; he made some of the apparatus, and relatives supplied more complicated items. He also learned to play the piano under his mother's tutelage, and became accomplished enough to play for the local cinema, which of course showed the silent movies of the day.

Arnold's mother died when he was 12, and after he passed an examination admitting him to University High School in Normal, Illinois, his father moved the family there. He mastered chemistry quickly, and when he graduated as valedictorian had completed 2½ years of college chemistry at Illinois State Normal University. He joined the Marines and, while stationed at the Brooklyn Navy Yard, met Mabel Meinzer, who a few years later became his wife. In the meantime he returned to Illinois too late to enroll in college and so took a trip to the West, where he played piano at the theater in Ashton, Idaho, and stayed at the owner's home. Thus began his love of the western United States.

That fall he returned home to study chemistry at the University of Illinois, where he distinguished himself as an undergraduate and also took his master's degree, both in 1922. He wanted to pursue his PhD at another school, and applied to the University of Chicago, MIT, and Caltech. He was admitted to all three and, in part because Richard Tolman had left Illinois for Caltech after Arnold became a student there, decided on Caltech. He did well, liked the Institute, but also longed to be nearer Mabel Meinzer, so in 1924 he dropped out of Caltech, went to New York, and got a job at Western Electric Engineering, in a group that soon became Bell Labs. He learned about vacuum tube electronics as well as manufacturing and quality control. He also saw a good deal of Mabel, and they were married in 1925. In the summer of 1926 they headed west so Arnold could finish his PhD in chemistry at Caltech. In 1928, with that accomplished, he was asked to join the Caltech faculty, and did. In a few years he was in charge of freshman chemistry and renowned as both a teacher and an instrument and apparatus designer at the institute.

He concurrently became an expert witness in lawsuits and a consultant to industry on a variety of scientific problems. For example, to overcome ink clogging in postal meters, he devised a new ink in which the pigment would not settle out. And when a friend asked him to devise a more quantitative way to measure acidity, he developed the pH meter.

He also formed the National Technical Laboratory to develop his inventions. The pH meter was developed into a portable device that was first shown at the American Chemical Society annual meeting in San Francisco in 1935. After it evoked much interest there, he was able to market it, and started what later became the very successful Beckman Instruments Company. Among the company's early instruments was a spectrophotometer, which evolved through several models. The most successful early model, the DU spectrophotometer, was described by one Nobel Laureate as probably the most important instrument ever developed toward the advancement of bioscience. More than 21,000 units were sold between its introduction in 1942 and 1964, when it was discontinued for newer models. It played a crucial role in the development of penicillin, vitamins, TNT, synthetic rubber, and many other important compounds.

Beckman was also called upon for numerous developments during World War II; the helipot that increased the accuracy of a variable resistor by a factor of 10 is one example that he was personally involved in developing.

He had a pioneering involvement with the California Institute of Technology. After leaving the faculty in 1939 to be engaged full-time in his company, he remained close to faculty and the Institute. He was the first Caltech graduate to be elected to the board of trustees (in 1953) and then became the first graduate to chair the board (1964–1974).

He and Mabel provided the funding to establish Beckman Auditorium in 1964, Beckman Laboratories of Behavior Biology in 1974, the Beckman Laboratory of Chemical Synthesis in 1986, and in 1989 the Beckman Institute to further interdisciplinary work between chemistry and biology. In recognition of his many contributions to the Institute, Caltech trustees and other friends established the Arnold O. Beckman Professorship in Chemistry, currently held by Harry Gray, founding director of the Beckman Institute.

Arnold Beckman believed in science and engineering education and research, and through the Arnold and Mabel Beckman Foundation the Beckmans gave more than $400 million to philanthropy, primarily toward scientific endeavors in higher education—more than 200 young investigators and 400 young scholars have been funded. In addition to their gifts to Caltech, they provided funds for the Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign, the Beckman Research Institute at the City of Hope, the Beckman Center for Molecular and Genetic

Medicine at Stanford University, and the Beckman Laser Institute at the University of California, Irvine. There are many other contributions that might be named, but especially in this tribute, the Arnold and Mabel Beckman Center of the National Academies of Sciences and Engineering in Irvine should be noted.

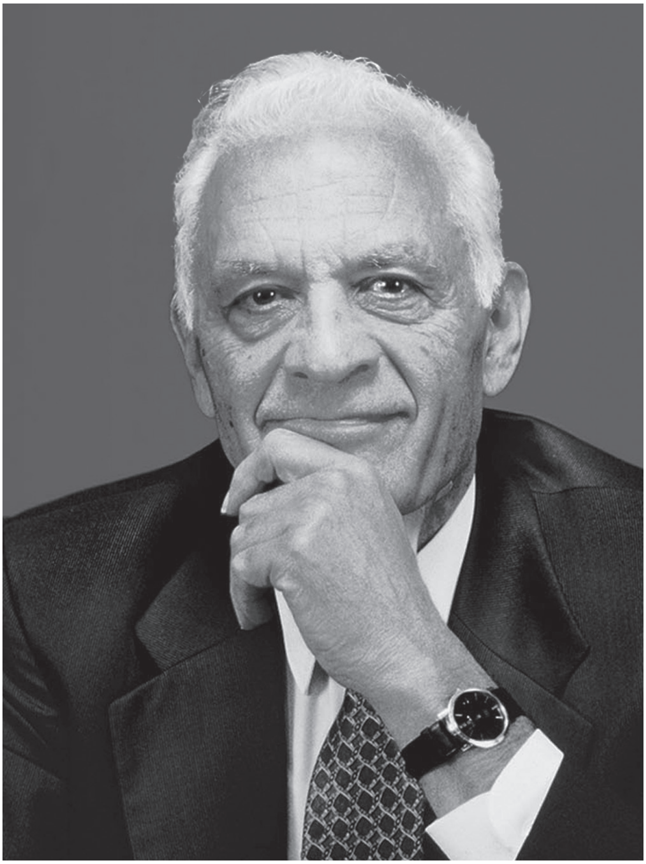
He received many honors during his life. The Arnold O. Beckman Award of the Instrument Society of America was named for him in 1960, and he received the "Illini" Achievement Award the same year. He was elected to the National Academy of Engineering in 1967 and the National Academy of Sciences in 1999. Of the many other awards he received, the following stand out:

- Life Achievement Award of the Instrument Society of America, 1981
- Golden Plate Award, American Academy of Achievement, 1982
- Distinguished Alumni Award, California Institute of Technology, 1984
- National Inventors Hall of Fame, 1987
- National Medal of Technology, 1988
- Presidential Citizens Medal, 1989
- National Medal of Science, 1989
- Bower Award for Business Leadership, Franklin Institute, 1992
- Hall of Fame, Alpha Chi Sigma, 1996
- Public Welfare Medal, National Academy of Sciences, 1999
- Othmer Gold Medal (Special Millennium Edition), Chemical Heritage Foundation, 2000
- Lifetime Achievement Award, National Inventors Hall of Fame, 2004

Arnold Beckman was a leader in many areas of life, from science and engineering to creative invention, service to education, and philanthropy. His influence was felt not only because he accomplished so much but because of the person he was, and perhaps the best way to convey that is to list his "seven rules for success":

1. Maintain absolute integrity at all times.
2. Always do your best; never do anything half-heartedly.
3. Never do anything to harm others.
4. Never do anything for which you will feel shame.
5. Always strive for excellence—there's no substitute for it.
6. Practice moderation in all things—including moderation.
7. Don't take yourself too seriously.

He lived by these rules his entire life, which spanned the twentieth century. He saw science and technology develop to its present-day state, and his contributions enabled much of that development.



AMAR G. BOSE

1929–2013

Elected in 1987

"For innovation and leadership in the science and engineering of sound reproduction, and for excellence in engineering education."

BY ALAN V. OPPENHEIM

AMAR GOPAL BOSE, chairman of the board and technical director of Bose Corporation, and professor emeritus of electrical engineering and computer science at the Massachusetts Institute of Technology, died on July 12, 2013, at the age of 83. He was born on November 2, 1929, in Philadelphia.

Dr. Bose received his bachelor's and master's degrees in 1952 and his ScD degree in 1956, all in electrical engineering from MIT. He was elected to the National Academy of Engineering in 1987. Throughout his career he received many awards and recognitions as an educator, inventor, researcher, and entrepreneur. He holds numerous patents in the fields of acoustics, electronics, nonlinear systems, and communication theory.

In 1956, as a member of the MIT Department of Electrical Engineering and the Research Laboratory of Electronics, Dr. Bose began a research program in physical acoustics and psychoacoustics. Much of his early interest in these areas stemmed in part from his passion for classical music and his disappointment in available sound reproduction systems. His research led to the formation of Bose Corporation in 1964. The associated patents provided the foundation for the company's consumer products—home entertainment systems; automotive sound systems; noise reduction headsets and headphones for the military, pilots, and consumers; and professional sound systems for commercial applications and for musicians.

Dr. Bose had a lifelong love of cars, particularly those with interesting technology. In 1956 he bought a Pontiac Bonneville with the first air suspension, and in the 1960s a Citroën with its revolutionary inverted wing under the car which provided tremendous traction at high speeds. It was inevitable that this love eventually combined with his research interests and led to the development of not only the Bose suspension system for vehicles and truck seats but also biostent medical testing devices.

In his mentoring at MIT and Bose Corporation Dr. Bose typically placed more weight on his belief in the individuals and their passion for the ideas they were pursuing than on the specific details of the idea. He understood that the kernel of an idea in the hands of an enthusiastic person with insatiable curiosity would follow an exciting path to new and creative results.

Throughout his research career at MIT and at Bose Corporation, he often pursued ideas that were controversial and that others felt were impractical. Consistent with his penchant for challenging conventional wisdom, engraved in a glass wall outside his company office is a quotation by the Belgian Nobel Laureate Maurice Maeterlinck: "At every crossway on the road that leads to the future, each progressive spirit is opposed by a thousand men appointed to guard the past."

His devotion to and belief in the importance of long-term research is embodied in the Bose Corporation mission statement, "Better Sound Through Research." By keeping the company private, he was able to maintain this research philosophy and discipline as the company grew from a startup to a worldwide corporation with over 10,000 employees and over $3 billion in annual revenue.

As just two examples of his long-term horizon in research, the Bose Wave radio was in development for 12 years before it became a consumer product. And the company's noise-cancelling headphones lost money for a decade before turning into a profitable product.

In a 2004 interview in *Popular Science* magazine Dr. Bose is quoted as saying "I would have been fired a hundred times at a company run by MBAs. But I never went into business to make money. I went into business so that I could do interesting things that hadn't been done before."

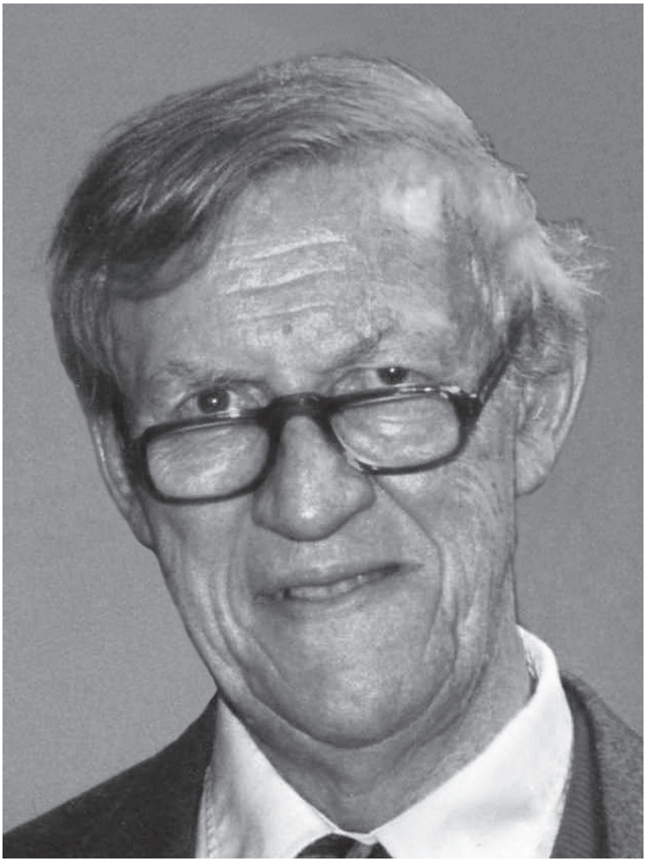
As a faculty member at MIT, Professor Bose was legendary. His classroom technique was masterful, and characterized by extraordinary standards—he expected the same of both the students and his teaching staff. He also invested considerable effort in the mentoring of students on his teaching staff, many of whom, inspired by him, went on to highly successful teaching and research careers.

Professor Bose had an extraordinary ability in the classroom to inspire, to mesmerize, and to convey complex material in eloquently simple ways. His course on acoustics was affectionately renamed by the students "Acoustics and the Philosophy of Life" and many students took it as much for his philosophy, insights, and anecdotes as for his elegant presentation of the complex technical aspects of acoustics.

On his induction into the National Inventors Hall of Fame in 2008 he said: "Research and teaching are two top professions that I have enjoyed the most. Management is the profession that I enjoy the least but realize that it's very, very important because people are the ingredient that makes everything possible. If you can motivate these people highly, the results are phenomenal."

Dr. Bose's favorite hobbies were badminton and research. He started playing badminton as a student at MIT and played every Sunday with an MIT community group for many decades. Later, he looked forward to spending time every winter in Hawaii, where he played badminton with a group from the University of Hawaii and could spend much of his free time on new research pursuits.

Amar Bose was extraordinary in his pursuit of excellence, his exceptional values and standards, his gifted leadership, his commitment to mentoring, and his courage and creativity in research. He often commented that as a teacher and mentor you influence an endless succession of generations. There is no doubt that through his teaching and mentoring at MIT, at Bose Corporation, and worldwide, his impact will live and expand forever. I personally miss him deeply as do many thousands of others. Meeting Professor Bose for the first time in 1960 was a life-changing event for me and I am so profoundly grateful for all that he taught me in the many decades since.



SIDNEY A. BOWHILL

1927–2012

Elected in 1971

"Contributions to aeronomy and the fostering of national and international programs in radio research."

BY LESLIE G. SMITH AND JAMES A. HUTCHINSON
SUBMITTED BY THE NAE HOME SECRETARY

SIDNEY ALLAN BOWHILL, a pioneering educator and researcher of Earth's upper atmosphere, was born on August 6, 1927, in Dover, England, to Sidney Allan and Violet (née Clarke) Bowhill. After attending Cheltenham Grammar School, he enrolled at Downing College, Cambridge University, where he earned a BA in physics in 1948. He undertook graduate work in Cambridge's legendary Cavendish Laboratory under the direction of the eminent radio physicist John A. ("Jack") Ratcliffe, and completed his PhD in 1954 with a dissertation entitled "Some Problems in Very Long Radio Wave Propagation."

From 1953 to 1955, working in the Baddow Research Laboratories of Marconi's Wireless Telegraph Company, Ltd., Bowhill supervised projects investigating long-distance pulsed radio signals. He then immigrated to the United States and embarked on a prolific academic career—the bulk of it with the University of Illinois at Urbana-Champaign (1962–1986)—during which he demonstrated the power of broad collaboration in bettering the understanding of our planet. He died on October 4, 2012, at age 85 in Concord, Massachusetts.

He joined the faculty of Pennsylvania State University in 1955 as an assistant professor and soon advanced to the rank of associate professor by virtue of his research work in the Ionosphere Research Laboratory (IRL) directed by Arthur H.

Waynick. At IRL, he headed up projects for the International Geophysical Year (1957–1958), when the sunspot cycle was at its maximum and satellites were deployed to enable more sustained observations of the ionosphere than what could be achieved until then using ground-based radar and rockets. These studies enhanced understanding of the structure and composition of the ionosphere in addition to helping prepare the way for manned space flights.

In 1962 Bowhill accepted the position of full professor at the University of Illinois at Urbana-Champaign, where he founded the Aeronomy Laboratory and quickly led the new lab to a position of international respect. His work helped explain the fading of low-frequency radio signals and dispersive characteristics of the ionosphere, high-frequency ionosphere absorption and Faraday rotation effects, electron density as a function of altitude, and photochemical and diffusion effects in the ionosphere.

He excelled as an experimentalist and theoretician. He designed a new type of radio propagation experiment that measures simultaneously the Faraday rotation, differential absorption, and probe current. The Faraday and absorption data were analyzed using generalized magneto-ionic theory and applied to rocket data to obtain electron density and collision frequency and to calibrate a Langmuir-type electron current probe that measured the fine structure of the electron density profile. To measure Faraday rotation and absorption, Bowhill and colleagues in the Aeronomy Laboratory designed and built an ingenious system for abstracting the data from a rocket shot. Both magneto-ionic modes were radiated from a pair of ground-based transmitters and a power ratio of 10 dB at the rocket receiver was maintained by servoloop, which included the variable power transmitters, the rocket-borne receiver, and the telemetry system. This system yielded remarkable results in sensitivity, accuracy, and reliability.

Wide-ranging collaboration was a hallmark of projects undertaken by Bowhill's laboratory, which hosted conferences attracting scientists from all over the world. Several international researchers served as visiting scientists in the laboratory during these years. Like the IRL at Penn State during the International Geophysical Year, the Aeronomy Lab played an important role in research projects surrounding the International Year of the Quiet Sun in 1964–1965, when the sunspot cycle had ebbed to its minimum. The lab helped spearhead the Middle Atmosphere Program, a 1980s project overseen by the International Council of Scientific Unions and implemented by the Scientific Committee on Solar-Terrestrial Physics, an international organization that was based at the Aeronomy Laboratory for a while during the 1980s.

Bowhill collaborated across disciplinary as well as national borders: Aeronomy Lab personnel specialized in physics, chemistry, electrodynamics, and meteorology; they joined forces with physical electronics experts to develop space-based lidar (laser radar) systems to measure atmospheric structure and composition, and with antenna experts to build a radar facility near the Urbana campus, from which meteor trails were tracked to glean information about upper-atmosphere winds. Furthermore, Bowhill developed an expertise in computational science and is counted among the first to adapt Monte Carlo computational techniques to study of the atmosphere. He was in the forefront of putting microcomputers to use not only in advanced research but also in the education of undergraduate engineering students.

During the Illinois years, the importance of his scientific work was evident in the many calls to serve the engineering and scientific professions, academia, and his country (he was naturalized in 1962). He chaired committees, panels, and boards of the Institute of Electrical and Electronics Engineers (IEEE), International Union of Radio Science (URSI), and NASA; edited the *IEEE Transactions on Antennas and Propagation*, *Journal of Atmospheric and Terrestrial Physics*, and *Radio Science*; served as a US delegate to international scientific gatherings all over the world; and conducted classified research for the US government as president of the Champaign-based Aeronomy Corporation.

After 24 years as a successful laboratory director, he left in 1986 to assume leadership of the Department of Electrical and Computer Engineering at the University of Lowell (soon to become UMass Lowell). There, he continued as a leading member of the atmospheric science community while applying his administrative skills to the task of transforming the department into a modern academic unit with research in addition to teaching at the core of its mission. He hired research-oriented faculty who brought expertise in semiconductors, photonics, signal processing, and other fields to the Lowell campus.

Part of Bowhill's appeal as a leader was his support for a broad range of research areas outside his own particular field of interest. He was also respected for his forthrightness, helpfulness, work ethic, fairness, and adherence to principle above politics and self-interest.

He remained active in service to the research community, chairing the US National Committee for URSI (1988–1990) and the US delegation to URSI's 23rd General Assembly in 1990, among a great many other service activities.

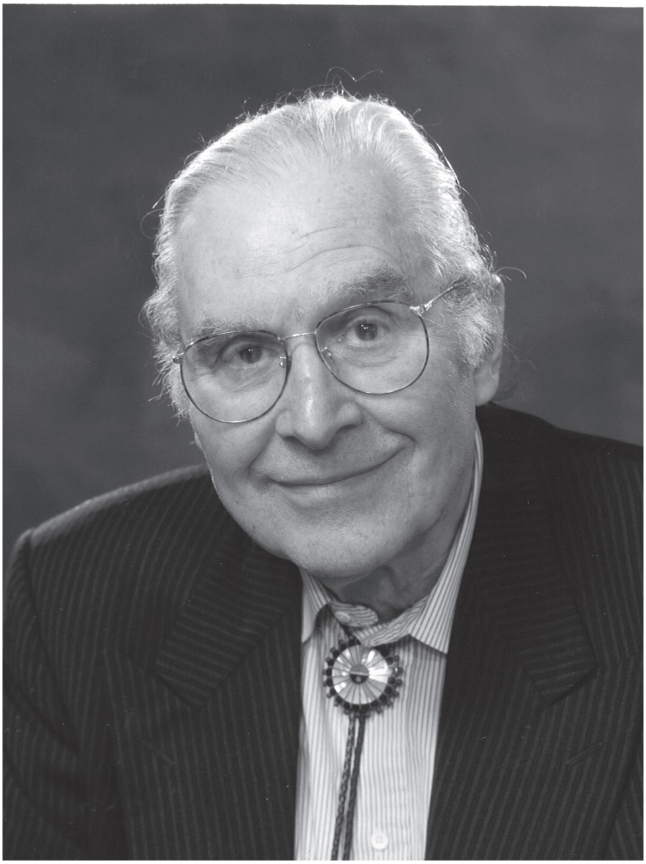
In addition to his NAE membership, Bowhill was a fellow of the American Association for the Advancement of Science, American Geophysical Union, American Astronomical Society, IEEE, and Physical Society of London. He authored or coauthored hundreds of publications on the dynamics and chemistry of the middle atmosphere, physics and structure of the ionosphere, artificial heating of the ionosphere, statistical theory of turbulence, transient wave propagation in the ionosphere, remote sensing of the atmosphere by radar and lidar, digital signal processing, and microcomputer applications hardware and software.

Among family, friends, and colleagues alike, Bowhill is remembered for his energy, intellect, creativity, and colorful character. The latter included an ingratiating laugh and a thespian streak that not only enhanced his classroom presence but also led him to leading roles—both on stage and behind the scenes—in community theater. He served as president of a community theater organization in State College, Pennsylvania, and was founding president of the Champaign-Urbana Community Theater. After retiring from UMass Lowell, Bowhill devoted himself to the craft of poetry with the same keenness he had applied to science, engineering, and theater. He loved the challenge of finding pleasure and freedom within the strictures of a poetic form, the sonnet being his favorite. Through classes, workshops, open readings, and independent study, he learned as much as possible about the subject, then generously shared his expertise with others. A mentor and friend to many, he offered incisive suggestions and treated all with respect.

Bowhill is survived by wife Rita Sagalyn of Lexington, Massachusetts; two children by his first wife Margaret (née McLaughlin): daughter Amanda Bowhill (Michael D'Addio) of San Jose and son Allan Bowhill (Joan) of Seattle; and stepsons Michael (Christy) of Norwalk, Connecticut, and Roger Sagalyn of Lexington, Massachusetts.

Meteor Shower
by Sidney A. Bowhill

I see you lying supine in the field,
enveloped by the canvas hood of night,
awaiting what the chilly hours will yield
to calm your mind, and put your fears to flight.
Gaze at the heavens now, below the stars,
and watch for changes. Your peripheral eye
can see the planets, Jupiter and Mars,
but do not turn your head to where they lie.
Instead, remain at rest, and watch with care
for darting lines of silver you will spy,
each one an arrow's path, as atoms tear
electrons from their orbits in the sky.
Your sense of wonder at each beamy track
will heal your wounds, and bring your spirit back.




Howard Brenner

HOWARD BRENNER

1929–2014

Elected in 1980

"Contributions in quantitatively modeling physicochemical transport processes in multiphase systems."

BY DAVID A. EDWARDS

HOWARD BRENNER, professor emeritus of chemical engineering at the Massachusetts Institute of Technology and a pioneer of the diverse phenomena that accompany the movement of mass, energy, and momentum in continua, died on February 17, 2014, at age 84. Modern understanding of fluid flow at low Reynolds number and transport phenomena of complex media is critically associated with his singular legacy.

Howard Brenner was born March 16, 1929, and raised in New York City. He earned his bachelor's degree from Pratt Institute in 1950 and his PhD in 1957 from New York University (NYU), both in chemical engineering. His research work with John Happel and later as an NYU faculty member (1955–1966) led to his first seminal textbook, *Low Reynolds Number Hydrodynamics* (with Happel; Prentice-Hall, 1965), a cornerstone of his work and reputation for several decades.

He was a highly visual, rigorous, and keenly intuitive applied mathematician. From the 1960s, and especially in his faculty position in the Chemical Engineering Department at Carnegie Mellon University (1966–1977), he published groundbreaking work on the movement of colloidal bodies. This work continued through his faculty positions at the University of Rochester (1977–1981) and MIT (1981–2014), and came to include a remarkable body of analyses of the movement of solid, flexible, and aggregated particle systems subject to Brownian motion and relevant to the study of diverse fields ranging from biology (i.e., Purcell's *Life at Low Reynolds Number*) to engineering separations and aerosol physics.

He authored articles of unusual scholarship, with hand-drawn images, reflective of an earlier era of scientific inquiry. These and other works, with forever-admiring graduate and postgraduate students, spawned fields of study that mark the careers of many theoretical and experimental researchers today, including those who study biophysics, filtration, osmotic membrane flow, and transport phenomena in multiphase systems. At the end of his life, his work to elucidate the foundations of transport phenomena, including his contention that fundamental fluid dynamic equations, notably the Navier-Stokes equations, should be reformulated, became a particular and consuming passion.

He published over 200 research articles and three textbooks during his distinguished career. His textbooks *Interfacial Transport Phenomena and Rheology* (coauthored with me and Darsh Wasan; Butterworth-Heinemann, 1991) and *Macrotransport Processes* (coauthored with me; Butterworth-Heinemann, 1993) formulated new areas of applied mathematical inquiry. *Interfacial Transport*, written following an earlier unpublished work by Li Ting, gave a coherent mathematical basis to what had for many years remained a field of study marked by the inherent confusion that follows the transposition of the laws of flat space into the physics of moving and deforming two-dimensional surfaces. The field was of direct pertinence to the food, cosmetic, and oil industries. *Macrotransport Processes* assembled a decade of effort by Brenner with his students and postdocs to provide a rational, systematic, if difficult approach to the movement of fluids and particles through complex media such as occurs in the movement of molecules and cellular bodies, in tissues, or oil through the ground.

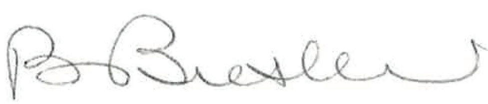
In addition to his election to both the National Academy of Engineering (1980) and the National Academy of Sciences (2000), Howard Brenner won many national and international awards for his research and teaching. He won all three principal awards of the American Institute of Chemical Engineers—the Alpha Chi Sigma Award for Chemical Engineering Research (1976), William H. Walker Award for Excellence in Contributions to Chemical Engineering Literature (1985), and Warren K. Lewis Award for Chemical Engineering Education (1999); the Fluid Dynamics Prize (2001) of the American Physical Society; the Bingham Medal of the Society of Rheology (1980); and the American Chemical Society Award in Colloid and Surface Chemistry (1988), among others.

Brenner deeply influenced those who worked closely with him during his long career. He had no patience for error. Those of us who worked with him for many years inevitably began at a place far from where we would end up intellectually. The first weeks and months working with him were likely to bring frustration—which thankfully dissipated as we learned.

His approach was that of the player-coach. Rarely did he ask of a student or postdoc what he could not himself do, if he gave himself the time, with perfection. We always knew this, and his reaction to our work, whatever it was, changed how we thought. We forged a special bond with him that many of us will never forget. We dined with him, occasionally went to a Red Sox game with him, and sat for long hours in our offices talking with him.

He was appreciated by those well beyond his professional circle, as attested by a letter from Ariel Mathiowitz, son of the Brenners' friend Edith Mathiowitz, professor at Brown University. Ariel wrote: "Howard was such a smart and fun person. Growing up he was my favorite guest at our Passover dinners. I looked up to him as a source of comedy, intellect, and wit. He always had a story to tell that lifted everyone's spirits. His presence was one of the main reasons that I, as a child, would stay just a bit longer at the dinner table before escaping upstairs to get away from the boring adult talk."

Howard Brenner is survived by his wife Lisa Glucksman; former wives Simone and Lorraine; daughters Leslie, Joyce, and Suzanne; seven grandchildren; and his sister Renee Brenner Gould.



BORIS BRESLER

1918–2000

Elected in 1979

"Pioneering in the structural design of large works to withstand combined stresses, sustained loads, corrosion, fires, and earthquakes."

BY VITELMO V. BERTERO, JOSEPH PENZIEN, KARL S. PISTER, AND EGOR P. POPOV

BORIS BRESLER, professor emeritus of civil engineering at the University of California, Berkeley, passed away on March 9, 2000, at the age of 81 in his home in Tel Aviv. He taught and conducted research at Berkeley for 32 years and had an exceptionally rich cultural and professional engineering life.

He was born in Manchuria on October 18, 1918, and was part of the Russian Jewish community that emigrated to Harbin before the Revolution. He graduated from the Harbin Commerce High School and acquired a superb knowledge of the Russian language, which proved useful in his professional career, enabling him to write critical reviews of Russian language technical articles, among them "Theory of Mechanisms" by Chebyshev in the *Quarterly Journal of the National Research Council* and "Solution of Thin-Walled Beams in Torsion by Complex Variable Polynomials" by Beerman in *Applied Mechanics Reviews*.

After attending St. John's University in Shanghai, he entered and graduated from UC Berkeley with a BS in civil engineering in 1941. He became a construction inspector and then a design engineer at the Kaiser Richmond Shipyards, where Liberty

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Ships were constructed. From 1943 to l945 he was employed as a stress analyst at Consolidated Vultee Aircraft Corporation in San Diego, where he was involved in the selection of load criteria for bombers. In the evenings he taught numerical stress analysis, strength of materials, and airplane structural design at the University of California's War Training Center in San Diego. He subsequently studied at the California Institute of Technology, where he pursued studies in the theory of elasticity, vibration analysis, and aircraft design, earning an MS degree in aeronautical engineering in 1946.

Later that year he was hired as a lecturer in civil engineering at Berkeley, where he held the additional title of research engineer on the pioneering Prosthetic Devices Research Project conducted under the direction of Howard D. Eberhart. He developed methods for analysis of the mechanics of human locomotion and established criteria for the structural design of artificial limbs. The research resulted in a number of papers on prosthetic devices and a series of lectures at graduate seminars of the Department of Orthopedic Surgery at UC San Francisco.

In 1948 he was appointed assistant professor of civil engineering and also registered as a professional engineer in California in mechanical engineering. He began to devote most of his research efforts to understanding the mechanical behavior of materials of construction, with particular reference to the behavior of structures exposed to complex loading and environmental conditions. He developed advanced analytical methods for the response of reinforced concrete structures to fire and other extreme temperature conditions, as well as systematic procedures for evaluating seismic hazards in existing buildings.

He became assistant dean for graduate studies in the College of Engineering (1956–1959) and was active in the affairs of the Berkeley Division, serving as vice chair of the Graduate Council and as a member of the Committee on Committees of the Division as well as the Statewide Academic Senate.

He authored or coauthored more than 70 technical papers. He was coauthor of *Design of Steel Structures* with T.Y. Lin and J. Scalzi (John Wiley and Sons, 1964), author of *Reinforced*

Concrete Engineering (John Wiley and Sons, 1974), and editor of the 1978 volume *Douglas McHenry International Symposium on Concrete and Concrete Structures*.

After retiring in 1978, Boris joined the consulting engineering firm of Wiss, Janney, Elstner Associates, Inc. as a senior consultant and manager of the California office. He developed design criteria for various types of structures, including high-rise buildings, offshore structures, and industrial and nuclear power plant facilities. He enjoyed his work as a consultant in structural engineering and as a member of numerous professional committees.

Consistent with the breadth of interest demonstrated throughout his life, he also chose to follow new paths. He established a publishing house, Benmir Books, in Walnut Creek, and, while residing for part of the year in Israel, edited a newsletter about the experiences of Jews in China.

His work resulted in numerous professional honors. He was co-recipient (with Karl Pister) in 1960 of the Wason Medal for Materials Research of the American Concrete Institute (ACI) and the Joe W. Kelly Award in 1978. In 1968 he received the ASCE State-of-the-Art of Civil Engineering Award and in 1979 was elected to the National Academy of Engineering. In 1988 he was cited by the *Engineering News Record* for his contribution to the field of fire protection engineering in the construction industry. In 1994 ASCE elected him an honorary member for "his many contributions to the profession of structural engineering, particularly in the areas of complex loading and special environments such as earthquakes and fire hazard."

Boris was an excellent teacher, not only in the classroom and office but also for his colleagues. He greatly influenced teaching and research on the Berkeley campus and left many friends there and in societies such as SEAONC, ACI, ASTM, and IABSE, in which he was an active participant. All of us will miss him, especially his great sense of humor.

Boris enjoyed a happy marriage with his wife Joy until her untimely death. He is survived by daughter Deborah Ann and son-in-law Michael Bloom, of Danville, and two grandchildren.

BERNARD BUDIANSKY

1925–1999

Elected in 1976

"Contributions to the understanding of buckling phenomena, materials behavior, and new mathematical analyses of structural response."

BY JOHN HUTCHINSON

BERNARD BUDIANSKY, an engineering scientist whose research and teaching shaped the fields of structures and the mechanics of materials, died at the age of 73 on January 23, 1999, in Lexington, Massachusetts. No one who interacted with Bernie would fail to remember the delightfully opinionated, thoughtfully probing, 6′4″ man with a large personality to match.

Bernie's career coincided with the US space effort and the expansion of engineering research in American universities. His first technical job after college was at the National Advisory Committee for Aeronautics (NACA). From 1955 until his retirement in 1995, he was on the faculty in the Division of Engineering and Applied Sciences at Harvard University, as the Gordon McKay Professor of Structural Mechanics from 1961 and then as the Abbott and James Lawrence Professor of Engineering from 1983.

His early research and consulting were heavily influenced by his exposure to developments in space structures at NACA (predecessor of the National Aeronautics and Space Administration, NASA). Many of his early contributions focused on plate and shell structures in studies of buckling, vibrations, and flutter. His research interests were as dynamic as his persona. Over his career, he made fundamental contributions to plasticity theory, composite materials, and many aspects of micromechanics, including geophysical materials and biomechanics.

As an engineering scientist, Bernie employed basic mechanics, the methods of applied mathematics, and numerical analysis to conduct his research. His career also spanned the growth of computer use in engineering, and he was at the forefront of this revolution.

Bernie was born in New York City on March 8, 1925, to Russian immigrant parents. His father left the family when Bernie was a small child and he was raised by his mother and grandfather. He studied civil engineering at the City College of New York and graduated in 1944 at the age of 19. He retained a lifelong pride in the fact that his undergraduate college produced so many of the nation's leading engineers and scientists.

At City College he honed his skills in mathematics and physics in addition to engineering. And his first job, in the Structures Research Division of NACA at Langley Field in 1944, turned out to be an ideal match for these skills and interests. His first paper, on the elastic buckling of plates, launched him on the road to becoming America's leading expert in the buckling of structures.

During his NACA years (1947–1950) Bernie matriculated at Brown University, where he received both an ScM and a PhD, advised by William Prager. In his PhD thesis he invented the slip theory of plasticity, which led to new understanding of metal plasticity and, in particular, its application to structures that buckle after they are loaded into the plastic range. His thesis spawned much follow-on research, especially in the Soviet Union. Some of the underlying ideas in the thesis had emerged from interactions at NACA with Sam Batdorf, whom Bernie came to regard as his most important mentor.

Motivation for the new slip theory came from an extensive series of plastic buckling experiments on plates and shells at Langley and elsewhere that revealed that predictions from the so-called deformation theory of plasticity (in reality, not a plasticity model but a nonlinear elasticity material model) consistently did a better job reproducing experimental results than those from the most widely used, and supposedly more physically acceptable, plasticity model. Budiansky's slip theory clarified this paradox by showing that the widely used plasticity model predicted overly stiff responses under deformation responses typically encountered in buckling, while, in an approximate way, the deformation theory captured the less stiff response expected from a more sophisticated plasticity model based on crystalline slip.

After his graduate years at Brown Bernie returned to NACA and in 1952 became head of the Structural Mechanics Branch. At Langley he met Nancy Cromer, a North Carolinian who assisted with large numerical computations before the era of electronic computers. The couple married in 1952 and had two sons, Michael and Stephen. Throughout the years that followed, Nancy balanced Bernie's faux aggressive, New York style with an equally smart, calm humorous manner. The couple shared many interests, such as literature, good food, travel, and even horse racing.

In 1955 Bernie accepted a position as associate professor of structural mechanics at Harvard University, where he soon assumed the Gordon McKay Professorship in Structural Mechanics. He remained at Harvard for the rest of his career. Initially, he continued his groundbreaking research on structures. One example is his work published in the early 1960s with a PhD student, N.C. Huang, on the nonaxisymmetric buckling of clamped spherical shell caps subject to pressure, an outstanding problem connected with reentry capsules. Their work demonstrated the utility to structural analysis of numerical methods executed by computers. Budiansky solved the nonlinear axisymmetric prebuckling problem, and the two men obtained the buckling pressure and mode by solving the nonaxisymmetric buckling problem. The results could not have been obtained without the aid of a computer.

An open question in the late 1950s and well into the 1960s was the reason for the exceptionally large discrepancy between experimentally measured buckling loads of shell structures and predictions of buckling loads for these structures from shell theory. The two extreme examples are cylindrical shells under axial compression and spherical shells under external pressure, both of which buckle at loads typically as low as a fourth or fifth of the theoretical prediction. Bernie appears to have been the first, other than W.T. Koiter himself, to appreciate that Koiter's general theory of elastic stability and imperfection sensitivity held the answer to the discrepancy.

In 1945 in war-time Holland, Koiter developed and published (in Dutch) his thesis at Delft University, an elegant theory of elastic stability that laid out nonlinear buckling behavior and the sensitivity of buckling to initial structural imperfections. This theory revealed why experiments and classical buckling theory are in general agreement for columns and plates (they are not imperfection-sensitive) and why they are in sharp disagreement for many shells (they are extremely imperfection-sensitive). With the help of a colleague who could read a little Dutch, Bernie translated Koiter's thesis into a mathematical form that in many ways was more transparent than the original and thus introduced it to the American structures community. Then, with the assistance of a young colleague (the author of this memoir), he wrote a series of papers on the nonlinear behavior buckling of structures based on this approach, which had a transformative influence on elastic stability and set the stage for a rational way of dealing with imperfection-sensitive structures.

During the same time period, and in parallel to his work on buckling, Bernie was one of the leading contributors to the development of the theory of shells. In this effort he collaborated closely with a colleague at Harvard, J. Lyell Sanders. Their work was carried out in harmonious coordination with Koiter in Delft.

In the early 1960s there were numerous competing sets of shell theory equations creating considerable confusion for engineering users. Koiter made a major breakthrough by showing that errors inherent to any two-dimensional theory of shells meant that many of the competing theories were equivalent as far as accuracy was concerned. Budiansky and Sanders followed up by identifying a theory that combined accuracy with additional desirable mathematical features. In their tongue-in-cheek title, they designated it "The Best Theory," and it remains the standard.

Beginning in the 1960s, much of the research in solid mechanics shifted from structures to materials, and Bernie was one of the leaders in this transition. His earliest contributions used self-consistent averaging methods to compute the stress-strain behavior of polycrystalline materials based on the elastic-plastic response of the single crystal constituents. With geophysicist Richard J. O'Connell he made a major contribution to the fundamental understanding of seismological wave speeds by applying these methods to determine the influence of microcracks, and the role of water infiltration into the cracks, on the effective elastic moduli of rocks. Many other contributions to what became known as micromechanics followed, including the role of fiber debonding and sliding in the tensile fracture of fiber-reinforced composites, fiber kinking as a mechanism for limiting the compressive strength of composite materials, phase transformations as a toughening mechanism in ceramics, and the mechanics of void growth in ductile fracture.

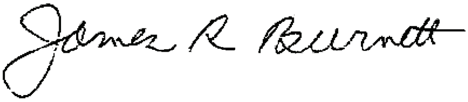
For more than 20 years beginning around 1970, Bernie was a member of a Defense Advanced Research Projects Agency (DARPA) group, the Materials Research Council (now called the Defense Sciences Research Council), that met each summer in La Jolla for four weeks to explore promising new ideas in materials and their applications. It was during this period that he developed close collaborations and friendships with Anthony G. Evans and James R. Rice. Rice later joined Budiansky on the faculty at Harvard, as did Evans for a few years. Evans, a materials engineering scientist, was a remarkable research leader who inspired Bernie to tackle the theoretical aspects of many challenging problems in micromechanics. Bernie was fond of pointing out that Evans knew well the limits of a theoretician (i.e., himself), and was careful not to confuse him by relating more background technicalities than necessary.

Bernie consulted for extended periods for a number of companies, including AVCO, General Motors, and Arthur D. Little. He was a member of NASA's Research and Technology Advisory Subcommittee on Aircraft Structures from 1966 to 1970, and its Space Systems and Technology Advisory

Committee from 1978 to 1984. He also served on the NRC Aeronautics and Space Engineering Board (1985–1990) and Committee on Advanced Space Technology (1992–1998).

He received many honors, including two of the most important in the field of structures and the mechanics of materials, the Timoshenko Medal of the American Society of Mechanical Engineering (1989) and the Theodore von Kármán Medal (1982) of the American Society of Civil Engineering. He was the Dryden Research Lecturer of the American Institute of Aeronautics and Astronautics in 1970. He was elected to the National Academy of Sciences in 1973 and the NAE in 1976, and as a foreign member of the Royal Netherlands Academy of Arts and Sciences (1977) and the Danish Center for Applied Mathematics and Mechanics.

Bernie Budiansky will be remembered by colleagues and students as an exceptionally incisive and creative engineering scientist who was always open to discussion and who relished resolving a technical matter. The resolution process was seldom smooth sailing, but it was always worth it.



JAMES R. BURNETT

1925–2012

Elected in 1975

"Contributions in guidance and control for space systems and in the engineering development of US strategic weapon systems."

BY GERARD W. ELVERUM

JAMES ROBERT BURNETT, a pioneer in the development of guidance, control, and total weapon systems engineering of ballistic missiles and critical defense satellites, died at his home in Carlsbad, California, on April 8, 2012, at the age of 86.

Bob was born on November 27, 1925, in Eldorado, Illinois, to James Lawrence Burnett and Edith Lillian (Bramlett) Burnett. He and his younger sister, Mary Jean, grew up and attended grade school and high school in nearby Carbondale. His father, an engineer for the state highway department, instilled in him a desire to understand how things worked and encouraged his interest in ham radio technology, chemistry, and mathematics.

When Bob graduated from high school, the United States was fully engaged in World War II. He joined the US Marine Corps and, based on his high school record, interests, and enlistment aptitude test, was placed in a Navy V-12 engineering program at Purdue University. Because the Navy could see the crucial operational importance of advances in electrical engineering and of the embryonic discipline of electronics to technologies such as radar and weapon control, they assigned him to an electrical engineering curriculum. What a fortuitous choice that turned out to be for the defense and security of the nation.

By the time Bob graduated with a BS in EE and a commission as a lieutenant in the Marine Corps, World War II was over. The Marine Corps asked him to sign up for a 4-year tour of active duty as a radar officer, but he declined in favor of staying at Purdue for an MS in EE. While earning his master's degree he met a young lady by the name of Anne Knox who was studying home economics at Purdue. They decided to get married, but because she wanted to finish her schooling he elected to stay at Purdue and earn a PhD, which he did in 1949. His dissertation title was "Use of Laguerre Polynomial Approximations in Non-linear Controls."

Bob was very enthusiastic about the technologies he was working on, so when the head of the Electrical Engineering School suggested he stay at Purdue and become a professor, he accepted. As associate professor of electrical engineering, he helped create a modern control systems curriculum. He soon realized that the evolving capabilities of digital computers could numerically compute nonlinear control system answers much faster than the approximation methods of his dissertation. Recognizing the power of digital methods to engineering, he formed a close association with the Math Department to evolve a new digital computer sciences capability at Purdue.

In 1955 one of his students, Robert K. Whitford, received his PhD and went out to California to work at a small company called Ramo Wooldridge, incorporated in 1953. Knowing that associate professors needed to consult in the summer to survive, Whitford called Bob in the spring of 1956 and suggested he apply to consult at RW for the summer—the company was doing work that needed just the kind of special disciplines that Bob had been evolving at Purdue.

When Bob arrived at RW he found that they were providing systems engineering and technical support to the US Air Force on development of the ballistic missiles Atlas, Thor, and Titan. This was a critical period for the United States to establish an unassailable position of strength as the Cold War was ramping up. Bob realized that here was an urgent national need for which his entire academic training, professional interests, and experience qualified him to contribute to the nation's defense.

Also, as he said in an interview, "there was a set of people, headed by Simon Ramo, who from an intellectual point of view were the brightest set of guys I'd ever run across in one place in my entire life." He never returned to the academic life.

At RW Bob was assigned as senior staff in the Guidance and Controls Department of the Guided Missile Research Division (GMRD). The complexity of developing and fielding a complete guided missile weapon system in as short a time as possible required the simultaneous evolution of a new engineering discipline called systems engineering, which in turn had to be combined with a new management discipline that could direct the efforts of dozens of large corporations.

Bob's training and superb skills enabled him to provide specific solutions to many critical missile control problems and to advance the systems engineering methodology. And his leadership skills contributed greatly to establishing the effectiveness and acceptability of a "technical direction" organization under contract to the Air Force's Ballistic Missile Command.

In late 1958, RW was reincorporated as Thompson Ramo Wooldridge (TRW); GMRD was dissolved and its elements reorganized into a separate new corporation called Space Technology Laboratories (STL), which would develop and deliver spacecraft systems while retaining a Systems Engineering Division (with total hardware/software product exclusion) with technical direction responsibility for Atlas, Titan II, and Minuteman.

Bob was appointed associate director and later director of the STL Electromechanical Laboratory, with responsibility for fundamental decisions about the final selection of the control subsystems for Titan II and Minuteman II. He became program manager of TRW's Minuteman program in 1961 and was a driving force behind the operationally advanced Minuteman III in 1965. That year he received the Air Force Systems Command Award in recognition of his outstanding contributions to the development and operational deployment of the Minuteman group of weapon systems.

In 1965 STL became TRW Systems, and a few years later Bob was promoted to vice president and general manager of the company's Systems Engineering and Integration Division. His accomplishments and importance were recognized by appointment as vice president and general manager of TRW's Defense Systems Group in 1980. He retired in 1991 as executive vice president and deputy general manager of the company's Space and Defense Sector.

Throughout his career Bob also served on numerous national task groups and advisory committees. These included almost ten years as a member of the Scientific Advisory Committee of the Defense Intelligence Agency, chair of the Scientific Advisory Board of the National Security Agency, member of the Defense Science Board, and chair of the Scientific Advisory Panel for the DOD Joint Strategic Targeting Group. After his retirement he remained active on advisory committees to elements of the government.

He was a member of Sigma Xi, Theta Tau Professional Fraternity, and Tau Beta Pi Engineering Honor Society. He received an honorary doctor of engineering degree from Purdue in 1969 and in 1992 was honored with the university's Outstanding Electrical Engineer Award. In 1975 he was elected a member of the National Academy of Engineering, and in 1981 a fellow of the American Institute of Aeronautics and Astronautics. He was selected in 2006 for the DOD Eugene G. Fubini Award, established to recognize "outstanding service to the defense community and the nation in an advisory capacity."

In 2003 Bob and Anne made a major gift to create and endow the Bob and Anne Burnett Professorship in Electrical and Computer Engineering at Purdue. Bob said at the time, "My Purdue education was the key to my professional career, and I want to give back."

Bob is survived by his wife of 66 years, Anne Knox Burnett; their children James W. Burnett (Kathy), Karen B. Cofer, Susan B. Hicks (Stephen), and Janice B. Clark (Kim); and 12 grandchildren.

Jim Burnett observed that "Dad always wanted to know how things worked. His academic and professional success was all due to his ability to understand how things worked and apply that knowledge to accomplish whatever he was working on."

Janice remembers how devoted her dad was to his family: "He was proud of his children and grandchildren. He loved spending time with everyone and hearing all about their adventures and experiences." Bob was an avid photographer all his life, and she recalls that "It was quite a feat to organize all of us and get us all in the annual Christmas picture." That was probably among his most enjoyable systems engineering and technical direction projects.

Bob Burnett possessed a combination of technical background, enthusiasm, integrity, and leadership skills that made him a unique and major contributor to the success of the nation's crucial intercontinental ballistic missile (ICBM) and military spacecraft programs. It was my great privilege to work closely with this brilliant scientist and engineer for over 30 years in providing rocket propulsion engineering support for the ICBM programs and propulsion subsystems for all TRW spacecraft. He was an inspiring leader and gentleman who energized everyone on his teams. I always will remember him with fondness.

JOHN C. CALHOUN JR.

1917–2012

Elected in 1985

"For outstanding contributions to the art and science of petroleum recovery, to the development of engineering education, and to the use and understanding of engineering in the public arena."

BY AKHIL DATTA-GUPTA

On November 29, 2012, JOHN C. CALHOUN JR. passed away peacefully at his Texarkana home with his wife of 71 years and family. He was 95.

Born March 21, 1917, in Betula, Pennsylvania, the fifth child of John C. and Mattie Rowe Calhoun, he grew up with seven siblings, and worked with them to support the family grocery store. He graduated valedictorian of his high school and attended Pennsylvania State University, where he earned a BS in 1937 and a master's in 1941, both in petroleum engineering. While there he met fellow student Ruth Elizabeth Huston and they married in June 1941. In 1946 he received his doctorate in petroleum and natural gas engineering from Penn State—one of the first three petroleum engineers in the United States.

That year he began his career in engineering education at the University of Oklahoma as an associate professor, and by 1950 he was named professor and chair of the School of Petroleum Engineering. In 1950 he returned to Penn State as head of the Department of Petroleum and Natural Gas.

From 1955 to 1987 he served Texas A&M University in various capacities: dean of engineering, director of the Texas Engineering Experiment Station and of the Texas Engineering Extension Service, dean of geosciences, and vice president for academic affairs. He also served the A&M system as executive vice chancellor for programs and deputy chancellor for engineering. Upon retirement he was honored with the designations Distinguished Professor Emeritus of Petroleum Engineering and Deputy Chancellor for Engineering Emeritus. Texas A&M President R. Bowen Loftin described his work as "instrumental in helping lay the groundwork for enhancement of the academic and related developments that made possible Texas A&M as we know it today."

Inducted into the National Academy of Engineering in 1985, Dr. Calhoun considered himself a "resource specialist" and routinely consulted with the federal government on the nation's marine resources. In 1963–1965 he was assistant and science advisor to the US Secretary of the Interior and acting director of the Office of Water Resources Research. He chaired the National Academy of Sciences Committee on Oceanography (1967–1970) and Ocean Affairs Board (1970–1973), and served on a number of NAS/NAE panels related to energy, the environment, and natural resources. He was a presidential appointee to the National Advisory Committee for the Oceans and Atmosphere (1972) and a member of the Advisory Committee on Mining and Mineral Resources Research, Department of the Interior (1987–1995).

Dr. Calhoun was president of the Society of Petroleum Engineers (SPE; 1964) and received its DeGloyer Distinguished Service Medal (1982) as well as the Anthony F. Lucas Gold Medal (1997), the highest SPE technical award. He was president of the American Society for Engineering Education (1974) and in 1993 received the ASEE Centennial Medallion. He was designated an honorary member of both ASEE (1978) and the American Institute of Mining, Metallurgical and Petroleum Engineers (1976).

He authored over 150 technical papers and reports as well as one of the earliest and most influential textbooks on *Fundamentals of Reservoir Engineering* (University of Oklahoma Press, 1976). On various aspects of oil and gas reservoir engineering, his work set standards that are still widely practiced by petroleum engineers worldwide.

Throughout his life, Dr. Calhoun joyfully shared with others not only his love of learning but also his gift of music. He took special delight in the power of words, especially those expressed in song. He knew that life is lacking "without a song," and he wrote many of his own that he dedicated to his four much-loved granddaughters. He leaves all who knew him with treasured memories of melodies rendered in his beautiful baritone.

His daughters remember an address he delivered at a high school commencement, with his theme taken from the Rodgers and Hammerstein lyric: "You gotta have a dream. If you don't have a dream, how you gonna have a dream come true?" Dr. Calhoun reminded the graduates that dreaming "comes from an optimistic spirit." These words perfectly capture the beliefs and heart of this father, grandfather, and educator who devoted his life to family and to others.

Dr. Calhoun was preceded in death by his son, John Huston, his seven brothers and sisters, and his parents. He is survived by three daughters and their spouses: Emily Calhoun and Robert Kerr of Boulder; Mary Beth and Larry Towles of Maryville, TN; and Ruth Ellen and David Whitt, of Texarkana, TX; four granddaughters and their spouses; and ten great-grandchildren. His wife and lifelong intellectual partner, Ruth, survived him by six months, passing away June 1, 2013.

JAMES J. CARBERRY

1925–2000

Elected in 1989

"For fundamental contributions to chemical reaction engineering and heterogeneous catalysis."

BY EDUARDO WOLF
SUBMITTED BY THE NAE HOME SECRETARY

JAMES JOHN CARBERRY passed away on August 27, 2000, at the age of 74. He was a renowned chemical engineering scientist and professor of chemical engineering for 40 years at the University of Notre Dame. He invented the spinning basket reactor, which significantly impacted experimental work in catalytic reaction engineering. He was also a multifaceted renaissance man who enjoyed opera, literature, and college football.

He was born in Brooklyn, New York, on September 13, 1925, and graduated from Brooklyn Technical High School, where he played as a single-wing halfback on the school football team, with less than notoriety, given the inadequacy of his small frame to play in such sport. During World War II he enlisted in the Navy and served aboard the US Navy *Denver* Light Cruiser, where he developed his taste for opera to counteract the boredom of life on board.

In 1946, after his Navy tour, Jim enrolled in the Chemical Engineering Department at the University of Notre Dame, where he obtained his BSc (1950) and MSc degrees (1951). As an undergraduate he cultivated his interest in Italian opera, in classical music as a member of the Glee Club, and in the humanities (he minored in English literature). He also became a devotee of St. Thomas of Aquinas, who was introduced to him in the required theology course taught by the famed Theodore Hesburgh, who went on to become Notre Dame president for 35 years. Jim's roommate at Notre Dame was Leon Hart, a Heisman trophy winner, who became his best friend. According to his daughter, Alison Carberry Kiene, the story was that Leon tutored her Dad in freshman chemistry (and laid the foundation for his textbook, *Chemical and Catalytic Reaction Engineering*) and her Dad helped Leon win the Heisman Trophy with his football knowledge.

Upon graduation in 1951 Jim joined the Explosives Department of the DuPont Company as a process engineer, but his colleagues encouraged him to pursue a PhD at Yale University, where he in enrolled in 1952. At Yale he further cultivated his engineering and other interests, developing a cordial and active professor-student relationship that characterized his later academic rapport with his students.

In 1957 he obtained his PhD in the fluid mechanics of reactors and returned to DuPont Engineering Research Laboratory, a site well known for the presence of many pioneers in the field of chemical and reaction engineering. They became his mentors and prepared him for his future academic career. During this period he also learned catalysis by taking courses at Johns Hopkins University under the famous Paul H. Emmett, one of the authors of the BET (Brunauer-Emmett-Teller) isotherm.

In 1961 Jim returned to Notre Dame as an assistant professor in the Chemical Engineering Department. With the support of the department chairman, the faculty, and (by then) President Hesburgh, the PhD program in chemical engineering was started, and with it a spectacularly fruitful period of maturation for the department.

In 1964 Jim conceived and developed the spinning basket reactor—or, as it is sometimes called, the "Carberry reactor." This experimental apparatus, which allowed researchers to obtain kinetic information from real catalysts in the absence of diffusional effects, was the precursor of commercial laboratory reactors universally in use today. Jim's research focused on the kinetics of catalytic reactions in his reactor and on the interaction of chemical and physical effects in catalytic reactors (using numerical simulations partly based on his industrial experience). He is also known for early work on oscillating catalytic reactions, all of which gained him recognition in both academia and industry.

He received numerous awards and recognitions. In 1965–1966 he was an NSF senior fellow at Cambridge University, a position that allowed him to dialogue with the pioneers in the field in the United Kingdom and to lecture extensively in Europe. In 1968 he received the Yale Engineering Association Award for the Advancement of Pure and Applied Science, and in 1972 was one of the cofounders of the US-Soviet Working Group in Catalysis, a bilateral agreement for the exchange of information in catalysis. In 1976 he received the prestigious R.H. Wilhelm Award in Chemical Reaction Engineering from the American Institute of Chemical Engineers (AIChE). In addition, he was named a fellow of the Royal Society for the Arts (1979), Sir Winston Churchill Fellow (1979, 1982), and R.K. Mellon Fellow (1979) at Cambridge University's Churchill College.

He also became a member of the Chemical Engineering Department advisory board of Princeton University (1980–1990), and was named in 1986 a fellow of the American Institute of Chemists and in 1987 a visiting and life fellow at Clare Hall, Cambridge University. In 1988 he received the first award for excellence in reaction engineering given by the Autoclave Engineers company, which produced a similar commercial version of his reactor. He was a visiting professor and fellow at Cambridge University in 1991, a visiting fellow at Princeton University in 1996–1997, and a visiting professor at Stanford University in 1985. He cultivated his love for things Italian by lecturing at the University of Naples, the University of Rome, and the Politecnico di Milano.

In 1989 he received the AIChE William H. Walker Award for Excellence in Contributions to Chemical Engineering Literature, and in 1993 the American Chemical Society (ACS) selected him for the E.V. Murphree Award in Industrial and Engineering Chemistry for his pioneering research in catalysis and reaction engineering.

Author of *Chemical and Catalytic Reaction Engineering* (McGraw-Hill, 1976), which has been published worldwide, and former coeditor of the prestigious journal *Catalysis Reviews Science and Engineering*, he published more than 120 technical and scientific papers. Recognition for his work and contribution culminated with his election in 1989 to the National Academy of Engineering.

His technical recognitions do not reflect the eclectic, colorful, and outspoken personality of Jim Carberry, always the center of attention in any gathering in which he participated. He held firm views about society through his reading of the classics, Aquinas, and Jacques Maritain and about the future of chemical engineering. He believed that civilized society should engage in civilized discourse among civilized persons, a far cry from the modern world. In chemical engineering education he advocated that the roots of the profession, which started in chemistry and then added physical engineering phenomena, should go back to applied chemistry. When we look at what chemical engineering departments around the country are doing today, we can appreciate that this was a rather prophetic view.

Professor Carberry is survived by his daughter Alison and two grandsons, Damian Lynn Kiene and Nicholas James Kiene. He was preceded in death by his wife Margaret Brugger Carberry in 1994; daughter Maura O'Malley Carberry on January 1, 2000; and uncle, John Joseph Cardinal Carberry, former Archbishop of Saint Louis, in 1998.

Alison remembered her father as

> ever the Renaissance man. One chapter in his book *Chemical and Catalytic Reaction Engineering* contains a subheading in Italian from Dante's *Inferno* which translates: "Leave behind all hope, you who enter"!
>
> His wit surpassed mere mortal men, such as the time the *International Who's Who in Music* solicited my Father for his musical biography for its next edition with an offer that he could get a copy at the pre-subscription price. He figured that if they were silly enough to want his biography in music, he would be silly enough to submit a spoof, which their editors

would surely catch. They did not, and it was published. He identified himself as Professor of Chemical Engineering and Operatics at the University of Notre Dame. A few notes to appreciate his humor: He stated that he received a diploma [from the] Accademia delle Nero Gatto and a diploma [from the] Scuola di Grande Massimo. The fact is that he had a black cat ("nero gatto") called Max ("Massimo") with whom he used to "sing" operatic duets to the delight of his friends and family. At least once they performed at a black-tie fund-raiser in South Bend (I don't think they were called back). He frequently called the cat Max the devil ("Massimo Diabole"). He cites to his credit "Canzone di Piedeballo" which translates to "songs of football."

Upon his good friend Coach Ara Parseghian's retirement from Notre Dame football, Dad was coaching Notre Dame's Sorin Hall Intramural football and offered Ara a backfield coach job. Ara was one of my Father's pall bearers.

My Father so loved the University of Notre Dame. It was his choice to move back to Notre Dame, just six weeks prior to his death, following the diagnosis of terminal lung cancer; he could think of nowhere else to be and from which, as he would say, to "go to the great beyond" (Heaven).

The Chemical Engineering Department at Notre Dame owes its current reputation in large part to Carberry, by attracting the faculty that built the department to a competitive position. The department would not be what it is today without his academic and professional leadership.

JACK E. CERMAK

1922–2012

Elected in 1973

"Development of experimental facilities and research contributions concerning wind forces on structures."

BY THOMAS H. VONDER HAAR

JACK EDWARD CERMAK, an esteemed member of the faculty at Colorado State University (CSU) for more than 50 years, died on August 21, 2012, at the age of 89. An active member of the National Academy of Engineering since his election in 1973, he was internationally recognized as "one of the fathers of wind engineering." In a statement recognizing his contributions, CSU President A.R. Chamberlain said in 1976: "Only on rare occasions do we find that the works of an individual span the evolution of a field of science and technology from conception, through scientific verification, to practical realization and on to direct application for the benefit of mankind. The works of Dr. J.E. Cermak—scientist, teacher, and engineer—are an embodiment of this evolutionary process for the newly recognized field of wind engineering."

Jack's pioneering research resulted in the development of unique wind tunnel facilities capable of simulating motion in the atmospheric boundary layer near the surface. With students and private sector colleagues, he applied this achievement to the physical modeling of wind effects on buildings and to the dispersion of air pollutants. He advised or coadvised

Much of the information in this tribute was provided by the Cermak family for his obituary in the Fort Collins *Coloradoan*, August 28, 2012.

many MS and PhD graduates at CSU. They now work around the world in universities, government laboratories, and large and small private sector businesses.

Jack was born to Joe and Helen Cermak on September 8, 1922, in the small farm town of Hastings, Colorado. His fascination with wind was said to begin with curiosity about wind-induced vortices swirling in the snow as he traveled down farm roads. He was educated in public schools in nearby Penrose (1928–1940) and then in the Civil Engineering Department at Colorado A&M (later CSU) in Fort Collins. He was a joint honor scholar in college (1940–1943) and served as a sound ranging officer in the US Army (1943–1946). He left the Army and continued service in the Army Reserve with the rank of lieutenant colonel. Later in his career, he used his knowledge of Army requirements and challenges to serve the Army Basic Research Committee of the National Research Council (NRC) from 1972 to 1982.

In 1947 Jack met Helen Carlson, who was caring for his father. They married and adopted two sons, Douglas and Jonathan.

After leaving the Army, Jack returned to CSU to obtain his BS in civil engineering (1947) and MS in hydraulic engineering (1949). He remained at CSU as a teaching assistant and instructor in civil engineering, and was appointed an assistant professor in 1951. By 1954 he had designed and built his first large boundary layer wind tunnel. In 1954–1955 he accepted the position of John McMullen Scholar in Engineering Mechanics at Cornell University, where he completed his PhD in 1959. When he returned to CSU as an associate professor, he founded the Fluid Dynamics and Diffusion Laboratory. After a NATO postdoctoral fellowship at Cambridge in 1961, he established the Fluid Mechanics and Wind Engineering Program and served as its director and professor in charge until 1985. And in 1966 he founded the Wind Engineering Research Council (later called the American Association of Wind Engineering) to disseminate technical information.

As a young and innovative professor, Jack was a tireless worker (some marveled at the few days of vacation he used), a trait that continued throughout his life. His small office in the Civil Engineering wing of the College of Engineering normally saw a line of students and faculty at its door. He advised undergraduate students from his classes, graduate students on their classes, and research and faculty on various matters. He was a firm taskmaster but always fair. Many remarked on his openness and availability for discussion.

During the 1960s and 1970s he flourished at CSU, which was developing from an agriculture-based land-grant college into a major research university. His Department of Civil Engineering was a leader in nationally and internationally recognized research.

Professor Cermak's pioneering research resulted in the development of unique wind tunnel facilities capable of simulating motion in the atmospheric boundary layer. In 1973 this achievement and its application to physical modeling of wind effects on buildings and dispersion of air pollutants were recognized by his election to the NAE. In 1988 the National Society of Professional Engineers selected the CSU Fluid Dynamics and Diffusion Laboratory for its Outstanding Engineering Achievement Award. In 1999 the CSU wind tunnels were selected by the *Engineering News-Record* as one of 125 outstanding engineering innovations between 1874 and 1999. And in 2000 the American Society of Civil Engineers established the Jack E. Cermak Medal for outstanding contributions to wind engineering.

For 50 years Dr. Cermak instructed undergraduate and graduate courses and conducted research on basic and applied problems related to environmental science and fluid mechanics at CSU. He led the development of the engineering science major (an interdepartmental undergraduate program), and served as chairman from 1962 to 1973. As a testament to his ability and effectiveness as a teacher, researcher, and mentor, he was selected as one of six inaugural University Distinguished Professors at CSU in 1986. His love of advising his graduate students continued when he established an endowment for the annual Jack E. Cermak Outstanding Advisor award, which is given annually to one faculty member from each college and graduate school. In 1997 the CSU Department of Civil Engineering honored his teaching and research by hosting a celebration of his 50 years in education. He retired from CSU in 2006 and became University Distinguished Professor Emeritus.

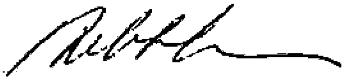
In addition to his active involvement with CSU, Jack served throughout his career as a consultant and advisor to many groups around the world. In 1981 he cofounded and served as president of Cermak Peterka Petersen (CPP, Inc.), a company doing both consulting and research on wind impact on structures. He also served as a nominator and reference for new NAE members and as a member of NRC advisory and review panels as well as state and national committees.

Some of the first wind engineering tests in the CSU wind tunnels were for the World Trade Center in New York City and Candlestick Park south of San Francisco. After the collapse of the WTC towers on September 11, 2001, investigators looked into whether underestimates of wind forces had led to the use of weaker than necessary exterior columns that proved unable to withstand the terrorist attacks. Dr. Cermak vehemently rejected that view and eventually it was widely agreed that it had been the intense heat from the explosions and fires caused by the planes' impacts that most contributed to the buildings' crumbling (Leslie Kaufman, *New York Times*, September 5, 2012, "Jack Cermak, a Wind Tunnel Innovator, Dies at 89").

Jack's wife Helen died in 2005. In August 2006 he married his longtime friend and CSU assistant, Gloria Garza, who survives him. Gloria is a good source of information on all of Jack's professional activities, networks, and former students. He is also survived by his sons Douglas and Jonathan.

Throughout his very active 50 years at the university, Jack's vision and strong work ethic were an inspiration to his colleagues, dozens of BS and MS students, and nearly 50 PhD students whom he advised. His colleague, business partner, and former student Jon Peterka said, "Jack had an image of where the discipline could go and spent his lifetime nudging us in that direction." Jack himself summarized his vision in the following excerpt from *Who's Who in America* (1997):

My thoughts and actions have been influenced always by a belief and an awareness that man, the near environment, and the far reaches of the universe are influenced by common natural laws. I believe that the order found in natural events, as revealed by scientific investigation, can someday become manifest in the behavior of man. Ultimately, through persistent and directed effort, I am confident that man will integrate religion, science, and technology to achieve harmony of man with man, and man with the environment. For the most part my achievements and contributions to society can be attributed to the motivation and direction stemming from these convictions.



RICHARD C. CHU

1933–2012

Elected in 1987

"For pathfinding contributions and creative technical leadership in the development of cooling technology and thermal systems for electronic equipment."

BY ROGER R. SCHMIDT

RICHARD C. CHU passed away at age 79 on September 8, 2012, at his house on Twin Lakes in Elizaville, New York. He was an internationally recognized authority in cooling technology for computer electronics. For four decades he played a key role in developing the world's most advanced computer cooling solutions for IBM.

Born in Beijing on May 28, 1933, Dick was the son of Liang-Hsi Chu and Yun Hwa Wang. He studied mechanical engineering and received his bachelor of science degree from National Cheng-Kung University in 1958 and his master's degree from Purdue University in 1960. He was later recognized by both as a distinguished alumnus, and received two honorary doctoral degrees: in 1992 from American University of the Caribbean and in 1996 from his alma mater, Purdue.

He began his professional career at IBM in 1960 as a thermal engineer. During his early years he worked on the development of the IBM System/360. His 1965 invention of a multilevel air-liquid hybrid cooling design was pivotal to IBM's successful introduction of its System/360 Model 91, the world's highest-performance computer system at the time. The introduction of this hybrid cooling system marked the beginning of the water cooling era, which lasted throughout the years of bipolar technology. In 1966 he was made a manager with the assignment of establishing and leading a heat transfer technology group to develop new and improved cooling technologies.

Throughout his career Dick was a prolific technical innovator, as demonstrated by his impressive record of inventions. He received 66 IBM invention awards for over 200 patents and 150 invention publications. As one of the inventors of the cooling scheme for the IBM thermal conduction module (TCM) he received an IBM Outstanding Innovation Award and a Corporate Award. This thermal conduction technology coupled with his modular cold plate cooling system concept formed the basis for the cooling design of IBM's large computer systems for over 15 years following the first shipment in 1980. Variations of this water cooling concept were adapted by each of the major worldwide computer mainframe manufacturers. He received three additional IBM Outstanding Innovation Awards for other innovative thermal solutions that were applied to various IBM products.

Dick's many contributions to IBM through his creativity, thermal expertise, and technical leadership led to his appointment as an IBM Fellow in 1983, the company's highest technical honor. He continued contributing in this capacity, with a small team dedicated to exploring cooling technology for future computers, until his retirement in 2011, after which he became an IBM Fellow Emeritus and maintained a strong presence at the company.

In 1996 he initiated an effort to study the feasibility of using lower-temperature cooling to enhance complementary metal-oxide semiconductor (CMOS) performance. He coinvented a dual-channel evaporator cold plate that enabled modular refrigeration cooling (MRC) with redundancy and concurrent maintenance; the MRC concept was used on all IBM CMOS-based high-performance computers from 1997 to 2010.

In addition to providing leadership in electronics cooling and thermal management, Dick was always looking ahead to the need for a new generation of thermal engineers. He spent time sharing the benefits of his experience and insight by serving as a mentor to many young engineers at IBM.

The influence of Dick's contributions to computer cooling technology extends well beyond the company where he worked. He was a strong promoter of a close working relationship between industry and academia. For 25 years he was the principal individual responsible for IBM sponsorship of electronic cooling research in air and liquid immersion cooling at MIT, Rensselaer Polytechnic Institute, Clarkson, Georgia Tech, Iowa State University, University of Minnesota, Purdue, City College of New York, Stanford, UC Berkeley, University of Rhode Island, Duke, and University of Arizona, yielding over 80 thesis-related publications, 20 percent of them at the PhD level. The results of this sustained industry-university collaborative research greatly strengthened the nation's competitiveness in the electronic cooling field. A further benefit of these research projects was the number of students who joined IBM and other companies to work in electronic cooling after completing their degree.

Dick was also widely known through his appearances at ASME- and IEEE-sponsored conferences, presenting papers and often serving as a keynote speaker sharing the benefits of his experience and knowledge. He published three books, nine book chapters, and over 50 technical publications. He was a coauthor of one of the earliest books on electronic cooling, *Heat Transfer in Microelectronic Equipment* (with John Seely; M. Dekker, 1972), and in 2002 he coauthored *Thermal Management of Microelectronic Equipment* (with Lian-Tuu Yeh; ASME Press).

The importance of Dick's contributions is widely recognized and attested to by the number of awards and honors he received. He was a member and past president of the IBM Academy of Technology. He received the ASME Heat Transfer Memorial Award, was the first recipient of the I-THERM Memorial Award, and was also a recipient of the Semi-Therm Significant Contributor Award and the InterPACK Conference Achievement Award, making him the only person to receive all of these awards from the major thermal conferences.

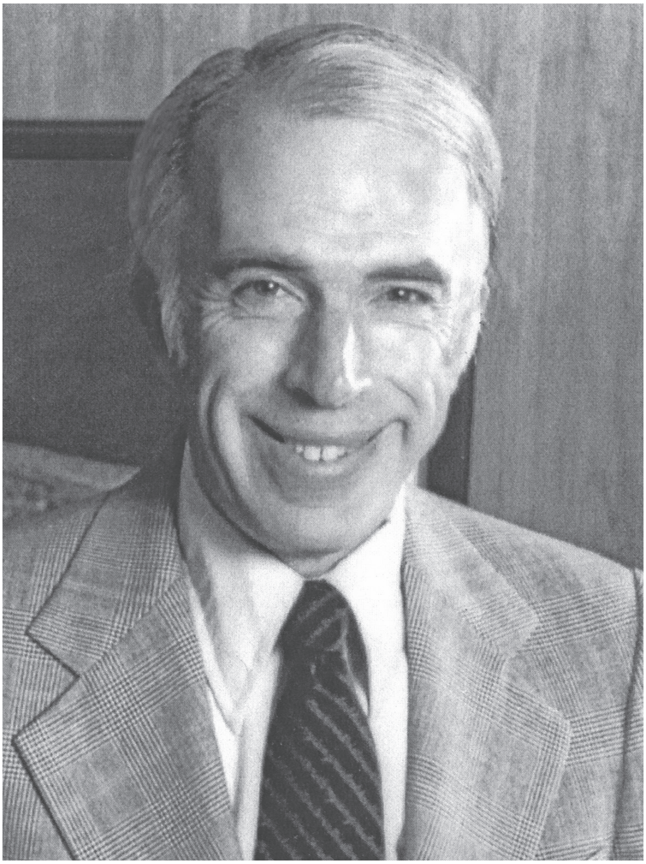
In addition to his NAE membership, he was an ASME fellow and a fellow of the American Association for the

Advancement of Science. As a member of the Academia Sinica (the Chinese Academy of Science in Taiwan), he participated in many activities sponsored by the Asian-American communities. In 1999 he received both the Professional Achievement Award from the Chinese American Academic and Professional Society (CAAPS) and the Asian Pacific American Corporate Achievement Award from the Organization of Chinese Americans (OCA) at its National Convention in Detroit, and in 2006 he was selected for the prestigious Asian American Engineer of the Year award.

Dick loved his work, but above all he loved his wife and family. On August 24, 1963, he had married Theresa Lee, whom he lovingly referred to as "Mother Theresa," and they led an active life together. He was a dedicated and loyal husband, father, grandfather, brother, uncle, colleague, mentor, and friend.

He also loved the Hudson Valley area where he lived most of his years, raised his family, and formed many lifelong friendships. His hobbies and passions included jogging, windsurfing, sailing, paddle boating, golfing, skiing, and travelling to visit his four surviving children and their families. His passion was riding his hydro bike at his favorite spot, his lake house on Twin Lakes.

Dick is survived by his wife; their children and spouses: Benjamin and Kara Chu, Benson and Mary Chu, Benedict and Adora Chu, and Bonnie and David Sclafani; grandchildren Kelsey, Aaron, Stephen, Lucas, Dylan, Ryan, Owen, Dean, Ty, and Ming Lee; and his sisters and their husbands, Cora and Shu Beam Eng, Linda and James Yuan, and Nancy Sher.



EDGAR M. CORTRIGHT

1923–2014

Elected in 1973

"Innovative leadership in aerospace research and development and in its practical application to significant national problems."

BY JAMES M. FREE
SUBMITTED BY THE NAE HOME SECRETARY

EDGAR MAURICE CORTRIGHT, a skilled engineer and manager of multifaceted space programs and organizations at the National Aeronautics and Space Administration (NASA), passed away on May 4, 2014, in Scarborough, Maine, at 90 years of age. His most significant accomplishments include establishment of the nation's first meteorological satellite and space probe programs; supervision of Viking, the first spacecraft to land on Mars; and direction of the Langley Research Center during the transitional period in the early 1970s.

Ed's government career began as a research engineer at the National Advisory Committee on Aeronautics (NACA)'s Lewis Flight Propulsion Laboratory, where he investigated aerodynamic issues with high-speed inlets and nozzles and headed activities in supersonic wind tunnels. In 1957 he was selected for a series of space-related planning committee projects that led to his transfer to headquarters in 1958. There he had responsibility for establishing NASA's initial satellite and space exploration programs. Throughout the 1960s he was a

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James M. Free is director of the Glenn Research Center where Ed Cortright spent the early years of his career. Robert Arrighi, historian and research associate at the Glenn Research Center, compiled the information used to prepare this tribute.

key manager of all the agency's unmanned space missions and launch vehicles. In 1968 he was named director of Langley Research Center, where he revitalized facilities and guided the successful Viking program. After retiring in 1975, he managed Owens Illinois Corporation and Lockheed-California Company, served on a number of boards, and started his own business.

Ed was born on July 29, 1923, in the Pennsylvania coal town of Hastings. He developed an early interest in aviation based on the stories of his father, Edgar Sr., about his experiences as one of the few US pilots in World War I. The family later relocated to Philadelphia where Ed earned his high school diploma. Although active in sports and other activities, he remained focused on aeronautics.

He began work on an aeronautical engineering degree at Rensselaer Polytechnic Institute but, as international tensions escalated in the fall of 1941, accepted his father's advice and enrolled in the school's Reserve Officers' Training Corps (ROTC). During this period Ed met his future wife, Beverly Hotaling.

In 1944, during his junior year at Rensselaer, he was assigned to the *USS Saratoga* aircraft carrier in the Indian Ocean. The vessel did not see enemy action during its initial mission supporting British raids in Indonesia, but Japanese kamikaze aircraft repeatedly struck during its subsequent assignment at Iwo Jima. The resulting casualties and damage necessitated the ship's return to the United States for repairs. Ed took the opportunity to marry Beverly. The *Saratoga* spent the remainder of the war training air crews in Hawaii, and Ed was assigned to the Naval Air Modification Unit in Johnsonville, Pennsylvania, where as a project engineer he installed turbo superchargers on Vought Corsair fighter aircraft. He returned to Rensselaer in the fall of 1946 and, as a research assistant, performed theoretical analysis on General Electric air-to-air missile systems. He graduated in the spring of 1947.

While he completed work on his master's degree at Rensselaer he applied for employment with NACA. In February 1948 he began work as an aeronautical research scientist at the Lewis Laboratory in Cleveland and was immediately thrown into Associate Director Abe Silverstein's hand-picked Applied Mechanics Group, which pursued theoretical aerodynamic calculations (and included four future National Academy of Engineering members). Ed later admitted that he struggled to apply his strong mathematical background in such a creative manner.

In 1949 he was named head of Lewis' Small Supersonic Tunnels Branch and became involved in more hands-on, applied research. In the mid-1940s Lewis had built a series of supersonic wind tunnels with comparatively small diameter test sections to provide high-speed aerodynamic data while the much larger 8′ × 6′ supersonic wind tunnel was being constructed. Ed and his colleagues used these tunnels to investigate supersonic aircraft inlets and exhaust nozzles.

He was directly involved in the study of side-mounted inlets, flow over afterbodies, supersonic diffusers, and the use of base bleeding to reduce the drag of blunt-base objects. The base bleed concept allowed a small amount of flow to leak behind the base to increase the pressure which reduced drag. The method was verified with wind tunnel tests using artillery shells.

In 1955 Silverstein tapped Ed to head the Supersonic Wind Tunnel Branch. Ed's 20-person group performed both original in-house research and military and industry development testing. The development work included the resolution of boundary layer control problems on the Convair F-106 Delta Dart, Lockheed F-104 Starfighter, and McDonnell-Douglas F-101 Voodoo.

In 1957 Silverstein pulled Ed into his personal circle of consultants, beginning his work in the space program. First he selected Ed to attend an exclusive in-house training program on nuclear propulsion. Lewis was designing a large nuclear test reactor at the time and becoming more involved in the Project Rover nuclear rocket engine program. Ed was then assigned the responsibility of presenting the introductory remarks at Lewis' influential Flight Propulsion Conference in November 1957. The classified forum, shortly after the launch of Sputnik, addressed an array of military weapon systems, including atmospheric and intercontinental missiles, long-range bombers, and satellites. The meeting was significant for its discussion of high-energy liquid propellants, ion propulsion, and possible future space missions such as a lunar landing. Immediately afterward Silverstein asked Ed to serve on Lewis' Committee on Space Flight Laboratory, a group developing requirements for a new NACA laboratory to develop chemical, nuclear, and electric propulsion systems. Ed was responsible for identifying the requirements for a multiuse space flight test facility that would include a nuclear rocket test stand. The proposed laboratory did not come to fruition, but Ed's experience establishing the budget, schedule, and logistics opened the door to his role in planning the new space agency.

In the spring of 1958, NACA Director Hugh Dryden brought Silverstein to headquarters to assist with the planning of what would become NASA. Silverstein in turn asked Ed and eight other Lewis staff members to assist in developing the necessary programs. Ed was concurrently named chief of the Lewis Plasma Physics Branch that studied ion engines, but increasingly he was travelling to headquarters. Initially the Lewis group would fly into Washington on a Sunday night, put in a week of 12- to 14-hour days (which were informally extended in Silverstein's room late into the night), then return to Cleveland the following Friday or Saturday. Over the course of several months, the Lewis team played a primary role in the assembly of the space agency and establishment of its initial programs. In October 1958 Ed permanently transferred to headquarters and the Cortrights purchased a house in Bethesda.

As chief of advanced technology in the Office of Space Flight Development, Ed was initially responsible for establishing NASA's first meteorological satellite programs, TIROS and Nimbus. His role then broadened to encompass all of NASA's space applications programs, including meteorological, communication, navigation, and geodetic satellites. He consulted with military and university researchers who had delved into these fields, organized the information, plotted out NASA's efforts, and developed program schedules and budgets. He was critical to the development of NASA project management policy by helping define the lines of responsibility between headquarters, the field centers, other agencies, and contractors.

Silverstein reorganized the Office of Space Flight Programs on February 7, 1960, and created two new offices: Lunar and Planetary Programs and Satellite and Sounding Rocket Programs. As director of the former, Ed managed all lunar, planetary, and interplanetary exploration efforts, including Mariner, Ranger, Lunar Orbiter, and Surveyor (both the spacecraft and their launch vehicles). He managed the technical and programmatic issues while his deputy handled the scientific concerns. In May 1960 NASA formally adopted Ed's system for naming exploration spacecraft: Lunar missions would refer to land exploration concepts (Surveyor), planetary probes would have nautical themes (Mariner), and unique missions would be assigned the name of the group working on them.

President Kennedy's May 1961 call for a manned lunar landing brought about a major reorganization at NASA that included Ed's appointment as deputy to Homer Newell in the Office of Space Science and Applications (OSSA) and Silverstein's return to Lewis as its director. The responsibilities of OSSA were similar to those of the Lunar and Planetary Programs Office, but the new plan to place a man on the moon increased the urgency to robotically explore the moon beforehand. Major issues with the Ranger and Surveyor spacecraft and the Atlas Centaur launch vehicle had to be addressed.

The Ranger program consisted of a series of spacecraft designed to transmit images back to earth while crashing into the moon. These were the first US spacecraft to reach the moon. Early tension between the Jet Propulsion Laboratory (JPL) and headquarters about the management of the program was exacerbated by a series of failures. Congress reduced funding for Ranger in June 1963, but maintained the program. However, despite a major overhaul of the program, the Ranger 6 mission failed as well. Cortright and Newell took responsibility for personally reviewing and approving the Ranger 7 vehicle before its launch—and the July 31, 1964, Ranger 7 mission provided the first close-up photographs of the moon.

In mid-1963, at the height of the Ranger problems, Ed began advocating for the lunar orbiter mission. He argued that one lunar orbiter taking high-resolution photographs while orbiting the moon would provide more information than several

Ranger flights. As Congress reduced funding for Ranger, it approved the lunar orbiter program. Notwithstanding the lack of spacecraft experience at both its home center, Langley, and its contractor, Boeing, the program proved to be a great success.

General Dynamics' Centaur second-stage rocket was a critical challenge for OSSA. Paired with the Atlas missile, Centaur was scheduled to launch a series of Surveyor spacecraft to the moon. The Surveyors would soft land on the moon, take samples, and explore sites for the Apollo landings. But Centaur, the first liquid-hydrogen and liquid-oxygen space vehicle, and its Pratt & Whitney RL-10 engines were suffering developmental problems under the management of Marshall Space Flight Center. The failure of the first test launch in May 1962 brought the crisis to a head. Major congressional and internal NASA reviews elicited calls to cancel the program. In September 1962 Ed convinced Silverstein to take on the program at Lewis. He then met with Wernher von Braun and Eberhard Rees at Marshall who wanted to launch Surveyor with a Saturn I rocket. Ed decided against the proposal and transferred Centaur to Lewis. It was a sound decision. After a year of testing and analysis, Lewis successfully launched an Atlas Centaur in November 1963. The rocket not only successfully completed the Surveyor missions in the mid-1960s but has served as the nation's primary space tug ever since.

In November 1963 Ed was named deputy associate administrator of OSSA. He retained responsibility for the lunar and planetary exploration missions and launch vehicles, while resuming his earlier management of earth and space observation satellites. His management was a key aspect of NASA's 50 successful unmanned missions completed by September 1965. In this role, he also participated in the planning for what would become the Viking missions to Mars.

In 1967 he compiled an impressive collection of photographs taken in space during the early years of the space program. *Exploring Space with a Camera* (NASA, 1968) presents images from the meteorological and earth observation satellites; the Ranger, Surveyor, and Lunar Orbiter missions to the moon; and the Mercury and Gemini flights. It was the first time many of these photographs were published, and the book was very popular.

In late 1967 Ed reluctantly accepted the position of deputy associate administrator of the Office of Manned Space Flight, his first direct role in the manned space program. The Apollo program was well under way by this point, so he had little direct influence. He spent several months in early 1968 reviewing equipment problems with contractors. His analysis and site visits revealed rampant problems in scheduling deliveries and qualification tests, as well as issues with subcontractors. He increased NASA oversight, implemented additional subsystem testing, and integrated subprime contractors in the decision process. During the next several months he began carving out a niche for himself with Skylab and other post-Apollo missions while keeping an eye out for other positions.

In 1968 he decided to apply for the position of director of the Langley Research Center. It was the first time he applied for a new job since joining NACA in 1948. NASA Administrator James Webb felt the center needed a significant change and the 45-year-old Cortright, who had spent the better part of the past decade dealing with the relationships between headquarters and the centers, seemed to be a logical selection. Ed was the first director from outside the center, and many Langley managers were somewhat standoffish at first. The situation was not helped by NASA's dramatic budget cuts and reductions in staffing levels.

Ed spent his first six months at Langley meeting with the different sections to learn about their activities. He was surprised to find that many division chiefs did not have a grasp of the work done by their staff. He began moving the center's leading researchers into management, and despite NASA downsizing was able to recruit younger staff and convince older members to retire. The result was an entirely new, younger management corps at Langley. Ed outlined his goals and established Aeronautics, Space, Electronics, and Structures directorates, and in 1970 allowed managers and a special task force to reorganize the staff around them. It was Langley's largest reorganization at the time. He also arranged for the rehabilitation of a number of buildings and test facilities and created a very popular visitors' center. Despite the agency's move away from hypersonics, he secured funding for a small transonic wind tunnel, which led directly to establishment of the National Transonic Facility in 1983.

In April 1970 Ed was appointed chair of the Apollo 13 Review Board, with representatives from the astronaut corps, Air Force, headquarters, and field centers. The board spent two months in Texas reviewing and analyzing the mission data and, after more than 100 different tests, concluded that the oxygen tank ignited after the Teflon wiring inside the tank sparked. The board's report in June 1970 presented nine recommendations for future Apollo missions.

Perhaps Ed's most successful and most controversial accomplishment at Langley was the procurement of the Viking program. He had been active in a 1966 proposal to use a Saturn V to launch explorer vehicles to the Martian surface. Langley and JPL were competing for the mission, then called Voyager, when it was cancelled in the summer of 1967. Cortright and Newell proposed four new Mars flyby and lander options to Webb, who in turn successfully lobbied Congress for funding. Ed, subsequently appointed director at Langley, took several steps to ensure that the Mars lander program, now known as Viking, was assigned to the center. He quickly converted Langley's Lunar Orbiter Office into the Advanced Space Flight Projects Office. He also made a concerted effort to transfer JPL astrobiologist Gerald Soffen to Langley; JPL, which was competing for the program, resisted until headquarters insisted.

Viking, assigned to Langley in December 1968, was perhaps NASA's premier mission of the 1970s and a major coup for the center. Ed had program manager Jim Martin report directly to him. Although Viking brought funding and publicity to Langley, many of the center's other researchers became concerned that other areas were suffering as a result. Ed later claimed that half of his time was devoted to Viking—and the effort paid off when the two landers touched down on Mars in July and September 1976. These first spacecraft to land on Mars provided a wealth of high-resolution photography, surface samples, and atmospheric data.

Ed received honorary doctorate degrees from George Washington University in 1973 and Rensselaer in 1975. He also edited a history of the Apollo Program as told by some of its most charismatic participants. *Apollo: Expeditions to the Moon* (NASA, 1975) featured chapters by Robert Gilruth, von Braun, Webb, and others, including Ed himself.

For Ed, the twin Viking launches in the summer of 1975 signaled the end of his tenure at Langley and he decided to leave the agency after 30 years of federal service. He made his first foray into private industry as corporate vice president and technical director of Owens Illinois Corporation. It was not only his first nongovernmental position but also his first outside the aerospace field. The Owens years proved to be a disappointment and he left in 1978 to become senior vice president for science and engineering at Lockheed-California, which was developing a number of military aircraft at the time, including the F-117 Nighthawk stealth fighter. The following year he was named president, a position in which he continued to enjoy working directly with staff to resolve issues. Over the next four years he helped turn the company's significant losses into profits.

During his retirement Ed served on the boards of several companies and began a land development business. He participated in the investigation of a TriStar airliner crash in 1980, and served on the Shuttle Safety Advisory Board that investigated Challenger as well as the National Research Council panel that advocated NASA's mixed fleet launch vehicle policy.

In addition to the NAE, Ed was a member of Sigma Xi, Tau Beta Pi, Pi Delta Sigma, and the American Institute of Aeronautics and Astronautics and American Astronautical Society (AAS). He received the Arthur S. Flemming Award (1963), NASA Outstanding Leadership Medal (1966), NASA Distinguished Service Medal (1967), and AAS Space Flight Award (1970).

The Cortrights retired to Palm City, Florida. Beverly passed away in 2012 after 67 years of marriage. Survivors are daughter Susan Weiss, son David Cortright, and three grandchildren.

STEPHEN H. CRANDALL

1920–2013

Elected in 1977

"Leadership in the theory, education, and practice of engineering mechanics, especially in random vibration analysis."

BY H. NORMAN ABRAMSON

STEPHEN HARRY CRANDALL, a beloved figure in the field of theoretical and applied mechanics, died on October 29, 2013, at the age of 92. He was the Ford Professor of Engineering (Emeritus) at the Massachusetts Institute of Technology, a title he held for more than 35 years.

Steve was born on December 2, 1920, in Cebu, the Philippines. After his family relocated to the United States from China, he undertook his engineering education at the Stevens Institute of Technology, where he graduated as valedictorian and received a master's degree in mechanical engineering in 1942. He joined the staff of the MIT Radiation Laboratory and continued his education, receiving a PhD in mathematics in 1946.

Thus began an illustrious career at MIT, where he remained throughout his career. He was appointed assistant professor of mechanical engineering in 1947, associate professor in 1951, professor in 1958, and Ford Professor of Engineering from 1975 until his death (emeritus since 1991). He served at least three separate terms as chair of the Department of Applied Mechanics (and/or Mechanics and Mathematics).

He was also a visiting professor at the following outstanding universities: Imperial College (London), Aix-Marseille, University of California, Berkeley, Harvard, University of Mexico, Korea Advanced Institute of Science and Technology

(KAIST), and the Technion–Israel Institute of Technology. In both his teaching and faculty leadership he strived to elevate mechanics to a higher level of engineering science. As a teacher he was calm and encouraging, but had high standards. One student said that it was not until he was reviewing for final exams that it dawned on him just how complicated the material was: Professor Crandall had explained it so clearly, he had made it seem self-evident.

Steve was also an effective and widely recognized author and editor of eight textbooks and more than 160 peer-reviewed technical articles. His publications in the field of mechanical vibrations, and especially in the emerging area of random vibrations, remain seminal contributions. Four of his books—*Random Vibration* (MIT Press, 1958), *An Introduction to the Mechanics of Solids* (coedited with Norman C. Dahl; McGraw-Hill, 1959); *Random Vibrations in Mechanical Systems* (coedited with William D. Mark; Academic Press, 1963); and *Dynamics of Mechanical and Electromechanical Systems* (McGraw-Hill, 1968)—were groundbreaking contributions.

Ever cognizant of his responsibilities to serve his chosen profession, Steve was active in technical societies and other advisory boards and committees. In the American Society of Mechanical Engineers (ASME), he chaired the Applied Mechanics Division and was vice president of Basic Engineering. He was president of the American Academy of Mechanics and served on several advisory panels of the National Science Foundation as well as the National Research Council's Committee on Army Basic Scientific Research.

His principal interest was in the realm of international scientific interactions and cooperation. He chaired the US National Committee for Theoretical and Applied Mechanics and as such was a US delegate to the International Union of Theoretical and Applied Mechanics. He also served on the board of the International Commission for Acoustics.

He travelled widely and maintained an active array of friends and colleagues in many countries, fostering international communications and cooperation wherever he went.

Recognition by one's professional peers is, of course, the foremost honor that any person can receive, and Steve received this many times over. ASME awarded him its highest grade of membership, honorary member, in 1988, accompanied by no fewer than four awards for his specific technical contributions: the Worcester Reed Warner Medal (1971), Timoshenko Medal (1990), J.P. Den Hartog Award (1991), and Thomas K. Caughey Dynamics Award (2009). In 1978 the Acoustical Society of America (ASA) presented him with its Trent-Crede Medal. Recognizing his broad contributions to engineering structures, ASCE awarded him its Theodore von Kármán (1984) and Alfred M. Freudenthal (1996) medals.

He earned the rare distinction of election to both the NAE (1977) and the NAS (1993). In 1989 the Alexander von Humboldt Foundation, Berlin, honored him with its US Senior Scientist Award, and in 1995 his alma mater, the Stevens Institute of Technology, presented him with its Honor Award. Other honors, national and international, include invitation to serve as an honorary professor at Zhejiang University in Hangzhou, China, in 1985; membership in the American Academy of Arts and Sciences; and election as a foreign member of the Russian Academy of Engineering (2000).

Steve was a person of unique and wonderful characteristics, with unexpected talents. He was slow and quiet of speech, but with great quality of content, and always with a huge smile and sense of humor.

His facility with languages earned him a warm welcome in the international community and with the many foreign students he nurtured at MIT, and he often delighted audiences at foreign universities by presenting his lectures in their own tongue. These were mostly in Spanish, French, and Russian, but over the years he worked on learning at least 11 languages by listening to tapes during his commute. He said that although professors assured him the students understood English, whenever he offered the choice of lecturing in either his slow careful English or their own language with his rather heavy accent, the students always preferred their own language.

Steve married Patricia (Pat) in 1949, and their home near MIT was always open to students and visiting academics as well as other scientific or technical persons who happened to be in the vicinity. With so many relevant conferences always being held at MIT, the Crandalls welcomed all. And with their penchant for international travel, they made every effort to support the many foreign students and their families at MIT. Pat especially was the ever gracious hostess and facilitator. Steve often entertained with his piano renditions of Dixieland and jazz music.

Steve was predeceased by Pat in 2011. He is survived by daughter Jane Kontrimas and family and son William (BC). They can be proud of his lasting heritage of a productive and joyous life. Jane shared these observations about her father:

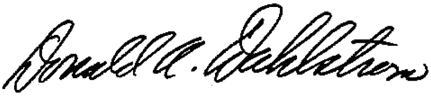
> He had a good sense of humor and enjoyed telling a good joke.
>
> He seldom got angry. He managed this by not taking personally an unkind word. He might look pained, but his comment was likely to be, "s/he is having a hard time right now." On the other hand, if he had inadvertently hurt someone else, he regretted it deeply.
>
> He was persistent, enjoying a challenging puzzle, rather than getting angry or frustrated. He looked at things in depth and from many angles. Rubik's cube was an early "hit."
>
> He did not mind being wrong: the important thing was to change your opinion to account for new information. As I grew up, I realized that is actually the *essence of science*: measure the data, clarify the facts, and base your opinions (theories) on what *is*.
>
> He was a good teacher, beginning at the beginning, building a foundation of understanding before going on to the next step; taking the time to find the word that meant exactly what he intended to say.
>
> He described himself as having been painfully shy. Early groups of students visiting the house in Lincoln were likely to be given a project to cut down a dead tree in the back yard. Later it occurred to me that he saw it as a good icebreaker for students who might otherwise feel shy visiting the house of their professor, and easier for him than making nonacademic

conversation. Also, I think he found it fun so he assumed they would too.

One of the very few pieces of direct advice he ever gave me was that you should let the people you work with know you are a team player. He was a team player.

Many have pointed out his tact, kindness, gentleness, and caring. He was sympathetic and a good listener, willing to go with the flow of the conversation. He cared about people and they cared back.

If we all could be kind and considerate team players, and tell the people we love that we love them, that will be a fine way to remember him.



DONALD A. DAHLSTROM

1920–2004

Elected in 1975

"Contributions to liquid-solids separation processes in mineral recovery and waste disposal."

BY BOB EMMETT
SUBMITTED BY THE NAE HOME SECRETARY

DONALD ALBERT DAHLSTROM, a leader in the practical application of liquid-solids separation theory to the filtration and sedimentation fields, died at age 84 on June 16, 2004, after a long illness.

Don was born on January 16, 1920, in Minneapolis, and spent his youth in Minnesota between city and farm, where he learned the values of hard work, diligent study, and concern for humanity that were to guide him throughout his life. He attended Macalester College, but earned his bachelor of science degree in chemical engineering at the University of Minnesota in 1942.

His interest in seeing the rest of the world led him to accept employment with the International Petroleum Company in Peru as a petroleum engineer. During the war years he helped develop and apply new technologies for enhanced oil recovery, such as water flooding of production zones, to improve output of this valued commodity. Not long after reaching Peru he was able to persuade his fiancée, Betty Cordelia Robertson (1919–1992), to embark on the long journey south, and they were married in Talara, Peru, in 1942.

Don returned from Peru in 1945 and joined the US Navy, serving for two years before enrolling at Northwestern University to pursue a doctorate while teaching in the

Chemical Engineering Department. He began his teaching career as an instructor and advanced to assistant professor and finally associate professor when he left Northwestern in 1956. His research centered on the liquid-solids cyclone, a relatively new processing innovation that was beginning to be applied in the minerals industry, particularly in the coal fields. He formulated the parameters necessary for sizing and applying the device, which is now widely used in many industrial and municipal applications, not just mining.

His stay at Northwestern was particularly marked by his open office policy, which allowed easy access for all students any time he wasn't in the classroom. Conversations were not limited to technical questions but included discussions of current events. Don was always ready with words of advice on personal matters when it was requested. His enthusiasm for life in general and his personal relations with his students in particular were demonstrated frequently during the lunch hour softball games on the lawn just outside the Chemical Engineering wing. His boisterous laughter and constant banter during these lively games remain a pleasant memory of those student days.

During his years at Northwestern, Don found time to build a home for his family, which now included five children—Mary, Don, Christine, Stephanie, and Michael—in the River Woods area near Deerfield, Illinois. Like many projects undertaken by busy people, the home became a work in progress for many years, continuing even after Don left his teaching job. His children recall that the house would become a hive of activity during his 4th of July pool parties for his company's staff and families or when, often at the spur of the moment, visiting dignitaries or colleagues from the 64 countries he traveled to in his life would be invited to dine or stay at his home instead of a hotel, treating his wife and children to fascinating cultural exchanges and insights into the world beyond Illinois. His wit and charm gave him an ability to make everyone feel at home. Two-week summer car camping trips with his family, hijinks around the pool, maintenance of his 2½-acre forested lot, and major snow removal operations or gravel driveway restorations became required preoccupations until he moved his home to Salt Lake City.

In 1953 Don accepted a position as director of research and development for the EIMCO Corporation, an up-and-coming manufacturer of vacuum filtration equipment, in Salt Lake City. At the time there were no established or theoretically sound methods in use for correlating bench-scale filtration data and scaling up to commercial operation. B.F. Ruth had proposed the Hagen-Poiseuille equation as a foundation for filtration theory; Don expanded on his work and promoted the correlation bases that are still in almost universal use. These correlations were very practical and can be used with confidence with a minimum of good data, an approach that has been confirmed in almost all processing industries. There was an immediate use for this approach as there was an urgent search under way for uranium. Don applied the techniques at newly discovered mining operations in Ontario, leading to a significant expansion of the company's business as well as timely production of uranium.

In 1957 EIMCO acquired Process Engineers, Inc., a small company engaged in the manufacture of gravity sedimentation equipment. This move, combined with the vacuum filtration equipment experience, was important in helping establish the company as a leader in liquid-solids separation technology, and Don's work contributed to a better theoretical understanding of this field.

He was very active in the professional engineering societies, even gently pressuring his staff engineers to follow his lead and support these entities with publications and active participation. He served as AIME director and vice president in 1973–1975 and as director and president of the Society of Mining, Metallurgy, and Exploration Engineers (SME; 1974–1976) and the American Institute of Chemical Engineers (AIChE; 1959–1964). He also was national president of Tau Beta Pi, the scholastic honorary society, and a member of the American Chemical Society and the Filtration Society of London. For the National Research Council, he served on the

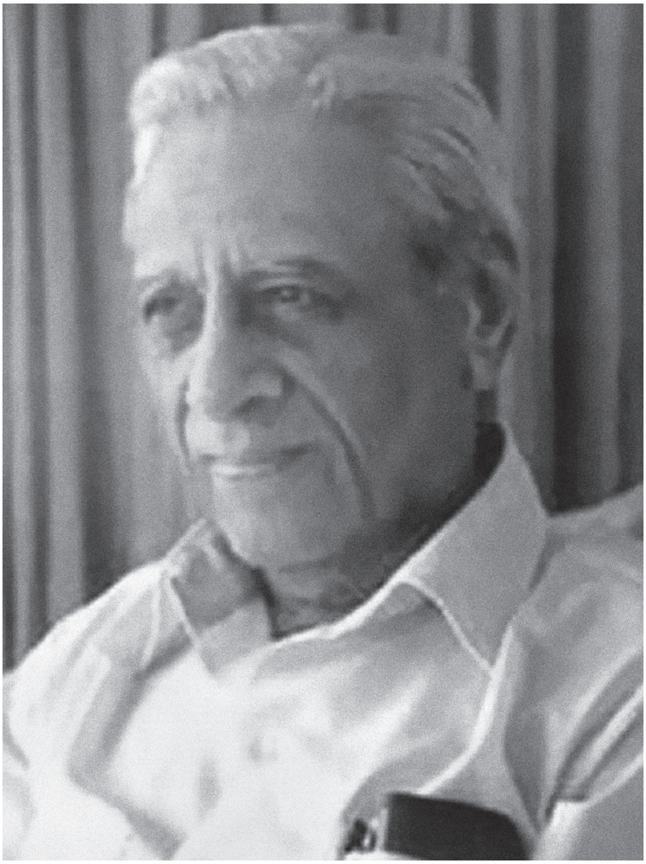
International Affairs Advisory Committee (1987–1992), the Committee on Onshore Mineral Development (1982–1983), and the Committee on Mineral Resources Technology, Phase II (1981–1984).

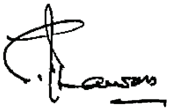
Possibly because of his sincere belief in teaching and promoting knowledge, Don was very active in extending these findings to a variety of industries. He was a tireless writer, producing more than 100 publications in various technical journals and textbooks. He was a contributor and section editor for *Perry's Chemical Engineers' Handbook* (4th through 7th editions; McGraw-Hill) and a contributor to the American Institute of Mining Engineers (AIME) *Mineral Processing Handbook*. At SME he was very active in promoting education in the minerals fields, and was one of the founders of GEM (Government, Education, and Minerals), which develops and distributes information for use in grammar schools to educate students about the critical importance of minerals in the modern world.

In addition to his NAE election in 1975, he was selected in 1983 as one of 30 Eminent Chemical Engineers on the occasion of the AIChE 75th Anniversary. He also received numerous honors for his outstanding work during his lifetime, including the Holgate Award (1949) and Merit Award (1965) from Northwestern University; the AIME Rossiter W. Raymond Memorial Award (1952) and Robert H. Richards Award (1976); the AIChE Founders Award for Outstanding Contributions to the Field of Chemical Engineering (1972) and Lawrence K. Cecil Award in Environmental Chemical Engineering (1977); and the SME Arthur F. Taggart Award (1982) and President's Citation Award (1988).

Don retired from EIMCO in 1984 to pursue his lifelong love of teaching, accepting professorships in chemical and fuels engineering and metallurgical engineering at the University of Utah. At the time of his departure, his technical group had grown from only four engineers in 1953 to more than 70, and EIMCO, now known as Envirotech Corporation, had become the worldwide leader in the filtration and sedimentation fields.

Don is survived by his second wife, Sally York Dahlstrom, whom he married in 1993 following the death of his beloved Betty, and by his five children and many grandchildren and great-grandchildren. He is fondly remembered by the many people whose lives were greatly enriched through their acquaintance with him.





SATISH DHAWAN

1920–2002

Elected in 1978

"Leadership in aerospace research and education and achievement in management of space applications and development programs."

BY RODDAM NARASIMHA AND
VENKATASUBBIAH SIDDHARTHA

SATISH DHAWAN, India's pioneering aerospace scientist and engineer, chair of the Indian Space Research Organization (1972–1984), and director of the Indian Institute of Science (1962–1981), passed away at age 81 on January 3, 2002. His career covered virtually the complete spectrum of professional involvement—teaching, scientific research, technology development, management and leadership of learned societies and large national institutions, and scientific advice to government at the highest levels—often in more than one of these capacities at a time.

Satish was born on September 25, 1920, in Srinagar, Kashmir. His parents came from professional families, and his father, Devi Dayal, retired as a respected judge of the High Court in Lahore (now in Pakistan). Satish graduated from the University of Lahore with an unusual combination of degrees: a BA in physics and mathematics (1938), an MA in English literature (1941), and a BE (with honors) in mechanical engineering (1945).

In 1946 he travelled on a government scholarship to the United States, where he obtained an MS from the University of Minnesota (1947) and then an MS in aeronautical engineering (1949) and a PhD in aeronautics and mathematics (1951) at the California Institute of Technology, with the distinguished fluid dynamicist Hans W. Liepmann as his advisor. The year he moved from Minnesota to Pasadena saw the Indian subcontinent in the throes of a violent partition, and Satish's family left Lahore for Delhi (never to return).

The Caltech Years

Dhawan wrote his thesis about the direct measurement of skin friction on a flat plate, using an ingenious floating element device whose deflection due to the wall stress was measured electronically. With Liepmann and Anatol Roshko he coauthored one of the first studies of shock wave–boundary layer interaction ("On Reflection of Shock Waves from Boundary Layers," National Advisory Committee for Aeronautics Report 1100, 1952). These investigations made an immediate impact on the understanding of the dynamics of compressible laminar and turbulent boundary layers, and are still mentioned in many current text books.

In an obituary on Dhawan, Liepmann commented on his "unusual maturity in judging both scientific and human problems," his sense of humor, and the way "he was immediately accepted and respected by the highly competent and proud group of young scientists" who worked with Liepmann at the time. Dhawan's technical gifts, charming personality, and cheerful and positive attitude left a deep and lasting impression on everybody he met at Caltech.

Research at the Indian Institute of Science

Dhawan left the United States in 1951 to join the Indian Institute of Science (IISc) as a scientific officer. He rose rapidly to become professor and head of the Department of Aeronautical Engineering in 1955 and, in 1963, director of the institute.

In the department he built the first high-speed aerodynamics and boundary layer laboratories in the country, both of them intended chiefly for research. Early studies involved transition from laminar to turbulent flow, in particular the intermittent transition zone, on a flat plate and in pipes and channels, base flows at high speeds, and a turbulent boundary layer undergoing some form of relaminarization in a Prandtl-Meyer expansion. Also studied were wall jets, axisymmetric and three-dimensional boundary layers, separation bubbles, and transonic flows, among others. Dhawan appeared to be working toward establishing a solid base from which any of a range of important topics in aeronautical fluid dynamics could be studied in India.

All of this work was carried out at low cost, with ingenious development or adaptation of the materials, skills, and instrumentation available at the time. With 100-horsepower compressors running supersonic tunnels and galvanometers and optical instruments measuring the flow in the tunnels, the laboratories conveyed at once (to a casual visitor) an impression of both science and engineering—scientific instrumentation in aid of acquiring engineering data (something unusual in India of the 1950s). The research conducted in the laboratory was always inspired in some way by the problems facing the newly born aircraft industry in Bangalore, but usually grew quickly into basic research in its own right.

In retrospect, it is clear that Dhawan was driven by a desire to establish a tradition of research in India along the lines of the engineering science or mechanics that had emerged in Europe and the United States. But the high-speed laboratory was also a pilot project for the design and operation of the larger wind tunnels built later at the National Aeronautical Laboratory (established by the Government of India in 1959), with several of Dhawan's IISc graduates playing a key role in the development of facilities in NAL's early years.

Around 1970 Dhawan was called upon by the government to assess the airworthiness of the HS-748 aircraft then flying for Indian Airlines. The task involved a large number of flight tests of a kind that were new in India, as well as innovative evaluation of acceptable airworthiness requirements using a computer simulation of a stochastic data-based model of an airline fleet, describing general performance deterioration during flying service, but undergoing improvement soon after nearly periodic maintenance checks.

Dhawan's approach to all of this work was characterized by ingenious design, meticulous execution, and cautious interpretation.

Directing IISc

As IISc director Dhawan devoted much time to the establishment of a number of new scientific programs—in automation and control theory, materials science, molecular biology and biophysics, computer science, technology for rural areas, theoretical physics, applied mathematics, solid state chemistry, and atmospheric sciences. He persuaded several distinguished Indian scientists working elsewhere in the world to join the institute, and persuaded the faculty to reform the educational program that had changed little during the previous decade or two.

His long tenure at the institute—the longest ever for an IISc director—transformed it from a relatively laid-back campus with some excellent people in certain areas to one humming with new ideas in a wide variety of subjects, with fresh young faculty and a great many more students. From 11 departments and 5 sections with a recurring annual budget of about 5.5 million rupees (about $1 million) in the early 1960s, IISc grew to some 40 departments and units and a recurring annual budget of 100 million rupees by the time Dhawan left.

Space Science and Technology

Dhawan was on a well-earned sabbatical at Caltech in 1971–1972 when he was called upon to take over India's fledgling space program after its visionary founder Vikram Sarabhai passed away at an early age. Dhawan responded by setting out his views about the space program that India should pursue, its administrative structure, and the need to keep it away from Delhi. If these were acceptable he would be honored to lead the program. The government agreed, and a new structure was set up involving a policymaking Space Commission, an administrative arm of the government called the Department of Space, and a science and technology agency called the Indian Space Research Organization (ISRO)—all three headed by one person.

Over the next decade Dhawan directed India's space program through a period of rapid growth and great achievement. Beginning with two Indian satellites launched from Russia, the first successful Indian launch took place in 1980 (the program director of this launch, A.P.J. Abdul Kalam, went on to become president of the Republic in 2002).

Perhaps the most striking and unusual of the many satellites launched in this period was APPLE (the Ariane Passenger Payload Experiment, 1981), which must have been (at that time) one of the most extensive societal projects carried out from a space platform anywhere in the world. Among other things, it beamed special educational and social content to 12 of the most backward areas in the country in the language spoken in each area. This project, a favorite of Satish's, was a tangible expression of his keen sense of the importance of promoting social justice in India. (Incidentally, having been a lifelong fan of Arthur Clarke's books and his vision on the uses of satellite technology, Satish was absolutely delighted to locate an antenna in Clarke's house in Sri Lanka!)

In addition, pioneering experiments in remote sensing and satellite communications led to operational systems that became a part of Indian life. It is no surprise that, by the 1980s, the Indian space program came to be seen as a model of technology development and application in the country.

Dhawan's qualities as a leader won much national and international acclaim. His unimpeachable integrity and sense of moral order and social justice were the bases for both his management style at ISRO and the staff he selected to assist him at headquarters. Technical reviews at various levels, conducted with expertise from outside ISRO (particularly from academia), helped identify alternative technical approaches in every project.

Dhawan demanded of his scientists, particularly the senior ones, the same standards of scientific integrity that he set for himself. Perhaps his US education and experience enabled him to embark on a management innovation that was, at the time, revolutionary for an Indian government organization. His touchstone in decision making was "Will this advance or retard the engineering effort, given the enabling technology available?"

Honors

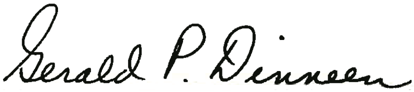
Dhawan was elected to the Indian Academy of Sciences in 1970 (which he also served as president, 1977–1979), and both the US National Academy of Engineering and Indian National Science Academy in 1978. He became a foreign honorary member of the American Academy of Arts and Sciences in 1972. He received honorary doctorates from the Cranfield Institute of Technology (UK) and several Indian academic institutions, and was named a distinguished alumnus of Caltech in 1969 and an IISc honorary fellow in 1981.

He was recognized by numerous Indian professional societies and the government for his services to the nation, culminating in the Padma Vibhushan (the country's second highest civilian honor) in 1981. He also received the Indira Gandhi Award for National Integration in 1999 as "one of our foremost scientists, teachers, and national builders,…who has made multidimensional contributions to scientific education, research, policy formulation, and implementation and is deeply concerned with the solution of national problems through the use of science."

Conclusion

In his diverse roles during his professional career, Dhawan transformed every institution he led or advised and left his own special imprint on each of them. His great human qualities, combining personal charm with a deep commitment to social values and an extraordinary objectivity in management, led several generations of students, colleagues, and administrators to efforts that they would otherwise not have undertaken.

His own education had integrated science, technology, and the humanities, and so did his life. A powerful combination of ability, integrity, and personality enabled him to both do and promote science, work for the state as well as society, and manage megatechnology while also championing little science. He left a precious legacy for his country, and did so at a special period in its history.



GERALD PAUL DINNEEN

1924–2012

Elected in 1975

"Contributions to the design of digital computer and satellite communications systems."

BY WILLIAM DELANEY

GERALD P. DINNEEN, a leader in national defense technology, died on May 30, 2012, at the age of 87.

He was born in Elmhurst, New York, on October 23, 1924, and received his early education there. Two years into his study of mathematics at Queens College, his formal education was interrupted by World War II. He enlisted in the US Army Air Corps and studied weather prediction at New York University as part of his military training. Sent to the Pacific Theater, he worked as an air transport officer, and remained in Japan for 10 months after the end of the war. When he returned to civilian life he completed his undergraduate studies, receiving a BS in mathematics from Queens College in 1947. He then studied at the University of Wisconsin, Madison, where he earned an MA and PhD in mathematics in 1948 and 1952, respectively.

Gerry Dinneen began his professional career at Goodyear Aircraft, developing applications of analog computers for real-time control systems. In 1953 he joined MIT Lincoln Laboratory and began a distinguished 24-year career as a technical innovator in digital computing, a leader in the development of the first solid state computers, a visionary in secure military communications, and eventually the director of Lincoln Laboratory for seven years.

Lincoln Laboratory in the 1950s was the lead organization for the US Air Force in the development of a nationwide strategic air defense system. The system architecture featured the first use of a large digital computer, an improved version of MIT's "Whirlwind" computer, for real-time control of the huge defense system. Students of the history of technology often point to this air defense system as the beginning of the "Information Age." Dr. Dinneen applied Boolean algebra to program the computer to carry out tasks related to air defense systems. He also explored the humanlike behavior of machines, a field now known as artificial intelligence. Early in the 1950s, when the advent of transistors was enabling smaller computers, he was one of the designers of a new, all solid state general-purpose computer that permitted the real-time control of an advanced radar—a novel concept at the time.

After five years as a member of the research staff, Dr. Dinneen advanced to more managerial roles in the laboratory's technical programs. Recognizing that improved military communication could significantly enhance the nation's defense capacity, Lincoln had directed its focus to the development and deployment of communication satellite systems. Dr. Dinneen and his colleagues began the development of satellites and ground terminals to communicate with fixed and mobile platforms (ships, aircraft, and vehicles). During a 10-year period, they built and successfully launched eight communication satellites that ranged in size from 40 to 1,100 pounds. The process involved the design of the satellites, the development of a dedicated space laboratory facility for building and testing them under the extreme conditions of space, and coordination with launch personnel at the Kennedy Space Center. Accompanying these satellites were highly advanced ground terminals that were the first to exploit, in hardware form, the many theoretical advances in communication technology that marked the 1950s and 1960s.

In 1970 Dr. Dinneen was appointed director of Lincoln Laboratory and professor of electrical engineering at MIT. It was a critical time in the laboratory's history that involved student unrest and general public distrust of the military, which led to a decline in funding for Department of Defense (DOD) research and development. Dr. Dinneen successfully guided the laboratory through these difficult times, shifting work to several new directions. In addition, he devoted considerable effort to assisting the DOD's R&D agencies with advice on military electronics technology and capability. He was a familiar figure in the halls of the Pentagon, and his engaging personality put him on a first-name basis with the senior civilian and military leadership.

In 1977, shortly after the inauguration of President Jimmy Carter, Dr. Dinneen was nominated assistant secretary of defense for communications, command and control, and intelligence. During his four years at the DOD, he held primary responsibility for communication satellites and oversaw the global positioning system, the satellite-based navigation system that was originally designed for military ships, aircraft, and ground vehicles and subsequently advanced to the point that it is now used by individuals worldwide. He also supervised programs that allowed data to be digitally communicated to pilots. This technology shift reduced the possibilities for pilot error and was more secure and reliable than traditional voice communication. In addition, he initiated a number of international programs in digital communication, and, in extensive negotiations, including two official visits to China, helped set policies for technology transfer to the People's Republic of China.

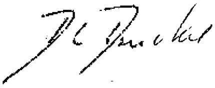
In 1981 Dr. Dinneen joined the Honeywell Corporation in Minneapolis. As chief technical officer he was particularly involved with semiconductor operations, including projects to improve control and security systems for homes and buildings. He also linked the research laboratories more closely to the business goals and objectives of the company, and established programs to encourage scientists and engineers to excel in applied research, including programs through which scientists and engineers could advance without becoming managers. As senior vice president for science and technology, he was extensively involved with the corporation's international R&D programs, forming joint teams and encouraging the mobility of engineers. He retired from Honeywell in 1988.

Dr. Dinneen was a senior fellow at the University of Minnesota's Institute of Technology and an adjunct associate at the university's Hubert H. Humphrey Institute of Public Affairs. His membership on many advisory boards and panels included an extended term on the Air Force Scientific Advisory Board. As an honorary trustee of the Science Museum of Minnesota, he was instrumental in developing a technology facility and exhibit. He was a member of the board of directors of Votan Corp., Microelectronics and Computer Technology Corporation, Honeywell Foundation, Corporation for Open Systems, and Honeywell-NEC Supercomputers.

Dr. Dinneen was elected to the National Academy of Engineering in 1975 and served as a member of its governing council (1984–1995) and as foreign secretary (1988–1995). He set policies and goals for the academy's foreign members and contributed to the growth and development of the international Council of Academies of Engineering and Technological Sciences (CAETS). He was also an active participant in and leader of the National Research Council (NRC)'s international programs. In 1995 he was elected a fellow of the Royal Academy of Engineering, and in 1996 the NAE honored his contributions with a special symposium, "The Global Agenda for American Engineering."

He received the DOD Medal for Distinguished Public Service and was twice awarded the Exceptional Civilian Service Award from the US Air Force. In addition, he received the Distinguished Service Medal from the Armed Forces Communications and Electronics Association, which also named him Man of the Year; the Navy Certificate of Commendation for service on the NRC Committee on Undersea Warfare; and the Army Certificate of Achievement for Service on the Army Materiel Acquisition Review Committee.

Gerry Dinneen was devoted to his wife of 65 years, Mary (Purington) Dinneen, and their two daughters, son, and five grandchildren. He was a man of great technical breadth who made substantial contributions to national security throughout his career. He was also a man of uncommon personal grace, standing tall, handsome, friendly, and always with a smile. He had the enviable talent of never forgetting a name. He will be remembered for his integrity, calm leadership, and dedication to the nation.



DANIEL C. DRUCKER

1918–2001

Elected in 1967

"Stress measurement and plastic deformation research."

BY CHARLES E. TAYLOR

DANIEL CHARLES DRUCKER, 83, died of leukemia on September 1, 2001, in Gainesville, Florida. He was known throughout the world for contributions to the theory of plasticity and its application to analysis and design in metal structures.

He introduced the concept of material stability, now known as Drucker's stability postulate, which provided a unified approach for the derivation of stress-strain relations for plastic behavior of metals. His theorems led directly to limit design, a technique to predict the load-carrying capacity of engineering structures. He also made lasting contributions to the field of photoelasticity. His 1940 paper has become a classic and Drucker's oblique incidence method is widely used in university and industrial photoelastic laboratories.

Dan Drucker was born in New York City on June 3, 1918, and started his engineering career as a student at Columbia University. His ambition was to design bridges, but as an undergraduate he met a young instructor named Raymond D. Mindlin (later a founding member, president, and honorary member of the Society for Experimental Stress Analysis, now known as the Society for Experimental Mechanics; SESA/SEM) who told him that "he would pursue a PhD degree and he would write a thesis on photoelasticity." Dan complied, and received his doctorate in 1940. It was during his student days that he met Ann Bodin; they eloped and were married in 1939.

He taught at Cornell University from 1940 to 1943 before joining the Armour Research Foundation. After serving in the US Army Air Corps, he returned to the Illinois Institute of Technology for a short time before he went in 1947 to Brown University, where he did much of his pioneering work on plasticity.

In 1968 he joined the University of Illinois as dean of engineering. During his more than 15 years there the College of Engineering was consistently ranked among the best five in the nation. The college was known for both its insistence on technical excellence and its commitment to equal opportunity for all.

Dan left Illinois in 1984 to become a graduate research professor at the University of Florida, from which he retired in 1994.

Few people have served the engineering profession with such dedication and distinction as Dan Drucker. He was a charter member of the American Academy of Mechanics (AAM), served as its third president, and received the AAM Award for Distinguished Service to the Field of Theoretical and Applied Mechanics. In addition, he was president of the American Society of Mechanical Engineers (ASME; and editor of the *Journal of Applied Mechanics* for 12 years), American Society for Engineering Education (ASEE), SESA/SEM, and International Union of Theoretical and Applied Mechanics (only the second American to serve in that office), among others.

ASME established the Daniel C. Drucker Medal in his honor to recognize sustained, outstanding contributions to applied mechanics and mechanical engineering through research, teaching, and/or service to the community. Dan was the first recipient of the medal, which was presented at an 80th birthday luncheon honoring him during the Thirteenth US National Congress of Applied Mechanics in Gainesville in June 1998. ASME also honored him with the Timoshenko Medal (1983), the Thurston Lectureship, the ASME Medal (1992), and honorary membership. SESA/SEM conferred upon him honorary membership, the William M. Murray Lectureship, and the M.M. Frocht Award (1971), and ASCE presented him the Theodore von Kármán Medal (1966). In addition, he was honored with the Gustave Trasenter Medal from the University of Liège; the Egleston Medal (1977) and the Illig Medal from Columbia University; the first William Prager Medal (1983), from the Society of Engineering Sciences; the John Fritz Medal (1985) from the Founder Engineering Societies; and the Modesto Panetti and Carlo Ferrari International Prize and Gold Medal (1999) from the Academy of Sciences of Turin. After his death, his daughter Mady found among his mementos a "Medal for Getting the Most Medals" that someone had jokingly presented to him.

In 1988 he received the National Medal of Science. He was a member of the National Academy of Engineering and of the American Academy of Arts and Sciences, and a foreign member of the Polish Academy of Sciences. He also had honorary doctorates from the Technion; Lehigh, Brown, and Northwestern Universities; and the University of Illinois at Urbana-Champaign.

An articulate speaker who gave stimulating and informative talks, Dr. Drucker was selected in 1966 as the ASTM Marburg Lecturer and was frequently invited to deliver keynote and other major addresses at engineering meetings. He had a reputation as an incisive thinker and his advice was eagerly sought, and generously given, at the university, state, and national levels. A list of such participation is too long to be given here, but recent examples include the NAS Committee on Human Rights, NRC Engineering Research Board, and National Science Board.

I met Dan during my first SESA meeting in 1949. I had just started working toward a PhD at the University of Illinois and intended to write a thesis on three-dimensional photoelasticity. Tom Dolan, my advisor, also attended that meeting and made sure that I met the important SESA members. When he saw Ray Mindlin and Dan Drucker across the room, he said to me, "Come over here, I want you to meet these two. They think things through pretty well before they speak, and are usually right." That was my introduction to Dan Drucker, and Tom was right.

After that I started to see Dan regularly at meetings and he always greeted me with a big smile and a handshake. He had just written the chapter on three-dimensional photoelasticity for the *Handbook of Experimental Stress Analysis* (John Wiley & Sons, 1950), so I often talked with him about my proposed thesis. He was easy to talk with and always very helpful. In a sense he was a mentor for me even while he was still at Brown University. That happy relationship continued as we both worked through the various SESA offices and during his tenure as a very busy dean at the University of Illinois. He always made time to talk with me about technical subjects or engineering society business.

My wife Nikki and I moved to Florida in 1981. When the Druckers became our neighbors in Gainesville three years later, our social life increased by a factor of ten. Ann was a very generous person with a great sense of humor. She was interested in everything and we all went to countless plays and musical performances together. Typically we would have dinner, attend the play, then end up at one of our houses for dessert. For Nikki and me those years were our Camelot.

When Dan came to Florida he immediately joined our department's "lunch bunch," which met every school day at noon. At various times the group included Knox Millsaps, Larry Malvern, Ray Bisplinghoff, Hans von Ohain, Chia-Shun (Gus) Yih, Dan, and me. What a wonderful group of colleagues! I felt truly blessed. Now all of these special friends have passed away and they are sorely missed.

Up until the last month of his life, Dan and I still tried to have lunch three days a week. Those were happy occasions, even though we both realized that the inevitable was sneaking up on him. We didn't dwell on that and found lots of things to laugh about. He had a great sense of humor, but never told a joke (off-color or otherwise). And in the thousands of hours we spent together, I never heard him utter a single swear word or spread gossip. I have never met a more honest or pure person.

He was the kind of person that we all try to be. He succeeded where the rest of us fall far short.

Several people who knew how special Dan was sent email messages after his death. Their words are much more eloquent than mine so I quote from them here.

From Philip Hodge: "I admired Dan the scientist-engineer. But I also admired and liked Dan the person. He was one of the most informed, the most fair, the most tactful, the most organized people I have ever known. I have watched him chair meetings of the ASME Council and of the IUTAM General Assembly—and it was a joy to see how he managed to make those highly autocratic bodies more democratic—and all without hurting anyone's feelings…."

Karl Pister wrote to several colleagues, "I know this [sad news] hits all of us hard. We have each had the privilege of knowing and working with Dan in some capacity. He was both a role model and a mentor for me, even at a distance, and he was invaluable as a member of my advisory committee while I was dean at Berkeley. What a splendid legacy he has left us, what an impact he had on so much—not just applied mechanics. We were fortunate to have known and worked with such a man. With sadness filled with respect, Karl."

Dick Christensen wrote to me, "I feel about the same way that you must. He really was very special. I know for sure the succeeding generations in our field don't have any more like him. I had been emailing with him and did so the last time 4 days before his death. At least I feel a little good about that."

Ben Freund said, "I am deeply sorry to learn that we have lost one of the brightest stars our field has known in my time. It happens that I have recently come back from this year's IUTAM Bureau meeting in Warsaw. While participating, I found myself thinking 'How would Dan handle this problem?' several times when sticky issues came up."

Mike Fourney added, "I was fortunate to send [Dan] an email and to receive a reply before he passed…. He was certainly a great guy and I know that you will miss him, as will we all."

The Drucker family received letters of condolence from all over the world; Mady was kind enough to give me a copy of most of them. The common thread in all the letters was that Dan was not only highly respected as an engineering leader but also tremendously admired as a person. Everyone mentioned that his kindness and help had influenced their careers and their lives. What an impact he made and what a legacy he left!

Dan and the 20-year-old girl with whom he eloped lived for more than 61 years as a very devoted and loving couple. In 1994 Ann suffered a severe stroke that confined her to a wheelchair. Dan stayed near always—although he had traveled extensively all of his professional life, he never left Gainesville after her stroke. She died on December 30, 2000. Their son, Dr. David Drucker, lives in Utica, New York, and daughter Mady Drucker Upham is in Rockport, Massachusetts. There are four grandchildren.

LESTER F. EASTMAN

1928–2013

Elected in 1986

"For pioneering and continuing contributions to communications technology resulting from the development of high-speed and high-frequency gallium arsenide devices."

BY WILLIAM G. HOWARD

LESTER FEUSS EASTMAN, enthusiastic, inspiring teacher, valued mentor, gifted innovator, and professor emeritus of electrical engineering and computer engineering at Cornell University, passed away August 9, 2013, after a long illness. He was 85 years old.

Les, as he was known, was born May 21, 1928, and grew up in Waterville, New York, a village 15 miles south of Utica. At the age of 18, he underwent Navy basic training at Great Lakes Naval Academy and served as a radar technician aboard the USS *Coral Sea* during its commissioning voyage (1946–1948).

After his discharge from the Navy he entered Cornell University, where he earned his bachelor of science (1953), master of science (1955), and doctor of philosophy (1957), all in electrical engineering. He promptly joined the faculty of electrical engineering (now electrical and computer engineering) for a career of more than 50 years at Cornell, including recognition, in 1985, as the John L. Given Foundation Professor of Engineering. He retired in 2011.

His early naval experience with radar prepared him ideally for his career researching leading-edge high-frequency solid state devices. With characteristic excitement, he embarked on development of compound semiconductor materials and devices. As a pioneering researcher in exotic devices made from even more exotic materials, Les and his faculty colleagues and students were forced to delve deeply into basic materials science and engineering and materials fabrication as well as device physics. His work encompassed compound semiconductor materials and devices, epitaxy, microwave and millimeter wave transistors and integrated circuits, and semiconductor lasers and photodetectors and their integration with transistors. His multidisciplinary research spanned six decades and helped stimulate the compound semiconductor industry and the electronic and optical device industry that now generate billions of dollars in annual revenue. The work he and his students did on gallium nitride and related materials now permeates defense and commercial applications.

Along the way he mentored an astonishing 125 PhD students, more than 40 master's students, and 75 postdoctoral researchers; together they authored more than 600 publications. His students have made significant contributions and won international prizes by advancing the state of the art of molecular beam epitaxy, microwave transistors and circuits, and optical devices. Countless former students have gone on to great achievements, among them Donald Kerr, former director of Los Alamos Laboratories and principal deputy director of national intelligence; David Welch, cofounder of Infinera, Inc.; and 27 professors in the United States and abroad. Others hold positions in patent law, venture capital, the US government, and industry.

Dr. Eastman eagerly participated in numerous US and international research programs. He "kept contact with the outside world" as an exchange faculty member at Chalmers University in Sweden (1960–1961) and as a researcher at the Sarnoff Laboratories (1964–1965), MIT Lincoln Laboratories (1978–1979), and IBM Watson Research Laboratory (1985–1986). He assisted Sweden and Germany in establishing nanoscale facilities, and was an external PhD examiner for several European universities. During his career he totaled 111 trips to Europe.

Together with several other Cornell faculty colleagues, he cofounded, in 1967, the university's National Science Foundation program on submicron structures, now the

National Nanofabrication Facility. In 1977 he was one of several founders, and then director for ten years, of Cornell's Joint Services Electronics Program. He was also cofounder of Cayuga Associates, a company that produced impact ionization avalanche travel time (IMPATT), Gunn oscillators, and very early gallium arsenide field-effect transistors (GaAs FETs) with micron-size structures.

He provided leadership throughout the compound semiconductor field, through his and his students' research and through his organization of conferences and workshops both at Cornell and around the world to disseminate information and inspire new research directions. In his honor, the Institute of Electrical and Electronics Engineers' Biennial Conference on High-Performance Devices was renamed in 2002 the Lester Eastman Conference on High-Performance Devices. In June 2008 friends and colleagues honored him with a symposium, "Tubes to Transistors, Megahertz to Terahertz," to celebrate his 60th year at Cornell.

Les received many awards and honors for his technical achievements. In addition to his election to the National Academy of Engineering in 1986, he received the 1991 Heinrich Welker Gold Medal and the Annual Award of the International Symposium on Gallium Arsenide and Related Compounds for outstanding research in the area of III-V compound semiconductors; the Alexander von Humboldt Senior Fellowship (1994); and the IEEE Aldert van der Ziel Award (1995), Third Millennium Medal (2000), and Electron Devices Society J.J. Ebers Award (2002). He was a fellow of the American Physical Society, Institute of Electrical and Electronics Engineers, and Electromagnetics Academy.

He served on the US Defense Department's Advisory Group on Electron Devices (1978–1988) and as IEEE Electron Devices Society National Lecturer (1983). He was a member of the senior advisory board of the Fraunhofer Institute of Applied Physics.

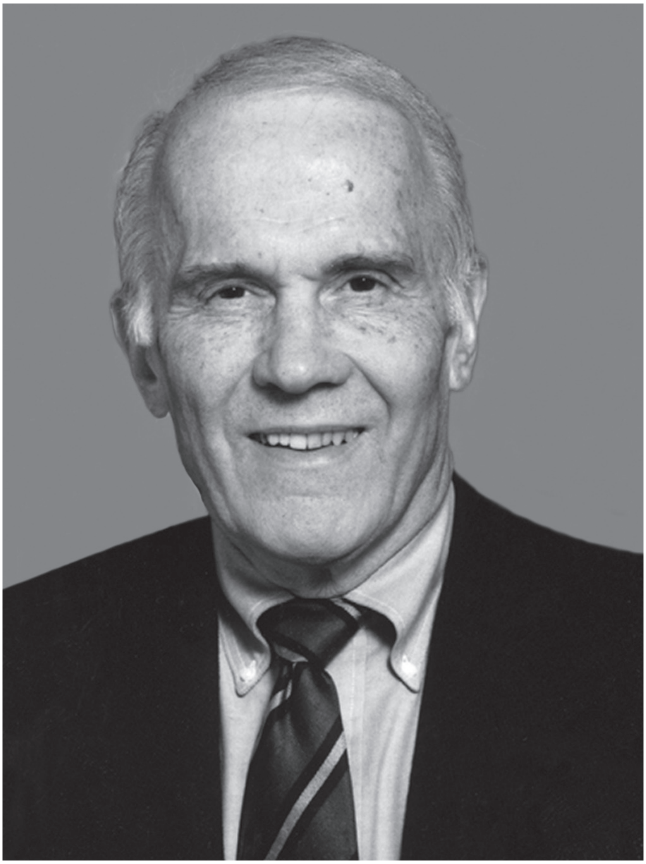
As impressive as Dr. Eastman's research accomplishments and activities are, he valued his educational contributions most of all. His love of his work and of people ideally suited him to an instructional and mentoring role; he really shone as a teacher, and his legacy is apparent in both his classroom and graduate alumni. As an undergraduate electrical engineering student at Cornell, I had the privilege of taking courses in electromagnetic fields and waves from him. His straightforward, concise explication of complex issues in transmission lines, antennas, and propagation made this otherwise complex subject intuitive. He had a knack for understanding students' misunderstandings and disentangling their confusion simply and clearly. He could bring out the best in his students, and in 2003 received the IEEE Microwave Theory and Technique Society Distinguished Educator Award in honor of his accomplishments as an educator.

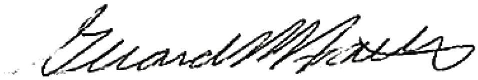
Michael Spencer, Cornell professor and former Eastman student, recalls, "Most of us who had Les remember him best as a research advisor. He always had a really great grasp of the overall picture, and he could determine where the key innovations or challenges were and where to focus everybody's energy and how to make the research group work as a team. I think that's where his talent was," Spencer says. "You could always come to his office at 8 o'clock in the morning, and he would give you a minilecture on the latest developments in compound semiconductors. It was almost like he was talking from a script. It was just a wonderful thing."

Les Eastman was a bear of a man, a former football lineman in the Navy at Great Lakes basic training and again at Cornell; he could appear, at first, imposing. His drive and boundless enthusiasm may have been amplified by his athletic exploits. But his bright, sparkling blue eyes and perpetual smile belied his physique. All his students, undergraduate and graduate, found him to be approachable, encouraging, friendly, and engaging. He was an enthusiastic participant in electrical engineering's Friday afternoon beer and snacks informal get-together for undergraduate and graduate students and faculty—an activity that did much to break down formal social barriers between traditionally stratified academic tiers.

Les was a man of many interests and a zest for life. He encouraged his students and family to maintain a healthy balance of research, study, work, and outside activities. He loved art (especially that of the French Impressionists), the ballet, and all kinds of music. Whenever he could he set aside time during his travels to visit a museum, to attend the ballet, or to enjoy a classical music concert or jazz venue, often with students in tow. He also had an exceptional vocabulary, studying Latin in high school, then memorizing a page of Webster's dictionary a day while he was in the Navy. He was passionate about sailing, particularly on Cayuga Lake, bringing along any family, students, or visitors he could corral into spending a few hours with him out on the water during the summer and fall. And finally, as he demonstrated through his enduring generosity and commitment to others, Les was a man of quiet but deep faith, regularly attending Sunday services and serving as a deacon for his church.

Les' beloved wife of 64 years, Anne, also died in 2013. They are survived by their children David, Daniel, and Laurie; grandchildren Elizabeth, Evan, Jason, and Jonathan; and nine great-grandchildren.





GERARD M. FAETH

1936–2005

Elected in 1991

"For seminal contributions to understanding the structure of combustive and noncombustive sprays."

BY C.T. BOWMAN AND W.A. SIRIGNANO

GERARD MICHAEL FAETH, Arthur B. Modine Distinguished University Professor of Aerospace Engineering at the University of Michigan and a principal investigator for a number of combustion experiments on Space Shuttle missions, passed away on January 24, 2005, at the age of 68.

Jerry was born in New York City on July 5, 1936, and grew up in Teaneck, New Jersey. At Union College in Schenectady he played varsity football and earned a bachelor's degree in mechanical engineering in 1958. He went on to study mechanical engineering at Pennsylvania State University, receiving an MS degree in 1961 and a PhD in 1964. He served on the Penn State mechanical engineering faculty from 1964 to 1985, and then joined the University of Michigan, where he was named Arthur B. Modine Professor of Aerospace Engineering and head of the Gas Dynamics Laboratory. In fall 2004 he was named a Distinguished University Professor, one of the highest honors a faculty member can receive.

During his diverse career he published more than 230 archival journal papers and 200 conference papers, presented more than 200 invited lectures and seminars, and mentored over 50 doctoral students and 20 master's students. His research was characterized by excellence and originality, and spanned many areas—combustion of fuel sprays, liquid breakup processes in jets, droplet breakup processes, turbulence properties of jets and plumes, turbulence in multiphase flows, flame structure, particulate formation in flames, heat transfer from combustion processes, fire suppression, and microgravity combustion. His research papers are exceptionally well cited and many are regarded as classical in their areas. In addition, he was editor of major journals in three different fields: *Combustion and Flame*, the *ASME Journal of Heat Transfer*, and the *AIAA Journal*.

Jerry was elected to the National Academy of Engineering in 1991 and a fellow of four technical societies—the American Institute of Aeronautics and Astronautics, American Society of Mechanical Engineers, American Association for the Advancement of Science, and American Physical Society. In 2004 the Combustion Institute awarded him the Alfred C. Egerton Gold Medal for his distinguished and continuing contributions to the field of combustion.

Clearly, his extraordinary achievements were widely recognized and, based on his exceptional energy, practical wisdom, and engaging personality, led to his selection for many leadership positions. He was active in public service, serving as a member or chair of numerous NASA, NRC, and NAE advisory panels. His universities often asked him to lead recruitment searches for high-level positions. He also served as reunion chair for Union College, his alma mater.

Jerry and Mary Ann, his late wife, were an active, visible, and immensely popular couple in social activities associated with scientific conferences. They took great pleasure in traveling to exotic locations together, and retreating each summer to their cottage in Eagles Mere, Pennsylvania, with close friends. They are survived by three daughters, a son-in-law, and six grandchildren.

HAROLD K. FORSEN

1932–2012

Elected in 1989

"For outstanding technical and leadership contributions to fission, fusion, and energy technology in industry and academia."

BY MICHAEL L. CORRADINI AND GERALD L. KULCINSKI

HAROLD KAY FORSEN, an early leader in the international thermonuclear fusion community who later served as an educator, industrial executive, and government advisor, died on March 7, 2012, at the age of 79.

Harold was born in St. Joseph, Missouri, on September 19, 1932. In 1952 he married his high school sweetheart Betty A. Webb while he served in the Air Force (1951–1955). After his tour of duty was finished, he enrolled in the California Institute of Technology and earned his BS and MS in electrical engineering in 1959. After graduation he worked at the General Atomics Company in San Diego on various nuclear energy issues including nuclear fusion, which later became an integral part of his career.

He decided that a PhD was required to make significant contributions in the plasma physics field, enrolled in the Electrical Engineering Department at the Berkeley campus of the University of California, and obtained his PhD in 1965 under the mentorship of Alvin Trivelpiece. His career then turned toward academia and in 1965 he was hired into the Nuclear Engineering Department of the University of Wisconsin–Madison. It was there that he became well known internationally for his insight and scholarly work in the field of plasma physics. He was also instrumental in starting the university's fusion technology program. Several of his PhD students went on to become leaders of the US fusion energy program.

The next chapter in his life was in nuclear fission. In 1973 he left the University of Wisconsin to lead a mostly classified program in the use of lasers to separate uranium-235 from uranium-238 at the Exxon Nuclear Company in Bellevue, Washington, where he eventually became an executive vice president.

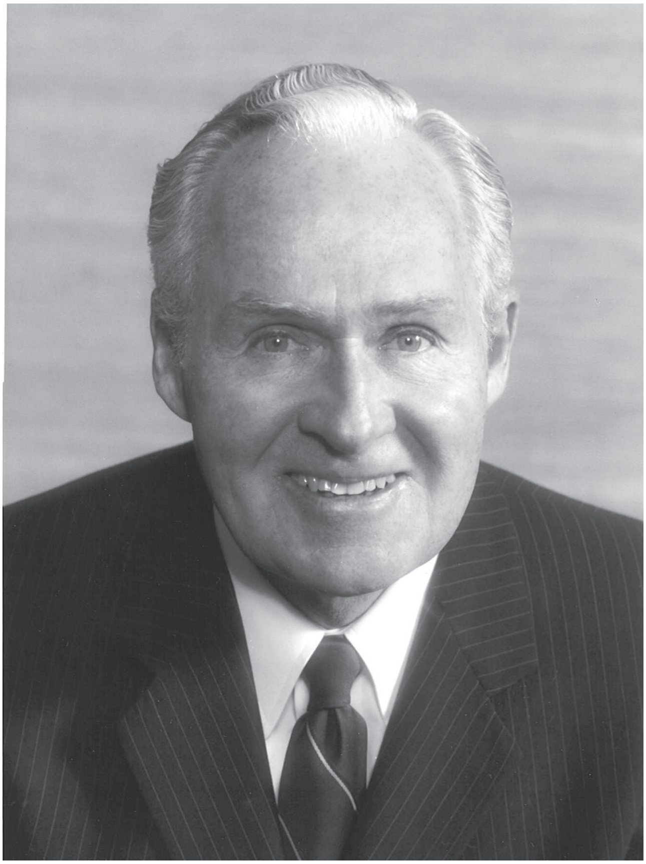
While at Exxon, Harold was also president and then chair of the board of the Pacific Science Center in Seattle for 6 years. In 1981 he was lured to the Bechtel Company in San Francisco to be vice president and manager of the technology group. After serving in that capacity for 14 years, he retired in 1995. He lived in three different locations after retirement: Kirkland, Washington, and North Lake Tahoe and Indio, both in California.

Dr. Forsen received many awards and honors. Perhaps the one he cherished most was his election to the National Academy of Engineering in 1989. He was very active in the governance of the NAE and served as foreign secretary for 8 years (1995–2003). He was elected as a foreign member to the Engineering Academy of Japan in 1998.

Harold was an avid skier and sailor. Like everything in his life, he approached these two hobbies with the same vigor and vitality that he devoted to his academic, industrial, and advising activities during his career. Despite several injuries in later years on the ski slopes in Truckee, CA, he consistently led all skiers in his age group in the yearly downhill vertical distances achieved. His boating trips on Puget Sound were legendary as he was not one to be deterred by inclement weather. This was also typical of the many Canadian fishing and canoe trips he participated in while at the University of Wisconsin.

Harold will be remembered by his colleagues as someone who embraced the need for new forms of energy and was willing to put in whatever effort was necessary to achieve that goal. He did so with a zest for life and an enthusiasm that was contagious. His trajectory across the landscape of the worldwide fusion energy programs will be remembered for a long time by his colleagues.

He is survived by Betty; children John (Gayle), Ron (Debbie), and Sandy (Tom); six grandchildren; and a sister-in-law and her children.



ROBERT W. GALVIN

1922–2011

Elected in 2002

"For leadership in the commercialization of innovative electronics technologies, and for advancing the principles of Total Quality Management."

BY JOHN L. ANDERSON

ROBERT WILLIAM GALVIN, chief executive officer of Motorola and an instrumental leader in the development of the Six Sigma quality improvement system, died on October 11, 2011, at the age of 89 in Chicago.

Born on October 9, 1922, in Marshfield, Wisconsin, Galvin attended Evanston (Illinois) Township High School and the University of Notre Dame. In 1944 he began his 57-year tenure with Motorola, holding a variety of positions before becoming president in 1956 and CEO in 1959 after the death of his father, founder Paul V. Galvin. From 1959 to 1990, the company grew from $290 million to $10.8 billion in annual sales. In 1990 Bob retired as senior executive decision maker of Motorola but remained as chair of the board until 2001.

The culture of Motorola was one of continuous innovation and quality improvement. Under Galvin's leadership, the company was at the forefront of the cell phone industry and was credited with many global "firsts": the first portable cell phone prototype (the DynaTAC), the first call from a portable cell phone, and the first portable cell phone demonstrations in New York and Washington (all in 1973); the first commercial cell phone call, made by a DynaTAC via Ameritech (1983); the first compact cell phone, the MicroTAC (1989); and the StarTAC, the first pocket-sized flip phone (1996).

Galvin contributed to Motorola's preeminence in other key industries as well. He created Motorola Semiconductors, which became one of the top suppliers of semiconductors in the world. Motorola Government Electronics, which had supplied communications equipment, including the Walkie-Talkie, to the military since World War II, moved into the space age under his direction as the supplier of radios for all of NASA's manned space flights. From automobile radios (the product family for which the company was ultimately named), public safety radios, and electronic pagers to televisions marketed under the company's Quasar brand, Galvin helped make the Motorola name synonymous with innovation and public service.

During his tenure Motorola also expanded globally, moving successfully into Europe, Latin America, Southeast Asia, Israel, India, and Japan. And it was the first major US corporation to establish operations in China.

Galvin's influence on business was felt beyond the technology sector. During his time at Motorola the company developed the Six Sigma quality improvement system, which had an impact on hundreds of corporations around the world. In 1988 the company received the inaugural Malcolm Baldrige National Quality Award for Manufacturing from the US Department of Commerce.

He was also proud of the company's contributions to the development of a highly structured process for developing and tracking of technology roadmaps, a technique that became extremely popular and widely used both in companies and in government research organizations. As he said, "The fundamental purpose of the technology reviews and the technology roadmaps is to assure that we put in motion today what is necessary in order to have the right technology, processes, components, and experience in place to meet the future needs for products and services."

Galvin took great pride in his employees, whom he encouraged to call him "Bob." This familiarity and his focus on engineering led him to create various forms of special recognition including the Gold Badge, worn by engineers with more than

10 patents; the Science Advisory Board Associates and the Dan Noble Fellows, respectively recognizing roughly the top 1 and 0.1 percent of the engineering population; the Regular Management Technology Review sessions (RMTRs) that he personally attended to review the company's technology roadmaps and various advances; and the elaborate Patent Awards Banquets held annually for each of the major business units.

Dennis Roberson, former Motorola executive vice president and chief technology officer, observed that "Bob viewed the technical community as the lifeblood of the company and recognized it accordingly. The Gold Badge was a particularly noteworthy example of this. These distinctive badges were worn with pride…and Bob would often single out the members of this elite community for special conversations on their area of technology prowess upon meeting them anywhere in the world."

He was an advocate for respect, integrity, training, and fair pay in Motorola's global management team, and he encouraged government leaders and policymakers to enact policies to foster business opportunities and economic growth in countries where US companies had operations. He also believed in continuous innovation even in well-established and profitable business units, and he institutionalized this belief at Motorola over his three decades of leadership. He liked to say "innovation is often the result of a minority of one."

Galvin advised several US presidents and cabinet leaders, serving on the US Foreign Intelligence Advisory Board and on delegations for the offices of the US Trade Representative, State Department, and Defense and Intelligence. With some frequency, foreign leaders would land first in Chicago to meet with Bob before they flew to Washington to meet with the US president. As one colleague noted, "It was always amazing the level of access that a Motorola business card provided."

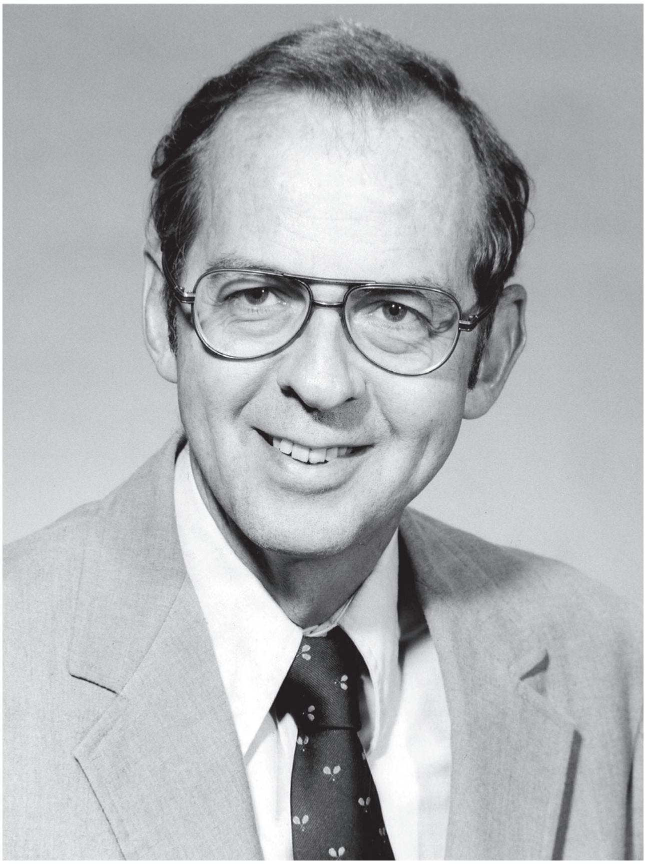
Bob chaired the task force on Alternative Futures for the DOE Laboratories (the "Galvin Commission," 1995) and cochaired the Commission on the Future of the National Science Foundation (1993), and in 1991 he was elected chairman of Sematech, a government initiative to revive the country's semiconductor competitiveness. He also served as president of the Electronic Industry Association and established the US Council on Competitiveness.

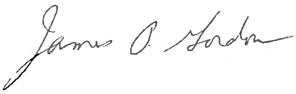
He founded two nonprofit think tanks during his retirement. The Galvin Electricity Initiative, now the Perfect Power Institute, aims to revitalize the electricity industry through development and demonstration of a microgrid-based perfect power system. The goal of the Galvin Transportation Initiative is to reduce automobile congestion in urban areas. Both initiatives seek to create 1 million permanent jobs in the United States over 50 years.

Bob was deeply committed to the Illinois Institute of Technology (IIT), a private, PhD-granting research university in Chicago. He joined its board of trustees in 1953 and served for more than 50 years, chairing it from 1979 to 1990. Under his leadership at Motorola, the company hired more than a thousand IIT graduates, many of whom went on to the highest levels of leadership in the company. In 1996, Galvin and Robert A. Pritzker each pledged $60 million as a challenge grant for the IIT capital campaign; their combined $120 million was one of the largest single gifts in higher education at the time. In spring 2011, the Robert W. Galvin Center for Electricity Innovation was established on the university's campus.

Recognized worldwide for his vision and spirit of innovation, Galvin was honored with several major awards, including the National Medal of Technology and Innovation, the Vannevar Bush Award from the National Science Board, the French Legion of Honor medal, the Founders Medal from the Institute of Electrical and Electronics Engineers, and the Marconi Society Lifetime Achievement Award. In addition to the NAE he was elected to the American National Business Hall of Fame, and he was the recipient of several honorary doctorates from universities including IIT (1990).

He is survived by his wife of 67 years, Mary Barnes Galvin, daughters Gail and Dawn, sons Christopher and Michael, 14 grandchildren, and 14 great-grandchildren.





JAMES P. GORDON

1928–2013

Elected in 1985

"For fundamental contributions to quantum electronics, including demonstration of the first maser and demonstration of the information theory of optical communication channels."

BY HERWIG KOGELNIK

JAMES POWER GORDON, a brilliant scientist and inspired research leader in the fields of lasers and quantum electronics at Bell Labs, died on June 21, 2013, at the age of 85. He was born in New York City on March 20, 1928. He attended Phillips Exeter Academy, received a BSc degree in physics from the Massachusetts Institute of Technology in 1949, and received his master's and PhD degrees in physics from Columbia University in 1951 and 1955, respectively.

In 1949 Jim joined the Columbia Graduate School of Arts and Sciences, where, in 1951, he was asked by Charles Townes to join him on a project to build the first coherent molecular oscillator. Even though a considerable number of skeptics foresaw low chances for the success of this project, Jim decided to participate and it became the subject of his PhD thesis.

In his article "Reflections on the First Maser," published in the May 2010 issue of *Optics and Photonics News*, he recalls a 1954 lunch meeting with Townes and Arthur Schawlow in which they created the name *maser* for the new device as an acronym for "microwave amplification by stimulated emission of radiation." Before long, Schawlow joked that the acronym stood for "money acquisition scheme for expensive research."

Gordon's thesis project was a very sophisticated experiment involving a vacuum chamber, a beam of ammonia molecules, a beam focusing device, and a microwave resonator cavity. Soon there was success: In December 1953 his team obtained a faint emission spectrum from the world's first maser. Further improvements increased the strength of the emission, and in May 1954 the first maser paper was submitted to the letters section of the *Physical Review*. These dates mark the beginning of quantum electronics (including masers and lasers). The field has seen impressive growth—thousands of scientists and engineers now work in it—and was the basis for more than a dozen Nobel Prizes.

Stimulated emission is now used to generate radiation at frequencies from microwaves, the far infrared, the infrared, and the optical spectrum up to the ultraviolet and the x-ray regime. To describe the expansion of the spectrum, the *L* from "light" was substituted in the acronym to create the *laser*.

Quantum electronics and its applications have revolutionized many fields and created new ones. There are new applications in spectroscopy, new biomedical applications such as laser surgery and optical coherence tomography (OCT), high-capacity optical fiber transmission systems providing the backbone of the Internet, the generation of ultrashort attosecond pulses, frequency combs for precision time keeping, LIDAR and atmospheric sensing, the reading of compact discs and DVDs, laser pointers, quantum information sciences, and the beginnings of energy generation using laser fusion.

Jim Gordon made important fundamental contributions to the growth of several of these new fields and essentially tutored many of his colleagues at AT&T Bell Laboratories, where he was a research scientist from 1955 until his retirement in 1996. (In 1962–1963 he spent a year as a visiting professor at the University of California, San Diego.) From 1958 to 1980 he headed the Quantum Electronics Research Department, located initially in Murray Hill and later Holmdel, New Jersey, conducting advanced research in quantum electronics, masers, and lasers. Highly noteworthy were the elegant simplicity and clarity of his presentations. Many a Bell Labs experimentalist came to him with problems they did not understand. Jim would politely listen and, a few days later, stop by with a beautiful theory written out for their problem.

At Bell Labs he at first continued work on masers, particularly on the noise properties of maser oscillators and amplifiers. He also studied quantum fluctuations and noise in parametric processes. In 1961 he published a fundamental insight to the understanding of laser resonators with Gary D. Boyd in the *Bell System Technical Journal*. It introduced the use of curved mirrors to laser technology, now the preferred practice because of their improved stability and lower diffraction loss (before that, Fabry-Pérot resonators with plane-parallel mirrors had been used). Analysis of the confocal resonator with curved mirrors showed that its modes and diffraction losses can be described analytically by prolate spheroidal wave functions, and that the diffraction losses of this resonator are the lowest among all resonator types of equal size. This paper also introduced the now widely used concept of Hermite-Gaussian modes for the study of resonators and the propagation of laser beams.

During this period Gordon started a string of publications that can be considered the beginning of the field of quantum information science (e.g., his 1962 paper "Quantum Effects in Communication Systems," published in the *Proceedings of the IRE* 50(9):1898–1908). In these articles he studied the incorporation of the quantum nature of light into the famous Shannon's information capacity limit governing the fundamental limitations of systems used for the transmission of information (e.g., telephony, radio, television, and the Internet). The new quantum version, relevant for optical communication, is now known as the Gordon-Holevo capacity limit.

Having joined Arthur Ashkin's efforts to manipulate microparticles with laser beams in the 1970s, Gordon wrote the first theory describing radiation forces and momenta in dielectric media. Later, he and Ashkin modeled the motion of atoms in a radiation trap, which they published in *Physical Review A* in May 1980. This work, together with Ashkin's experiments, was the basis for what developed into the fields of atom trapping and optical tweezers.

As the optical communications field evolved, Gordon continued to do research that yielded knowledge and insights critical both to fellow researchers and, ultimately, to deployed systems. He provided a much needed theoretical basis for nonlinear pulse propagation in fibers in general and of solitons in particular. With Linn F. Mollenauer and Roger H. Stolen, he coauthored the 1980 report on the first observation of soliton propagation in optical fibers ("Experimental Observation of Picosecond Pulse Narrowing and Solitons in Optical Fibers" in *Physical Review Letters* 45(13):1095–1098). His seminal work with Hermann Haus on what is now called the Gordon-Haus effect identifies and provides the understanding for the most important bit-rate-limiting effect in soliton transmission due to the random walk of coherently amplified solitons ("Random Walk of Coherently Amplified Solitons in Optical Fiber Transmission," *Optics Letters* 11(10):665–667, 1986).

In 1990 Gordon and Mollenauer pointed out a fundamental limit to coherent high-capacity optical fiber communication systems, which have become very prominent in recent years ("Phase Noise in Photonic Communications Systems Using Linear Amplifiers," *Optics Letters* 15(23):1351–1353). This limit is the phase noise created by the combination of optical amplifier spontaneous emission and fiber nonlinearities.

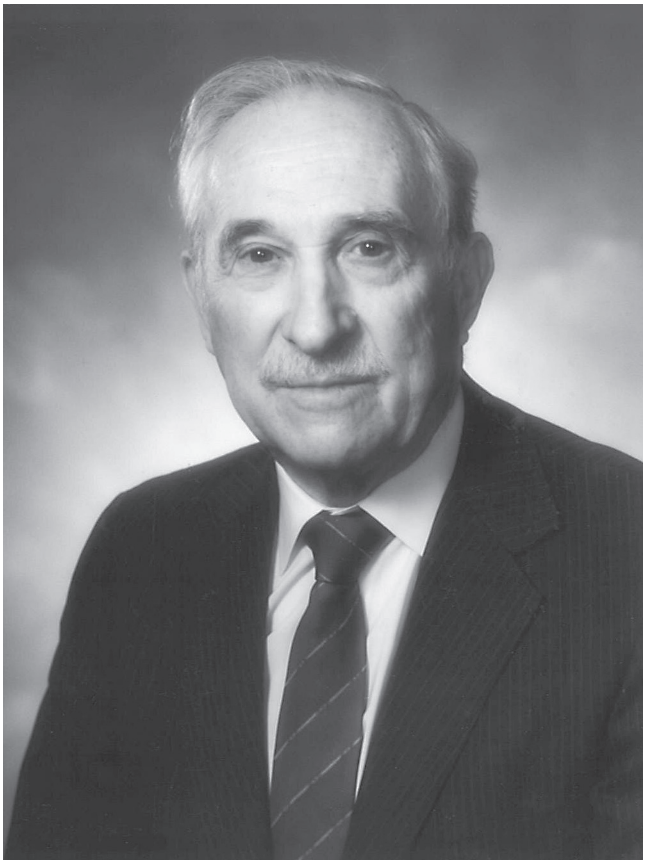
In 2000 Jim coauthored another well-known paper on the impediments of the statistical phenomenon of polarization mode dispersion in high-speed optical fiber systems, caused by randomly aligned fiber sections of different birefringence. As this writer was a coauthor he prefers to quote an article from Wikipedia: "Gordon's most recent major contribution to the field of fiber-optic communications was in the mathematical formulation of the phenomenon of polarization mode dispersion (PMD), which constitutes one of the most important factors in determining the performance of fiber-optic systems. [The] paper ... appeared in the *Proceedings of the National Academy of Sciences* [97(9):4541–4550], and the formulation presented therein became standard in many of the subsequent texts dealing with polarization phenomena in optical fibers."

Jim Gordon's accomplishments were greatly admired by the worldwide scientific and engineering communities. This admiration is reflected in his election to the National Academy of Engineering in 1985 and the National Academy of Sciences in 1988. He was also an honorary member and fellow of the Optical Society of America (OSA) and a fellow of the American Physical Society. Among the prestigious awards he received are the Charles Hard Townes Award (1981), the Max Born Award (1991), the Willis E. Lamb Award for Laser Science and Quantum Optics (2001), and the OSA's highest award, the Frederic Ives Medal (2002).

Researchers were in awe of his brilliance, but also touched by his modesty, particularly when they saw a poster in his office with a variation of a Harry S. Truman quote: "There is no limit to what can be accomplished if it doesn't matter who gets the credit."

In sports Jim was a highly skilled tennis and lawn tennis player as well as a very successful player of platform tennis. He won several club and Bell Labs championships in tennis. In platform tennis he won the US National Championships in men's doubles in 1959, and in mixed doubles in 1961 and 1962.

Jim married Susanna Bland Waldner, a graduate of Vassar and former Bell Labs computing expert, in 1960. In addition to her, he is survived by their children James Jr., Susanna, and Sara and four grandchildren.



HENRY J. GRUY

1915–2012

Elected in 1989

"For contributions in oil and gas evaluations and for leadership in the petroleum industry."

BY LOUIS W. POWERS
SUBMITTED BY THE NAE HOME SECRETARY

Legendary petroleum engineer and geologist HENRY JONES GRUY rode off into the sunset for the last time on December 19, 2012, at age 97. He was born June 10, 1915, in Victoria, Texas, the only child of Bessie Jones Gruy and Henry Gruy, who emigrated from Austria in 1908.

Hank graduated from Central (now R.L. Paschal) High School, Fort Worth, in 1932 and went to work on his uncle Joe Gruy's ranch in Hebbronville. He recalled the experience with fondness as it gave him a lifelong love of horses and riding—he was a regular on the Houston rodeo trail drives during the late 1970s and early 1980s.

When his uncle asked why he wasn't going to college, Hank told him he had been accepted at Rice but couldn't afford it. Joe said he'd pay if Hank would agree to go to Texas A&M. Hank graduated in 1937 with a bachelor's degree in petroleum engineering.

After college he worked for Standard Oil of Texas and then Shell before joining the consulting firm of DeGolyer and MacNaughton from 1945 to 1950, when he set out on his own and founded H.J. Gruy and Associates, where he remained active until he was 95 years old. His company was a pioneer in the transition of engineering calculations from mechanical calculators to computers.

Hank loved serving as a technical expert in complicated oil and gas legal matters. He was called to testify before the Federal Power Commission and the Securities and Exchange Commission, and frequently also testified before state and district courts and the Texas Railroad Commission on various technical matters. He even prepared a paper on how to be a good technical expert and how to avoid being put down by opposing lawyers. He was proud to share his knowledge with younger engineers. He authored numerous technical and legal articles and papers, including one on the mystery of the Bermuda Triangle. He also testified for numerous foreign governments. In addition to his office in Dallas, he had offices in Houston, Corpus Christi, Washington, Monrovia, Beirut, and Bogotá.

Hank was an extremely fair man and so his employees were very loyal to him. When business was in a downturn the first salary cut was his, and on more than one occasion he took no salary so that he could pay his employees. He hired handicapped people long before there were rules or laws about this. And he was interested in hiring and training young engineers from countries all over the world, particularly those associated with the Austrian and Tunisian national oil companies.

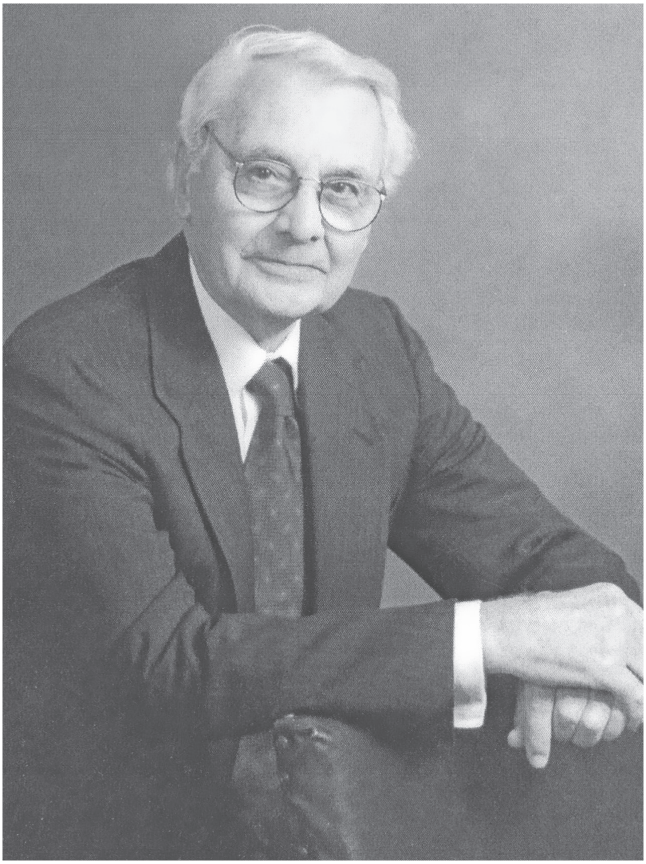
Hank was passionate about his Austrian heritage and at some meetings spoke German. He also loved to tell stories, had a quip or a toast for any occasion, and could recite entire verses of poetry. One time he was on a trip to the Soviet Union in 1989 with the People to People Organization. Soviet-US relations were just beginning to thaw. The group had been delayed some 36 hours, partly by weather and partly by red tape. By 3:00 AM in a Moscow airport some of us were ready to bolt and head for the nearest route back to the good old USA. Hank began to recite poetry to the mostly sleeping and worn-out crowd, and at 3:30 AM we were all on a plane headed for Bugulma, in the Tatar Ural Mountain region, about 600 miles east of Moscow, for an 8:00 AM meeting. We landed about 5:30 AM. We were all dead tired but Hank carried on as if nothing had happened and the program went on as planned, with the Russians all there in suits and ties and some wearing their World War II ribbons.

Hank earned many professional accolades. He was proudest of his induction into the National Academy of Engineering in 1989. He was a lifelong member of the Society of Petroleum Engineers (SPE) and served as its president in the 1960s. In 1983 he received SPE's highest honor, the DeGolyer Distinguished Service Medal. He also received a Lifetime Achievement Award from the National Oil and Natural Gas Producers Association and the Great American Producer Award from the Independent Petroleum Association of America.

He was a member of numerous other industry organizations including the Society of Petroleum Evaluation Engineers (SPEE) since 1962 and the Houston-based Pioneer Oil Producers Society, which he served as president in the 1990s and whose monthly meetings he attended as long as his health permitted.

Hank was named a Distinguished Alumnus of Texas A&M University. He loved the university, which educated multiple generations of Gruys. In 2007 he and his wife dedicated the Rae T. and H.J. Gruy '37 Fountain on the College Station campus outside the alumni building.

He was predeceased by his wife Rae T. Gruy, who died in May 2012, and former wives Evelyn Hudson Gruy (the mother of his three children) and Erma Bell Jopling Gruy. He is survived by sons Robert (wife Connie Hedrick) and William (wife Laura Holmes), daughter Janet Gruy Winter (husband George), and their children and grandchildren.



Carl W. Hall

CARL W. HALL

1924–2014

Elected in 1989

"For fundamental research in agricultural product processing and food engineering."

BY PAUL J. HERER
SUBMITTED BY THE NAE HOME SECRETARY

CARL WILLIAM HALL, a highly accomplished engineering leader, passed away on April 18, 2014, at age 89. His numerous and diverse contributions in education, research, and professional service spanned four decades.

He was born on November 16, 1924, in Seneca County, Ohio. As a staff sergeant in the 99th Infantry Division in World War II, he participated in three major campaigns, including the Battle of the Bulge, for which he was awarded the Bronze Star and the Combat Infantryman's Badge.

After the war he got a BS in agricultural engineering in 1948 from Ohio State University and went on to obtain his master's degree in mechanical engineering from the University of Delaware (1950) and his PhD from Michigan State University (MSU; 1952). Upon graduation, he joined the MSU faculty and subsequently served as department head (1964–1970). During his tenure he guided over 50 graduate students. His specialty area was biological aspects of food engineering. From MSU he went to Washington State University (1970–1982), where he was dean of the College of Engineering and professor of mechanical engineering.

From 1982 to 1990 Dr. Hall was deputy assistant director of engineering at the National Science Foundation. He provided leadership in implementing the 1985 reorganization of the then newly established Directorate for Engineering, chairing a task force to develop and implement this plan. He also played a major role in the development of the foundation's new Engineering Research Centers program. He worked with the White House, Congress, the National Academy of Sciences/ National Academy of Engineering, and numerous groups at NSF to make the ERCs a viable program to strengthen US competitiveness through partnerships with industry in engineering research and education.

At the time, the program represented a new direction in the way NSF supported engineering education and research. Since then it has nurtured many new and emerging research fields and over 60 industry-university partnerships. For his leadership in formulating the program and guiding its implementation Dr. Hall received NSF's Distinguished Service Award (1988).

Brahm Verma, of the University of Georgia, remembers Carl Hall as a champion of the role of biology in engineering education and research. At a 1987 meeting of agricultural engineering department heads from North America, Dr. Hall elaborated on "the age of biology":

> We have engineering based on physics, we have engineering based on chemistry, but we do not have engineering that is based on biology. We should take leadership in building the discipline of biological engineering.…

These visionary words started a movement that led to the establishment of the Institute of Biological Engineering (IBE), the first professional society with a vision of this discipline.

Also during his tenure at NSF he founded (in 1983) and became the first editor of *Drying Technology: An International Journal*. According to McGill University professor Arun Mujumdar, a pioneer in the field, Dr. Hall brought together an invaluable body of knowledge that had been scattered widely until the emergence of this journal. The journal has promoted international cooperation and attracted a large number of both young and seasoned researchers from diverse disciplines and industrial sectors to conduct R&D in this challenging field. As energy costs rise and resources become scarcer, there is no doubt that R&D in this area will necessarily intensify in the future.

A prolific researcher, Dr. Hall authored, edited, or coedited 38 books and over 400 papers and presentations. He was honored by numerous national and international organizations. Among the awards he received are the Distinguished Faculty Award of Michigan State University (1963), Ohio State University's Centennial Achievement Award (1970), and the University Distinguished Career Award from the University of Delaware (2006); France's Ordre du Mérite (1979); Germany's Max Eyth Medal (1979); the ASEE Centennial Achievement Award (1993); and designation by the National Society of Professional Engineers as Federal Engineer of the Year (1986).

Although very professionally accomplished, Carl was a gentle, unassuming, and caring person and his wise counsel and guidance benefited the careers of many young people. He was committed to finding creative ways to enable engineers to tackle society's most important problems. We are truly grateful for the numerous contributions he made to engineering education, research, and professional service. He will be greatly missed.

He is survived by his wife of 64 years, Mildred; daughter Claudia Genuardi; three grandchildren; and six great-grandchildren.

ELVIN R. HEIBERG III

1932–2013

Elected in 1995

"For contributions, both professional and managerial, in civil, environmental, and space technology across national and global horizons."

BY JIM LAMMIE AND RICHARD TUCKER

Lieutenant General ELVIN RAGNVALD HEIBERG III, retired former chief of the US Army Corps of Engineers, died on September 27, 2013, at age 81. He left an outstanding record as a civil engineer, military engineer, manager, and strategic planner. He set for himself high standards of professional achievement, ethics, and leadership and always exceeded those standards.

Vald was born on March 2, 1932, at Schofield Barracks, Honolulu, in a third-generation military family with West Point traditions. His family moved frequently. While at Fort Leavenworth, Kansas, Vald attended high school, met his future wife, Kathryn Louise (Kitty) Schrimpf, and successfully competed for an appointment to the US Military Academy at West Point, which he entered in 1949. He lettered in track and graduated 5th in his class of 512 in 1953.

After graduation, as an officer in the US Army Corps of Engineers, he earned a master's of science in civil engineering at the Massachusetts Institute of Technology (1958) and a master's degree in government (1961) from George Washington University. He had a strong desire to teach at West Point, and this was the motivation for his second master's degree. His father was professor and head of the West Point Department of Mechanics and, because a family member could not serve on his staff, Vald earned the MA in government to qualify as an assistant professor in the Social Sciences Department. In 1971 he completed an MS in administration at George Washington University and graduated from the Industrial College of the Armed Forces, the Department of Defense Senior Business Program. He became a Registered Professional Engineer in 1975.

During his military career Vald's assignments ranged from a water supply system in Greenland to the Nixon White House, where he was executive to the head of the Office of Emergency Preparedness (now FEMA), to the Pentagon as executive officer to two secretaries of the Army, and to the Ballistic Missile Defense Command ("Star Wars") Program. His widely varied posts in the civilian sector were in parallel with his military engineering career commanding troop units in Korea, Germany, and Vietnam, where he commanded a combat engineer battalion blocking North Vietnamese resupply routes. These assignments demanded leadership, courage, a wide range of military engineering skills, and strong management ability.

The capstone of Vald's military career was his selection in 1984 as 46th Chief of Engineers of the US Army, the youngest chief since 1838. In this position he led the integration of new environmental skills, technology, and awareness into a huge global engineering and construction agency. He led the planning for many emergency decisions in floods and natural disasters, and was the "front man" for the Corps in funding and environmental issues. He displayed judgment and political acumen before Congress and the public at all times, showing the leadership and example needed to run the Corps of Engineers. He was tireless in industry advancement efforts and championed the involvement of the Corps in the Construction Industry Institute and personally participated in its research teams.

After retirement from the Army in 1988 he joined Rollins Environmental Services as a senior executive, moved to JA Jones Construction Company, headed the Jones Construction Services Company, and then started a new company, JA Jones Environmental Services, in Charlotte, North Carolina. He was also on the board of directors of Stone & Webster Inc.

In 1993 he moved back to the DC area and founded his own consulting firm, Heiberg Associates. For one interesting assignment he returned to the Pentagon for a year and recruited staff for the Coalition Provisional Authority in support of the Iraq Ministry of Transportation.

It is not surprising that in such a varied and distinguished career, Vald received many national and international awards and honors, among them the Order of the Crown (Commander) from the King of Belgium (1985); the Order of Military Merit (Grand Commander), Brazil (1986); the Edward J. Cleary Award for Excellence in Environmental Management, American Academy of Environmental Engineers and Scientists (1987); Public Works Leader of the Year, American Public Works Association (1987); the American Association of Engineering Societies Chair's Award (1987); and Engineering Manager of the Year, American Society for Engineering Management (1988). Added to this impressive list are many military awards: the Army Distinguished Service Medal (1983 and 1988), the Silver Star, the Distinguished Flying Cross, the Bronze Star Medal, the Legion of Merit, and a Meritorious Service Award from the White House.

Vald was elected to the NAE in 1995 and became very active in Section 4, Civil Engineering, serving on the section's Peer Committee (as member, vice chair, and chair), and on the NAE Committee on Membership. He was also appointed to a number of NRC committees—on Flood Plain Mapping, Systems Integration for Project Constellation, the Federal Role in the Marine Transportation System, and Supercollider Site Evaluation—as well as the Federal Facilities Council of the Board on Infrastructure and the Constructed Environment, Board on Army Science and Technology, Commission on Engineering and Technical Systems, and Transportation Research Board Executive Committee (ex officio).

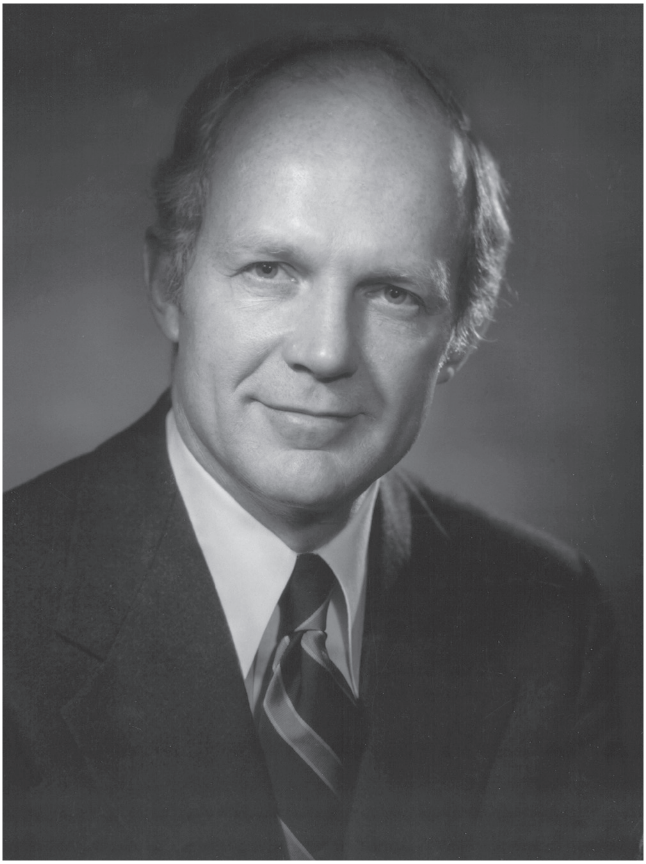
He was inducted into the National Academy of Construction in 2002 for "Exemplary leadership in both the private sector positions and the highest level of management." He was also active in the Construction Industry Institute, Mississippi River Commission, Society of American Military

Engineers (past president), Coastal Engineering Research Board, US Committee on Large Dams, American Society of Civil Engineers, National Society of Professional Engineers, and Permanent International Association of Navigation Congresses (for which he was head of the US delegation, international vice president, and honorary international vice president of the Consultative Committee).

Near the end of his professional career, Vald joined the fray on one last major issue, the flooding of New Orleans after Hurricane Katrina and the question of who had responsibility. In a letter to the New Orleans *Times-Picayune*, he wrote, “as too many continue to rush around to find someone to blame for the Katrina engineering failures, they can blame me. I gave up too early.” Vald explained that in the 1970s, when he commanded the New Orleans District of the US Army Corps of Engineers, he led the fight for special flood barriers but lost to strong local opposition. When the “barrier battle” erupted again and he was chief of engineers, he decided to stop fighting the local and federal opposition. He said, “in retrospect, that was the biggest mistake I made during my 35 years as an Army officer.” However, as reported in the *New York Times*, “Alfred Naomi, a former senior project manager for the Corps…agreed that the barriers might not have made a difference for Katrina…but he expressed admiration for General Heiberg’s public stand. That showed integrity and moral certitude that you don’t find a lot in today’s society…. Right or wrong, he took the hit—and took some responsibility.”

Throughout his career, Vald did the right thing—took the hit, accepted the responsibility, and moved forward in the best interests of the Army and the nation. He was also an avid and some say fierce but gracious competitor on the handball and racquetball courts until his late 70s, and a lifelong philatelist.

Vald is survived by his loving wife of 60 years, Kitty, and four children and five grandchildren: Kathy Heiberg-Browning (Guy); Walter Heiberg (Heike Kessler-Heiberg and children Andrew and Corinna); Elvin R. Heiberg IV (Beth and daughter April); and Kay Heiberg Bransford (Todd and children Cole and Carly).



WILLIAM C. HITTINGER

1922–2013

Elected in 1976

"Contributions to high-frequency transistors and management in industries involving advanced technology."

BY ALICE P. GAST

WILLIAM C. HITTINGER, a leader in the electronics industry and a former executive vice president of RCA Corp., died March 17, 2013, at the age of 90.

Born November 10, 1922, and raised in Bethlehem, Pennsylvania, he attended Liberty High School, enrolled at Lehigh University in 1940 as an advanced ROTC student, and graduated with honors in 1944 with a bachelor of science degree in metallurgical engineering. He played on the football and baseball teams and was one of the first recipients of an Alumni Student Grant financial aid award in recognition of his promise as an athlete-scholar and potential leader. His leadership and success are held as an example and aspiration for those who receive the award today.

In 1943 Bill went on active duty in the US Army and rose to the rank of captain. Upon his return from service in World War II, he took on a number of leadership positions and responsibilities in the booming electronics industry. He began at Western Electric Company as a materials engineer and moved on to the National Union Radio Corporation Semiconductor Division where, as production manager, he began focusing on semiconductors. In 1959 he was named director of Bell Telephone Laboratories Semiconductor Device Laboratory and in 1962 he became executive director of its Semiconductor Device and Electron Tube Division.

Hittinger was one of the pioneers in developing processing technology for silicon into semiconductor devices in the 1950s. In an oral history project through the Institute of Electrical and Electronics Engineers (IEEE) Global History Network, he spoke about making the transition to silicon as Bell Laboratories employees at Western Electric, where their mission was to drive new discoveries to commercial production:

> We found a very receptive group of maybe a half a dozen well-trained semiconductor engineers who were willing to take on the job. It was just a matter of plain hard work, to get the area cleaned up to…be able to work with high-purity silicon, and before long Western Electric started to manufacture such a product…. Really, it was a matter of knowing the right people to work with, and Western Electric had…an able group of younger people.

In 1966 he was appointed president of Bellcomm, Inc., a company performing systems engineering for NASA's manned spaceflight program under American Telephone and Telegraph Company and Western Electric Company. He was president of the General Instrument Corporation from 1968 to 1970, when he joined RCA as vice president and general manager of the Solid State Division. Appointed executive vice president in 1972, he assumed responsibility for RCA Consumer Electronics. In 1974 he was given the additional responsibility of Electronic Components (subsequently realigned into various product divisions) and elected to the RCA board of directors.

His oversight of research expanded in 1976 when he was appointed executive vice president of research and engineering for the RCA Corporation. In this post, he had direct responsibility for the company's research and engineering activities, including the RCA Patent Operations and Laboratories at the Princeton headquarters, as well as international business and marketing development.

Bill provided much service to the nation, serving as a member of President Reagan's National Security Telecommunications Advisory Committee from 1982 to 1986, the US-Brazil Presidential Committee on Science and Technology in 1987, and the board of the National Action Committee for Minorities in Engineering. In corporate governance, he was a director of UNC Inc., Biotechnic International, Stabler Companies, Bethlehem Steel, Thomas and Belts Corporation, Allen Bradley, Epitaxx Corporation, and American Fletcher Corporation.

An active and dedicated member of the NAE, he served on peer and awards committees for Electronics, Communication and Information Systems Engineering and served on and ultimately chaired the NAE Public Information Advisory Committee (1986–1993). He also served on the NRC Cross-Disciplinary Engineering Research Committee and the Committee for the Study of the Causes and Consequences of the Internationalization of US Manufacturing, which issued its report in 1990. He was a fellow of the Institute of Electrical and Electronics Engineers and the Royal Society of the Arts, and a member of Tau Beta Pi.

He devoted much of his energy to his alma mater, even coming out of retirement in 1997 to serve as Lehigh's interim president for a year. He joined the university's board of trustees in 1972 and served on a wide range of committees throughout his 24-year tenure (including 6 years as chair), distinguishing himself for his broad understanding of issues in higher education, his leadership qualities, and his ability to reconcile differences between factions. He is remembered for his effective leadership of the university board of trustees in overseeing the construction of the Zoellner Arts Center and enhancing the university's support of student financial aid.

Always eager to share his knowledge, he lectured at Lehigh on the history of the electronic revolution of the mid-20th century, describing the transition from early materials work in germanium and silicon that were incorporated in a range of manufacturable products for industry, consumers, and the military after World War II. He received an honorary doctor of engineering degree from Lehigh in 1973 and was honored with the "L-in-Life Award" from the Lehigh Club of New York for distinguished service to his alma mater and induction into the Lehigh Sports Hall of Fame for his contributions on and off the field.

Bill Hittinger was a warm and generous leader and a gracious role model and mentor to many. He left a meaningful legacy in the electronics industry, at Lehigh University, and in the National Academy of Engineering. His humble leadership style was evident in his dedication to his alma mater, where he was perhaps the only former president and board chair to sit at Lehigh's front admissions desk as a volunteer whose warm welcome greeted prospective students and their families for years.

Always a loving and giving family man, Bill was also a friend and advisor to many in the community. After retiring in 1986, he spent his time in philanthropic pursuits, travel with his wife, visits with their children and grandchildren, and golf and tennis. He is survived by his wife of 68 years, Elizabeth, two sisters, four children, 11 grandchildren, and six great-grandchildren (and three more on the way as of this writing).

Charles H. Holley

CHARLES H. HOLLEY

1919–2012

Elected in 1976

"Pioneering contributions to the evolution of turbine-generator design."

BY JAMES M. FOGARTY
SUBMITTED BY THE NAE HOME SECRETARY

CHARLES HENRY HOLLEY, active throughout his career in the electric power industry, died on October 9, 2012, at the age of 93.

Chuck, as people knew him, was born in Pittsburgh on April 15, 1919, and raised in nearby Ford City. He attended Duke University and graduated in 1941 with a degree in electrical engineering. A tall man for the times, he was recruited by the university to play basketball and was the starting center for the Duke Blue Devils. A lifelong Duke fan, he returned to campus several times in his 70s and 80s to play in the annual Duke alumni basketball games.

Upon graduation, he joined the General Electric Company's Test Program with assignments in Lynn (Massachusetts) and Philadelphia before taking a position as a field engineer in Pittsburgh. In 1945 he came to Schenectady and joined the Generator Engineering Section, which was responsible for the design and development of the large steam turbine–driven generators used for electric power generation.

In the early 1950s Chuck, together with Charles Kilbourne, also of GE, developed the concept of cooling the high-voltage AC windings of power generators with liquid (oil) flowing in the copper conductors themselves. This approach allowed a step change in power density that all other manufacturers have since copied. The first unit, put into operation in 1956 at the Cleveland Electric Illuminating Eastlake plant, remains in service today.

In 1962 Chuck was promoted to manager of generator engineering and for more than a decade led a team that saw the size of power generation units increase from 300 to 1,400 MW. During that period he led the development of new rotor cooling methods, extended the use of high-voltage water-cooled electrical windings to new levels, improved mica-based insulation systems, and introduced several new excitation systems. Many of those steam turbine generators from the 1960s are still in service, a testament to the thoroughness of the engineering and testing behind them.

In 1974 he was recognized for his leadership and technical capabilities by being promoted to general manager of GE's Electric Utilities System Engineering Department. His stature and reputation in the company enabled him to extend the influence of this department. He was again promoted, to manager of Turbine Technology Assessment Operations, what a modern business would call a chief technology officer, and retired in 1983 after a stellar 42-year career.

Chuck was a fellow of the Institute of Electrical and Electronic Engineers (IEEE) and in 1978 was awarded the IEEE Nikola Tesla Award for "contributions to the evolution of turbine generator designs with achievement in performance and reliability." And in 1993, in recognition of his lifelong service, Duke University's Pratt School of Engineering bestowed upon him its Distinguished Alumnus Award.

He was a member of the US State Department/National Science Foundation delegation on Energy Development and Commercialization to the Soviet Union in 1979. He was also a US delegate to the International Congress on Large Electrical Systems (CIGRE) for nine years, and served on many industry technical and standards committees.

In addition to all his technical skills and accomplishments, Chuck was an astute manager of people. He set the overall tone in the organization to be one of cooperation, respect, and support of others, believing that these led to success and were simply how people should be treated. When it came to developing people, he took the long view, recognizing that building strong teams must take precedence over the inevitable ups and downs of the economic cycle. More than one individual recalls that, "If you called him Mr. Holley, he would say, 'I don't see my father here. My name is Chuck.'" Everyone he worked with over the decades has a story about how he reached out to young engineers, engineers new to the United States, and even those of long service. Even people who never worked with him said, "I respect him."

And people always mention his sense of humor, which was with him to his last days. It could be dry and witty, and was always disarming. For example, he found that "a man hiding under his desk clutching a teddy bear" was just the right image more often than you might expect. He used his humor and his smile to send messages, lighten conversations, or simply put people at ease.

Chuck is survived by his wife Mary (Polly), daughters Barbara and Catherine and son Kevin, six grandchildren, and several great-grandchildren and nephews and nieces. His wife Winnie (McGinn) Holley and son Richard predeceased him.

THOMAS V. JONES

1920–2014

Elected in 1986

"For leadership in the introduction of reliability and maintainability into advanced aircraft design, resulting in systems which combine high performance with unprecedented reliability."

BY KENT KRESA

THOMAS VICTOR JONES, former Northrop Corporation chairman, chief executive officer, and president who led the company to the top tier of the defense industry, died on January 7, 2014, at age 93.

He is remembered as among the last of the true mavericks whose names became synonymous with their corporations, a bold visionary who took daring risks and whose commitment to innovation ignited a transition that both significantly grew the company and influenced the direction of the Cold War. His vision lived in his company's innovative aircraft, many of which continue to protect and project freedom around the world.

Born on July 21, 1920, in Pomona, California, Tom graduated magna cum laude from Stanford University in 1942 with a bachelor's degree in aeronautical engineering. He received an honorary doctor of laws degree in 1967 from George Washington University and an honorary doctor of science degree in 1990 from Northrop University.

He began his career in 1941 as an engineer with Douglas Aircraft Company and remained there until 1947, when he began work for the Brazilian government as technical advisor to the Air Ministry in Rio de Janeiro. At the same time, he held the post of professor and department head at the Aeronautical Institute of Technology of Brazil.

In 1951 he joined the staff of the Rand Corporation, scientific advisors to the US Air Force and other entities. While there he directed and wrote a widely used logistical study, *Capabilities and Operating Cost of Possible Future Transport Airplanes* (Rand Report R-249, 1953).

He joined Northrop in 1953 as assistant to the chief engineer, and his progress to the top of the company was swift. In 1958 he was named senior vice president for development planning and he was elected president of the company in 1959, chief executive officer in 1960, and chair of the board in 1963. He served in all three leadership capacities until 1975 and retired in 1990. During those 37 years he nurtured and grew a solid but relatively small manufacturer of tactical fighter aircraft into a company involved in key national strategic and tactical defense programs, holding a prominent position in several market areas. From 1959 to 1988, company sales grew from $263 million to $5.8 billion. Along the way, Tom graced the cover of *Time* magazine and counted world leaders and other giants of industry as colleagues and friends.

A hallmark of Tom's approach was to commit company funds to the resources necessary to deliver advanced-technology products that combined capability, quality, reliability, and economy. During the 1980s alone, Northrop invested more than $2.5 billion in facilities and equipment to achieve increases in productivity, set new standards of quality, and reduce costs to customers. The company's success during his tenure and beyond speaks for itself. Among the numerous significant developments he oversaw were the following aircraft:

- The F-5, a supersonic fighter combining low cost, ease of maintenance, and great versatility. Northrop delivered the first fighter to the US Air Force in 1964 and went on to develop several versions of the plane. Militaries in more than 30 countries would use this aircraft.

- The T-38 supersonic trainer, used to train tens of thousands of pilots for the US Air Force and other nations' forces.
- The YF-17 Cobra, which led to the F/A-18 Hornet, the US Navy's frontline carrier-based strike fighter. Northrop Grumman is the principal subcontractor to the Boeing Company for this aircraft, and the F/A-18, in updated configurations, is still manufactured today.
- The B-2 Spirit stealth bomber, the only US aircraft that combines long range, large payload, and stealth in a single platform, giving it the ability to project air power anywhere in the world. This is the flagship of the nation's long-range-strike arsenal. Its stealth enables it to penetrate the most sophisticated defenses. The B-2 has demonstrated its capabilities in several combat scenarios, most recently during Operation Iraqi Freedom and, in Libya, Operation Odyssey Dawn.

In addition to his full-time Northrop responsibilities, Tom was a member of the board of governors of the Aerospace Industries Association until 1989, served as its chairman in 1985, and in 1990 was appointed a member of the honorary advisory committee to the board of governors. He was an honorary fellow of the American Institute of Aeronautics and Astronautics and in 1985 received its Reed Aeronautics Award, the institute's highest honor. He was elected to the National Academy of Engineering in 1986, and the National Aeronautic Association awarded him the Wright Brothers Memorial Trophy in 1989. He served as a director of the Los Angeles World Affairs Council and was among the founders of the Music Center of Los Angeles County. He also belonged to the California Round Table and the Nature Conservancy of California.

Tom's retirement in September 1990 brought to a close a remarkable, even legendary, career. He reached heights and achieved results others could not have accomplished given twice the time. He could have retreated into retirement and lived his life quietly had he wished. For him, though, retirement simply meant striving to succeed in another area of interest, and, true to form, he did. In 1959 he had purchased a home in the Bel Air section of Los Angeles that had belonged to Victor Fleming, director of *Gone with the Wind* and *The Wizard of Oz*. Upon leaving the company he had nurtured and grown, Tom turned his attention to the grapes he had begun planting in 1978 and developed the highly regarded Moraga Vineyards wines, thus achieving success in a "second career" that he loved.

Tom Jones achieved a full life well lived. Whether he was transforming a company or developing wines, he accomplished great things by committing, nurturing, and growing. His influence on aerospace and defense is permanent; the aircraft he championed have protected people in all corners of the world and directly influenced future generations of highly sophisticated systems. Today, the company he helmed is creating products he could only have dreamed of, but they would not have been possible without him.

His wife of 67 years, Ruth, died in 2013. He is survived by son Peter Jones, daughter Ruth Marilyn Jones, brother George Jones, sister Margaret Whyte, and two grandchildren.


Daniel D. Joseph

DANIEL D. JOSEPH

1929–2011

Elected in 1990

"For development of ingenious analytical tools and laboratory experiments used in the discovery and elucidation of novel fluid-mechanic phenomena."

BY KATEPALLI R. SREENIVASAN

DANIEL DONALD JOSEPH, a highly versatile fluid dynamicist, died on May 24, 2011, at the University of Minnesota Hospital. He was Regents Professor Emeritus and Russell J. Penrose Professor Emeritus in the Department of Aerospace Engineering and Mechanics of the University of Minnesota.

He was born on March 26, 1929, in Chicago and followed an unusual path in academics: he earned an MA in sociology from the University of Chicago in 1950 and worked for a few years as a machinist (and an activist sympathizer of the working class). Not getting "enough respect," he enrolled in engineering at the Illinois Institute of Technology (IIT) in 1957, where he earned a BS in mechanical engineering, an MS in mechanics, and a PhD in mechanical engineering.[1] He started teaching at IIT in 1962 but left to join the University of Minnesota in 1963 soon after earning his doctorate. He retired in 2009 but remained at the university until his demise. His matter-of-factness about the academic job—"it seemed like a good job, the pay was good enough, the prestige was good enough, and

[1]Quoted phrases and sentences are Dan Joseph's own words, most of them from his remarks upon receiving the 1995 Timoshenko Medal of the American Society of Mechanical Engineers.

I liked ideas and I liked to study"—belies the enjoyment he derived and success he attained in academia.

Dan's interest in fluid dynamics was accidental (as he sometimes said), but the passion he developed was deep and real. He began with a study of fluid flows in geometries with permeable bounding surfaces and ended with considerable interest in small particles that disperse violently upon contact with a liquid surface. As he put it, "My career can…be understood in two phases, the first emphasizing mathematics and the second engineering." This is a plausible basis for summarizing his work.

Another perspective on his career is evident in his publications. Even as he authored or coauthored more than 400 journal articles, many of them highly original and laden with excellent physical understanding, he often viewed research papers as the prelude for writing books. Each of the seven books he wrote, and the six more he edited, represents a different facet of research that interested him at different points of his career and indicates what he regarded as important.

For the "first phase" of his work, Dan focused on the rich topic of stability of fluid motion. He was a pioneer on the energy theory of stability, and his work in this area led to two highly regarded monographs. Among other topics, they present original work on the global stability and uniqueness of flow through annular ducts, Couette flow between rotating cylinders, spiral Couette-Poiseuille flows, and flow between concentric rotating spheres. He also discussed the global stability of a motionless heterogeneous fluid with constant gradients of temperature and concentration, the variational theory of turbulence applied to convection in porous materials heated from below, stability problems for viscoelastic fluids, and problems of interfacial stability. With Gérard Iooss, he wrote the popular textbook *Elementary Stability and Bifurcation Theory* (Springer-Verlag, 1980), whose timing was perfect for the development of the subject.

After a decade of immersion in these mathematical problems, Dan directed his attention to the "second phase" of his research, on engineering problems, one of which was the rheology of viscoelastic fluids with a focus on slow-moving flows. The work did not distance itself from mathematical formulations but made undoubtedly better contact with experiment and data. His book *Fluid Dynamics of Viscoelastic Liquids* (Springer, 1990) develops a tour de force mathematical and physical theory that resulted primarily from the research of his group. A significant discovery was that the unsteady vorticity equation for many models of viscoelastic fluids is hyperbolic, giving rise to waves of vorticity. In steady flows, the vorticity field can be hyperbolic in one place and elliptic in another, as in transonic flows. The key quantity in the discussion of hyperbolic waves of vorticity is the speed of shear waves. Spurred by theory, Dan invented a device in 1986 for measuring the speed of these waves, and followed it up with measurements in a large number of fluids and flows.

His next investigations concerned two-phase fluids, presented in two volumes of *Fundamentals of Two-Fluid Dynamics* (Springer, 1992), coauthored with Yuriko Renardy. A good part of this work concerns the loss of stability of interfaces between phases, an area in which Dan devised a number of elegant experiments to explore physical phenomena and proposed simple explanations for his observations. Another part is concerned with water-lubricated transport of heavy viscous crude oil. The oil travels in a sheath of water along the pipeline, thus reducing the drag and the pumping power, a phenomenon that Dan explained in anthropomorphic terms: "High-viscosity liquids are lazy. Low-viscosity liquids are the victims of the laziness of high-viscosity liquids because they are easy to push around."

Although Dan himself thought there was some discontinuity of emphasis between the "first" and "second" phases of his work, I expect that history will record them as a continuum: the flow configurations he considered in the "second phase" were often not different from those of the "first." There was no doubt, however, that he was turning attention increasingly to experiments and to a style and tradition combining them with analysis to extract an essential physical understanding.

In the late 1980s and early 1990s he realized that analytical theory and experiment alone were insufficient to understand the complex phenomena to which he was drawn. He was proud of his decade or so of commitment to the development of computational approaches that could provide details of the particle-level physics of suspension flows. In fact, he led a multi-institution team to develop efficient direct numerical simulation methods and used them to develop models for particles in dense suspensions. He was a true pioneer in this area. His web-based book *Interrogations of Direct Numerical Simulation of Solid-Liquid Flows* (2002) discusses work in fluidized suspensions in which the inertial effects associated with wakes were identified as important. The "drafting-kissing-tumbling" scenario, corresponding to a rearrangement mechanism by which a sphere interacts with the wake of the preceding one, has now become the standard test case in the validation of direct numerical simulation techniques for particulate flows.

In the last decade of his life Dan worked on viscous irrotational flows, and regarded this work as best suited to his taste—fundamental yet specific. He held the view that, when considering irrotational solutions of the Navier-Stokes equations, it is never necessary, and typically not useful, to put the viscosity to zero; and that, 'though convenient, phrases such as "inviscid potential flow" or "viscous potential flow" confuse properties of the flow (potential or irrotational) with properties of the material (inviscid or viscous): it is better and more accurate to speak of the irrotational flow of an inviscid or viscous fluid. He was quite disappointed that the rest of the community did not share the same level of enthusiasm for this subject. The results obtained by his group, dispersed in a number of scientific articles, were published in *Potential Flows of Viscous and Viscoelastic Fluids* (Cambridge University Press, 2007).

In the midst of this extraordinary research life, Dan somehow found time to serve as associate editor of 13 scientific journals, varying in range from the *Archives of Rational Mechanics and Analysis* to *International Journal of Multiphase Flow* to *SIAM*

Journal of Applied Mathematics. Their diversity provides further evidence of Dan's breadth of interests.

Scholarship did not intrude on his abiding interest in practical matters. He consulted for 13 companies on a variety of problems involving, mostly, multiphase and viscoelastic flows, and held ten patents on tools to address practical problems (e.g., a tensiometer to determine the interfacial tension between immiscible liquids, methods for preventing fouling of pipe walls for lubricated transport, processes for suppressing foam formation in a bubble reactor, and a process for pumping bitumen froth through a pipeline).

In recognition of the impact of his work, Dan was honored in many ways, including membership in both the National Academy of Engineering and National Academy of Sciences, a fellowship of the American Academy of Arts and Sciences, a Guggenheim fellowship, the G.I. Taylor Medal of the Society of Engineering Science, the Timoshenko Medal of the American Society of Mechanical Engineers, the Schlumberger Foundation Award, the Bingham Medal of the Society of Rheology, and the Fluid Dynamics Prize of the American Physical Society, among others.

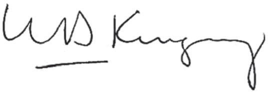
In summary, Dan was a giant in his field. Three accurate characterizations of him were astuteness, creativity, and hard work. In the preface to *Potential Flows*, which he wrote with Toshio Funada and Jing Wang, is this statement: "We worked day and night on this research; Funada in his day and our night and Joseph and Wang in their day and his night. The whole effort was a great pleasure." This work ethic describes Dan to the end. He did not succumb to expensive equipment nor, most of the time, heavy computations. He attributed his success, partly in jest, to his fondness for "low-hanging fruit," but the statement masks his astuteness in selecting problems that required first-order understanding.

He never let a potential controversy, such as an occasional negative review of an article, interfere with his creativity. More than once he said that one "should take care of [one's] reputation." He was a committed jogger for the many years I knew him ("you must take care of your body" was his refrain);

consulted for local and international companies; closely followed the rise and fall of the stock market ("you must take good care of your money"); and did a fair amount of politicking for his students and colleagues. What brought him true pride were the 48 PhD students he supervised ("I owe so much to the string of superb students who have worked with me"). They, in turn, are greatly devoted and loyal to him.

Never one to rest on his laurels, Dan was incessantly pushing himself and those around him to think about new problems. He kept himself young in this way—and, in the minds of many who knew and admired him, he will never die.

He is survived by his wife Kathleen Joseph, sons Charles Joseph and Samuel Guillopé Weissler, daughter Shifra Chana Hendrie, and 13 grandchildren.



W. DAVID KINGERY

1926–2000

Elected in 1975

"Leadership in the science and engineering of ceramic materials, spanning the whole spectrum of physical phenomena, structure-property relationships, innovative processing, and applications to modern technologies."

BY DONALD UHLMANN AND PAMELA B. VANDIVER

WILLIAM DAVID KINGERY, recognized as the father of modern ceramics who effected a paradigm shift in the field, from a focus on craft-type technologies to a discipline based on an integration of solid state physics, chemistry, and crystallography, died of a heart attack on June 29, 2000, at age 73. He played a critical role in establishing ceramics as a materials science and was also a major contributor to archaeological ceramics and art history. He was an inspiring teacher, a mentor to generations of students from around the globe, a valued consultant to industry, an entrepreneur, and a respected advisor to government.

Dave was born on July 27, 1926, in White Plains, New York, the son of a physician. He received a BSc in inorganic chemistry from the Massachusetts Institute of Technology in 1948 and was recruited by F.H. Norton to stay on for his graduate studies. He earned his PhD in 1950 (a remarkably short time spent in graduate school), was appointed to the MIT faculty in 1951, and became a full professor in 1962. In 1987, he left for the University of Arizona, where he was a professor of materials science and engineering and of anthropology, initiated an interdisciplinary program on culture, science, and technology, and was named Regents' Professor.

His research in physical ceramics spanned a remarkably broad front. He made major contributions in areas as disparate as ceramic processing, diffusion in ceramics, sintering of ceramic particles by various mechanisms, grain boundaries in ionic crystals, thermal conductivity in ceramics, and even the mechanical properties of ice and snow (rather unusual ceramic materials), to name only a few. In all cases, he combined elegant experimental characterization of materials with physical and mathematical modeling of the observed behavior to yield critical insight.

His research was published in several hundred papers, and he authored, coauthored, or edited more than a dozen books on a variety of subjects, from *Ceramic Fabrication Processes* (John Wiley & Sons, 1958) and *Kinetics of High-Temperature Processes* (John Wiley & Sons, 1959) to *Ceramic Masterpieces: Art, Structure, and Technology* (Free Press, 1986) and *Ceramics and Civilization* (American Ceramic Society; a multivolume series). The best known of his books is the classic *Introduction to Ceramics* (John Wiley & Sons, 1960), which was translated into many languages and served as a bible for generations of students in ceramics around the world.

Dave received nearly every award of the American Ceramic Society (ACerS) and in 1983 became a Distinguished Life Member. In 1992 the Society established the W. David Kingery Award, of which he was the first recipient. He was a distinguished lecturer at several universities around the world, and the first chair of the board of trustees of the International Academy of Ceramics. He became a member of the National Academy of Engineering in 1975, a member of the American Academy of Arts and Sciences in 1984, and in 1999 he was awarded the prestigious Kyoto Prize in Advanced Technology for his fundamental contributions to ceramic science and technology. He received honorary doctorates from the Tokyo Institute of Technology and the École Polytechnique Fédérale de Lausanne.

In parallel to his classic work on physical ceramics, he observed and studied the formation of scientific problems with the creative anticipation of solutions and their potential impact. He taught a graduate class, "Planning for Discovery," that is celebrated as a key to success by many of his students.

Starting in the 1960s he applied his knowledge of ceramic processes and problem formation to ancient ceramics, first by establishing a microscopic method of determining original firing conditions and later by systematically determining what methods of materials research were applicable to archaeological ceramics and refractories. Later studies focused on particular art objects representative of an unknown or poorly characterized practice, and ancient technologies were investigated in terms of variability in time and geography, essentially using an anthropological paradigm. *Ceramic Masterpieces* reported research on the phases as well as the microstructure and microcompositional variations that are the structure of ceramic art objects to explain the appearance, variability, and optical properties of a ceramic practice.

In Dave's edited volumes from his year at the Smithsonian, *History from Things* (Smithsonian Books, 1995) and *Learning from Things* (Smithsonian Institution Press, 1998), he expanded his view to objects in other materials and to historical and cultural interpretation. He used the same strategy to study ancient technologies as modern ones, and opened an interdisciplinary collaboration involving art, science, and conservation. In starting the Material Culture Forum at the Smithsonian, he explored how and what we can learn from objects and the development of a common vocabulary across many scholarly fields. Similarly, in the ten-volume series *Ceramics and Civilization*, he assembled contributors to ACerS meetings and recognized their strides and interconnections in understanding particular ancient and modern high-tech ceramics, cross-craft interactions, craft organization, and special classes of materials and kilns.

Invention cannot be established in the archaeological record, but innovation as development can, and, with appropriate historical records, can be traced, as in Dave's study of lighting filaments. This iconic study led him to pursue an empirical approach to the study of the processes of rapid technological developments in ceramics by comparing and contrasting innovation through cross-cultural studies. The resulting conference and volume, *Japanese/American Technological Innovation: The Influence of Cultural Differences on Japanese and American Innovation in Advanced Materials* (Appleton & Lange, 1991), involved participants in and leaders of the revolution as well as observers, anthropologists, and sociologists in first eliminating common myths and biases and proceeding to case studies and their assessment.

Dave often said, "You have to know something to learn something"; he would probably agree that this statement characterizes much of the creative engineering of the 20th century as well as his own contributions. He was not only a thoughtful and accomplished academician but also an engineer with a keen interest in and knowledge of technology. In this capacity he contributed valuable insight to the numerous companies for which he served as a consultant, and also formed a company, Lexington Laboratories, to develop and commercialize some of his ideas for new technology. Out of this company came, among other technological advances, the basic patent on injection molding of ceramics.

He consistently demonstrated a knack for identifying the critical elements in complex, multivariable problems and a remarkable ability to master those elements and obtain creative solutions to the problems. He further advanced the field through the accomplishments of his students and of the young faculty he mentored and inspired, through the motivation and insight that speakers derived from the probing questions that were his hallmark, and through the ideas he advanced in meetings large and small.

Dave was also an ardent sailor, and generations of MIT students experienced first-hand his joy of sailing. He organized the Marion-Bermuda Yacht Race and was an active participant for many years. Oceans were no barrier for him: he sailed across the Atlantic to Europe (during which his vessel was de-masted) and across the Pacific to Tahiti, both for sabbaticals. When he got to Arizona he took up horseback riding and learned to pilot a plane.

When Dave passed away, shortly after his active participation in a meeting of the Academy of Ceramics in Naples, the world lost a brilliant engineer, a creative mind, a master of scientific principles, a motivating teacher, a real innovator, and the man who made ceramics a scientific and engineering discipline. The authors of this brief tribute lost a mentor and dear friend.

WARNER T. KOITER

1914–1997

Elected in 1977

"Contributions to solid mechanics, stability theory, aircraft safety, and aeronautics."

BY JOHN W. HUTCHINSON

WARNER TJARDUS KOITER, the world's leading expert on elastic stability theory and shell theory, died at the age of 83 on September 2, 1997.

He was born in Amsterdam on June 16, 1914, and grew up in the eastern region of the Netherlands in the town of Zutphen. His academic career, from his BSc and MSc (1931–1936) to his PhD (completed in 1945), was spent at the Technological University of Delft. Before becoming chair of Applied Mechanics there in 1949 he worked in several government research positions mainly related to aircraft development, including the National Aeronautical Research Institute (1936–1938) and the Department of Civil Aviation (1939–1949), where he became head of the Engineering Division.

During his career he made fundamental contributions to some of the most important areas of aeronautical structures and solid mechanics more broadly. His PhD thesis on elastic stability is regarded by many in the field of solid mechanics as perhaps the most important thesis of the past century. He applied his stability theory to plate and shell buckling problems arising in aeronautics, and was the lead researcher in the continuing development of shell theory during this period. He made seminal contributions to plasticity theory, crack mechanics, and understanding of the interplay between buckling and imperfection sensitivity in structural optimization.

In addition to his research, he was one of the most effective and visible leaders in the international mechanics community, serving for many years on the executive council of the International Union of Theoretical and Applied Mechanics (IUTAM). He was also active in the Netherlands on national committees devoted to aircraft development and safety.

The story of Koiter's thesis, *Over de stabiliteit van het elastisch evenwicht* (*On the Stability of Elastic Equilibrium*; Uitgeverij H.J. Paris, 1945), deserves telling.[1] A strong tradition existed in structures and mechanics at Delft, personified by Koiter's thesis supervisor, Cornelis Benjamin Biezeno. In the first half of the 20th century, it had become clear that there was a major discrepancy between experimentally measured buckling loads for the elastic buckling of many shell structures and theoretical buckling predictions derived from shell theory. The behavior was in stark contrast with the well-established behavior of columns and plates, for which the elastic buckling predictions of idealized geometries were generally in good agreement with buckling experiments. Some attributed the discrepancy to the inadequacy of existing shell theories.

Koiter instead explored the nature of the solution that bifurcates from the state of fundamental compression using perturbation techniques in a completely general framework applicable to any conservative elastic solid or structural system. In addition, he took into account the influence of small imperfections in the geometry of the structure, which for shells are slight undulations of the middle surface or small thickness variations.

Although most column and plate structures have stable postbuckling behavior and are relatively insensitive to imperfections, Koiter found that many shell structures have unstable postbuckling behavior and, concomitantly, are highly sensitive

[1]Parts of this story and other information in this tribute were informed by the 1999 memoir of W.T. Koiter by a colleague from the Netherlands, D.H. van Campen, published in *Biographical Memoirs of Fellows of the Royal Society London* 45:269–273.

to imperfections because they drastically lower the maximum load the structure can carry. The cylindrical shell under axial compression and the spherical shell under external pressure are the most imperfection-sensitive, with experientially measured loads that are typically as low as one fifth of the prediction for the perfect shell.

Koiter carried out his thesis work in the dark period of World War II when the occupiers of the Netherlands did not permit publication in the country's native language. Although his thesis was completed in 1942 he delayed publication until 1945 when it could be published in Dutch, and then it was almost two decades before the rest of the world began to appreciate his thesis. More than any other individual, Bernard Budiansky at Harvard University, with the aid of an Afrikaans colleague who translated the Dutch, accelerated the dissemination by publishing papers applying Koiter's theory to a series of important shell problems. Budiansky was assisted in this task by the writer of this memoir who made the mistake of asking Koiter, when they first met, why he had not published his thesis. Looking down his long nose at the neophyte researcher, Koiter replied that he *had* published it, in Dutch!

Nearly all of his subsequent papers were published in English—and with a command of the language matched by few technical authors. He claimed that he polished his English writing skills by reading Winston Churchill's history of the Second World War. Although he resisted all attempts to republish his thesis, we are fortunate that a former student and colleague, Arnold van der Heijden, published a book that comprehensively presents Koiter's course lectures on elastic stability.[2]

Koiter was also a dominant figure in the development of shell theory in the two decades beginning in the mid-1950s. His major new contributions were to nonlinear shell theory, but he also performed an enormous service to the field by helping to settle the fractious dispute about which of the

[2]van der Heijden, A.M.A., ed. 2009. *W.T. Koiter's Lectures on the Elastic Stability of Solids and Structures*. Cambridge University Press.

many competing systems of linear shell theory equations was the correct one. He showed that certain differences between one theory and another were allowable, and indeed inevitable, owing to the errors inherent in the construction of two-dimensional equations for a shell as an approximation to the three-dimensional body. He established that several (but not all) of the competing theories were equivalent within these inherent errors. In fact, the linear shell equations in the classic elasticity treatise of A.E.H. Love, first published in 1911, were shown to be among those acceptable (when the Beatles became popular, Koiter even delivered a talk entitled "All You Need Is Love").

The state of affairs for nonlinear shell theory was far from satisfactory in 1960. Buckling phenomena are inherently nonlinear and in his thesis Koiter had addressed some of the unresolved issues of nonlinear shell theory. Because no single set of equations is capable of characterizing all nonlinear shell phenomena, a specific set of equations must be identified for a given class of problems (e.g., large strain membrane behavior versus finite amplitude bending and stretching). His subsequent contributions, which expanded on those of J. Lyell Sanders published in 1962, systematically laid out various nonlinear shell theory approximations and identified the class of problems for which each would be accurate.

Koiter's enormous stature in the mechanics community was also reflected by his leadership role in IUTAM, for which he served on the executive committee for 16 years, including as president (1968–1972). His service coincided with the period in which outstanding mechanicians from the Soviet Union had increasing, but complicated, interactions with counterparts from the west. Such difficulties, and Koiter's strength of character, were illustrated by the 1976 IUTAM International Congress held in Delft and chaired by Koiter. As was not uncommon during this period, authorities in the Soviet Union manipulated the list of attendees such that a number of the most prominent Soviet invitees did not appear but were replaced by others with the idea that these individuals would fill the open lecture slots. This was unacceptable to Koiter and his colleagues and they decided against reassigning these slots as a silent, but effective, protest.

Koiter's contributions were internationally recognized by medals, honorary degrees, and academy memberships. He was elected to the Royal Netherlands Academy of Sciences in 1959, the US National Academy of Engineering in 1977 (as a foreign member), the French Academy of Sciences in 1981, and the Royal Society of London in 1982. In 1965 he was awarded the Theodore von Kármán Medal of the American Society of Civil Engineers. In 1968 he received the Timoshenko Medal of the American Society of Mechanical Engineers (ASME) and in 1980 he became an honorary member of the society. In 1996 ASME created the Warner T. Koiter Medal to be awarded every year to a solid mechanician distinguished in both research and international leadership, reflecting the career of its namesake. The writer of this memoir had the honor of presenting on behalf of ASME the first Koiter Medal to Koiter himself at a festive gathering of his former students, colleagues, and family at Delft in January 1997.

Koiter was a devoted family man, married in 1939 to Louise Clara, known affectionately by all as Lous. They raised two boys and two girls.

DANIE G. KRIGE

1919–2013

Elected in 2010

"For development of statistical methods and their application to resource valuation."

BY RAJA V. RAMANI

DANIE GERHARDUS KRIGE, a pioneer in the application of basic tenets of mathematical statistics to evaluation of mineral ore deposits, died on March 2, 2013, at the age of 93 in Johannesburg. He is survived by his wife Ansie, son Jaco and wife Maria, daughter Tersia and husband Tinus, daughter Helene and husband Johan, daughter Annemarie, stepdaughter Anelle and husband Johan, stepdaughter Elna, and 19 grandchildren.

In a professional career spanning more than seven decades and punctuated with significant achievements, Krige made fundamental contributions to the art and science of orebody evaluation very early in his career, revolutionizing the application of statistical techniques to this important area. For his pioneering contributions he was elected to the National Academy of Engineering in 2010, the first person from not only South Africa but the African continent.

Danie was born August 26, 1919, in Bothaville, Orange Free State (OFS), South Africa. At the age of 19 he graduated from the University of the Witwatersrand (Wits) with a bachelor's degree in mining engineering. From 1938 to 1943 he worked for the Anglovaal Group in its gold mines, gaining valuable practical experience in surveying, sampling, and ore valuation. This was followed by an appointment on the technical staff of the Government Mine Engineer's Department, where his responsibilities included uranium price negotiations with the British and American authorities and the handling of lease applications in the OFS and Klerksdorp gold fields.

His experience led to his concern that decisions of critical importance were being made on a limited number of drill hole samples without sound scientific analysis of the risks of failure. He therefore began research on the development of statistical methods and their application to resource evaluation. His early work concentrated on improving the solutions of mine valuation problems on the Rand from values at sampled locations using specialized statistical techniques.

In 1951 he was awarded an MSc in engineering from the Wits for his research on the application of mathematical statistics to ore evaluation. His work laid the foundation for important mining industry sampling and estimation concepts such as sample support, spatial structure, weighted moving averages, selective mining units, and ore tonnage curves. His early papers were translated into French and led to a worldwide interest in the adoption of new techniques to increase the efficacy of reserve estimation.

In 1952 he returned to Anglovaal as financial engineer, with responsibility for ore evaluations, mining projects, financial and share valuations, and technical computing facilities. He made outstanding contributions in a number of areas, particularly financial risk analysis in mine investment and the role of mine taxation on industry development.

His research into ore evaluation continued mainly in practical applications. He carried his message to all the major mining districts of the world with lots of case studies, making converts in many countries. His early work also expanded into the new field of geostatistics, the application of statistics to the study of spatial correlation and spatial extrapolation in earth sciences, particularly geology. In 1963 he received a DSc from the Wits.

In recognition of his contribution to the emerging field, in 1963 the interpolation technique in geostatistics in which the surrounding measured values are weighted to derive a predicted value for an unmeasured location was dubbed *Kriging* by Georges Matheron, founder of the Centre de Géostatistique et de Morphologie Mathématique, in Fontainebleau, France. Geostatistical tools, particularly Kriging, are now used extensively for analyzing spatiotemporal datasets in such diverse fields as hydrology, meteorology, biology, forestry, geography, and medicine, to name a few.

Danie retired from Anglovaal in 1981 and joined the Wits Mining Engineering Department, where he taught and researched on geostatistics and mineral economics. The next ten years saw him direct students from around the world to graduate degrees, blending words of wise counsel and guidance with words of caution and correction, always with love and encouragement.

From 1991 until a short time before his demise, he remained active as a highly sought after mining consultant for ore evaluation and financial analysis for several South African and international mining and consulting companies.

He was repeatedly honored by his beloved South Africa as a great ambassador for the country. In 1989 he was recognized by the South African president with the Order for Meritorious Service Class 1 Gold medal, and again in 2012 with the Order of the Baobab (Silver) for exceptional and distinguished contributions in business and the economy, science, medicine, and technological innovation and community service.

Danie was active in many technical and professional societies in South Africa, both in the trenches and in leadership roles. As a professional engineer, he served for many years on the mining committee of the Engineering Council of South Africa. He was elected an honorary life member of the South African Institute of Mining and Metallurgy, which he served as a treasurer for an extended period of time and from which he received several honors: gold medals in 1980 and 1996, silver medals in 1979 and 1993, and the highest award, the Brigadier Stokes Memorial Award (a platinum medal), in 1984. In 1982 the South African Akademie vir Wetenskap en Kuns gave him the Gold Medal for Scientific and Technical Achievements.

Danie saw the need for professionals in specialized fields to get together to further science and applications in a timely manner, and founded organizations to facilitate this. He is a founding member and honorary life fellow of the South African Statistical Association, and was at the birth of the South African and Australian Geostatistical Associations. He is an honorary life member of the Institute of Mine Surveyors of South Africa and a fellow of the Royal Society of South Africa. In 1998 he received the Royal Society's John Herschel Gold Medal for outstanding contributions to science in South Africa.

He was also the recipient of several major international awards. He was a founding member of the International Association of Mathematical Geology, which awarded him the William Christian Krumbein Medal in 1984 and called him the "father of mathematical mining geology." In 1987 the Society for Mining, Metallurgy, and Exploration honored him with the prestigious Daniel C. Jackling Award and in 1988 made him a Distinguished Member, the first South African to receive these recognitions.

Danie was a constant presence at the symposia on the Application of Computers and Operations Research in the Mineral Industries (APCOM) and represented South Africa on the APCOM International Council. A positive voice for expanding both the council and international participation, he was the first elected council chair who was not from the United States. He was awarded the APCOM Distinguished Achievement Award in 1989.

Danie was a most prolific author, with over 100 publications in leading journals, symposium proceedings, and handbooks. His monograph on the *Lognormal–de Wijsian Geostatistics for Ore Evaluation* (South African Institute of Mining and Metallurgy, 1981) is an excellent overview of early statistical developments, the three-parameter lognormal distribution, and later developments in geostatistics.

Always in demand as a speaker, he delivered keynote speeches at congresses and lectured at universities in Australia, Canada, Chile, China, Colombia, France, Germany, Greece, Italy, Russia, Slovenia, South Africa, Spain, Taiwan, the United Kingdom, and the United States. He received honorary doctorates from the University of Pretoria (1981), University of South Africa (1996), Moscow State Mining University (1997), and University of Witwatersrand (2011).

To appreciate Danie Krige merely as a great mining engineer and an expert geostatistician would be a disservice to a great man. He was brilliant and famous yet very humble, caring, and approachable. His simplicity left a deep impression on all—colleagues, friends, and students—who came to know him, and all loved and respected the man. I met him in 1968, when he was already a giant in the field, and several times after that, the last time in 2010. After each meeting, I came away with a sense that he was investing in me, challenging me with new ideas and with a desire that I succeed.

Till his last breath, Danie was devoted to every one of his passions—Ansie and their children, his friends and students, the mining industry, South Africa, and APCOM. We will miss his physical presence, but will have his legacy for all time.

DAVID M. LEDERMAN

1944–2012

Elected in 2002

"For designing, developing, and commercializing heart failure assist and heart replacement devices, and for leadership in engineering science education."

BY JOHN T. WATSON

DAVID M. LEDERMAN, a brilliant engineer, entrepreneur, friend, and family man, who created the environment for and led the development of the first fully implantable artificial heart (TAH), died on August 15, 2012, at his home in Marblehead, Massachusetts, at the young age of 68.

Working with Robert T.V. Kung and Param Singh, David set out to design and develop a fully implantable TAH, the AbioCor, which became a scientific and engineering phenomenon. The requirements for the AbioCor are analogous to the complexity of submerging an unmanned, unprogramed submarine that travels around the world and returns to the same location some years later without any outside help.

Twenty years after their quest began, a patient lived with the AbioCor for 17 months in central Kentucky. Surgeons Laman Gray and Robert Dowling implanted the AbioCor and treated Tom Christerson, who had less than a month to live when he received the device. Gray deemed the AbioCor the most sophisticated device ever implanted in a human being.

David Mordechai Lederman was born in Bogotá, Colombia, on May 26, 1944. His parents, Rifka and Israel Joseph Lederman, had emigrated from Poland to escape the Nazis. David was educated at the Colegio Americano and then studied at the Universidad de los Andes, both in Bogotá.

In 1964 he moved to the United States to study engineering physics at Cornell University. He received degrees simultaneously from both Cornell and the Universidad de los Andes in Bogotá in 1966 and went on to earn a master's degree in aerospace engineering and a PhD in laser physics/aerospace engineering from Cornell. He returned to Colombia to become an associate professor and director of biomedical research at the Universidad de los Andes. In 1974 he came back to the United States to work for Avco Everett Research Laboratory in Boston, where he worked on cardiac assist technology. He was hired as a senior research scientist and in 1979 was named chair of the Medical Research Committee.

We met in the late 1970s when I was chief of the Devices and Technology Branch of the National Heart, Lung, and Blood Institute (NHLBI). The institute's policy was to conduct site visits with research contractors, such as Avco, on a regular basis; David and I met during one such visit. It was obvious that he held the respect of his colleagues and was dedicated to leading the team to create innovative solutions for treating heart failure. We quickly became professional friends.

A few years later, on a crisp morning in 1981, we were walking around the footings of a new construction site in the Danvers (MA) Business Park. David was starting the federal contract novation process to transfer the Avco cardiac assist program to his new company, Abiomed. The site visit was to ensure that the new entity had the facilities, financial systems, personnel, intellectual property, and equipment to complete the research projects funded by the NHLBI. It was clear that David was not only an outstanding engineer but also a natural businessman who could complete the novation process and make Abiomed a success.

A remarkable turn of events occurred in the late 1980s. Based on the recommendations of outside experts, in January 1988 the NHLBI awarded contracts worth more than $22 million to four research groups to continue research and development of the TAH. Four months later, the NHLBI announced that support for developing and integrating systems for a TAH would be suspended as of September. The director, Claude Lenfant, stated in a *New York Times* editorial that "The human body just couldn't seem to tolerate it." The decision was based on the experience of Barney Clark and four other patients implanted with a tethered TAH rather than a fully implanted artificial heart.

David contended that this decision was based on outdated technology and conveyed a well-supported vision for the future of the technology, with continued public funding, to Senator Edward Kennedy (D-MA). Soon Senators Orrin Hatch (R-UT), ranking Republican on the Senate committee that approved NIH authorizations, and Kennedy, chair of the committee, were working together to suggest to the NIH that it was premature to eliminate the expert clinical, engineering, and technological capacity needed to develop an implantable TAH.

Senator Hatch, with the backing of Senator Kennedy, drafted legislation that would require NIH to fulfill existing contracts, such as those supporting the TAH development, before starting any new programs. The American Heart Association and the American College of Cardiology also voiced concern and requested that the TAH program be restored because of the clinical need. Based on David's reasoned assessment, the input of the clinical community, and the efforts of Congress, the TAH research contracts were restored by the end of 1988. This funding provided the support needed for the AbioCor design.

Although only 15 patients received the AbioCor, thousands of heart failure patients have benefitted from the innovative technologies that Abiomed has created to assist and replace the cardiac function of the heart—in 2012 more than 2,000 heart failure patients received a ventricular assist system. As a result of David's contributions, many of these patients will live 10 meaningful years—or longer—with their medical implant.

David was quick to share his research and business experience, and published and lectured on many aspects of implantable medical device science and engineering. He also served on advisory boards at Cornell and the University of California at San Diego.

He had many happy moments with friends and family. He had compassion for all, sometimes even putting their health above his own. At his funeral at Chabad of the North Shore in Swampscott, he was remembered as a great scientist/engineer, and as a humanitarian who funded a summer camp north of Boston for Israeli children from the town of Sderot when it was being shelled by rockets from Gaza.

"He had integrity, honesty, and compassion, all wrapped up in one very intelligent person," said Dr. Kung, who met Lederman at Cornell. "I think he went too early, but he left his legacy. He touched many, many people's lives."

He is survived by his wife of 45 years, the former Natalie Hirsch, son Jonathan and daughter Jeanine Goodwin, 10 grandchildren, sister Pearl Awenstern, and brothers Max and Benjamin.

TINGYE LI

1931–2012

Elected in 1980

"Co-discovering the existence of low-loss electromagnetic-wave modes in open structures with application to laser resonators."

BY HERWIG KOGELNIK

TINGYE LI, an inspired visionary research leader in the fields of lasers and optical fiber telecommunications at Bell Labs and later at AT&T Research, died on December 27, 2012, at the age of 81.

Tingye was born in Nanjing, China, on July 7, 1931. As the son of a diplomat, he saw much of the world in his early youth, and his travels continued throughout his life. In recent years he traveled more than one gigameter to and from China.

He received a BSc degree in electrical engineering from the University of Witwatersrand, Johannesburg, South Africa, in 1953, and MS and PhD degrees in electrical engineering from Northwestern University in 1955 and 1958, respectively. He was also awarded an honorary doctor of engineering degree from National Chiao Tung University, Hsinchu, Taiwan, in 1991, and an honorary doctorate from the University of Witwatersrand in 2011.

He joined AT&T Bell Laboratories, in Holmdel, New Jersey, in 1957, where he did research in the fields of antennas, microwave propagation, lasers, and optical communications, and contributed more than 90 patents, papers, and book chapters in these fields.

He first worked on antenna research. One of his publications, which appeared in the July 1963 special Telstar issue of the *Bell System Technical Journal*, deals with the radiation pattern of the famous horn antenna at the Bell Labs Crawford Hill Laboratory that is now a National Historic Landmark. It was designed and used for the world's first experiments in satellite communications, project Echo in 1960 and Telstar in 1962. This antenna was later used by Bell Labs radio astronomers Arno Penzias and Bob Wilson, who found the microwave background radiation originating from the Big Bang that created the universe and later received the Nobel Prize for this discovery.

Modern optical communications require lasers and optical fibers. Tingye got into lasers very early using the Huygens-Fresnel integral he had learned from antenna theory. He teamed with A.G. Fox and contributed a groundbreaking paper on laser resonators, starting research worldwide in the field of laser beams and resonators. Their paper, "Resonant Modes in a Maser Interferometer," appeared in the *Bell System Technical Journal* of March 1961; in 1979 it was named a Citation Classic. This pioneering work on laser resonator theory showed the existence of transverse laser resonator modes, provided for their understanding, and led to much further research. It showed that a laser beam bouncing back and forth between a pair of mirrors can resonate in a number of modes of energy distribution; each mode has a different characteristic phase velocity and diffraction loss per transit.

Tingye continued to write important papers in this field, including "Laser Beams and Resonators" (coauthored with this author), published in *Applied Optics* in October 1966. The article was noted in the journal's 50th anniversary issue as the second most cited paper in its history.

As a result of their pioneering work, Fox and Li received the 1979 IEEE David Sarnoff Award, "For the discovery of modes in open structures and their applications to laser resonators," and in 1980 he was elected to the National Academy of Engineering. He was also elected to the Chinese Academy of Engineering and to the Academia Sinica.

In 1967 Li was appointed head of the Repeater Techniques Research Department at the Crawford Hill Laboratory, with responsibility for research on optoelectronic devices and signal regenerators for optical communication. Soon after the early low-loss fibers and continuously operating semiconductor junction lasers were announced, Tingye and his department succeeded with an experimental demonstration of a prototype optical repeater for a fiber optic transmission system operating at 6.3 Mb/second. In 1972 he presented these results at Crawford Hill to top AT&T executives and the results were documented in the *Bell Laboratories Record* of May 1973. This milestone accomplishment was an important factor in the AT&T decision to consider optical fiber transmission, and led to the Chicago Project of 1977, in which AT&T installed 1½ miles of fiber in the city's public network and transmitted messages at a bit rate of 44.7 Mb/second.

From 1976 to 1984 Li led the Transmission and Circuit Research Department and, briefly, the Lightwave Media Research Department, concerned with research on transmission media and circuitry for optical fiber systems. From 1984 to 1996 he headed the Lightwave Systems Research Department, in charge of research on high-speed techniques and high-capacity systems for lightwave transmission and networking. In these capacities he and his department were deeply involved in the research that led to the worldwide commercial application of optical fiber communications and to the exponential growth of the capabilities of lightwave systems: the capacity per fiber increased by approximately a factor of 100 every ten years, from the 6.3 Mb/second of the early research system to research demonstrations exceeding 100 terabits/second. Commercial deployment of advanced systems was generally five to seven years behind the laboratory demonstrations. Key innovations that enabled these advances included single-mode fibers, single-frequency lasers, erbium-doped fiber amplifiers, and wavelength-division multiplexing (WDM). Details of these advances are reported in Li's article "The Impact of Optical Amplifiers on Long-Distance Lightwave Telecommunications" in the November 1993 *Proceedings of the IEEE*.

During this time of rapid worldwide technological advances, Tingye's Systems Research Department was recognized as a world leader in high-speed single-channel fiber transmission. He and his colleagues did early work on WDM systems, testing and selecting the best technology components with the final goal of a practical systems demonstration. Their success stimulated a field trial by AT&T at its Roaring Creek Facility (Pennsylvania) that was also very successful. The trial was published by Jonathan A. Nagel and colleagues at the Optical Society of America (OSA) Topical Meeting in 1992, describing their use of optical amplifiers and four WDM channels operating at 1.7 Gb/s each.

Another of their milestone accomplishments was documented in an article by Andrew R. Chraplyvy and colleagues entitled "8*10 Gb/s Transmission through 280 km of Dispersion-Managed Fiber" in the *IEEE Photonics Technology Letters* of October 1993. Then came the breaking of the one-terabit-barrier announced at the Optical Fiber Communications Conference of 1996 in a presentation by Alan H. Gnauck and colleagues titled "One Terabit/s Transmission Experiment."

In 1996 Li was appointed manager of AT&T's Communication Infrastructure Research Laboratory. He retired in 1998 and worked as a consultant, including for several startup companies.

Tingye Li was admirably active in the worldwide research community in lasers and optical fiber communications. He was a member of the program committee of the first conference on optical fiber communication (OFC) held in Williamsburg in 1975; in 1982 he chaired the program committee and in 1984 the conference. In addition, he was a program committee cochair and general cochair of the Conferences on Lasers and Electro-Optics (CLEO).

He was a fellow of the OSA, the Institute of Electrical and Electronics Engineers (IEEE), and the American Association for the Advancement of Science. His professional society activities included chairing the Photonics Division of the OSA Technical Council and the OSA International Activities Committee; he was also a member of the board of governors and chair of the awards committee of the IEEE Lasers and

Electro-Optics Society. He was elected OSA vice president in 1993 and president in 1995.

He was a member of the editorial boards of the *Proceedings of the IEEE* and *Microwave and Optical Technology Letters*, associate editor and topical editor of *Optics Letters*, associate editor of the *Journal of Fiber and Integrated Optics* and *IEEE/OSA Journal of Lightwave Technology*, and guest editor of a special issue of the *IEEE Journal of Quantum Electronics* on devices for optical fiber communications. He edited a book series on *Optical Fiber Telecommunications* that has served for three decades as the comprehensive primary resource covering progress in the science and technology of optical fiber telecom. It is an essential for the bookshelves of scientists and engineers active in the field.

Li's highly successful leadership in optical fiber communication was recognized by a string of awards, including the 1995 OSA/IEEE John Tyndall Award for "sustained advances in high-capacity optical fiber communication systems created by his pioneering research, leadership, and personal contributions over more than two decades"; the 1997 Frederic Ives Medal, OSA's highest award, recognizing overall distinction in optics; the 2004 IEEE Photonics Award for "leadership, vision, and pioneering contributions in the field of optical fiber communications and laser science"; and the 2009 Edison Medal for "leadership, vision and pioneering contributions in the field of broadband optical fiber communications."

As a research leader, Tingye attracted great talent to his department at Bell Labs. He used to say "I hire only people who are smarter than I am"; indeed, several former members of his department are now members of the NAE. He had unusual wisdom, great insights, and was an outstanding and encouraging mentor of younger generations. At Bell Labs in Crawford Hill he did many things that enhanced the intellectual level for all of us (for example, he considerably improved this author's writing in English). He also made sure that we understood that China invented almost everything, including paper, printing, gun powder, and the compass. And he taught us quite a bit about Kung Fu-Tsu and his sayings, one of which is a perfect description of Tingye: "The superior man is modest in his speech, but exceeds in his actions."

Tingye's family was a great source of pride for him. He had met his future wife Edith Wu at Northwestern University and told his friends "I wooed Wu and won Wu." They married in 1956 and had two daughters, Debbie and Kathy. Kathy writes:

> Dad, or "Gung Gung" to his grandchildren, was someone who not only taught us valuable lessons in life but also showed us how to live. From his skiing adventures to his "China 101" educational trips with his daughters and their families, to his globe-trotting trips with Mom, he always enjoyed to the fullest, wherever he went. Every Christmas he spent in Snowbird, Utah, one of his favorite places. We celebrated Christmas, Chanukah, family, and great skiing. In the early years, he would often stay inside to play with [grandchildren] Jessi and Michael. Later, he took them down Chickadee and Big Emma, the beginner runs. And later, he was so proud of their skiing as they became athletic, expert skiers. But almost every night, we'd sit down for dinner, three generations, at the same table and talk about our day on the slopes.

Debbie concludes:

> So much of what my father embodied can be described in one word: passion. He lived his life with passion—a joie de vivre. And this approach to life he passed on to his children and grandchildren. Our family grabbed at the opportunity to move to London because Gung Gung had lived all over the world and had told us so many exciting stories. [Grandchildren] Jay and Scott have found careers that combine their strengths and their passions. Skiing, photography, poetry, travel, and a love for Chinese art and oriental rugs—all are in our lives because of him.
>
> My father sometimes lamented the fact that the Li family name would not be continued in future generations as he only had daughters and nieces. However, he did not realize that the legacy of Tingye Li would truly live on forever in the countless stories, memories, and pearls of wisdom his family, friends, and colleagues cherish and will continue to pass on for many years to come.

STEPHEN MALKIN

1941–2013

Elected in 2008

"For pioneering research in and the implementation of grinding-system simulation and optimization."

BY YORAM KOREN

STEPHEN MALKIN, an internationally renowned guiding force in manufacturing science and a University Distinguished Professor Emeritus at the University of Massachusetts Amherst, passed away on August 19, 2013, at the age of 72.

Steve was born in Malden, Massachusetts, on June 20, 1941. In high school he was an ambitious student who pushed himself to excel, so it is no surprise that he was admitted to the Massachusetts Institute of Technology, where he completed his bachelor's degree in 1963. He got a taste of research during his undergraduate studies and decided to attend graduate school at MIT, specializing in manufacturing engineering. He earned his MSc in 1965 and his ScD in mechanical engineering in 1968.

In 1968 Steve became an assistant professor at the University of Texas, Austin, and in 1974 he moved to the University of New York in Buffalo, where he was promoted to associate professor. In 1976 he emigrated to Israel, where he was a professor at the Technion–Israel Institute of Technology until 1986, when he returned to the United States and became a professor of mechanical engineering at the University of Massachusetts Amherst. From 1987 to 1995 he was director of the university's Manufacturing Engineering Program and cofounder of the Center for Manufacturing Productivity, which paired faculty members with small- to medium-sized manufacturers to enhance productivity and competitiveness. He was named Distinguished Professor in 1998, and headed the Department of Mechanical and Industrial Engineering from 2000 to 2006. He retired in 2009.

Steve did a superb job during his two terms as department head. He was a visionary, a leader, and above all an excellent mentor for younger faculty members, as evidenced by the number of new faculty members who were hired or promoted and nationally and internationally recognized during his tenure.

His unique style of inclusiveness and impartiality together with his intellectual and professional rigor were demonstrated in several of his initiatives, which highlight the department's diversity and richness. The wind energy and human performance programs became internationally prominent and have been recognized as the two signature programs of the department and the college. And the department's human and fiscal resources grew significantly: many new faculty members were hired, enrollment increased by over 50 percent, and research expenditures increased by 44 percent.

A primary objective of Steve's early research was to develop both a fundamental understanding and quantitative models to describe the diverse aspects of grinding, including the mechanics of the process, temperatures, thermal damage to the workpiece, precision, and surface topography. He then realized that this fundamental processing knowledge could be more practically applied by taking a comprehensive systems approach in which the grinding model parameters are updated and intelligent control is used to optimize the process. He developed a virtual manufacturing system that provides quantitative and visual computerized simulation of the process to predict what will occur and to identify optimal conditions. These simulations are currently used in industry and, according to experts, have saved millions of dollars. Among the companies that use his methods are General Motors, Ford Motor Company, SKF, General Electric, Alcoa, Norton, Eaton Corp., Pratt & Whitney

(United Technologies), Caterpillar, AlliedSignal, the Timken Company, TRW, Warner & Swasey, and Iscar Blades.

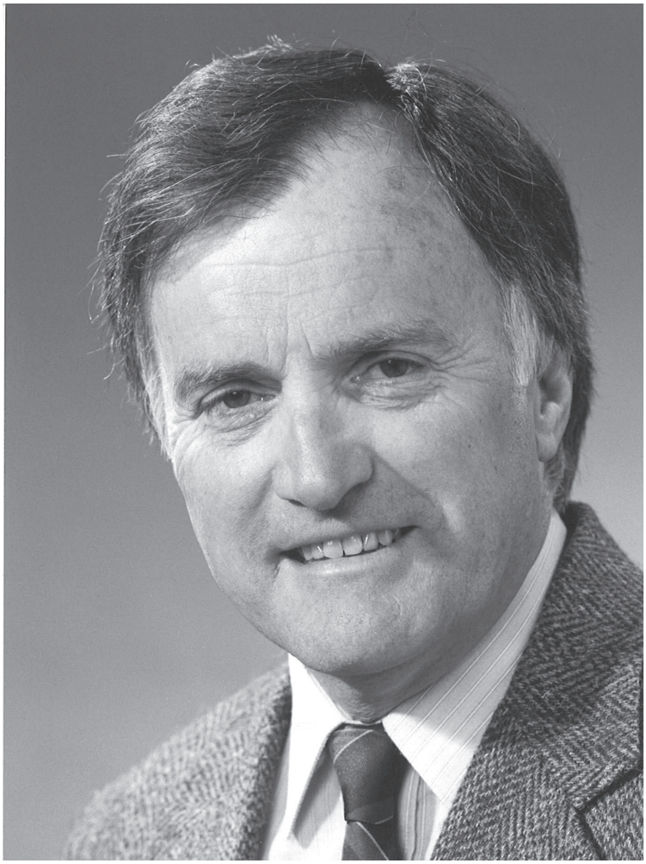
Steve Malkin authored a scholarly body of papers that spearheaded innovative research in modern grinding optimization technology, and he was instrumental in transforming the technology from an empirical craft to an applied science by laying the foundation for grinding system theory and developing enabling technologies to improve system efficiency. His book *Grinding Technology: Theory and Applications of Machining with Abrasives* (Industrial Press, 1989) presents a comprehensive and consistent treatment of grinding theory and its practical aspects. It has been cited over 1,300 times.

Steve authored 200 scientific papers and supervised 50 graduate students, most of whom now work in high-level engineering positions and management. He loved his students and maintained close relationships with them. In addition to his positions at Amherst, he was the R.S. Springer Visiting Professor at the University of California, Berkeley, and Lady Davis Visiting Professor and later Safra Visiting Professor at the Technion.

He was a life fellow of the American Society of Mechanical Engineers (ASME) and a fellow of the Society of Manufacturing Engineers (SME) and International Academy for Production Engineering (CIRP). He received ASME's Blackall Machine Tool and Gage Award (1993) and William T. Ennor Manufacturing Technology Award (2004), and the SME Gold Medal (1996). He was named doctor honoris causa by Jan Evangelista Purkyně University of the Czech Republic, an honorary member of the Romanian Society of Mechanical Engineering, and an honorary professor at the National Huaqiao University in China.

Steve continually sought opportunities to serve the community and to advise, lead, and help others. He will be greatly missed.

He is survived by his beloved wife of 41 years Maccabit, son Gonen and daughter Ruth, granddaughters Noa, Shai, Judith, and Millie, his sister Celia, and a nephew and niece.



JAMES L. MASSEY

1934–2013

Elected in 1991

"For outstanding contributions to the theory and practice of communication engineering, and for excellence in education."

BY DANIEL J. COSTELLO
SUBMITTED BY THE NAE HOME SECRETARY

JAMES LEE MASSEY, internationally acclaimed pioneer in digital communications (information theory, coding theory, and cryptography), died of colon cancer on June 16, 2013, in Copenhagen, Denmark, where he had lived with his wife Lis Kofod Massey since his 1998 retirement from the Swiss Federal Institute of Technology (ETH) in Zürich. Funeral services were held June 22 in the Sondra Chapel in Copenhagen and his ashes were interred in Garnisons Kirkegård, a cemetery near the American Embassy in Copenhagen.

Jim was born in Wauseon, Ohio, on February 11, 1934, firstborn twin son of Ethel Pry Massey (later Ethel P. Sperry) and Charles Arnold Massey. After his father was killed in an automobile accident in December 1940, his mother moved the family (the twins and an older sister, Ethel Joan) to Mendota, Illinois, where they lived for seven years. They moved to Ottawa, Illinois, in 1948 when his mother married Russell C. Sperry, longtime proprietor of Ottawa Battery Supply.

Jim graduated in 1952 from St. Bede Academy in Peru, Illinois, and attended the University of Notre Dame on a Naval ROTC scholarship, graduating maxima cum laude in electrical engineering as the 1956 class valedictorian (his twin brother Jerry, also a 1956 Notre Dame maxima cum laude graduate, ranked second in the class). While at Notre Dame he met Kathryn Kramper, a student at St. Mary's College in South Bend. They married in 1958 and had four sons.

After three years of active service as a communications officer in the US Marine Corps (1956–1959), Jim attended the Massachusetts Institute of Technology (MIT) on a National Science Foundation fellowship, earning MS (1960) and PhD (1962) degrees in electrical engineering. From 1962 to 1977 he served the University of Notre Dame as a professor in the College of Engineering, where he was appointed the Frank M. Freimann Professor of Electrical Engineering, acquiring the distinction of filling Notre Dame's first endowed chair.

After leaving Notre Dame in 1977, he taught briefly at MIT and UCLA before accepting in 1980 a professorship in digital techniques at ETH, Europe's leading technical university, where he worked until his 1998 retirement as professor emeritus.

Jim's scientific work focused on coding theory and cryptography, two branches of information theory. His work in coding theory included developing links between convolutional codes and linear systems, and codevelopment of the Berlekamp-Massey algorithm for decoding BCH codes. His work in cryptography includes the invention of the block ciphers IDEA and SAFER+, both of which have found widespread use and inspired other block cipher designs.

Jim was instrumental in founding Codex Corporation in 1962 to market error-correction equipment invented during his doctoral research. His "threshold decoders" were the company's principal product during its first five years. Codex was acquired by Motorola in 1977. He was also involved in the founding in 1984 of Cylink Corporation, which became a leading supplier of data encryption and e-commerce security products. Cylink was acquired by Safenet Corporation in 2003.

Jim received virtually every honor and award available to communications scientists and engineers. He was elected to the Swiss Academy of Engineering Sciences (1990), the US National Academy of Engineering (1991), the European Academy of Arts and Sciences (1991), the Hungarian Academy of Sciences honoris causa (1993), and the Royal Swedish

Academy of Sciences (1995). He was also elected a fellow of the Institute of Electrical and Electronics Engineers (IEEE) in 1969 and the American Academy of Arts and Sciences (2004). He was a member since 1971, and a fellow since 2009, of the International Association for Cryptologic Research.

He was the 1992 recipient of the IEEE Alexander Graham Bell Medal for "contributions to the theory and practical implementation of forward-error-correcting codes, multiuser communications, and cryptographic systems; and for excellence in engineering education." He also received the two most prestigious awards given by the IEEE Information Theory Society: the Claude E. Shannon Award in 1988 for "consistent and profound contributions to the field of information theory" and the Aaron D. Wyner Distinguished Service Award in 2004. In 1998 he also received the Jubilee Tesla Medal from the Nikola Tesla Society for "outstanding contributions to the field of information theory," and in 1999 he was awarded the Marconi Prize (which includes a $100,000 honorarium and an original work of sculpture) for "theoretical and practical contributions to cryptography and related coding problems." In addition, he received four awards from the University of Notre Dame related to distinguished teaching, service, and research.

For his published work, he received the 1964 IEEE Information Theory Society Paper Award for the MIT Press monograph *Threshold Decoding*; the W.R.G. Baker Prize in 1987, awarded for "the most outstanding paper reporting original work" in any IEEE publication, for "The Collision Channel Without Feedback" (coauthored with Peter Mathys; *IEEE Transactions on Information Theory* 31(2):192–204); and a 1998 IEEE Information Theory Society Golden Jubilee Paper Award for his 1969 article "Shift-Register Synthesis and BCH Decoding" (*IEEE Transactions on Information Theory* 15(1):122–127).

He was awarded honorary doctoral degrees by Xidian University (China; 1985), the Beijing University of Posts and Telecommunications (1988), Lund University (Sweden; 1990), the Russian Academy of Sciences (1998), and the Technical University of Munich (2006). Until his death, he held adjunct research appointments at Lund University (from 1998) and the Technical University of Denmark (from 2004). He remained an active and productive researcher, scholar, and sought-after lecturer to the end of his life.

Jim particularly liked to tackle challenging problems brought to him by research institutes and companies whose own scientists and engineers had been unable to solve them; he would say that there must be something interesting about such problems that made them resist solution and fight back. Revered and honored as a teacher, he became mentor to an entire generation of communication engineers and scientists.

Jim was survived by his wife of 36 years, Lis Kofod Massey of Copenhagen, a Danish lawyer who died on June 3, 2015. Other survivors include his former wife Kathryn, in Evansville, IN; twin brother Gerald J. Massey, Distinguished Service Professor of Philosophy Emeritus at the University of Pittsburgh; sister Joan Massey Kramer of Sylvania, Ohio; sons Thomas Aquinas Massey, Robert Bellarmine Massey, Peter Canisius Massey, and John Damascene Massey; stepsons Flemming Kofod Bonde and Jesper Kofod Bonde; grandchildren Rachel, Brianna, Scott, Robert, Elizabeth, and Brittney; step-grandchildren Regitse, Christine, Mille, Matilde, Mikkel, Katinka, and Sebastian; and step-great-granddaughter Caya.

TONY MAXWORTHY

1933–2013

Elected in 1991

"For outstanding research contributions to the understanding of complex flows important to aerodynamics, biomechanics, combustion, and geophysics."

BY YANNIS C. YORTSOS

TONY MAXWORTHY, a giant of fluid mechanics, died on March 8, 2013, at the age of 79. He passed away on the University of Southern California (USC) campus in the same building, Biegler Hall of Engineering, where he taught and conducted research over the years.

In 2012 he had celebrated 45 years at USC. Biegler Hall was the original and official center of the school. It was fitting that Tony drew his last breath working in the place where engineering started at the university and where he deployed his remarkable creative talent.

Tony was born on May 23, 1933, in Ealing, England, and earned a bachelor's degree from Imperial College London before going on to Harvard University, where he received a doctorate in 1960. Joining the University of Southern California in 1967, he rose to the rank of professor of aerospace engineering in 1970, was named Smith International Professor of Mechanical Engineering, and chaired the Department of Mechanical Engineering from 1979 to 1989.

He received a number of accolades in recognition of his many contributions: He was a life fellow of Clare Hall at the

Material for this tribute was also provided by Larry Redekopp and Geoff Spedding.

University of Cambridge; elected fellow of the American Physical Society (APS) in 1975; selected for the APS Otto Laporte Award in 1990; elected to the National Academy of Engineering in 1991; elected fellow of the American Academy of Arts and Sciences in 2001; awarded the G.I. Taylor Medal of the Society of Engineering Sciences in 2003 and the APS Fluid Dynamics Prize in 2011; and appointed Distinguished Professor of Aerospace and Mechanical Engineering at USC in January 2013.

Tony was a giant in the field of fluid mechanics. His work reshaped the field and contributed immensely to USC Viterbi School of Engineering's reputation for excellence. His work was eclectic, elegant, simple but not simplistic, deep, and, in many ways, artistic. He followed Einstein's exhortation to "make it as simple as possible, but not simpler than that." His close colleague Geoff Spedding wrote: "He worked on the fluid mechanics of almost everything, it seemed, from microscale processes in immiscible fluids and jets, to the planetary scales of oceans and atmospheres on earth and also on Jupiter, where he uncovered the dynamics of the Great Red Spot."

Tony explored flows ranging from the Antarctic Circumpolar Current to the emptying of champagne from a bottle to the aerodynamics of insects; slow creeping motions, fluid dynamics of inkjet printers, sonic booms, volcanoes, and flows in the Jovian atmosphere; bubbles and drops, the motion of immiscible and miscible fronts in porous media, the motion of fronts in directional solidification of alloys and in crystal growth, and combustion. He explored fluid mechanical phenomena described by the broadest array of dimensionless parameters, and he did so in apparatuses that, for the most part, he conceived, designed, and assembled—and then he conducted the preponderance of the experiments with his own hands.

Tony was full of curiosity to understand and explore all wonderful aspects of fluid motion, and he had magical insight. He studied how vortex rings form and dissipate, how dust devils are formed on heated surfaces with only weak breezes, how vortices form and break down over delta wings, how aircraft trailing vortices can be modified. He conceived a unique experiment to explore the aerodynamics of insect flight, clarifying the mechanism whereby insects generate lift during hovering flight. This experimental work opened the way for an aerodynamic understanding of unsteady vortex lift on rapidly pitching, moving, three-dimensional wings. His experimental platforms have been replicated in a number of laboratories, and he had a very influential role, for example, in the construction of the world's largest rotating table, in the Coriolis facility in Grenoble, France, for simulating geophysical fluid dynamical phenomena.

His long-time collaborator and colleague Larry Redekopp says: "It always seemed to me that Tony thought in 'vorticity space'—he always saw a fluid flow from the standpoint of its vortical structure; he 'thought' in vector space, and then he formed the essential vector balances intuitively at teraflop speed. This quality of his intuitive brilliance stood out clearly…and was manifested at multiple times in multiple fluid contexts. It was genuine and it was real."

Tony was a USC pillar, and shaped the golden era of fluid mechanics. It was an era of beautiful, elegant classical fluid mechanics: He epitomized the British school and the celebrated G.I. Taylor, elegantly tying applied mathematics to physical insights to understand the complexity of fluid dynamics using simple, but clever, experiments. Methods of experimentation and modeling now rely on sophisticated devices and powerful computers, but the fundamental principles and truths revealed by Tony and his colleagues have an enduring and lasting value.

His broad range of interests brought him into much-valued collaborations with research groups around the world and extended research visits to facilities in Australia, England, France, Germany, Switzerland, New Zealand, Norway, Israel, Spain, and Portugal. Geoff again: "The twin characteristics of wide travel and intellectual interests led to certain signature phenomena…. He was said to have mastered the art of being simultaneously everywhere and nowhere. A starting postdoc at institution *x* might discover upon arrival that Tony was in fact at *y*, and so there was strong incentive for such people to be self-starters, and then to be even more grateful when he did materialize."

Tony loved to spend time in France as a visiting professor and in the summer. There is an aspect of art in French fluid mechanics research, perhaps because of the visualization of the complex flow patterns involved. Tony's work fit beautifully in that context. I recall vividly a 4th of July event, sometime in the late 1990s, when I was also on an extended visit in France. We were both at the École Supérieure de Physique et de Chimie Industrielles (ESPCI); I presented a talk on bubble growth in porous media, Tony spoke about his work on combustion. It was somehow fitting that July 4th was celebrated by giving scientific talks!

My scientific interactions with Tony started in the early 1990s when my group published a theory of solitary waves in a Hele-Shaw cell, a device he often used himself. When I presented the theory in an AME seminar, Tony was curious and skeptical. He asked in his understated, but gentle, way, with a touch of skepticism, "What is the mechanism that drives this process, young man?" I kind of mumbled an answer, to which he replied with his characteristic "I see," meaning "You have no idea what you are talking about." Motivated, I embarked on an experiment to demonstrate the validity of my theory—in the largest HS cell in the world! That experiment confirmed the theory, and I think earned me membership in the club of the people Tony accepted. After that he took me slightly more seriously and we even shared a research group for a while. Then I joined the dean's office when Max Nikias (now USC president, then dean of engineering) beckoned. I remember Tony's bemused expression: "What is a nice guy like you doing in an office like the dean's!"

In November 2001 we held a symposium in Tony's honor, entitled "A Fascination with Fluids," a fascination that characterized his pursuits for over 50 years.

Tony was hugely transformative at USC. His presence helped recruit or influence the recruitment of the likes of Larry Redekopp, Chi Ming Ho (now at UCLA), Juan Lasheras (now at UCSD), Patric Huerre (now at École Polytechnique), Geoff

Spedding, and Mike Kassner. Two years ago I hosted a dinner in Baltimore at the fall APS meeting to celebrate Tony's winning the APS Fluid Dynamics prize, which many of the above colleagues attended. It was a beautiful gathering and I am very glad we did that on behalf of the school. Soon after, I learned that Tony was appointed USC Distinguished Professor; I am glad USC was not too late in awarding that distinction. When he learned about it he emailed me: "I suspect you were behind it." I said, "It was long overdue."

Throughout his life Tony was humble, considerate, thoughtful, dignified, wise, intellectually rigorous and innovative, blessed with acute powers of observation and piercing insight…all packaged into a rather British shell of calm, reserved dry wit and humor. He will remain forever in our hearts and in our history.

Anna, his wife of 35 years, writes:

> In this soft-spoken and very reserved man there was such a wealth of love for life. First and foremost, his love of science, his colleagues, and his teaching. But also his love of music and art, of nature, of food and wine, and of sports. Every year we spent months abroad. Tony would first find an interesting scientific conference to attend, then study the *Michelin Guide* to find the best historical sites to visit, plus good hotels and restaurants. During his travels over the years, Tony made friends everywhere because of his openness, congeniality, and humility, not to mention his scientific abilities. Many of his international relationships have lasted decades. Tony always returned to USC with joy and dedication, and felt greatly honored when USC generously awarded him the title of Distinguished Professor in 2013. He was a gentle and peaceful man, easy to live with, and he went as he lived—peacefully—leaving his family and friends in deep sorrow.

Tony is survived by Anna, daughters Kirsten Neville and Kara Dotson, stepdaughters Dominique Naylon and Dana Parks, brother Gary Maxworthy, and seven grandchildren.


Walter McCarthy

WALTER J. McCARTHY JR.

1925–2013

Elected in 1984

"For his outstanding engineering contributions to the electric power industry and his corporate and civic leadership."

BY CAREN BYRD
SUBMITTED BY THE NAE HOME SECRETARY

WALTER JOHN McCARTHY JR., a leader in the US nuclear energy industry and former Detroit Edison chief executive officer, passed away on July 24, 2013, at the age of 88.

Mac, as he was generally called, was born in New York City on April 20, 1925, and grew up in Manhattan. All his life, no matter where he lived, whenever asked where he was from, he proudly responded, "I'm from New York." He loved the city of his childhood and in retirement took each of his 14 grandchildren to explore his hometown. He would always point to the George Washington Bridge and say, "In my house, that was called 'the God-damned bridge' because it replaced my grandfather's ferries." He reminisced about his happy childhood summers working on the ferries and believed that it was admiring those ferry engineers that led to both his love of boats and his desire to become an engineer.

He graduated from Cornell University in 1949 with a degree in mechanical engineering and was a member of Pi Tau Sigma, the engineering honorary society. He began his professional life as an engineer at Public Service Electric and Gas Company in Newark, New Jersey, during which he attended the Oak Ridge School of Reactor Technology, where he was mentored and influenced by Admiral Hyman Rickover and Nobel Prize winner Hans Bethe.

Mac quickly distinguished himself in the burgeoning field of nuclear engineering and was chosen in 1952 to head the nuclear and analytic division of the newly formed Enrico Fermi Breeder Reactor Project, a consortium of utilities exploring the potential of nuclear energy. This study led him to Detroit Edison Company (now DTE Energy), where, for the next ten years, he oversaw the development of Fermi I, the nation's first commercial nuclear power plant, which came online in 1963. At this time, Belgium sent over four of its top engineers to learn under Mac and bring nuclear energy technology back to Belgium. Those Belgians became like brothers to Mac and they shared a lifelong friendship. Belgium showed Mac its gratitude for his contribution to the country's development of nuclear energy by bestowing on him its highest honor, the Order of Leopold, of which Mac was extremely proud.

For the next 27 years at Detroit Edison, Mac was a pioneer in the field of nuclear energy. He helped ensure the safe resolution of a partial core meltdown at Fermi I in 1966: no radioactive material was released, and the plant was repaired (it was shut down in 1972). He deftly managed the development of Detroit Edison's Fermi II, which came into commercial operation in 1988 and has been providing reliable and cost-effective power to customers in Southeast Michigan for more than 25 years.

Mac was a lifelong advocate for safe nuclear power and repeatedly testified before Congress on the advantages of nuclear energy. Focused on ensuring operating excellence, not just compliance with regulations, he rose to leadership in the industry and in 1989–1992 chaired the Institute of Nuclear Power Operations (INPO). INPO is a national group of the operators of all nuclear units, formed in response to the Three Mile Island disaster to monitor and improve nuclear operations. Mac used his unparalleled knowledge to respond, adapt, and lead the industry through uncertain times; when a crisis like Chernobyl struck, he was a steady hand. He was instrumental in the formation of the World Association of

Nuclear Operators (WANO), which continues to unite every company and country in the world with an operating commercial nuclear plant to achieve the highest standards of nuclear safety.

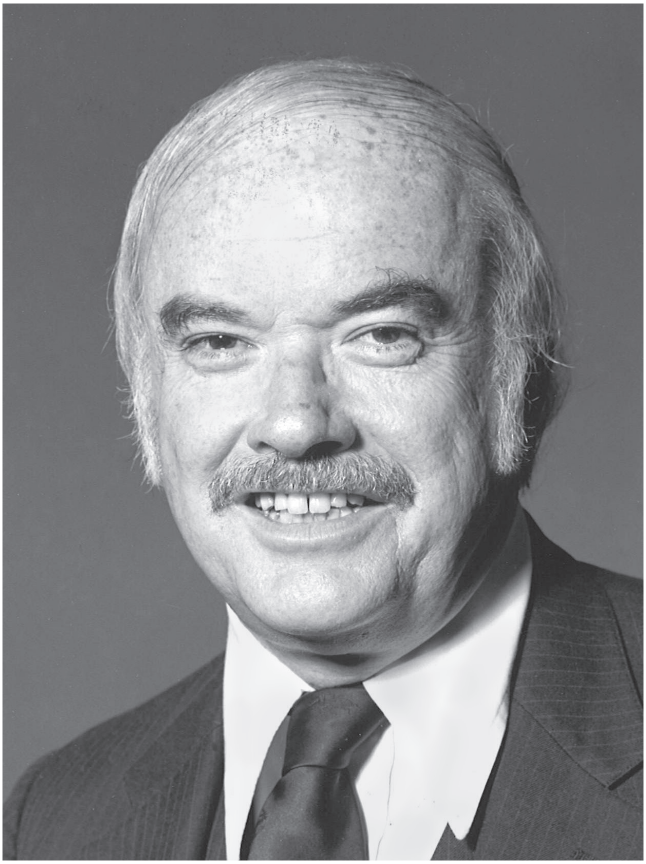
From 1981 to 1990 Mac was CEO of Detroit Edison, where his tenure was highlighted by consolidation with the New York branch of the company in 1983; the commercial operation of Fermi II in 1988, his company's largest capital investment ever; and record corporate stock prices in 1989. He was widely respected and is remembered as a loyal manager who knew the names of all of his 10,000 employees.

In addition to his nuclear achievements, Mac was credited with the formation of Midwest Energy Resources Company, a wholly owned subsidiary of Detroit Edison, to transport cleaner coal over 1,000 miles from the West to the Midwest by a combination of rail and vessel, with 14,000 tons of coal in each trip. In honor of his retirement from Detroit Edison, a 1,000-foot coal freighter was renamed *The Walter J. McCarthy Jr.* During his last 22 years, the highlight of the summer for Mac and his wife, Linda, was an annual trip on the Great Lakes aboard his namesake, colloquially known by shipmates as the "Big Mac."

Mac was well known in Detroit for his philanthropy and served on numerous boards. He chaired the Detroit Symphony Orchestra (DSO) from 1980 to 1987 and, as a passionate champion, fought to keep it going through tough labor battles and economic downturns. One of the highlights of his life was serving as a guest conductor for the DSO. In 1983 Mac initiated the Distinguished Clown Corps, a staple of the Detroit Thanksgiving Day Parade that has raised over $2 million for the annual celebration.

In 1985 Mac earned the coveted Silver Beaver Award for distinguished service in the Boy Scouts of America, awarded to adult leaders who have made an impact on the lives of youths. With all four sons in the Scouts, his camping days were numerous. Fellow Scout leaders could always count on Mac to be the first to lead a sing-along around the campfire and to have a backpack heavy with gourmet treats. He was proud that each of his five children achieved high ranks in scouting.

Mac retired to Carmel, California, where he was active in the community and pursued his passion for music by serving as president of the Monterey Symphony. He is survived by his wife Linda; former wife Alice; daughter Sharon; sons Walter, Dave, Jim, and Bill; stepdaughters Carrielynn, Laura, and Lisa; and 14 grandchildren. He will be remembered for his heroic leadership, unwavering integrity, sense of humor, and intellectual curiosity.



James E. McGrath

JAMES E. McGRATH

1934–2014

Elected in 1994

"For integration of synthesis with the performance and applications of polymeric materials and their composites."

BY DONALD R. PAUL

JAMES E. McGRATH, a world-reknowned polymer scientist who straddled the industrial-academic interface with great skill, died of brain cancer on May 18, 2014, in Blacksburg, Virginia.

Jim was born on July 11, 1934, in Easton in upstate New York and grew up on a farm there. He received a BS degree in chemistry in 1956 from Siena College and did graduate studies at the University of Akron, where he received an MS degree in 1964 under the direction of Alan N. Gent, working in the area of ozone cracking of rubber, and then a PhD in 1967 working under Maurice Morton in the area of synthesis and characterization of block copolymers. Before entering the University of Akron, he worked on cellulose fibers for Rayonier, Inc. and then during his first years of graduate study he worked for Goodyear Tire and Rubber Co. After his PhD, he joined Union Carbide Corp., where he was involved in research on various engineering thermoplastics and polyolefins. His industrial career spanned 17 years, during a prolific period of invention in polymer technology.

In September 1975 he joined the chemistry faculty of the Virginia Polytechnic Institute and State University, where until his death he had a very successful career in cutting-edge research and education in broad aspects of polymeric materials. Through his leadership and vision, Virginia Tech developed one of the world's leading educational and research programs in polymer science and engineering. He was also director of one of the first science and technology centers sponsored by the National Science Foundation, under the title High-Performance Polymeric Adhesives and Composites, from 1989 to 2000.

Jim and his colleagues established a series of enormously popular short courses on polymer science and polymer chemistry, sponsored by the American Chemical Society (ACS), that remain popular today with over 6,000 alumni. His collaborative research with Garth Wilkes in the Department of Chemical Engineering led to the Polymeric Materials and Interfaces Laboratory, predecessor of the university's Macromolecules and Interfaces Institute.

With his broad experience, Jim naturally gravitated toward complex and challenging problems in polymer science with societal and economic impact, and his students carried with them his great enthusiasm for interdisciplinary research. He supervised over 100 PhD and 17 MS students and more than 80 postdoctoral associates; they have gone on to populate leading university and industrial research laboratories around the world.

Jim received many awards and honors, among them election to the National Academy of Engineering (1994), the Society of Plastics Engineers International Research Award (1998), Virginia Scientist of the Year (1999), Herman F. Mark Award from the ACS Polymer Chemistry Division (1996), ACS Award in Applied Polymer Science (2002), George S. Whitby Award for Distinguished Teaching and Research from the ACS Rubber Division (2009), election as ACS fellow (inaugural class of 2009), ACS Award in Polymer Chemistry (2008), and the Charles G. Overberger International Prize for Excellence in Polymer Research (2013). He shared the Paul J. Flory Award in Polymer Education with his Virginia Tech colleagues Tom Ward and Garth Wilkes in 2004 and was a member of the Society of Plastics Engineers Hall of Fame.

Jim McGrath was one of the giants in polymer science and engineering. His pioneering research resulted in more than

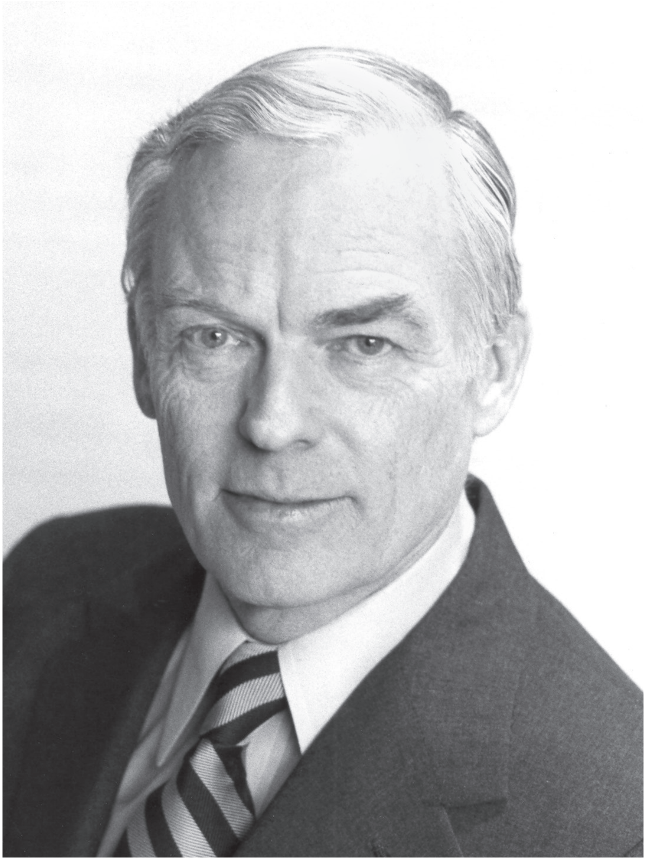
500 publications, an equal number of preprints, and over 50 patents. His coauthored book *Block Copolymers: Overview and Critical Survey* (with Allen Noshay; Academic Press, 1977) had significant impact in this important field. His broad-based research ranged from new high-temperature polymers for adhesives and composites to creative multiphase polymeric systems, novel ionic polymerization systems, fundamental mechanistic understanding of cyclic siloxane polymerizations, and important new materials based on this chemistry. His latest research focused on high-performance polymeric membranes for fuel cells, water purification, and gas separations.

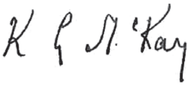
He was in great demand as an industrial consultant and was a familiar visitor at many industrial polymer research organizations. His contributions in the area of composites enabled many models of commercial jet aircraft, and his wide-ranging papers are frequently cited. He dedicated much time to professional activities, serving the ACS Division of Polymer Chemistry in every office. He pioneered the enormously successful workshops of the ACS Polymer Chemistry Division and continued to chair workshops through 2013. He also served on a number of journal editorial boards and advisory boards for government agencies and professional societies.

Jim had a bigger-than-life personality and was a wonderful friend for many in the polymer community. His infectious smile and his fun-loving participation in meetings around the world, where he often was seen wearing his Virginia Tech cap while singing and playing the trombone or piano, will be long remembered. His stimulating lectures on advances from his research group generated much enthusiasm and will be greatly missed.

To recognize his approaching 80th birthday, his friends planned a workshop, "From Anionic Polymerization to Aerospace Materials to Membranes," in southern Italy June 29–July 2, 2014, sponsored by the ACS Polymer Division. Unfortunately, Jim passed away a few weeks before this event; the workshop was held anyway and became a wonderful tribute to his career and life that was attended by approximately 100 friends, colleagues, and their families.

Jim and his wife, Marlene, had six children—Colleen Kraft, Patricia McGrath Hoover, Matthew McGrath, Barbara McGrath Costain, Elizabeth Throckmorton, and Joseph McGrath—and ten grandchildren. Jim spent the last 30 years of his life with his partner and collaborator Professor Judy Riffle, who provided constant care for him during his final days.





KENNETH G. McKAY

1917–2010

Elected in 1968

"Developments in communications, especially in systems engineering and management of technical advances."

BY WOLCOTT DUNHAM
SUBMITTED BY THE NAE HOME SECRETARY

KENNETH GARDINER McKAY, physicist and executive of Bell Telephone Laboratories and AT&T, died March 5, 2010, in New York City at the age of 92. He had a long career that combined physics and engineering, and his publications included papers on avalanche breakdown in semiconductors and interactions between electrons and solids.

KG, as he was affectionately known by his many friends, was born April 8, 1917, in Montreal. Starting with an amateur radio receiver and transmitter he built while still in grade school in Montreal, he took an early interest in physics and electronics, as he explained in a letter to his daughter:

> I started with a fascination with what makes things tick, which led to a lifelong involvement with physics—the desire to understand the world of nature—atoms and electrons, stars and gravity waves, and everything in between. However, I also wished to create things to be used which, starting with amateur radio, led to engineering. …Then back to physics research at Bell Labs. After establishing a world reputation in solid state physics (now called condensed matter physics) I shifted to the development of devices followed by years of systems engineering, both at Bell Labs and at AT&T. As an officer of the largest corporation in the world, I attempted to introduce technical concepts into the thinking of my fellow officers.…

> This shifting back and forth between physics and engineering has had a common technological basis. This also underlies my participation in advisory committees to Stanford, University of California, MIT, the National Academies of Sciences and Engineering. A scientist does not have to be a narrowly focused person as he/she is often portrayed. By applying the fundamental principles of research, the scientist can happily enter many fields of endeavour and contribute usefully by exercising a different viewpoint. This is a capsule of one scientist's career. It has all been enjoyable.

At McGill University KG earned a BSc in 1938, winning the Anne Moldson Gold Medal for Mathematics and Natural Philosophy, and an MS in 1939. He received a Moyse Traveling Fellowship to support further graduate study at Oxford University, but the start of World War II prevented his attendance, so he earned his doctorate in physics from the Massachusetts Institute of Technology in 1941. He returned to Canada and designed radar equipment during wartime service with the National Research Council of Canada in Ottawa (1941–1946). After the war, he came to the United States and joined Bell Telephone Laboratories, where he established his reputation in solid state physics.

His long career began in 1946 in the Bell Telephone Laboratories group that invented the transistor and applied it in practice. He was selected "to lead a transistor-development team that would work more or less in parallel with Shockley's group in order to maintain breadth of effort." He invented, among other things, bombardment-induced conductivity in solid insulators, an amplifier and a photomultiplier utilizing bombardment-induced conductivity, a negative resistance semiconductive apparatus, an alpha particle counter, and an electron camera tube for television.

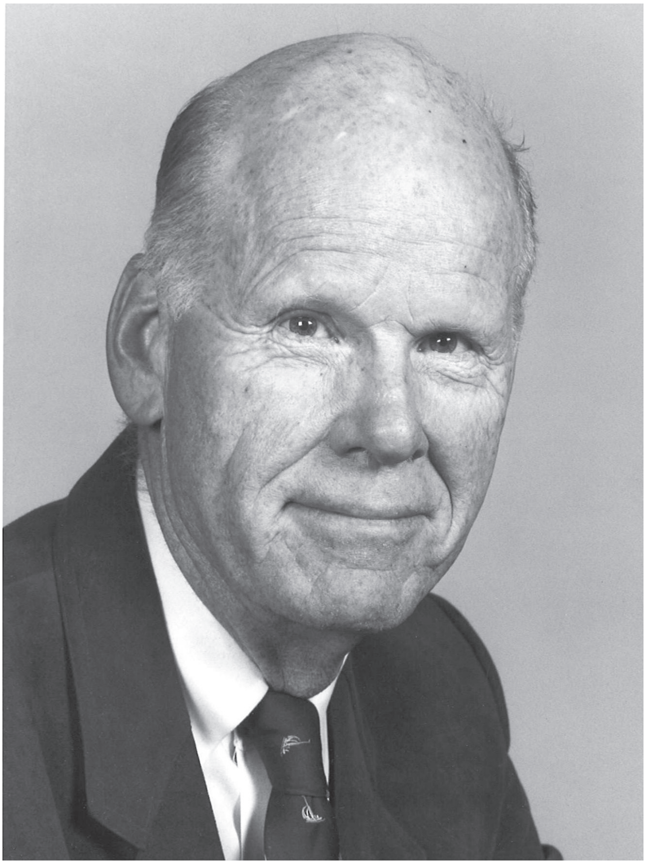
He was appointed director of solid state device development (1957–1959) and became the lab's youngest vice president (systems engineering, 1959–1962). In 1962 he was intimately involved with the launching of Telstar, America's first successful telecommunications satellite. From 1966 to 1973 he was vice president of engineering for AT&T, the parent company of the Bell System, and chair of the board of Bellcom Inc., which was charged with overseeing communications for the NASA Apollo Program. He also served on the boards of Bell Telephone Laboratories, Bell of Canada, and Sandia Corp. He retired as executive vice president in 1980.

After retiring from the Bell System, he chaired the board of the Charles Stark Draper Laboratory, in Cambridge, Massachusetts (1982–1987), and was an advisor on telecommunications to ministries in Egypt and Taiwan (1982–1996). In Taiwan he helped to draft a National Telecommunications Development Plan, arranged for Bell Labs to send personnel to assist Taiwan's Institute of Telecommunications (a research arm of the Ministry of Transportation and Communications), and advised on AT&T's establishment of a plant to manufacture digital switches equipment.

He also served as a director of Keuffel & Esser Co. (1954–1982), National Aviation and Technology Corp. (from 1982), National Telecommunications and Technology Fund (from 1982), and Network Control Corp. (from 1985). He was a member of the board of governors of McGill University (1973–1978); the board of trustees of Stevens Institute of Technology (from 1974); the board of governors of the New York College of Osteopathic Medicine (from 1980); the Scientific and Academic Advisory Committee of the University of California (from 1980); the advisory council of the School of Engineering, Stanford University; the NAE Academic Advisory Board (1985–1988) and the Commission on Sociotechnical Systems of the US National Research Council; and the US Department of Commerce Technical Advisory Board. NASA gave him its Public Service Award and its Public Service Group Achievement Award in 1969.

He was a fellow of the Institute of Electrical and Electronics Engineers, the American Physical Society, and the New York Academy of Sciences, and a member of the National Academy of Sciences and Sigma Xi. He was elected to the National Academy of Engineering in 1968 and served as councillor from 1970 to 1973. He was also a member of the Century Association of New York.

Dr. McKay was survived by his wife of 67 years, Renee McKay, a professional artist who died in 2011, son Kip McKay, daughter Margo McKay Mulligan, and grandchildren Lisa and Chris.



LAWRENCE M. MEAD JR.

1918–2012

Elected in 1988

"For outstanding technical accomplishment and leadership in the design and development of naval aircraft."

BY MICHAEL V. CIMINERA
SUBMITTED BY THE NAE HOME SECRETARY

LAWRENCE MYERS MEAD JR., the longest-serving Grumman officer, with over 50 years of outstanding accomplishments for the company, the aerospace industry, and the nation, died August 23, 2012, at the age of 94.

Larry was born in Plainfield, New Jersey, on May 11, 1918, grew up in Beijing (then called Peking), China, and attended the Hill School in Pottstown, Pennsylvania. He graduated from Princeton University in 1940 with a BS in engineering with highest honors and keys to the honorary scholastic and scientific fraternities Phi Beta Kappa and Sigma Xi, and in 1941 earned a degree in civil engineering.

Larry was gifted with an innate ability to visualize the flow of forces and stresses in structures that enabled him to perform redundant structural analyses in his graduate year, and this talent was recognized by the chief of structures at the Grumman Aircraft Engineering Corporation. He joined the company's engineering department in June 1941, when Grumman had been in existence for only 11 years. His first assignment involved developing a pioneering shear-lag analysis that could predict structural failures in a carrier-based aircraft folding wing. Successive lead stress analysis efforts on the F6F Hellcat wing fold and center section and the F7F

Tigercat wing led to his responsibility for the stress analysis of the entire F8F Bearcat airframe.

After World War II he became the structural project engineer for the XF9F-1 Panther, responsible for the structural integrity of the aircraft. The US Navy awarded Grumman a contract for the variable sweep wing XF10F-1 Jaguar in 1948 and Larry was involved with the preliminary design of the aircraft; he was appointed assistant project engineer to manage the design team, but the aircraft was cancelled because of technical problems. He was then assigned as assistant project engineer for the XF11F-1 Tiger fighter aircraft, which flew in 1954—just 16 months after contract award!

Grumman engineering management carefully groomed Larry for his next assignment on the A2F-1 (A6A) Intruder. As project engineer he was in charge of the preliminary design team as well as the proposal to the US Navy. After award he was responsible for the total weapon system development, including the aircraft, logistics, and electronics. He guided the A2F-1 program for seven years through development, flight test, initial production, and carrier trials. In November 1963 he became head of the engineering staff and in 1964 assumed additional duties as head of preliminary design.

Before the demise of the F-111B in 1968, the Navy engaged in new aircraft studies in the mid-1960s for the VFAX, an advanced fighter concept. He managed these studies as well as those for the Air Force FX program.

It was at this time that I met Larry. I was a young preliminary design engineer conducting VFAX parametric aircraft design studies and he asked many penetrating questions based on his vast experience. He was always fair and considerate with the "youngsters."

He then headed the Titanium Committee at Grumman that involved many departments. The large use of titanium was a key Grumman development that led to the successful award of the F-14 program in 1968. He led the proposal effort and became director of manufacturing and manufacturing engineering for the F-14.

In 1969 he was appointed a vice president and his vast experience, talent, and management skills were put to the test again when he was tapped to lead Grumman's space shuttle proposal to NASA. This was an enormous undertaking that required not only designing the space shuttle system but also developing strong team relationships. Grumman battled down to the wire with Rockwell, which was selected for the contract in 1972.

Grumman greatly benefitted from Larry's promotions to vice president of technical operations in 1973 and then senior vice president and director of departmental operations in 1975. In these capacities he pushed hard to refresh the company's engineering staff by hiring the best and brightest and by streamlining key processes such as cost estimating and design-to-cost. He also was instrumental in establishing a Plasma Physics Laboratory at Princeton and providing the leadership for Grumman to be one of the first companies to adopt computer-augmented design and manufacturing (CADAM).

In 1976–1977 Larry put on another hat as vice president and program manager of Grumman's effort to design the Gulfstream III executive jet. This was a most successful program and the G III flew in 1979. As part of the company's expanding international programs Larry also made several trips to China and promoted much good will. The last major project in his impressive career was to oversee the design, construction, and sea trials of the Israeli hydrofoil program launched in 1981.

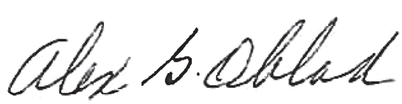
He retired in 1983 but served as a Grumman management consultant for another ten years. He was also active as chair of the AIAA Awards Committee and a member of the management committee of the Aviation Industries Association, the Long Island Technology Forum, the board of trustees of the New York Hall of Science, and the advisory committee of Princeton's Aerospace and Mechanical Engineering Department.

I had the distinct pleasure of conversing and exchanging notes with Larry over the last three years as part of my research on a book about the aircraft designers of Grumman. I also vividly remember his last visit to the Grumman Vice President Reunion in 2011 on Long Island, to which he drove from Connecticut by himself. He regaled us with his memories of Grumman in 1941 when he was hired, and we will cherish his wit, clarity, and recall.

It is fitting to end this tribute with a quote from Larry's autobiography:

> Whatever the outcome, there is no doubt that the 52 years that I spent with Grumman were the best ones of its 65 years of existence. There was always something new to learn, some new technical or management challenge. It was a great place to work because of the Grumman family spirit which pervaded the environment.

Larry is survived by sons Lawrence, Kirtland, and Bradford; sisters Elizabeth Bolton and Margaret McCutchen; nine grandchildren; and six great-grandchildren. His wife of 59 years, the former Janet Chase, died in 2001.



ALEX G. OBLAD

1909–2000

Elected in 1975

"Leadership in the development of important commercial hydrocarbon and petrochemical processes."

BY BURTRON H. DAVIS AND HAYWARD B. OBLAD
SUBMITTED BY THE NAE HOME SECRETARY

ALEX GOLDEN OBLAD, an authority in the catalytic chemistry of petroleum refining and petrochemical production, died on September 19, 2000, at age 90. He began as a research chemist at Standard Oil (Indiana) and Magnolia Oil (Texas), and progressed to associate director of R&D at Houdry Process Corp. (Pennsylvania) and vice president of R&D at the M.W. Kellogg Co. in New York City. Later he was distinguished professor and dean at the University of Utah.

Alex was born in Salt Lake City on November 26, 1909, the second child of five born to Alexander Hugo and Louie May Oblad. He was salutatorian of his class at East High School and then, contrary to his father's wishes, entered the University of Utah to study physics, working his way through college playing the clarinet and saxophone in jazz bands. Seeing that chemists had better job prospects, he switched majors and earned a BA in chemistry with a minor in physics in 1933 and an MA in physical chemistry in 1934. He then accepted a fellowship at Purdue University, where he studied supercooled glycerol, a glassy material, with Roy F. Newton. His now proud parents traveled all the way to Indiana to watch their humble but enterprising son receive his PhD in chemistry in 1937.

The Standard Oil Co., a leader in thermal cracking of petroleum, immediately hired this bright young chemist to help compete in the superior catalytic cracking process developed by Eugene J. Houdry. At the refinery lab in Whiting, Indiana, Alex began quantifying the thermodynamics of many beneficial hydrocarbon reactions, preceding the major effort begun in 1942 under the auspices of Project 44 of the American Petroleum Institute. He also formulated catalysts for naphtha reforming to produce high-octane gasoline. This was groundbreaking chemistry for there was very little in the literature on it before 1940.

Alex demonstrated phenomenal results using platinum on a ceramic matrix, but was directed by his supervisor, Ernest W. Thiele, to find a less expensive metal. He settled on silica-alumina and chromia, the catalyst that Standard used in its subsequent commercial reforming process. Coke formation deactivated the catalyst over time; using model compounds, Alex showed why and proposed operating under 100–250 psi of hydrogen pressure, an approach that prevented deactivation and greatly prolonged catalyst performance. Catalytic reforming produces toluene, the precursor of TNT and a critical component of aviation fuel for military aircraft. Alex filed for a patent on an integrated toluene process in 1940, but his work was kept secret during World War II; the patent (US 2383072) was finally issued on August 21, 1945, one week after V-J Day. Alex also developed a "super" distillation column with 200 theoretical plates, a very high number for the time. He used a similar device in his toluene production process, a forerunner to the gas chromatograph.

In the 1930s the Standard Oil Companies of Indiana and New Jersey, Anglo-Iranian Oil, Texas Oil, Dutch Shell, M.W. Kellogg, and UOP formed a consortium to develop the new process known as catalytic cracking. Moving bed reactors were better than Houdry's fixed-bed batch process, but the bucket lifts, rotary screws, and rotary feeders abraded quickly from contact with the hot catalyst.

In his lab Alex built a glass standpipe to handle his inventory of fine catalyst. The device was about 30 feet tall, with interior tuyeres in the tapered bottom and a rubber hose and clamp. One day some engineers stopped in and asked him to explain and demonstrate it. He opened the air valve to the tuyeres that fluidized the particles and drained some, like water, into a beaker. The engineers huddled in quiet conversation and soon after patented a fluidized-bed cat-cracking process. Alex also worked on the chemistry of a synthetic silica-alumina cracking catalyst at Standard of Indiana and later in much greater depth at Houdry.

He left Standard Oil in 1942 to become chief of chemical research at Magnolia Petroleum Co., owned by Socony-Vacuum Oil. Here he pioneered the use of homogeneous acid catalysts, especially $AlCl_3$ and $AlBr_3$, to polymerize alkenes. One of the products he formulated was a completely synthetic lubricant that excelled in test engines. The Socony-Vacuum managers failed to see the value of polymers, so they furloughed the staff and closed the lab, but offered Oblad a position in Paulsboro, New Jersey. Alex refused it and joined the Texas Research Foundation as head of industrial research.

Not long afterward he was personally visited and recruited by Chalmer G. Kirkbride, president of Houdry Process Corp. of Marcus Hook, Pennsylvania, and in 1947 he accepted the position of associate director of R&D in the company's lab in Linwood, PA. In 1950 his team at Houdry published their work on the structure, composition, and powerful acidic action of the metal oxide sites in highly porous cracking catalysts.

Alex maintained ties with faculty members at the University of Utah and published results with them on the dynamic mechanisms of heterogeneous catalysis and of anion/cation exchange in the early 1950s. In support of the Houdriforming® process, he coauthored a paper in 1953 with G. Alexander Mills, Heinz Heinemann, and Thomas H. Milliken that unveiled the mechanism of bifunctional catalysis.[1] In this stepwise reaction the dehydrogenating/hydrogenating metal forms a reactive intermediate, alkene, which diffuses to the other catalyst function, the acid site, and isomerizes to a higher-octane-value

[1] "Naphtha reforming involves dual functional catalysts: Mechanism for reforming with these catalysts." *Industrial and Engineering Chemistry* 45(1):134–137.

product before diffusing back to the metallic function to rehydrogenate and stabilize. They also explained how cycloalkanes became aromatics. This paper stimulated hundreds of studies to define these reactions more completely, and remains a classic and seminal publication in catalysis today. Oblad also published progress with coworkers in 1955 on the Houdresid® hydrocracking process for upgrading low-value residua. In 1955 and 1972 he penned benchmark reviews of catalysis for the *Oil and Gas Journal*.

In 1957 he joined the much larger M.W. Kellogg Company as vice president of R&D. Under his able management and direction, Kel-Chlor®, the Kellogg Milli-Second Furnace®, the Orthoflow®, steam cracking and steam reforming of hydrocarbons, synthetic ethanol and methanol, and other important processes were developed or improved.

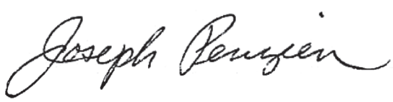
He received the E.V. Murphree Award in Industrial and Engineering Chemistry in 1969 and the American Institute of Chemists' Chemical Pioneer Award in 1972. The Kellogg ammonia process to which he contributed now accounts for a large portion of the world's enormous fertilizer capacity, and in 1967 the company was honored with the Kirkpatrick Chemical Engineering Achievement Award for its development of synthetic ammonia and other critical industrial chemical technologies. In 1972, after Nixon's historic trip to China, Kellogg received perhaps its greatest reward when the country placed consecutive orders for Kellogg ammonia plants. Alex felt honored to have played a small role in helping to feed billions of people worldwide.

In 1969, after more than 32 years in industry, Alex returned to the University of Utah as a Distinguished Professor to develop advanced processes to exploit the state's abundant oil sands, coal, and shale oil deposits. He helped secure several very large research contracts from the Department of Energy and led the university to become highly regarded in fossil energy research. He was acting dean of the College of Mines and Earth Sciences from 1972 to 1975 and in 1989 was elevated to dean emeritus, a title he never sought. He retired in 1995 after 26 years in academia.

Among his many honors he received the Purdue Chemist Award (1959) and honorary doctorates from Utah and Purdue. He was a Distinguished Alumnus of Utah (1962) and Purdue, served on the advisory councils of Utah and Dixie State Universities, and was a member of the Brigham Young University Management Society, which founded the Marriott School of Management and funded the construction of its building. He served as secretary, chair, and managing editor of preprints of the American Chemical Society Division of Petroleum Chemistry (1951–1969) and was an ACS member for more than 60 years. He was also a member of the American Institute of Chemical Engineers (AIChE), the Faraday Society, AACS, and the International Congress of Catalysis, a founder of the Philadelphia Catalysis Club (predecessor of the North American Catalysis Society and the International Congress on Catalysis) and Rocky Mountain Fuel Society, and an active participant in the Gordon Conferences.

Alex always developed productive relationships with colleagues and students. He was modest in the extreme, considered others friends and peers, and consistently recognized their contributions and achievements. Though calm and affable in his demeanor, he always stimulated scientific competition and encouraged excellence. Above all, he was open to opinions that differed from his own. His aim was to help the work and others progress and he was gratified when they succeeded. For this he was and still is respected, honored, and loved.

As an undergraduate, while playing in a band in Escalante, Utah, he met Bessie Elizabeth Baker, whom he married on February 23, 1933. They reared six children who all hold degrees from the University of Utah, and Alex became a grandfather of 23 and great-grandfather to about 40. He was devoted to his family, his work, his alma maters, and the Church of Jesus Christ of Latter-day Saints. He died in his sleep and was buried in Salt Lake City.



JOSEPH PENZIEN

1924–2011

Elected in 1977

"Pioneering research on probabilistic methods in earthquake engineering, with emphasis on linear and nonlinear structural response analysis."

BY ANIL K. CHOPRA AND KARL S. PISTER

JOSEPH PENZIEN died on September 19, 2011, as a consequence of a fall at his home in Lafayette, California. He was born on November 27, 1924, on a farm near Philip, South Dakota. The family lived in a tarpaper shack with no running water and he attended a one-room school with sixteen classmates. The Great Depression of 1932, together with the drought that produced the Dust Bowl, prompted the family to move to a farm in Nampa, Idaho, where Joe helped his father and completed high school.

Aided by a series of fortuitous circumstances, he attended the University of Washington and received a BS in civil engineering in 1945. During the next two years he worked first for the Army Corps of Engineers and then as a lecturer at the University of Washington. He received a full scholarship at the Massachusetts Institute of Technology, where he earned his ScD in civil engineering in 1950—and married Jeanne Ellen Hunson. Their children are Robert Joseph, Karen Estelle, Donna Marie, and Charlene May.

He then joined Sandia Laboratory in Albuquerque, working on blast effects on structures, followed by similar work at

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Convair in Ft. Worth, Texas. In 1953 he joined the faculty of the Division of Civil Engineering and Irrigation in the Department of Engineering at the University of California, Berkeley as an assistant professor. Moving through the ranks he was promoted to professor in 1962 and retired in 1988. He moved to Taipei, Taiwan, with the consulting firm Eastern International Engineers, which he had started with local partners in the early 1980s. After a year there he returned to his home and with Wen S. Tseng launched International Civil Engineering Consultants, a Berkeley firm that he chaired until 2007.

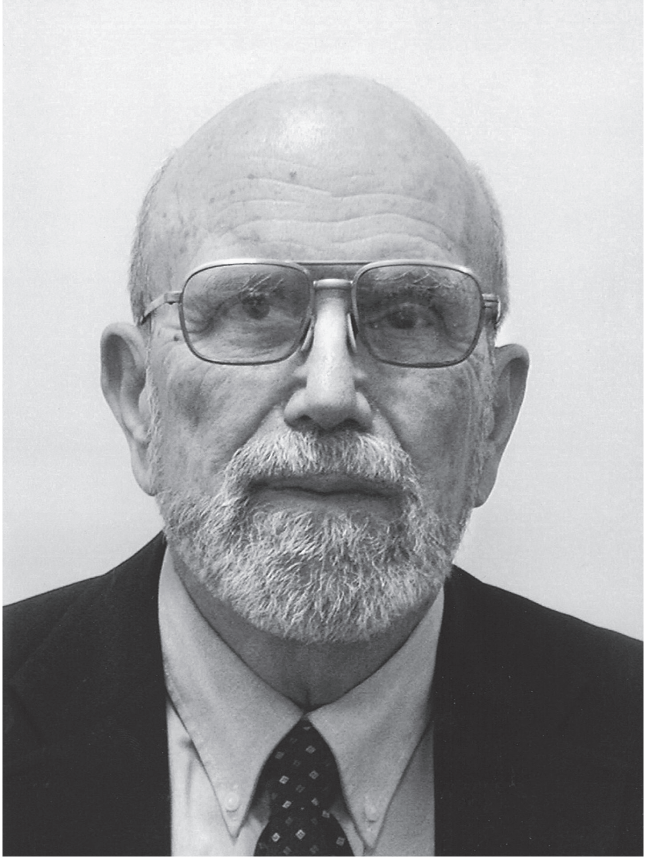
Together with colleagues Ray Clough and Vitelmo Bertero, Joe developed the teaching and research programs in structural dynamics and earthquake engineering that many considered the best in the world. His scholarly contributions and engineering analysis and design expertise received international acclaim.

Among his many accomplishments we note the following. He developed perhaps the earliest course in random vibrations and their relevance to earthquake engineering, offered in civil engineering departments in the United States. As founding director of the Earthquake Engineering Research Center (EERC), his leadership was responsible for the rapid recognition of EERC as one of the foremost research centers in the world in earthquake engineering. With Dixon Rea he was responsible for designing and operating the first modern servo-controlled shaking table of significant size. The center attracted a stream of visitors from all over the world, especially from Japan. Joe's special rapport with Japanese earthquake engineers led to significant collaboration in research over three decades.

In addition to his impact on research, his book *Dynamics of Structures* (McGraw-Hill, 1975), coauthored with Ray Clough, was a landmark in terms of its broad scope, comprehensive coverage, and philosophy. It was translated into six languages and influenced several generations of students and engineers as well as subsequent textbook writers.

That his career as an engineering scholar and consulting engineer had a major impact is validated by his honors and awards: he was a member of the National Academy of Engineering; fellow of the American Academy of Mechanics; honorary member of the Peruvian Association of Earthquake Engineering, US Earthquake Engineering Research Institute, Architectural Institute of Japan, American Society of Civil Engineers (ASCE), and International Association of Earthquake Engineering; and winner of ASCE's Nathan M. Newmark Medal (1983), Alfred M. Freudenthal Medal (1986), and Ernest F. Howard Award (2000); the California Earthquake Safety Foundation's Alfred E. Alquist Medal (1996); the Earthquake Engineering Research Institute's George W. Housner Medal (1993) and Distinguished Lecture Award (2000); the Silver Medal of Paris (1980); and the Berkeley Citation (1988). In 2008 he was recognized as a Legend of Earthquake Engineering during the 14th World Conference of Earthquake Engineering, in Beijing.

From a tarpaper shack near the badlands of South Dakota to an elegant home in Lafayette; from a one-room school to a high school student who did not have the funds for college to a doctoral degree at MIT in 2½ years; from a farming family of eight children whose father did not trust educated people to an eminent professorship at the University of California, Berkeley—Joe traveled a long, hard road with incredible success. As his colleagues we stand in grateful appreciation of his friendship, and of the gracious, kind, humble, and generous person that was Joseph Penzien.



THEODORE ROCKWELL

1922–2013

Elected in 2001

"For contributions to the development of reactor shielding technology and nuclear-power reactor safety."

BY DOUGLAS M. CHAPIN

THEODORE ROCKWELL, retired founding partner and board member, MPR Associates, died on March 31, 2013. He was born on June 26, 1922, in Chicago and earned MS and BS degrees in chemical engineering at Princeton University. After graduation in 1943, the then top secret uranium enrichment program recruited him to Oak Ridge, where he met and married Mary Compton, who became his wife of 63 years (she predeceased him in 2009). They had four children—Robert C. (who died in 1997), Lawrence E., W. Teed, and Juanita C.—and, eventually, two grandchildren and a great-granddaughter.

Ted's initial job at Oak Ridge National Laboratory began his spectacular career over seven decades as one of the pioneers and drivers of the peaceful uses of nuclear energy. In 1949 he was recruited by then Captain Hyman Rickover to work in the nascent Naval Nuclear Power Program, and in 1954 he became technical director at Naval Reactors, responsible to Admiral Rickover for developing criteria, procedures, and facilities for safe operation of the nuclear Navy as well as for the first commercial nuclear power plant at Shippingport, Pennsylvania.

In 1964 he left Naval Reactors and with two colleagues founded MPR Associates, with the prime objective of achieving engineering excellence applied to major problems. MPR is now regarded as one of the premier engineering companies in the world and at the time of Ted's death was closing in on its 50th anniversary. Ted "retired" from MPR in 1987 but remained on the board, and provided international leadership in nuclear power and radiation safety for the following 26 years. He also was a founding director of Radiation, Science, and Health, Inc.

In 1960 he was awarded an honorary ScD degree for contributions to the development of nuclear power. His many awards include distinguished service medals from both the US Navy and the Atomic Energy Commission, and the first American Nuclear Society Lifetime Contribution Award, thereafter known as the Rockwell Lifetime Achievement Award. One of his patents is a "landmark US Atomic Energy Patent." He was elected to the National Academy of Engineering in 2001 and in 2003 was the first NAE-sponsored Sigma Xi Distinguished Lecturer. In addition, he was a member of the Health Physics Society, fellow of the American Nuclear Society, life member of the Philosophical Society of Washington, and ruling elder of the Presbyterian Church. In 2006 he received the Edward Teller Medal by Doctors for Disaster Preparedness, and he was selected as Distinguished Speaker at the World Nuclear University Summer Institute in 2006 and 2007.

Ted was a prolific writer and speaker on technical topics, wrote popular interest articles, and established a blog, "Learning about Energy." He edited the *Reactor Shielding Manual*, the fundamental reference used worldwide since its initial publication in 1956. He also authored two nonfiction books—*The Rickover Effect: How One Man Made a Difference* (Naval Institute Press, 1992) and *Creating the New World: Stories and Images from the Dawn of the Atomic Age* (AuthorHouse, 2003)—and a novel, *The Virtual Librarian: A Tale of Alternate Realities* (coauthored with his son Bob; iUniverse, 2007).

These facts give only a glimpse of the breadth and depth of this incredibly energetic, personable, and capable individual. Ted found time for many pro bono activities; for example, he was a member of the NIH Advisory Committee on Artificial Heart Research and of the Princeton Chemical Engineering Department Advisory Committee. At age 90, he organized and led the special session on radiation safety at the American

Nuclear Society national meeting and was hard at work on a documentary on Admiral Rickover.

In everything he did, Ted studied deeply, mastered the details, and made lasting contributions. A great example is the shielding design on nuclear submarines. Those who serve on such vessels are exposed to less radiation once underway than those who stay behind—a difficult achievement, as shielding tends to be bulky and slow the ship. Ted's designs did not assume naval personnel were heroes in dangerous service and needed to take risks: his implementation of shielding had to be safe for fathers and mothers, sons and daughters, brothers and sisters, not heroes.

Ted was a lifelong outspoken visionary, who consistently produced elegant real-world implementation of his visions and considered engineering the highest professional calling. His tools were a brilliant mind, hard work, relentless attention to detail, and unbending integrity. You always knew where you stood with Ted. One of his favorite maxims was "silence is assent." It was better to ensure we got it right than to worry about how you looked when you asked questions or challenged assumptions.

In a 1968 letter to the *Princeton Engineer*, a magazine he cofounded as an undergrad, he spoke directly to a younger generation of engineering students:

> [I]n today's mechanized world, there are few opportunities for a man to take pride in an elegant piece of creative workmanship. An engineer, working in a truly professional environment, can do this. He can maintain a high degree of professional integrity and competence, and turn out a product in which he can take pride and from which others can draw inspiration. In a day when many young people have concluded that the only way they can "do their own thing" with integrity is to withdraw from man's universal struggle into a private world, the engineer has a unique opportunity to carry out his profession with creativity and individuality, and in so doing have the further satisfaction of knowing he is responding to the most urgent and basic needs of all mankind in a way very few of his fellow men are qualified to do.

Ted responded to those urgent needs over and over during his long life and in his own cheerful, bold, and inspiring way.

The closing words on Ted's life are also his own: "I like to stir up spirited discussions on important issues. Socially, I like to comfort the afflicted and afflict the comfortable."

REUEL SHINNAR

1923–2011

Elected in 1985

"For the breadth and quality of his research in reactor design, control theory, chemical kinetics, statistical analysis, and process economics."

BY MORTON M. DENN

With the passing of REUEL SHINNAR on August 19, 2011, at the age of 87, the engineering community lost an increasingly rare member of the profession, one whose interests and accomplishments covered a truly amazing range, from purely academic subjects to those having immediate and identifiable practical importance, and from exclusively engineering and scientific topics to economics and the reform of the prison system. He was Distinguished Professor of Chemical Engineering Emeritus at the City College of New York (CCNY) at the time of his death.

Reuel was born in Wiener Neustadt, Austria, on September 15, 1923. He grew to a carefree adolescent who came from a comfortable home and attended a fine school, where he excelled as a student, but he was forced out of high school in 1938 after the German annexation of Austria, when the survival of his family became increasingly threatened. Shortly thereafter his parents sent him and his sisters to Sweden in a Kindertransport. In Stockholm, a wealthy businessman offered to pay his tuition expenses at a technical school for one semester, but Reuel would have to perform at a level that would qualify him for a scholarship in order to complete the rest of his education. The headmaster was happy to assist so promising a student, but only if he studied chemical engineering, which most students avoided because they considered it too difficult, and Reuel agreed.

In 1941 the Jewish Agency, which supported the basic needs of the Kindertransport refugees, decided that some of the teenagers should be sent from Sweden to prestate Israel by train through the Soviet Union and Turkey. Reuel asked his supervisor at the agency to fund his tuition at the Technion and, although he had not graduated from high school and the school he had attended in Sweden was not for college-bound students, he passed the qualifying exams and was accepted. He wanted to study mathematics, but his supervisor objected—mathematics was too theoretical to be practical. Because engineers were in short supply and Reuel had already studied chemical engineering, his tuition would be funded if he continued on this track. He earned a BS (1945) and MS (1954) from the Technion and an ScD from Columbia University in 1957, all in chemical engineering.

From 1947 to 1962, except for the three years he studied at Columbia, Reuel was employed by the Israel Defense Industry as technical manager of explosives and ammunition and, from 1957 to 1962, as chief engineer. He also held a half-time position at the Technion from 1957 to 1962 as associate professor of chemical engineering.

In 1962–1964 he was invited to Princeton University's Guggenheim Laboratories as a visiting research fellow to work at the Jet Fuels Institute. From there he joined the CCNY Department of Chemical Engineering as a professor in 1964 to help establish the new PhD program, and he was named a Distinguished Professor in 1979. He also maintained a vigorous consulting practice until his death, serving both industry and government agencies.

Much of his early research concerned physical processes that have a stochastic component; this included the study of dispersion and particle-size distributions in mixing vessels, crystallizer dynamics, coalescence, and the use of residence-time distributions for process understanding. He also carried out research on the flow of non-Newtonian fluids; his work on the unusual breakup dynamics of jets of dilute polymer solutions continues to be cited after more than 40 years.

His experience with Israel Military Industries and his work on oxidation kinetics at the Guggenheim Laboratories led him naturally to chemical reaction engineering, where he published several book chapters and many significant papers on the design, operation, and control of stirred tank, fixed bed, and fluidized bed reactors and the thermodynamic analysis of reaction systems. Reaction engineering was also the primary focus of his consulting practice, and he held 16 patents on hydrocarbon processing, separation processes, power generation, and thermal storage, many of which are still practiced; for example, 30 fluidized catalytic cracking units based on his novel design are in use around the world.

The hallmark of his work was the integration of his experience as a designer into his fundamental research, enabling him to utilize the tools of engineering science in practical applications, and his novel insights have had a strong impact on the practice of chemical engineering. In one series of insightful papers, for example, he pointed out that the inherent inaccuracies and uncertainties in the process models used in the chemical industry require that the design methodology for controllers be fundamentally different from that in the aerospace and electronics industries. These papers were a turning point in the application of modern control theory to real chemical processes, and they initiated a major shift in research by the chemical engineering control community.

Reuel also exhibited unusual physical intuition, and was well known for his ability to identify the relevant mechanisms for design or control, with rigorous corroboration by colleagues following only later. Though he was an inveterate modeler, he noted that "a model is only useful when it fails," that is, when it tells you that something important is missing.

After his election to the NAE in 1985, he served on the NRC Panel on Energy and Natural Resources Processing (1985–1988) and Committee to Examine the Research Needs of the Advanced Extraction and Process Technology Program (1992–1993), and the NAE's Chemical Engineering Peer Committee

(1997–2000). He was a fellow of the American Institute of Chemical Engineers (AIChE) and recipient of its Alpha Chi Sigma Award for Chemical Engineering Research (1979) and Founders Award (1992).

Reuel made a point of addressing the broader technical community, and published many papers on process technology, economics, and energy issues in periodicals such as the American Chemical Society's *ChemTech* and the AIChE's *Chemical Engineering Progress*.

He also used his analytical skills to address problems well beyond conventional chemical engineering. Two papers on the criminal justice system published in the *Journal of Criminal Justice* (1973) and *Law & Society Review* (coauthored with his son Shlomo; 1975), which use mathematical modeling and control theory concepts to analyze the effect of imprisonment on crime rates, are still routinely cited in criminology texts and analyses of sentencing guidelines. A paper on industrial performance, published in the *Journal of Business* (1989), has had a profound effect on economic thinking about corporate financial analysis. An analysis of Modern Jewish Orthodoxy, published by the Jerusalem Center for Public Affairs (1998), is a significant sociological study of his own religious community, and he also published numerous shorter pieces in Jewish publications such as *Shma*. A paper on new-onset seizures in children in the *Annals of Neurology* (2001), also coauthored with Shlomo and using control concepts, is among his most highly cited publications. And as he became increasingly concerned in the decade preceding his death about globalization and its impact on our readiness to respond to a military threat, he wrote articles on the export of strategic segments of the US industrial complex and the impact of imported fossil fuels on economic and military security, together with recommended solutions.

Reuel had a capacity for penetrating analysis and was a keen and outspoken critic of ideas that he thought had not been thoroughly thought through. He encouraged younger colleagues to come to him to discuss their research ideas, but they had to be forewarned to anticipate the inevitable response to the first presentation: "That's crap" (pronounced approximately like the French *crêpe*, with a guttural rolled *r*, and sometimes unrecognizable as a criticism to an unwarned recipient). Those with the courage to return found him a supportive and caring mentor. Younger engineers in industry faced with a Shinnar cross-examination during a consulting visit approached him with trepidation, but they ultimately viewed him as an indispensable asset because of his broad knowledge and analytical skills as well as his honesty and integrity.

A 2003 letter in *Chemical & Engineering News* illustrates the classic Shinnar approach: It starts with an indisputable array of evidence, demands a logical but unpopular conclusion, and ends with this observation: "How the promoters of fuel cells could convince government agencies to subsidize with large sums of money a technology that wastes money and poisons the environment with greenhouse gases is a subject that I will leave to sociologists to explain."

Reuel instilled a love of science and academia not only in his many students but also in his children. Both his sons obtained a PhD and an MD, and both are professors. He was a devoted family man, the undisputed patriarch of the clan who loved to have the entire family together during the holidays. He delighted in giving advice on life not just to his students but also to his grandchildren, who were the recipients of Shinnar lectures that mirrored his discussions with young faculty: simultaneously blunt and supportive.

He is survived by his wife Mildred; a sister, Ruth Matar; sons Shlomo and Meir; six grandchildren; and nine great-grandchildren. His first wife, Miryam, died in 2000.

Author's Note

I am grateful to Mildred and Shlomo for information about Reuel's early years, and to Andreas Acrivos, Amos Avidan, Fred Krambeck, Dan Luss, Manfred Morari, David Rumschitzki, and George Stephanopoulos for commenting on a first draft and providing recollections and suggestions.

Cedomir M. Sliepcevich

CEDOMIR M. SLIEPCEVICH

1920–2009

Elected in 1972

"Creative research and development in liquefaction, ocean transport and storage of natural gas, fundamental behavior of flames, and combustion."

BY TOM LANDERS
SUBMITTED BY THE NAE HOME SECRETARY

CEDOMIR M. SLIEPCEVICH, a pioneer in liquefied natural gas technologies and George Lynn Cross Research Professor of Engineering at the University of Oklahoma, died on October 22, 2009, at the age of 89.

Cheddy was born in Anaconda, Montana, on October 4, 1920, the son of Herzegovinian immigrant parents. He graduated from Anaconda High School in 1937 and attended Montana State College in Bozeman for a time. As his love for mathematics and science grew, so did his ambition. He moved to Ann Arbor to continue his studies in chemical engineering at the University of Michigan, where he earned his BS (1941), MS (1942), and PhD (1948) degrees.

His doctoral dissertation, *The Design, Construction, and Operation of a High Temperature, High Pressure Plant*, focused on the kinetics of catalyzed reactions at elevated temperatures (up to 1000°F) and pressures (1000 psi) in a tubular reactor and the rates of dehydration of butanol over an alumina-silicate catalyst. He was fortunate to work with George G. Brown, from whom he learned how to mentor others.

At the University of Michigan he was an instructor (1946–1948), assistant professor (1948–1951), and associate professor (1951–1955) in chemical and metallurgical engineering. His promise as an educator was evident, and he taught many of the courses and offered the first seminar on kinetics of chemical reactions in the department. He was also the first faculty member in his department to utilize high-speed electronic computation in academic research.

In 1955 Dean William H. Carson recruited Cheddy to the University of Oklahoma (OU) where, as professor and chair in chemical engineering, he began transforming the research and graduate studies culture of the College of Engineering. Just one year later he added the title of associate dean, which he held until returning to full-time teaching and research in 1962. He also established and chaired the general engineering department that implemented his plan for a core curriculum. During his career he advised 68 doctoral and 29 master's students, and effected important curriculum reform at the University of Oklahoma, with advanced graduate courses and a rigorous undergraduate program, to meet the scientific and technical demands of the space age.

He published more than 165 papers that reveal an extraordinary breadth of scientific and technical interests—energy scattering, high pressure design, reaction kinetics, catalysis, cryogenics, thermodynamics, process dynamics, flame dynamics, heat and mass transfer, viscoelasticity, extractive and powder metallurgy, desalination, energy conversion, and biomedical engineering.

His career was marked by strong academic and industrial collaboration. In 1952–1953 he took a leave of absence from the University of Michigan to serve as senior chemical engineer at Monsanto Chemical, which led to many other industrial affiliations during his career. The project for which he is perhaps best known, and one that he called the most significant of his career, built on his expertise in liquefied natural gas (LNG), including behavior of materials at cryogenic temperatures. As manager of research and engineering for the Constock Liquid Methane Corporation, he led design and construction of the Methane Pioneer, a marine tanker for transport of LNG that docked at Canvey Island, UK, on February 20, 1959.

Besides Constock and Monsanto Chemical, companies for which he consulted or served on the board of directors were

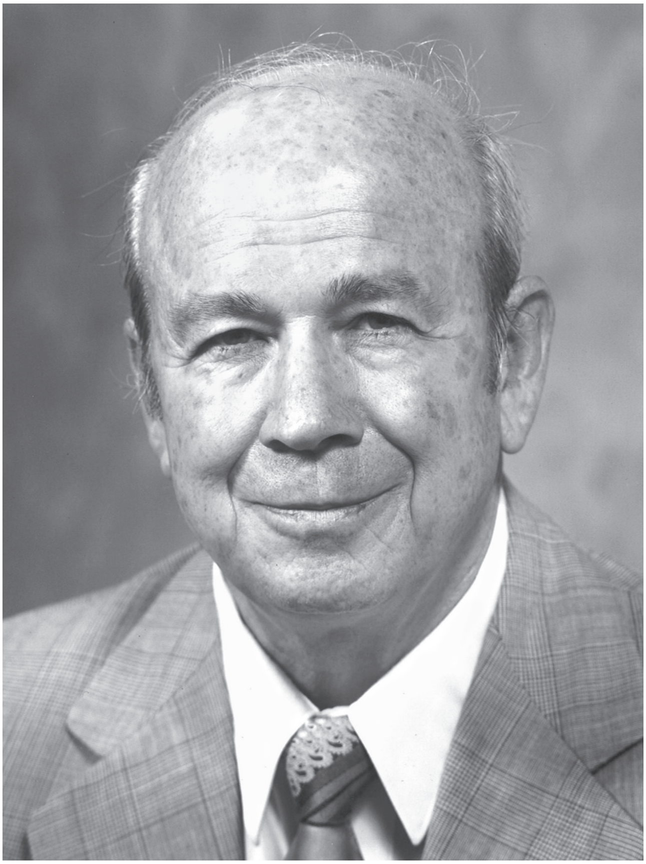
Continental Oil Company, Dow Chemical, Owens-Corning Fiberglass, E-C Corporation, and Autoclave Engineers. An entrepreneur, he was also president and CEO of two successful startup companies in Oklahoma: University Engineers, Inc. and University Technologies, Inc.

Projects included V-2 rocket testing at White Sands, classified work on proximity fuses at the Johns Hopkins Applied Physics Laboratory, heat transfer through finned tubes in nuclear weapons production at Oak Ridge, and particle size characterization by light scattering using the US Army ENIAC computer at Aberdeen Proving Grounds. He also performed electron microscope studies of the crystalline structure of hydrated Portland cement, and collaborated on development of a flat-plate kidney dialysis unit. As director of the OU Flame Dynamics Laboratory, he performed important work on flame propagation in wildfires.

In addition to his election to the National Academy of Engineering (1972), his numerous national honors and awards include the Curtis W. McGraw Research Award, from the American Society for Engineering Education (ASEE), for contributions in energy scattering (1958); International Ipatieff Research Prize, American Chemical Society, for contributions to high-pressure and catalytic chemistry (1959); ASEE George Westinghouse Award for distinguished contributions to the teaching of engineering students (1964); University of Michigan Sesquicentennial Award for Distinguished Alumni (1967) and D.L. Katz Lectureship (1976); William H. Walker Award, American Institute of Chemical Engineers (1978); and Gas Industry Research Award, American Gas Association Operating Section (1986).

At the state and local level in Oklahoma, his honors and awards include the OU George Lynn Cross Research Professorship of Engineering (1963); Oklahoma Hall of Fame (1974); OU Distinguished Service Citation (1975); Award of Merit, Oklahoma Academy of Science (1975); OU Robert M. Hughes Centennial Professor of Engineering (1989) and College of Engineering Honorary Member, Distinguished Graduates Society (1993). The C.M. Sliepcevich Professorship in Chemical Engineering at OU was created in his honor and endowed by alumni, friends, and corporations for his many contributions to industry and education.

Cheddy had a strong command of widely ranging scientific principles coupled with intellectual curiosity and an eagerness to work on diverse engineering problems. Friends enjoyed his dry and self-deprecating sense of humor, and speak especially fondly of his caring way of mentoring graduate students and junior faculty. He and his wife Cleo often entertained his protégés in their home near the OU campus; there and at the laboratories, he engaged them in stimulating discussions on scientific and technical topics.



HAROLD G. SOWMAN

1923–2012

Elected in 1984

"For pioneering development of sol ceramics technology into new industrial materials, including ceramic fibers and abrasives."

BY JAMES R. JOHNSON

HAROLD GENE SOWMAN, a remarkably productive engineer at the forefront of the changing field of post–World War II ceramic science and technology, died on November 29, 2012, at age 89. He was a pioneer in ceramic materials for nuclear reactors in his early career and later developed sol ceramics technology into new processes for manufacturing ceramic materials and products. In the course of this work he added much to the science of these materials as well.

Born on July 21, 1923, near Murphysboro, Illinois, Hal grew up in the southern Illinois coal mining country. He was grateful for the many who helped him get through his schooling, including a kindly landlady in whose boarding house he stayed and where he worked part-time to pay for room and board. He joined ROTC, graduated as a second lieutenant in the Corps of Engineers at Ft. Belvoir, Virginia, and was awaiting service in the Pacific when World War II ended. His wife to be, Gladys (Timmie), worked in nearby Washington and after the war they moved back to the University of Illinois, where he obtained his PhD in 1951. In the mid-1950s they adopted a daughter, Letitia (Letty), and a son, Daniel (Danny).

Hal joined the Titanium Alloy Division of National Lead Co. in 1951 but by 1952 was fascinated by the emerging atomic energy field and went to work at General Electric's Knolls

Atomic Power Laboratory in Niskayuna, New York. Here he developed ceramic materials for the Navy submarine project and was involved with both cermets and ceramic oxides for commercial reactors. He was part of the very early UO_2 fuel pellet program.

He left GE five years later to work with 3M in its new nuclear energy lab. At 3M he was coinventor of a number of nuclear materials patents that formed the basis of microspherical coated fuel particles embedded in graphite fuel elements such as the ensuing pebble bed reactors. These particles were first used in a prototype reactor designed for space rocketry, the Kiwi B4-E 301, successfully tested by Los Alamos National Laboratory in the Nevada desert. The technology was put on the shelf after the demise of nuclear reactor construction in the 1970s–1980s but it is making a comeback, in the Chinese construction of a modern version of a high-temperature reactor.

Hal became interested in developing sol gel ceramics, which he saw as the basis of revolutionary ways of making 3M abrasives and reflective beads of high index of refraction. He investigated detailed phase relationships of many ceramic oxides related to his sol gel products. His combined work in the field led to making sol gel–derived fibers, beads, bubbles, and thin films. The fiber work was soon found to be useful in classified nuclear projects, and later other fibers were used to toughen and strengthen the insulating tiles for the space shuttle.

His technology was especially useful in replacing conventional processes for making abrasive grains, which can now be formed essentially at room temperature and in compositions not obtainable by traditional methods. In turn the products have made major changes in the finishing of stainless steels and other metals. His ceramic fiber technology encouraged the related refractory fiber industry worldwide and provided a means for producing much lighter alumina-reinforced aluminum electric power transmission lines. And the safety of roadways has been improved with better light-reflecting microsphere media that resist traffic abrasion.

Many other uses have been found for his broad range of sol gel–derived ceramics, including medical and dental applications. He had 30 patents and authored 25 publications.

Hal received many honors in his lifetime: 3M's highest honor, election to the Carlton Society (and 3M received the National Medal of Technology, accorded to the members of the Society); the Minnesota Wonders of Engineering Award, the I-R 100 award for his fibers, the University of Illinois Engineering Distinguished Alumni Award, and several prestigious awards from the American Ceramic Society, of which he was a fellow, for his many innovations in ceramic materials and processes. He was especially honored to be elected to the NAE in 1984 for his engineering accomplishments.

He was proud of his home state and a generous contributor to the University of Illinois, from which he obtained his undergraduate and graduate degrees. His service outside his local community included two years as industrial advisor for the Department of Engineering at Tuskegee University, membership on the NAE Steering Committee on the Commercialization of Technology and the Materials Advisory Board, and numerous activities for the University of Illinois Ceramic Engineering Department.

Hal was a born innovator and major contributor to his field. He was a great friend and generous man to many. He will be missed.

MARSHALL B. STANDING

1913–2010

Elected in 1984

"For pioneering and lasting contributions to petroleum reservoir engineering technology and phase behavior of mixtures of natural gas, crude oil, and water."

BY ROLAND N. HORNE

MARSHALL B. STANDING, a research engineer at Standard Oil Company of California (now Chevron) and professor of petroleum engineering at Stanford University, died November 13, 2010. He was 97.

He received his BS from the University of Utah (1936) and MS (1937) and PhD (1941) from the University of Michigan, all in chemical engineering.

After joining the Standard Oil Company in 1941 as a research engineer, he became head of the production research effort in 1943 and continued in research until 1963. He was then transferred to the corporate production staff, where he served until 1973 as an engineering consultant for reservoir engineering and formed and operated the company's in-house reservoir engineering schools. In 1973 he retired to accept a visiting professorship of petroleum engineering at the University of Trondheim in Norway. After 18 months there, he joined the faculty of Stanford University.

Long active in the Society of Petroleum Engineers (SPE), Dr. Standing received the SPE Lester C. Uren Award in 1965. In 1977 he received the Anthony F. Lucas Gold Medal from the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME), in recognition of his contributions to the knowledge of reservoir and well performance and to the effective teaching of their practical applications. He was one of SPE's first Distinguished Lecturers, in 1964–1965, and was described in the Society's history of the program as an "industry luminary." In 1991 he was designated an honorary member of SPE and AIME.

His professional career had significant impact on the oil industry. He was instrumental in setting up the California Research Company in La Habra, which ultimately became the Chevron Oilfield Research Company, the research arm of Chevron Corporation. His pioneering work on understanding the complex phase behavior of oilfield hydrocarbons, and describing them usefully with (relatively) straightforward correlations, formed the basis of oil and gas reservoir engineering from the 1940s until today. The "standing correlations" are still in use, although perhaps embedded in computer software rather than the charts and nomograms in which he published them originally.

"Muz," as he was known to his friends, was an engineer's engineer. He built his own airplane in his garage and flew it to meetings and for recreation. He owned a VW Beetle decades before automobile fuel efficiency was a public concern, and he kept it in pristine condition for many years doing all his own maintenance—even to the point of stitching the seat upholstery during a refurbishment. Clearly not just an "indoor" engineer, he was also a champion ski jumper in Utah in the early 1930s.

Known to his students as gruff and not easily impressed, he was in fact a very generous person with a genuine concern for other people. He wanted his students to understand fully, implement correctly, and make useful contributions to society. He, too, contributed; for example, after retirement he turned his interest (and his extensively equipped workshop) to the design and construction of aid devices for disabled people.

DONALD O. THOMPSON

1927–2013

Elected in 1991

"For major contributions to placing quantitative nondestructive evaluation on a firm foundation of interdisciplinary science and engineering."

BY LEONARD J. BOND
SUBMITTED BY THE NAE HOME SECRETARY

DONALD OSCAR THOMPSON was a creative force who recognized that there was not an adequate science base for nondestructive testing (NDT) to be more quantitative and went on to establish the field of quantitative nondestructive evaluation (QNDE). He died on July 29, 2013, at the age of 86. A week before he died he achieved his goal of attending the 40th QNDE meeting in Baltimore, where he was recognized as a leader in the development of the global NDE community and the founder of the *Review of Progress in Quantitative Nondestructive Evaluation*.

Don was born on February 27, 1927, in Clear Lake, Iowa, a rural vacation community midway between Minneapolis and Des Moines. He enjoyed his high school years there—he participated in three sports and band, and was dedicated to academics. He also worked during his school years, delivering groceries and newspapers and at a meat packing facility in nearby Mason City. He played trumpet and won a national championship in a band contest.

He was drafted into the Navy in the summer of 1945. During boot camp, the Navy determined that he should attend NROTC at the University of Idaho, where he met and fell in love with Barbara Newell. They married and moved back to Iowa, where he attended the University of Iowa, graduating summa cum laude with a bachelor's degree in physics, a master's, and in 1953 a PhD. He became a member of Phi Beta Kappa.

After university he switched branches of service and became a commissioned officer in the US Air Force; he worked at the Air Force Cambridge Research Center, Hanscom Field (Bedford, Massachusetts), in the Atomic Effects Directorate research facility for two years. He was then transferred to Tennessee as part of the Atomic Energy Commission and in 1954 was assigned to Oak Ridge National Laboratory, where he worked in the Solid State Physics Division.

In 1963 he returned to civilian life and for 15 years worked in a variety of positions for Rockwell International Science Center in Thousand Oaks, California. While there he recognized that to be able to effectively perform fracture mechanics, a field that was emerging in the 1970s, a quantitative basis was needed for NDT. His goal was to provide the science, and then technology, needed to determine the significance of a crack or defect in service, to reliably detect it, and to provide its characteristics, including size.

Don's vision was to establish unified lifecycle engineering (ULCE) and the tools needed in addition to QNDE. The ULCE concept itself is not his—it emerged in USAF parlance—but he had a strong view of QNDE as a critical component of ULCE. He advocated for QNDE being integrated into lifecycle system design activities. By doing so he promoted NDE from an in-service-oriented reactive function to a science-based, proactive, reliability assurance function. He wanted to see design tools that could enable NDE (and stress) analysis, in a parts design process that would allow the full impact and benefits of a fracture mechanics approach.

The path to develop QNDE began with a program of the Defense Advanced Research Projects Agency (DARPA), a funding source noted for visionary and enabling research, the culmination of which was an understanding of the role of QNDE in supplying the defect properties for an effective implementation of a fracture mechanics design philosophy. A key feature of the program was the Annual Review of Progress in QNDE, which became a conference series under the same title; the proceedings of these meetings, which he edited (with Dale Chimenti), now represent 40 years of the progress literature for QNDE.

In 1979 Don and Barbara moved to Ames when he joined the Department of Energy Ames Laboratory and Iowa State University (ISU), where he became Anson Marston Distinguished Professor in the Aerospace Engineering Department. He initiated the creation of, and was the founding director for, the Center for Nondestructive Evaluation (CNDE), an NSF Industry-University Cooperative Research Center (I/UCRC) devoted to researching, teaching, and practicing NDE, moving NDT to a more quantitative and science-based approach for analyzing the condition of materials and safe life for structures.

Founded in 1985, CNDE is one of only a few of the 150 centers that have prospered through three full terms of this NSF program. Don did much to leverage the model, which is unique in that these NSF I/UCRCs involve a core of research professionals and faculty and enable them to build larger funded programs. At CNDE this included a NIST program for integrating NDE with the design process (design for inspectability)—part of a pioneering effort to raise the status of NDE as an important part of lifecycle engineering and damage-tolerant design and—major Federal Aviation Authority (FAA)–funded programs, which added a Center for Aviation Systems Reliability (CASR), an Aging Aircraft Center of Excellence (AACE), and the Engine Titanium Consortium (ETC). The latter two were large multidisciplinary and multi-institutional R&D programs that had important benefits for the aerospace engineering community nationally and internationally. For example, the ETC resulted in advances that reduced the numbers of uncontained engine failures by 80 percent. A number of other programs for which Don was in large part responsible engaged almost every US federal agency with interests in advanced NDE.

Through a collaboration between CNDE and ISU's College of Engineering, Don helped develop a fully accredited minor in NDE at the college, a first-of-its-kind program. He also worked to establish NDE both nationally and internationally.

Together with his colleagues and staff, they developed the CNDE into a world-class scientific organization and hub for the World Federation of NDE Centers, which Don created.

Don was honored for his distinguished contributions to engineering and science by election in 1991 to the National Academy of Engineering. He served on the NAE Panel on Non-Destructive Inspection (1980–1983) and on the NRC Committee on Aging of US Air Force Aircraft (1996–1997). In 2002 he was one of only 19 foreign scientists elected to India's National Academy of Engineering. He was also a fellow of the American Physical Society, Institute of Electrical and Electronics Engineers, and Rockwell International Science Center. He was honored by Iowa State University as one of 150 Visionaries that shaped the institution.

He began phased retirement in early 1997. In 1999 he accepted a position as scientific advisor to the director of ISU's Institute for Physical Research and Technology. He remained active in the organization of the Annual Reviews of Progress in QNDE, and was president of QNDE Programs, a nonprofit he had founded to sponsor the meeting.

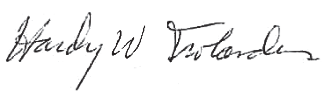
Don Thompson was a tenacious fighter for what he believed in, and his vision and perseverance did much to establish NDE in both the US and global R&D community. His legacy includes a 52,000-square-foot center with faculty, staff, students, and alumni who form a network of national and international connections. The center, a global resource, has seen more than 120 graduate students successfully complete its programs and they now practice NDE on at least six continents.

At the July 2013 Annual Reviews meeting one of Don's long-time colleagues commented in his speech, "Don ruled with an iron hand, but was compassionate and the best boss I have ever known." He will be greatly missed by his many friends and colleagues in the NDE community.

Besides his professional science and engineering life, Don was an accomplished trumpet player and played in several bands in his spare time. As a young man he parlayed this into a money-making effort as part of a traveling musical ensemble that played at clubs and roadhouses in the Midwest and the West! In his later years he played with the Non-Semble, a Clear Lake band of retirees who gathered once a week to enjoy music and friendship and to share their joy in performances at community events.

Don was very much a family-focused, faith-based man. Summers would find him on Clear Lake with family and friends or cruising the Mississippi River with his boys. He enjoyed sharing his time and passion for boats, including one that he built. And his dogs were regular companions.

Don is survived by Barbara, his wife of 67 years; sons Jim, Steve, and John and their spouses; 9 grandchildren, and 15 great-grandchildren.



HARDY W. TROLANDER

1921–2013

Elected in 1992

"For creative development of precision sensors for medical and industrial applications and leadership in worldwide commercialization of these products."

BY ANITA BROWN
SUBMITTED BY THE NAE HOME SECRETARY

HARDY WILCOX TROLANDER, retired CEO of YSI Incorporated, died at his home in Yellow Springs, Ohio, on October 11, 2013. He was 92 years old.

He was born on June 2, 1921, in Chicago and grew up on the South Side during Prohibition. His father was a chemist and his mother a former office manager. At a young age, Trolander started taking things apart; he tinkered with radio electronics he'd garnered from neighbors' basements and clandestinely experimented with public street lights and railroad crossings. He was educated in the Chicago school system and graduated from high school in 1939.

He began his college studies at Purdue University, but transferred to Antioch College in Yellow Springs after his freshman year. In Antioch's work-study program, he was employed by the Museum of Science and Industry in Chicago and later at the Sperry Gyroscope Company's radar laboratory in Garden City, New York, where he worked for Russell Varian, inventor of the Klystron tube.

He enlisted in the Army Air Corps in early 1942 and in 1944 received his commission as a communications officer from the Air Corps Officers School at Yale University. He was assigned to fly unescorted single plane missions along the coast of Japan to locate Japanese radar installations, but was relieved of duty after the first nuclear bomb was dropped.

He returned to Antioch and graduated with a BS in engineering in 1947, and remained as a temporary instructor in physics and engineering for a year. During that time, he approached two of his former Antioch classmates with the notion of starting an engineering laboratory. Yellow Springs Instruments Company, later YSI Incorporated, was founded in the basement of the Science Building at Antioch College, with Trolander serving as its first president and CEO starting in 1948.

Among YSI's early developments was a very accurate camera timer developed for the Air Force. To achieve the necessary accuracy at its highest setting, 0.005 percent, Trolander conceived of a form of early computer circuitry using vacuum tube flip-flops and stepping relays. Today it would be characterized as a 16K ROM with onboard crystal clock and heavy-duty input and output gates, but in 1950 some of these terms were yet to come into use. The YSI timers were used in the training of Air Force bombardiers.

Trolander's next important development was in 1952 when he and Leland Clark Jr. conceived the telethermometer, the first practical medical electronic thermometer. His subsequent invention of a process for tightening the tolerance of thermistors used as sensors for the thermometers to better than 0.1 degrees became the major step in ensuring their acceptance.

In 1958 he invented and patented the precision interchangeable thermistor, which he considered the most important of his inventions. Described as a method for producing close tolerance uniform thermistors for the measurement of medical and biological temperatures, the precision interchangeable thermistor solved the variation problem previously inherent in thermistors, making it practical for commercial applications. It became the breakthrough needed to make thermistor technology important in medicine, medical and biological research, and a wide variety of scientific and business applications.

Other inventions followed, including an n-term electrical network in 1967 that made use of two or more nonlinear thermistors to achieve a highly linear response from the non-linear elements. With this invention, Trolander became one of the first American inventors to be awarded a Russian patent.

In 1978, almost 20 years after first noticing an apparent inconsistency between the behavior of thermistors and their accepted theory, he conceived of a new form of their structure that involved glass encapsulation. This new form improved their long-term stability by more than an order of magnitude.

Trolander believed that measurements were the "ultimate truth," and he was confirmed in this belief through his work with engineering scientists all over the world. No matter the government, religion, or culture, a measurement could be agreed upon by very different people.

He worked with Leland Clark on the process for measuring dissolved oxygen in liquids that enabled open-heart surgery and the first heart-lung machine, which led to YSI's in-house development of biosensors. The Model 23-A was introduced in 1975 for the measurement of whole blood glucose and incorporated the world's first commercial biosensor. It has been recognized by the Chemical Heritage Foundation as one of the top 50 instruments that "changed the world in the 20th century." It and subsequent designs are still recommended by the US FDA as the reference standard for measuring glucose.

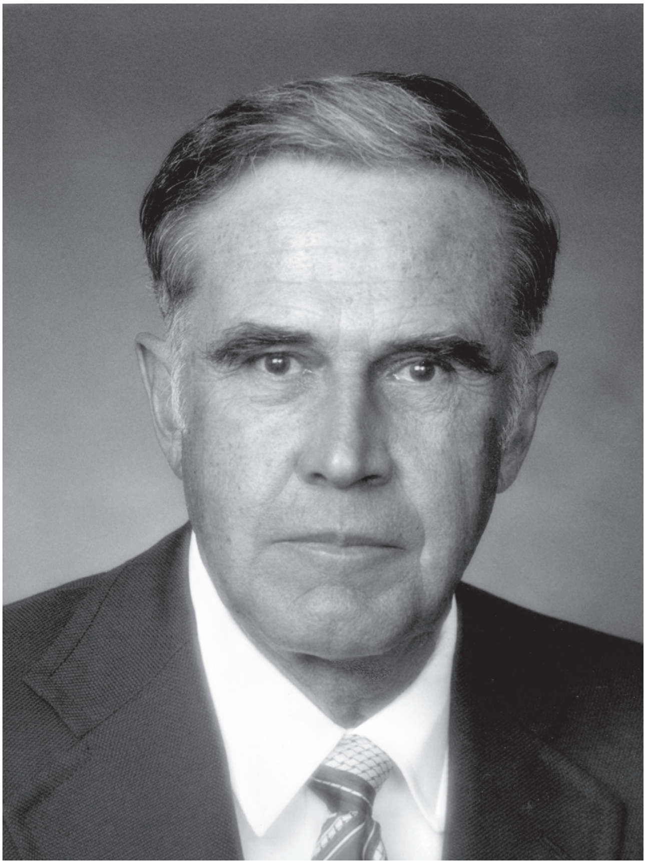
Trolander considered inventions incomplete until they were developed and manufactured as useful, affordable, and high-quality products. He took great pride in helping determine the official melting point of gallium, which was adopted in 1990 as a primary point on the International Temperature Scale.

He was part engineer, inventor, businessman, and civic leader. A big believer in the social benefits of meaningful, economically viable work, he also advocated for corporate responsibility throughout his career, and was proud of YSI's early personnel policies based on trust. Under his leadership, the human side of enterprise was given a high priority at YSI, where many progressive concepts were pioneered, such as aggressive employment of minorities, group and individual flex time, and the removal of time clocks for recording employee attendance.

Trolander retired in 1986 after nearly 40 years as YSI's first president, having seen the firm grow from three employees in a small rented college laboratory to an employee-owned company with 400 people working in plants in Yellow Springs, New Mexico, and Japan. He stayed on as chair until 1990.

His leadership was visible through many affiliations, including board memberships with the International Institute for Medical Electronics and Bioengineering (founder), Bioinstrumentation Advisory Council of the American Institute of Biological Sciences, International Organization of Legal Metrology, National Bureau of Standards (now the National Institute of Standards and Technology), Engineering and Science Foundation of Dayton, Dayton Engineers Club Foundation, Foundation for Skeletal Health Antioch College, Miami Valley Regional Business Innovations, Yellow Springs Community Foundation (cofounder), and American Civil Liberties Union. He was elected to the National Academy of Engineering in 1992.

Trolander's wife, Imogene, predeceased him. He is survived by daughters Megan Trolander and Pati An, grandson Noah Trolander An, son-in-law Jim Spangler, and his final sweetheart, Bev Price.



LELAND J. WALKER

1923–2014

Elected in 1984

"For his outstanding practice as a civil engineer and for his distinguished service to the profession and engineering education."

BY WILLIAM J. CARROLL

LELAND JASPER WALKER died December 31, 2014, at age 91 in Missoula. He was born in Fallon, Nevada, to Albert Willard Walker and Grayce Wilkinson Walker on April 18, 1923. The family moved to Fairfield, Montana, in 1929. Lee attended school in Choteau and Fairfield, graduating in 1940 as valedictorian of Fairfield High School.

Following in his father's footsteps, Lee pursued a career in civil engineering at Montana State College in Bozeman. However, his studies and his term as student body president were interrupted by World War II. He enlisted in the Navy's V-12 College Program and completed his civil engineering degree at Iowa State College in Ames. During the war, he served with the Navy's Seabees in the Pacific Theater. He was recalled to active duty during the Korean conflict and served at the Civil Engineering Research and Evaluation Laboratory in Port Hueneme, California, retiring from active duty as a lieutenant commander.

Lee married his college sweetheart, Margaret Frances Noble, on January 21, 1946, and thus began a 68-year enjoyable and successful marriage. They have three children: Tom (Judy), in

Gary Quinn, one of Lee's associates at Northern Testing Laboratories, furnished information for this tribute.

Phoenix; Peggy (Patrick Marx), in Missoula; and Tim (Sheila), in West Linn, Oregon; and three grandchildren: Patrick Marx Jr. and Lucy and Liam Walker.

Lee started his civil engineering career with the US Bureau of Reclamation in 1946 and worked there until 1955, interrupted by his Navy service during the Korean conflict. In 1955–1958 he was vice president of Wenzel and Co., consulting engineers in Great Falls, Montana.

In 1958 he launched Northern Testing Laboratories, Inc. (later Northern Testing and Engineering), to which he dedicated the rest of his engineering career. With a lot of confidence he started the company as a one-man, basement-of-his-home operation, and over the years the business grew under his guidance and management to a prestigious professional organization of more than 140 employees. The company did geotechnical engineering and material testing, and its work was known to be of the highest quality, conducted with integrity, accuracy, and client service as fundamental objectives. Projects that Lee oversaw spanned large power plants, hydroelectric dams, industrial and mining developments, military installations, repair of various geohazard problems, and projects for homeowners with cracked foundations.

Thanks to his engineering leadership in the northwest region, Lee is remembered by many as the "Father of Geotechnical Engineering" in Montana, Washington, Idaho, Wyoming, and North Dakota.

Lee was truly dedicated not only to his profession but to all the organizations and people he came in contact with. He was a man who felt obligated to serve, and he gave his energy, compassion, skills, and finances to make his community and world a better place for all. He was a teacher of ethics, management, and leadership, and incorporated common sense in all his endeavors.

His contributions to the engineering profession were remarkable in their excellence and insights. One of his most important leadership roles was as president of the American Society of Civil Engineers (ASCE) in 1976, when he introduced the concept of "management by objectives," which has served the

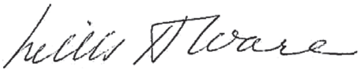
Society extremely well. ASCE was only one of many organizations in which he played an important role. As president of the Accreditation Board of Engineering and Technology (ABET) during a transition period, his strong leadership ensured the continued success of the organization in watching over the quality of engineering education in the United States. He was also president of the Montana Consulting Engineers Council, national secretary of the American Council of Independent Laboratories, and a member of the executive committee of the American Association of Engineering Societies.

In addition, Lee was active in the Academy. He served on the steering committee for the Conference on Innovative Finance for Transportation, the Committee on Membership (two terms), the Civil Engineering Peer Committee (three terms), the Panel on Construction and Structural Design System Research, and the Panel on Graduate Education and Research.

Lee also devoted his time and energy to organizations other than engineering ones. He was deeply involved with numerous community and church organizations, such as the United Methodist Church, where he was a member of the National Board on Overseas Relief and president of its administrative board; a trustee of Rocky Mountain College; a member of the President's Advisory Council of Montana State University and vice president of the university's Endowment and Research Foundation; and president of the board of trustees of Montana Deaconess Hospital. He was also involved with several philanthropic organizations.

Lee Walker loved his state of Montana and his hometown of Great Falls. He also loved people. To quote his wife Margaret: "Several people—some employees, some not—have said that he turned them around when they were headed in the wrong direction by showing them what they could achieve if they turned around. To others he was simply a role model and helper. But I think he liked getting involved with people and things."

Lee Walker was a giant to both the engineering profession and the community.



WILLIS H. WARE

1920–2013

Elected in 1985

"For pioneering contributions to computer technology, from development of machines and systems to operations and engineering for national security and civil capability."

BY MICHAEL D. RICH
SUBMITTED BY THE NAE HOME SECRETARY

The field of computer science is relatively young, but it has seen its share of visionaries and trailblazers. Few, however, have pushed the frontiers of technology with as much persistence and longevity as WILLIS HOWARD WARE, who passed away on November 22, 2013, at the age of 93.

Born in Atlantic City on August 31, 1920, Willis showed an early passion for engineering and circuitry. Working with salvaged parts and loaf pans pilfered from his mother's kitchen, he constructed primitive two- and three-tube radios. After completing his undergraduate and master's degrees in electrical engineering at the University of Pennsylvania and Massachusetts Institute of Technology, respectively, and shortly after the United States entered World War II he took a job at Hazeltine Electronics. There, his work on classified military systems exposed him to new signals equipment at a time when, as he remarked, "the phrase 'digital technology' was not yet in the lexicon."

At war's end, his experience brought him to John von Neumann's newly established computer development program at Princeton University's Institute for Advanced Study (IAS). Willis found two attractive benefits to working at Princeton: a tuition-free PhD and an opportunity "to learn all about this newfangled thing called a computer."

Since late 1945 a small US Air Force project housed at Douglas Aircraft Company in Santa Monica had also been probing the frontiers of computing technology. By the time the RAND Corporation was established as an independent organization in 1948, it needed something more powerful than a labor-intensive process involving mechanical calculators, handwritten worksheets, and analog computer simulation to meet its increasingly ambitious data needs. It dispatched a team to visit laboratories and universities across the country. The results were not encouraging—until the team visited IAS at Princeton. There, Willis, von Neumann, and other pioneers were building what would become the model for the next decade and a half of electronic computing technology and the basis for the "Johnniac" (named in honor of von Neumann), the backbone of RAND's modern computer-driven analysis.

"Johnniac demonstrated a lot of firsts—a machine that could run hundreds of hours without an error, early program tricks of the trade, a multiuser environment, the first rotating drum printer…and, for a short while, the largest core memory," Ware said during an interview with IEEE *Annals of the History of Computing* (July–September 2011, pp. 67–73).

Willis moved west after completing his PhD in electrical engineering at Princeton in 1951, dabbling in aerospace engineering at North American Aviation in Los Angeles. He found the cultural leap a challenge, but from there it was a small geographical leap to RAND's Santa Monica headquarters, where he spent the next 55 years.

RAND's Johnniac was in development in 1952 when project leader Bill Gunning broke his leg in a skiing accident. With so much expertise concentrated among so few staff, the project was at risk. Willis modestly recalled that George Brown, then director of RAND's numerical analysis department, "suddenly realized that RAND had all its Johnniac eggs in one person and would be vulnerable if something more serious were to happen to Bill. Some insurance seemed like a valuable asset to have." Enter Willis.

In the early 1960s he took the reins as head of RAND's Computer Sciences Department, where Paul Baran conducted his seminal work on packet switching and distributed communications. Thinking beyond the practical applications of computer technology, Willis predicted with remarkable accuracy how the digital revolution would change—and challenge—society. In 1966 he wrote in a paper presented at RAND, "The computer will touch men everywhere and in every way, almost on a minute-to-minute basis. Every man will communicate through a computer whatever he does. It will change and reshape his life, modify his career, and force him to accept a life of continuous change."

He also recognized that the ubiquity of computers would expose new vulnerabilities by distributing data processing and centralizing data storage. In 1967 he led a task force of the Advanced Research Projects Agency (now DARPA) to help defense agencies protect their classified computer systems from unauthorized access, user error, and data loss.[1] The "Ware Report" established guidelines for security that remain standard practice today.

Decades before data breaches, malware, and phishing began to make headlines, his 1973 paper "Records, Computers and the Rights of Citizens"[2] decreed, among other things, that there should be no secret data recordkeeping systems and that people should know what information about them is being recorded and have a way to correct it. He led several committees aimed at safeguarding computer user privacy rights, including the Privacy Protection Commission created by President Gerald Ford, which led to the federal Privacy Act of 1974.

[1] *Security Controls for Computer Systems: Report of Defense Science Board Task Force on Computer Security*, ed. Willis H. Ware. RAND Report R-609. 1967 (reissued 1979). Published by the RAND Corporation for the Office of the Secretary of Defense.

[2] *Report of the Secretary's Advisory Committee on Automated Personal Data Systems*. DHEW Publication Number (OS)73-94. Washington: US Government Printing Office.

Willis honed his analytical talents throughout his long career at RAND, conducting studies for the Air Force and eventually serving as deputy vice president of Project RAND, now RAND Project AIR FORCE.

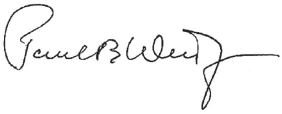
In the 1990s, as more and more personal, business, and government activities came to rely on the Internet, he continued his focus on the vulnerability of the nation's information infrastructure to external attacks and other kinds of disruptions. In a study of privacy in medical recordkeeping, he argued for the need to hold organizations accountable for the use of personal medical data, recommending critical legal and procedural changes to safeguard patients' privacy. In 1994 he was selected as a member of a National Research Council committee to examine national cryptographic policy; policies on data encryption had never before been examined in a cohesive way or by a nongovernmental group.

He received honors too numerous to list, including the Computer Pioneer Award from the IEEE Computer Society, a lifetime achievement award from the Electronic Privacy Information Center, and a Pioneer Award from the Electronic Frontier Foundation. In 1985 he was elected to the National Academy of Engineering and in 2013 inducted into the National Cyber Security Hall of Fame.

He served on more than 30 influential panels and committees of the National Academies; among others, he chaired the Committee to Review the Social Security Administration's System Modernization and Strategic Plan and the Committee on Computer Security in the Department of Energy. He was a fellow of the Institute of Electronic and Electrical Engineers, American Association for Advancement of Science, and Association for Computing Machinery.

As he wrote in his 2008 "professional memoir," *RAND and the Information Evolution: A History in Essays and Vignettes* (RAND Corporation; p. 21), "The history of an organization is more than the sober presentation of such things as major accomplishments, key decisions, changes in corporate name, physical locations, and clients served. While each is important in its own right, the people who make them happen have their own importance and place in history." Willis Ware did more than earn his place in that history: He helped create it.

He is survived by daughters Alison Ware and Deborah Pinson, son David, and two grandchildren.



PAUL B. WEISZ

1919–2012

Elected in 1977

"Contributions in pioneering the use of molecular sieves as cracking catalysts for petroleum hydrocarbons."

BY THOMAS F. DEGNAN JR.

PAUL BURG WEISZ, an internationally recognized expert in petroleum refining catalysts, died on September 25, 2012, in State College, Pennsylvania, at the age of 93. His work at Mobil Oil, with collaborators including Nai-Yuen (N.Y.) Chen, Vince Frilette, John McCullough, Dwight Prater, Jack Wise, Al Schwartz, Heinz Heineman, and Fritz Smith, helped lay the foundations for zeolite catalysis. His seminal work in the use of natural zeolites as highly shape-selective conversion catalysts set the stage for 50-plus years of highly productive process research and revolutionized the refining and petrochemical industries.

Born in Pilsen, Czechoslovakia, on July 2, 1919, to Alexander and Amalia Weisz, Paul grew up with an innate desire to become a scientist and published his first article in a ham radio journal at the age of 16. He emigrated to the United States from Berlin in 1939, interrupting his graduate studies in pre–World War II Germany to attend Auburn University, where he completed his BS degree in less than a year. After graduation he worked as a researcher at the Bartol Research Foundation of the Franklin Institute in Swarthmore, PA. He

Editor's note: This tribute was slightly adapted from the obituary published by the North American Catalysis Society, of which the author is a trustee.

later moved to the Massachusetts Institute of Technology where, as an electronics engineer, he participated in the development of LORAN, a long-range radio signal–based aid to navigation.

He joined Mobil Research and Development Corporation in 1946 as a research associate at the company's research laboratory in Paulsboro, New Jersey. He progressed through a number of technical assignments to reach the position of senior scientist, the highest technical position in Mobil, in 1961. He managed the company's Exploratory Process Research organization in 1967–1969 and then its Central Research Laboratory in Princeton through 1982. He retired in 1984.

Shortly after joining Mobil, Paul turned his attention to diffusion and catalysis, the foundation of a lifelong interest in porous materials as catalysts and specifically in crystalline hydrous aluminosilicates known as zeolites. Along with several Mobil collaborators, he pioneered the use of natural and synthetic zeolites as catalysts for petroleum refining and petrochemical manufacture. These zeolite catalysts eventually revolutionized many refining processes because they facilitated only certain reactions between molecules of specific dimensions.

In 1960 Paul published a ground-breaking paper, coauthored with Vince Frilette, another Mobil scientist, that became the foundation of "shape-selective catalysis" and one of his most widely cited papers ("Intracrystalline and Molecular-Shape-Selective Catalysis by Zeolite Salts," *Journal of Physical Chemistry* 64(3):382). Processes based on Paul's concept of shape-selective catalysis were first commercialized in the early 1960s, and throughout the 1970s and 1980s he was closely associated with Mobil's development of new catalytic materials and the processes that were developed around them.

While working at Mobil, Paul took a sabbatical in 1964 to earn his doctoral degree from the Eidgenössische Technische Hochschule (ETH) in Zurich in 1966. His thesis presented an analysis of the permeation of dyes into fibers that was the foundation for some of the fundamental laws associated with diffusion of dye molecules into fibers.

One of Paul's formidable strengths was his ability to communicate complex theories succinctly. He was a constant contributor to the ACS publication *ChemTech* throughout the 1970s and 1980s, enlightening and delighting readers with his insightful observations of how phenomena such as diffusion and kinetics applied to everyday life.

His 1962 article with J.S. Hicks, "The Behavior of Porous Catalyst Particles in View of Internal Mass and Heat Diffusion Effects" (*Chemical Engineering Science* 17(12):265–275), was selected as one of the 50 most influential articles in *Chemical Engineering Science* in the publication's 1995 *Frontiers in Chemical Engineering Science* commemorative edition (50(24): 3849–4141). His 91 US patents and more than 180 journal publications cover topics ranging from carbonaceous deposits on catalysts to chemical agents that affect the diffusion of drugs in human cells.

After he retired from Mobil in 1984, he began a third highly productive career, applying chemical and physical principles to biomedical research first at the University of Pennsylvania and then at Pennsylvania State University. Working with Madeleine Jouille at the University of Pennsylvania he synthesized molecules that mimic some of the healing properties of heparin but do not exhibit its potentially dangerous side effects.

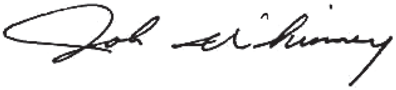
His numerous industrial research accomplishments and contributions to the science of catalysis were well recognized over the years: he was selected for the E.V. Murphree Award in Industrial Chemistry from the American Chemical Society (ACS; 1972), the Chemical Pioneer Award from the American Institute of Chemists (1974), the ACS Leo Friend Award (1977), the R.H. Wilhelm Award in Chemical Reaction Engineering from the American Institute of Chemical Engineers (1978), the Lavoisier Medal from the Société Chimique de France (1983), the ACS Langmuir Distinguished Lecturer Award (1983), the Perkin Medal from the American Section of the Society of Chemical Industry (1985), the ACS Carothers Award (1987), and the National Medal of Technology from President George H.W. Bush in 1992. He was elected to the National Academy of

Engineering in 1977 and served on the NAE Panel on Future Directions in Fundamental Research Related to Fossil Energy (1987) and Panel on Energy and Natural Resources Processing (1985–1988). He received an honorary doctorate (ScD in technological science) from ETH in 1980.

Paul Weisz leaves behind a very rich scientific and technical legacy that has greatly impacted the academic and industrial catalysis research communities. His work continues to inspire chemists and chemical engineers working in the area of catalysis and biomaterials.

His family remembers Paul enjoying many hours contacting other amateur radio operators. In addition, he was an excellent chess player and spent time exploring above and below the ocean.

He is survived by his wife, Rhoda Burg, and two children, Ingrid and Randy Weisz.



JOHN R. WHINNERY

1916–2009

Elected in 1965

"Contributor to the fields of microwave theory, plasma propagation, and lasers."

BY TED VAN DUZER

JOHN ROY WHINNERY, former dean of engineering at the University of California, Berkeley, and a distinguished innovator in the field of electromagnetism and communication electronics, died February 1, 2009, at his home in Walnut Creek, California. He was 92.

He was born in Read, Colorado, on July 26, 1916, and moved with his family at the age of 10 to Modesto, California, where his father continued farming but also maintained an avid interest in electrical and mechanical systems. Whinnery's father had bought and operated a light plant to generate electricity for a small town in Colorado, and that probably played an influential role in the boy's development.

By the time Whinnery graduated from high school in 1933, the Great Depression was under way and obtaining money to attend college was a struggle. According to the introduction to an oral history of his life, he could only afford to attend a local junior college, but greatly impressed his instructors there. They knew he would flourish at UC Berkeley, but funding was beyond his reach. Unbeknownst to him, several of his teachers took up a collection and financed a scholarship to send him to

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UC Berkeley. And after he transferred there in 1935, he proved those instructors right, graduating in 1937 with a bachelor's degree in electrical engineering and earning the University Medal, the campus's highest student honor, awarded to the top graduating seniors.

He worked the next nine years at General Electric Corporation in Schenectady, New York. His earliest research, on discontinuities in electromagnetic wave devices, led to innovations in microwave amplifiers such as triodes, which were used in World War II communication devices and radar receivers. His later work in the microwave field was in traveling-wave tubes, including the backward-wave amplifier, which is still used in radar and satellite communications. Also at General Electric he met Simon Ramo, and they coauthored the seminal textbook, *Fields and Waves in Modern Radio* (John Wiley and Sons, 1944).

In 1946 Whinnery returned to UC Berkeley as a lecturer while working on his PhD in electrical engineering. When he received his doctorate in 1948 he was immediately appointed an associate professor of electrical engineering, and advanced to full professor in 1952.

In the early 1960s he became interested in the emerging field of lasers and laser applications in communications. He and his students produced advances in ultrashort optical pulses, which can be used to study fast processes in materials and chemical reactions. He was recognized as one of the country's top experts on the fundamentals of quantum electronics.

He held a number of leadership positions while at UC Berkeley: director of the Electronics Research Laboratory (1952–1956), chair of the Department of Electrical Engineering (1956–1959), and dean of the College of Engineering (1959–1963). He has been credited with driving the postwar transformation of the university's Electrical Engineering Department from the handbook era into a modern science-based program. He led in recruiting many outstanding faculty members and students, and fostered a culture of excellence and cooperation that characterizes the department to this day. He earned a national reputation in matters of engineering education and played a key role in the 1963 creation of the national Commission on Engineering Education.

During his four-decade academic career at UC Berkeley he was given the rare honor of being named University Professor, a special designation as a professor-at-large for all University of California campuses that is considered the UC system's most prestigious recognition of scholarship. Only 36 faculty members, 14 of them from UC Berkeley, have been accorded the title since its creation in 1960.

Besides being recognized for his research, Whinnery is widely credited with helping to bring the study of applied electromagnetic theory to a broader audience with his pioneering 1944 textbook (later editions took the title *Fields and Waves in Communications Electronics*). It made electromagnetic theory understandable and accessible; modern editions of it are still used in college courses today. In 1994 friends and former students surprised Whinnery at a celebratory event honoring the book's 50th anniversary by endowing a faculty chair in his name.

During leaves from Berkeley, Whinnery served as head of the Microwave Tube Research Division of the Hughes Aircraft Company (1951–1952), was a Guggenheim Fellow at the Swiss Federal Institute of Technology (ETH Zurich; 1959), participated in research in quantum electronics at Bell Laboratories in New Jersey (1963–1964), and held visiting professorships at UC Santa Cruz and Stanford University. He also served on the Science and Technology Committee on Manned Space Flight of the National Aeronautics and Space Administration (NASA) for the Apollo Space Program.

In 1992 his research contributions, excellence as an educator, and record of service earned him the National Medal of Science, the nation's highest scientific honor, bestowed by President George H.W. Bush. The many other awards and honors he won over his lifetime include the Benjamin Garver Lamme Award of the American Society for Engineering Education (1974), UC Berkeley Engineering Alumni Society's Distinguished Engineering Alumnus Award (1980), Medal of Honor of the Institute of Electrical and Electronics Engineers

(1985), NAE Founder's Award (1986), and Berkeley Citation (1987). He also earned the uncommon distinction of being elected to both the National Academy of Engineering (1965) and the National Academy of Sciences (1972). In 2007, 20 years after he retired from UC Berkeley, the Department of Electrical Engineering and Computer Sciences dedicated a room in Cory Hall as the John R. Whinnery Room.

Friends and colleagues point out that, despite his awards and achievements, Whinnery remained remarkably unassuming. Outside of his professional life, he was known for his love of writing poetry and children's stories, cultivating fine wines, and hiking in the mountains. He was an enthusiastic golfer, and he loved spending weekends on California's north coast with his family and friends.

He was preceded in death in 2007 by Patricia, his wife of 63 years. He is survived by daughters Carol, Cathy, and Barbara Whinnery and three granddaughters.

DAVID C. WHITE

1922–2012

Elected in 1975

"Contributions as an engineering educator and leader in energy conversion technology, energy systems analysis, and energy planning."

BY STEPHEN R. CONNORS
SUBMITTED BY THE NAE HOME SECRETARY

DAVID CALVIN WHITE, a leader of multidisciplinary energy research at the Massachusetts Institute of Technology and founding director of the MIT Energy Laboratory, died on January 11, 2012, at the age of 89.

David was born in Sunnyside, Washington, on February 18, 1922, and grew up in the Pacific Northwest. He interrupted his electrical engineering studies at Multnomah Junior College and Oregon State College to work as an electrical engineer during World War II at the Kaiser Industries' Columbia River shipyards, building Liberty ships. After the war he resumed his schooling and obtained his BS (1946), MS (1947), and PhD (1949) in electrical engineering from Stanford University.

After three years as an associate professor at the University of Florida, Gainesville, he joined the electrical engineering faculty of MIT in 1952. He became a full professor in 1958, and was honored in 1962 with appointment as one of MIT's first Ford Professors of Engineering. His research focused on electrical energy conversion and machinery.

He also devoted much time and effort to finding better ways to educate young engineers. During the 1950s and early 1960s he developed both new curricula and teaching labs in electrical engineering. Among other activities, he and fellow faculty member Herbert H. Woodson constructed a generalized rotating energy converter to help educate students about the differences between AC and DC as well as induction and synchronous generators and motors. In 1959 the two published the seminal textbook *Electromechanical Energy Conversion* (Wiley).

David was a great mentor of students and colleagues throughout his career, as was evident in his role as housemaster of Burton-Conner on the MIT campus from 1963 to 1968, and in his work during the next two years as a visiting professor and senior advisor to the Birla Institute of Technology in Pilani, India.

On returning from India in 1970, he began to focus on broader issues of energy science, engineering, economics, and policy. He was the founding director of the MIT Energy Laboratory in November 1972, almost a year before the first mid-East oil crisis. He led the lab throughout the 1970s and 1980s, supporting basic and applied research across MIT in combustion and fuels, power systems, transportation, energy system modeling and analysis, environmental management, energy economics and policy, and more. Under the auspices of the lab were such organizational units as the Sloan Automotive Laboratory, the Combustion Research Facility, and the Center for Energy and Environmental Policy Research.

David handed over the directorship of the Energy Lab to Jefferson Tester in 1988 but remained involved until his retirement in 1992. In 2006 the lab, by then renamed the Laboratory for Energy and Environment, became part of the campuswide MIT Energy Initiative, established by MIT President Susan Hockfield and directed by Professor Ernest Moniz, the current US Secretary of Energy.

Retired MIT President Paul Gray, a former student of David's, recalls him as a constructive force at MIT and a mentor to a great many students and faculty over the years. David would frequently invite MIT students, faculty, and visitors down to his home on Cape Cod for a weekend of relaxation and fishing in Nantucket Sound off the back of his boat.

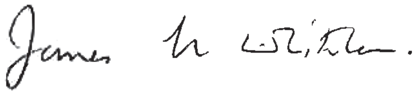
He received the George Westinghouse Award from the American Society for Engineering Education and was recognized as an honorary professor of the Instituto Politécnico Nacional, Mexico, both in 1961. In addition to his membership in the National Academy of Engineering, he was a fellow of the Institute of Electrical and Electronics Engineers and the American Academy of Arts and Sciences, and a member of the American Society for Engineering Education and honorary societies Phi Beta Kappa, Sigma Xi, Tau Beta Pi, and Eta Kappa Nu.

He served in a number of professional capacities during his career: he was a trustee for the Lowell Technological Institute (1972–1974) and a member of the Corporation of the Woods Hole Oceanographic Institution (1977–1986), Research Coordination Panel for the Gas Research Institute (1977–1986; chairman, 1981–1983), Liaison Subcommittee on Energy Systems of the Advisory Committee of the International Institute for Applied Systems Analysis (1977–1982), Energy Research Center Visiting Committee at Lehigh University (1979–1982), Advisory Council of the Electric Power Research Institute (1980–1987; chairman, 1984–1986), Electrical Power Peer Search Committee of the National Academy of Engineering (1980–1984), and Energy Engineering Board of the National Research Council (1986–1989).

His daughter Connie wrote:

> David was a generous man who enjoyed coaching and mentoring others in the achievement of their goals. He shared his knowledge and wisdom freely with colleagues and students, only asking that they apply themselves diligently and honestly. On a personal level, Dave's family and friends will most remember his gentle ways, exceptional brilliance, and unconditional love for his family. He was a caring husband and exceptional father and he spent his last year embracing his love of family while living with his wife, daughter, and son-in-law in Scottsdale, Arizona. Dave's other great love was the ocean. He spent much of his life on Cape Cod: tinkering with boats, boating to the nearby islands, blue fishing, and entertaining over a lobster dinner. Whether at work or play, he lived life deliberately in the company of those he cared for.

At the time of his death, David White was survived by his wife of 45 years, Margot Fuller White (1929–2014); daughter Constance Anne White; and granddaughter Heather Glorianna Coman. He was predeceased by daughter Julie Ann Coman and his first wife, Glorianna Guilii White. He is also survived by his sister, Eloise W. Johnson; sons-in-law Steven J. Schettler and William L. Coman; and grandson-in-law Jiri I. Herrmann.



JAMES H. WHITELAW

1936–2006

Elected in 2000

"For contributions to fluid mechanics, heat transfer, and combustion instrumentation, and to education and the dissemination of new information."

BY STEPHEN B. POPE

JAMES HUNTER WHITELAW, a pioneer of laser-based flow instrumentation who spent most of his career at Imperial College, London, died on August 16, 2006, at the age of 70.

He was born on January 28, 1936, in Newmains, near Glasgow, Scotland, and spent the first 25 years of his life in and around the city. He was an only child and grew up in a warm home that included an aunt and grandmother in addition to his parents.

After his education at local primary and secondary schools he gained admission to Glasgow University, where he took a "sandwich course" in mechanical engineering. This consisted of alternating six-month stints studying at the university and receiving training in different industries—the Coal Board, Esso, and the Caltex refinery in Bahrain. These experiences presaged the strong interactions between academic work and industrial applications that Jim fostered throughout his career.

After graduation he was briefly a graduate apprentice at Rolls-Royce. Feeling that he was not learning and advancing in that position, he applied for and received a research

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This tribute draws extensively from the account of Jim Whitelaw's life and career prepared by Brian E. Launder in the *Biographical Memoirs of Fellows of the Royal Society* (2007), vol. 53:385–399.

assistantship at Glasgow University, enabling him to pursue a PhD, under the supervision of C.D. Weir, on research sponsored by Merz & McLelland. The task was to measure the viscosity of steam at the high pressures and temperatures encountered in supercritical boilers. During his PhD studies Jim married Elspeth Shields, and they were devoted to each other throughout their lives together.

In 1961 Joseph Kestin of Brown University visited the laboratory. His work was on the measurement of the thermophysical properties of gases, and following technical discussions with Jim he immediately offered him a postdoctoral position at Brown. And so it was that Jim made the first of what must have been close to a hundred visits to the States, setting up his laboratory in the basement of Brown's Applied Mathematics Department.

While the two years at Brown were productive, Jim looked for new directions for his return to the United Kingdom. In 1963 he joined the Imperial College of Science and Technology as a lecturer in mechanical engineering, with the objective of providing an experimental arm to Brian Spalding's research group, which was developing calculation procedures for turbulent flows. Jim remained at Imperial College for the rest of his career, quickly progressing up the ranks to professor and head of the Fluids Section.

A pivotal point in his career was in 1968, when he became aware of the fledgling technique of laser-Doppler anemometry (LDA), which offered the prospect of enabling detailed measurements of velocity in complex turbulent flows. Over the next five years, in collaboration with Franz Durst, Jim developed a compact integrated optical system for LDA, which became the basis for the commercial systems marketed by DISA (later Dantec Dynamics). His pioneering work on laser diagnostics continued through the 1980s with the phase-Doppler anemometer, and into the 1990s with the shadow-Doppler anemometer.

To Jim, diagnostic techniques were a means to understand and characterize turbulent flows, usually complex flows related to industrial applications. Through the thesis research of 85 PhD students, he investigated a huge range of flows and combustion phenomena, including secondary flows in ducts, blood flow in veins and capillaries, industrial burners, internal combustion engines, spray combustion, pulverized-coal combustion, opposed-jet flames, and combustion-induced oscillations in afterburners.

Jim initiated and led many activities to bring researchers together and to disseminate new findings. At Imperial College he ran many short courses on LDA and experimental methods; in 1977 he jointly initiated and organized the Turbulent Shear Flows Symposia, which ran successfully for 10 biennial meetings and then spawned the Turbulence and Shear Flow Phenomena meetings; and in 1983 he cofounded the journal *Experiments in Fluids*.

He was an incessant traveler, and California was a frequent destination. He consulted with many major companies in the United States, among them McDonnell Douglas, General Electric, and NASA Ames Research Center. He was also an honorary professor at Hong Kong Polytechnic University, and later took a part-time position there as the Chair Professor of Combustion and Pollution. He bravely continued traveling after his diagnosis with an atypical form of motor neurone disease.

Jim was well recognized not only for his scientific contributions but for leadership in the research community. He was a fellow of the Royal Society and Royal Academy of Engineering, a foreign member of the US National Academy of Engineering, and received honorary doctorates from universities in Lisbon, Valencia, Dublin, and Athens.

All who knew him will remember his cheerful disposition and sense of humor, his ability to challenge and spur students and others to greater achievements, and his devotion to his family.

He is survived by Elspeth, sons Alan, Stuart, and Jamie, and six grandchildren (three born after his passing).

Paul A. Witherspoon

PAUL A. WITHERSPOON

1919–2012

Elected in 1989

"For pioneering achievements in geothermal energy, underground storage, hydrogeology, and the flow of fluids in fractured and porous rocks."

BY R. ALLAN FREEZE, IRAJ JAVANDEL, AND SHLOMO P. NEUMAN

The hydrologic community lost one of its most charismatic leaders with the death of PAUL A. WITHERSPOON on February 10, 2012, in Berkeley, California. He passed away from complications brought on by Parkinson's disease. He was 93.

Paul was a dynamic and influential research leader in hydrogeology for more than 50 years. Working from his base at the University of California, Berkeley (UC Berkeley) and later from the Lawrence Berkeley National Laboratory (LBNL), he made significant contributions to the understanding of the flow of fluids in porous media and fractured rock, and he applied his findings to a diverse set of societally important issues, including the development of geothermal energy, use of underground gas storage, and siting and design of nuclear waste disposal facilities. In all these spheres of interest he emphasized the need to marry theoretical studies and field testing. He was especially passionate about the need for large-scale, in situ, underground experiments to guide and corroborate the predictions of theoretically based numerical models.

This tribute was published in *Eos, Transactions American Geophysical Union* 93(31):304, July 31, 2012. Reproduced with permission of John Wiley & Sons, Inc.

Perhaps even more importantly, he was an inspirational mentor for many years to a large number of graduate students and postdoctoral fellows who went on to develop successful research careers in their own right. His circle was always populated by students and colleagues from around the world, and he reveled in their diverse cultures. To enter Paul's orbit was to experience a stimulating mix of high intelligence, deep curiosity, and love of life.

Paul was born on February 9, 1919, in Dormont, Pennsylvania. His father was a civil engineer who worked for a time for the Carnegie Coal Company, and Paul took his first trips underground into coal mines with him. When Paul was in high school, his father started a small cable tool drilling company to drill for natural gas, and Paul often worked on the rigs. These early experiences had a direct and lasting influence on his choice of career.

Paul graduated from the University of Pittsburgh in 1941 with a BS in petroleum engineering and then worked for eight years in various capacities for the Phillips Petroleum Company in Oklahoma, Texas, and Kansas. In 1949, at the age of 30, he enrolled at the University of Kansas, and completed his MSc in petroleum engineering physics in 1951. Shortly afterward he accepted a position as head of the petroleum engineering division of the Illinois State Geological Survey in Champaign. The survey offices were on the University of Illinois campus, and for the next five years, while working full time for the survey, he pursued a PhD in the university's department of geology. His doctoral work was directed by the eminent clay mineralogist Ralph Grim, whom Paul credited as his role model in scientific life.

Paul joined the faculty in UC Berkeley's Department of Mineral Technology in 1957. Declining enrollments in petroleum engineering prodded him toward research on a broader suite of geological engineering topics, especially those involving groundwater issues.

His experience with leaky cap rocks in underground gas storage projects led him to recognize the importance of aquitards (units of lesser permeability than aquifers) in hydrogeological systems sooner than many of his colleagues. His early research into the hydraulics of aquifer-aquitard systems was a precursor to issues that would soon arise in connection with contaminant transport problems, geothermal energy production, land subsidence, and nuclear waste isolation. In 1971 he organized a seminal meeting at the Asilomar Conference Grounds, California, that was the first conference to bring attention to the role of aquitards in groundwater flow systems.

In 1977 Paul became the first director of LBNL's Earth Sciences Division, while maintaining a dual appointment with UC Berkeley, where he taught until 1989. At LBNL he and his team made major contributions in geothermal reservoir engineering, numerical modeling of flow through fractured rocks, large-scale field and laboratory testing of flow and transport parameters, and the integrated assessment of the thermohydrologic and hydromechanical couplings between the flow field, stress field, and heat field in subsurface environments.

LBNL's Earth Sciences Division also became heavily involved in the development of viable methodologies for underground nuclear waste disposal. Paul and his team took the lead American role in an international research program at the Stripa Mine in Sweden, a project that provided the first comprehensive studies of flow and transport in fractured rock at depth. On the home front, Paul regularly offered his expertise to the US Department of Energy in its assessment of the proposed nuclear waste site at Yucca Mountain, Nevada.

Paul was widely honored for his work. In 1976 he received the O.E. Meinzer Award from the Hydrogeology Division of the Geological Society of America (GSA), in 1989 he was elected to the National Academy of Engineering, and in 1990 he was awarded the Robert E. Horton Medal (now the Hydrologic Sciences Award) from the American Geophysical Union. He also received GSA's George Burke Maxey Distinguished Service Award in 1996.

In addition, Paul's colleagues and graduate students honored him with three memorable research conferences at LBNL on the occasions of his sixtieth, seventieth, and eightieth birthdays. Each conference not only provided a wonderful opportunity to catch up with friends and former coworkers but also turned into an important venue for scientific exchange that led to highly regarded published proceedings.

Paul is survived by his wife Elizabeth and daughters Kathy and Claire. He was predeceased by son David, who was killed in a car accident in 2006 at the age of 57.

Readers can learn more about Paul in his own words in a 2007 videotaped interview posted on the website of the International Association of Hydrogeologists (http://timecapsule.ecodev.ch/). The association also published a biographical article based on the interview (*Hydrogeology Journal* 16:811–815, 2008).

APPENDIX

Members	Elected	Born	Deceased
Arthur P. Adamson	1980	March 14, 1919	May 3, 2014
Leo R. Beard	1975	April 6, 1917	March 21, 2009
Arnold O. Beckman	1967	April 10, 1900	May 18, 2004
Amar G. Bose	1987	November 2, 1929	July 12, 2013
Sidney A. Bowhill	1971	August 6, 1927	October 4, 2012
Howard Brenner	1980	March 16, 1929	February 17, 2014
Boris Bresler	1979	October 18, 1918	March 9, 2000
Bernard Budiansky	1976	March 8, 1925	January 23, 1999
James R. Burnett	1975	November 27, 1925	April 8, 2012
John C. Calhoun Jr.	1985	March 21, 1917	November 29, 2012
James J. Carberry	1989	September 13, 1925	August 27, 2000
Jack E. Cermak	1973	September 8, 1922	August 21, 2012
Richard C. Chu	1987	May 28, 1933	September 8, 2012
Edgar M. Cortright	1973	July 29, 1923	May 4, 2014
Stephen H. Crandall	1977	December 2, 1920	October 29, 2013
Donald A. Dahlstrom	1975	January 16, 1920	June 16, 2004
Satish Dhawan	1978	September 25, 1920	January 3, 2002
Gerald P. Dinneen	1975	October 23, 1924	May 30, 2012
Daniel C. Drucker	1967	June 3, 1918	September 1, 2001
Lester F. Eastman	1986	May 21, 1928	August 9, 2013
Gerard M. Faeth	1991	July 5, 1936	January 24, 2005
Harold K. Forsen	1989	September 19, 1932	March 7, 2012
Robert W. Galvin	2002	October 9, 1922	October 11, 2011
James P. Gordon	1985	March 20, 1928	June 21, 2013
Henry J. Gruy	1989	June 10, 1915	December 19, 2012
Carl W. Hall	1989	November 16, 1924	April 18, 2014
Elvin R. Heiberg III	1995	March 2, 1932	September 27, 2013
William C. Hittinger	1976	November 10, 1922	March 17, 2013
Charles H. Holley	1976	April 15, 1919	October 9, 2012
Thomas V. Jones	1986	July 21, 1920	January 7, 2014
Daniel D. Joseph	1990	March 26, 1929	May 24, 2011
W. David Kingery	1975	July 27, 1926	June 29, 2000
Warner T. Koiter	1977	June 16, 1914	September 2, 1997
Danie G. Krige	2010	August 26, 1919	March 2, 2013
David M. Lederman	2002	May 26, 1944	August 15, 2012

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Members	Elected	Born	Deceased
Tingye Li	1980	July 7, 1931	December 27, 2012
Stephen Malkin	2008	June 20, 1941	August 19, 2013
James L. Massey	1991	February 11, 1934	June 16, 2013
Tony Maxworthy	1991	May 23, 1933	March 8, 2013
Walter J. McCarthy Jr.	1984	April 20, 1925	July 24, 2013
James E. McGrath	1994	July 11, 1934	May 18, 2014
Kenneth G. McKay	1968	April 8, 1917	March 5, 2010
Lawrence M. Mead Jr.	1988	May 11, 1918	August 23, 2012
Alex G. Oblad	1975	November 26, 1909	September 19, 2000
Joseph Penzien	1977	November 27, 1924	September 19, 2011
Theodore Rockwell	2001	June 26, 1922	March 31, 2013
Reuel Shinnar	1985	September 15, 1923	August 19, 2011
Cedomir M. Sliepcevich	1972	October 4, 1920	October 22, 2009
Harold G. Sowman	1984	July 21, 1923	November 29, 2012
Marshall B. Standing	1984	November 9, 2013	November 13, 2010
Donald O. Thompson	1991	February 27, 1927	July 29, 2013
Hardy W. Trolander	1992	June 2, 1921	October 11, 2013
Leland J. Walker	1984	April 18, 1923	December 31, 2014
Willis H. Ware	1985	August 31, 1920	November 22, 2013
Paul B. Weisz	1977	July 2, 1919	September 25, 2012
John R. Whinnery	1965	July 26, 1916	February 1, 2009
David C. White	1975	February 18, 1922	January 11, 2012
James H. Whitelaw	2000	January 28, 1936	August 16, 2006
Paul A. Witherspoon	1989	February 9, 1919	February 10, 2012