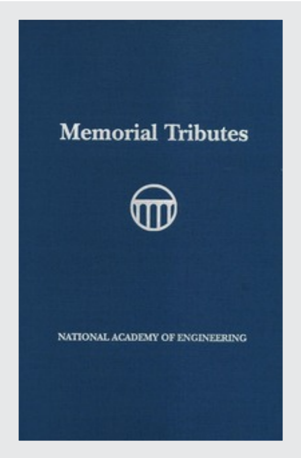

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FOREWORD

THIS IS THE TWENTY-FIFTH 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 international 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 have personal knowledge of the interests and engineering accomplishments of the deceased.

Through its members and international members, the Academy carries out the responsibilities for which it was established in 1964 as an organization of outstanding engineers. Members are elected by their peers on the basis of significant contributions to engineering theory, practice, and literature or for 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 government on matters of science, technology, and medicine. 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 international members—our colleagues and friends—whose special gifts and accomplishments we remember in these pages.

Carol K. Hall
Home Secretary

Memorial Tributes

NATIONAL ACADEMY OF ENGINEERING

JAN D. ACHENBACH

1935–2020

Elected in 1982

"Leadership in making fundamental contributions to, and engineering applications of, the propagation of mechanical disturbances in solids."

JIANMIN QU AND ZDENĚK P. BAŽANT

JAN DREWES ACHENBACH, Walter P. Murphy Professor and Distinguished McCormick School Professor Emeritus-in-Service at the McCormick School of Engineering and Applied Science, Northwestern University, passed away peacefully in Evanston, Illinois, on August 22, 2020, just 2 days after his 85th birthday.

A renowned educator, celebrated researcher, and respected leader of the scientific community, Jan had an illustrious career. He dedicated his entire professional life to science and engineering education. In this memorial of our dear colleague and friend, we celebrate his life and his contributions to the scientific literature and to engineering education and practice.

Jan was born August 20, 1935, in Leeuwarden, a provincial town in the northern part of the Netherlands, which was occupied by Germany during World War II, from May 1940 until April 15, 1945, when the Canadian Army liberated this part of the country. The town was in the path of British and American bombers flying from England to Germany. In addition, a German airbase for fighter planes was established on the

Adapted with permission from *Biographical Memoirs of the National Academy of Sciences*, available at www.nasonline.org/memoirs. The authors are grateful to Marcia F. Achenbach's sisters Wendy Baynard and Judy Winslow for sharing Achenbach family stories.

outskirts of the town and, toward the end of the war, Jan and his young friends would get as close as the barbed wire and minefields would allow to see the German fighter planes take off to engage the Allied planes overhead. The excitement of watching the planes in action generated his lifelong interest in aviation.

After schooling in Leeuwarden Jan studied aeronautical engineering at Delft University of Technology (TU Delft). The launch of Sputnik in 1957 and the ensuing space race that stimulated rapid growth in both fundamental and applied research at US universities inspired him. He applied to Stanford University for his graduate studies, was awarded a scholarship, and received his PhD in aeronautics and astronautics in 1962.

After a year as a postdoctoral fellow at Columbia University, in 1963 Jan was appointed assistant professor in the Department of Civil and Environmental Engineering at Northwestern University, where he remained except for sabbatical leaves to the University of California at San Diego and TU Delft.

As an early member of the solid mechanics group at Northwestern, Jan was instrumental in building a team of scholars that led to the university's national and international leadership in solid mechanics. Established in the early 1960s by George Herrmann (NAE 1981), Northwestern's Theoretical and Applied Mechanics (TAM) Program became a hub of outstanding research. In addition to Jan, the members of the group in the Civil Engineering Department in the 1970s included John Dundurs, Leon Keer (NAE 1997), Toshio Mura (NAE 1986), Zdeněk Bažant (NAE 1996), Sia Nemat-Nasser (NAE 2001), and Ted Belytschko (NAE 1992), and, in the Materials Science Department, Johannes (Hans) Weertman (NAE 1976). The group's largest, multimillion-dollar effort, joint with Los Alamos National Laboratory, was funded by NSF's RANN (Research Applied to National Needs) program and led by Weertmann (1974–79). The goal was to analyze a proposed hot-dry-rock geothermal energy scheme and drill in the Jemez caldera in northern New Mexico. The findings had a major influence on policy and research in the United States and Japan.

Beginning in the mid-1960s and continuing for the next two decades, the solid mechanics group in the Civil Engineering

Department, with Jan at its helm, was very collaborative—and social. Every Friday at 4 p.m., there was a mechanics seminar, usually led by a guest speaker. Long discussions often followed, in a group standing at a three-leaf blackboard filled with equations and sketches in chalk (this mode of presentation, from which one could actually understand the speaker's argument, unfortunately disappeared with the arrival of transparencies and PowerPoint). Dundurs made sure that after each seminar there was a party with the speaker at someone's home. One memorable party in 1972, at Toshio's home, lasted until 4 a.m. as the speaker, Ronald Rivlin (NAE 1985), entertained all with anecdotes about other mechanicians.

In 1981 Jan was designated the Walter P. Murphy Professor in the Departments of Civil and Environmental Engineering and Mechanical Engineering. In 1985, with support from the Federal Aviation Administration, he founded at Northwestern the Center for Quality Engineering and Failure Prevention (QEFP). It initially focused on developing nondestructive evaluation (NDE) technologies for the aerospace industry, then gradually expanded its scope to many areas of engineering applications, including structural health monitoring of civil infrastructures and nuclear power facilities. The center quickly attracted many promising students, postdoctoral fellows, and visiting professors from all over the world. In the NDE community it was well known that there were two centers of excellence: at Northwestern the QEFP focused on fundamental research, and at Iowa State on applied research.

In 1992 Jan was named Distinguished McCormick School Professor. During his career he supervised over 40 PhD students and numerous postdocs. He was a strict mentor with very high standards—and his high expectations inspired many to achieve beyond their potential. Some of his former students, such as Ben Freund (NAE 1994, NAS 1997) and C.T. Sun, went on to become distinguished researchers themselves.

Jan was a preeminent researcher in solid mechanics for over half a century, doing both analytical and experimental work. His doctoral dissertation at Stanford in 1962 dealt with waves and vibrations in viscoelastic solids, a problem of considerable interest for the dynamic response of solid-rocket propellants. He solved the three-dimensional problem by means of a viscoelastic correspondence principle for transient waves and presented simplified solutions based on a novel viscoelastic constitutive model.[1]

After making important advances in dynamic fracture mechanics early in his career, he went on to major contributions in the field of propagation of mechanical disturbances in solids; achieved important results in quantitative NDE of materials, damage mechanisms in composites, and vibrations of complex structures; and developed methods for flaw detection and characterization by ultrasonic scattering methods. He also achieved valuable results on earthquake mechanisms, the mechanical behavior of composite materials under dynamic loading conditions, and vibrations of solid propellant rockets. In addition to numerous journal and conference papers, he published several books that consolidated and synthesized many of his advances in these areas.[2]

During 1964–75 his work focused on dynamic behavior of composite materials. In the mid-1960s these inhomogeneous materials were represented by a homogeneous anisotropic material via the "effective modulus" theory. This representation, however, was often unacceptable at higher frequencies. Jan developed a better model for laminated media and fiber-reinforced composites based on a generalized continuum theory and formulated a method to calculate the material constants from the elastic constants of the constituents and geometrical parameters. His new theory properly represented dispersion of wave motion at high frequencies. He published

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[1] Achenbach JD, Chao CC. 1962. A three-parameter viscoelastic model particularly suited for dynamic problems. *Journal of the Mechanics and Physics of Solids* 10:245–52.

[2] *Wave Propagation in Elastic Solids* (North Holland Publishing Co./American Elsevier, 1973); *Ray Methods for Waves in Elastic Solids–with Applications to Scattering by Cracks* (with Gautesen AK, McMaken H; Pitman Advanced Publishing Program, 1982); *Reciprocity in Elastodynamics* (Cambridge University Press, 2004).

numerous papers on this subject and eventually summarized them in an influential monograph of lasting value.[3]

During the period 1968–80 Jan was one of the first investigators to advance understanding of the dynamic effects on fracture caused by either high crack propagation speeds or dynamic external excitation. He derived expressions for elastodynamic stress intensity factors and combined them with energy conditions for the propagation of a crack. His first paper on this subject set a new direction,[4] and many other researchers (primarily Freund) developed his approach further.

He also obtained important results on diffraction coefficients. Working with his postdoctoral assistant Arthur K. Gautesen and student Harry McMaken, he generalized the geometrical theory of diffraction to elastodynamics by solving two canonical problems, both concerned with the diffraction by a semi-infinite crack of a plane wave incident under an arbitrary angle with the edge of the crack. Along with applications to scattering by cracks of finite dimensions, he consolidated this work in their coauthored 1982 book.

Jan's 1973 book on elastic waves, written during a sabbatical at TU Delft, covered the then state of the art and was extremely well received. It is still in print and remains the most frequently referenced book on waves in elastic solids.

Jan became widely known for his groundbreaking contributions to acoustic microscopy. Around 1985 he started a laboratory in quantitative ultrasonics. Among the advanced instrumentation that he used and further developed was a line-focus acoustic microscope. He supplemented the experimental work on measurement of the $V(z)$ curve by a theoretical analysis based on measurement models. His theoretical and experimental research, particularly on the determination of the elastic constants of thin films, resulted in a number of significant papers (coauthored with graduate students). A novel

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[3] *A Theory of Elasticity with Microstructure for Directionally Reinforced Composites* (CISM Monograph 167; Springer, 1975).

[4] Extension of a crack by a shear wave. *Zeitschrift für Angewandte Mathematik und Physik* 21:887–900 (1970).

feature was Jan's use of an accurate measurement model with all the systemic features of the actual measurement process, but based on rigorous analysis. His model made it possible to obtain the material parameters with great accuracy by systematically minimizing the difference between the measured and calculated $V(z)$ curves. He eventually summarized his results in an influential review paper.[5]

Beginning in 1985 the emphasis of his work was on the theory and applications of ultrasonic methods to quantitative NDE, particularly on the measurement of elastic properties of thin films by acoustic microscopy, and the detection of cracks and corrosion in safety-critical structures. He also began to work on the development of probabilistic methods for structural health monitoring of fatigue damage in structural components for the purposes of diagnostics and prognostics. His pioneering ideas often defined new directions of research.

In the late 1990s Jan returned to classical elastodynamics. He derived a new formulation to express Lamb waves in terms of a carrier wave propagating in the midplane of the layer. The carrier wave, which is the solution of a simple reduced-wave equation, carries the thickness motion of the layer.[6] This information, in conjunction with a novel application of elastodynamic reciprocity, was extremely useful in deriving expressions for wave motion in an elastic layer (generated by a time-harmonic point load of arbitrary direction) in terms of superposition of wave nodes.

Jan was also very successful in practical applications of his results on quantitative ultrasonic NDE. With his colleagues, he made major contributions to practical applications of ultrasonics to detection and sizing of cracks and corrosion damage in metal structures. An example is the detection of corrosion and stress-corrosion cracks in the wing box of the DC-9. In the mid-1990s Northwest Airlines had in operation more than 125

[5] Achenbach JD, Kim J, Lee YC. 1995. Measuring thin-film elastic constants byline-focus acoustic microscopy. In: *Advances in Acoustic Microscopy*, vol 1, ed Briggs A. New York: Plenum Press.

[6] Lamb waves as thickness vibrations superimposed on a membrane carrier wave. *Journal of the Acoustical Society of America* 103:2283–86 (1998).

DC-9 aircraft older than 20 years. These aircraft needed periodic inspections for corrosion in the inner layers of the wing box, which is a fuel compartment. The old way was to enter the wing box for visual inspections or to disassemble the wing from the fuselage, a procedure that took about 800 hours.

Jan led a team that developed an ultrasonic technique for nondestructive testing of the wing box from the outside of the wing, without entry or disassembly. This reduced the inspection time to 50 hours and saved Northwest Airlines millions of dollars. The technique is now also used by other airlines and by the US Air Force. Vital details of this technology were published[7] and his team received the 1995 McDonnell-Douglas Aerospace Model of Excellence Award.

In June 1999, the night before a planned flight to Korea, Jan suffered serious cardiac arrhythmia with a loss of consciousness. He was kept for 2 weeks in an induced hypothermic coma. Upon waking, his first phone call was to his secretary to check on his project funding. It took him a year, but his recovery was remarkable. It is a testimony to Jan's will, determination, and perseverance that he successfully restarted his research programs.

In his later years Jan focused his research on applying the elastodynamic reciprocity to obtain closed-form solutions for the scattering of elastic waves by surface cracks in plates and pipes.[8] In 2009 he switched to emeritus status to enable his departments to hire younger faculty, but continued his research, supervised PhD students, and published numerous papers.

Throughout his career, a distinctive feature of Jan's research was the elegant application of rigorous mathematical methods in engineering applications. For example, traditional ultrasonic nondestructive methods are based on empirical

[7] Achenbach JD, Komsky I, Andrew G, Grills B, Register J, Linkert G, Huerto G, Steinberg A, Asbaugh M, Moore D, Weber H. 1995. An ultrasonic technique to detect corrosion in DC-9 wing box: From concept to field application. *Materials Evaluation* 52(7):848–52.

[8] Reciprocity and related topics in elastodynamics. *Applied Mechanics Reviews* 59:13–32 (2006); A new use of the elastodynamic reciprocity theorem. *Mathematics and Mechanics of Solids* 19:5–18 (2014).

measurements and heuristic analysis based on signal processing. It was Jan who introduced quantitative analysis of scattering of ultrasonic waves by defects to nondestructive evaluation. Late in his career, when asked what work of his he was most proud of, he answered "I added the letter Q to NDE." Indeed, the research field is now called quantitative nondestructive evaluation (QNDE). In 2008 Jan delivered the plenary lecture at the 27th Annual Review of Progress in Quantitative Nondestructive Evaluation, the prime annual gathering of the international QNDE community. His lecture, titled "NDE with a Q," was a brilliant blend of science with a retrospective on progress in engineering.

Jan was also active in the professional community, as a member of the ASME-AMD Executive Committee and US National Committee on Theoretical and Applied Mechanics (1987–94), founder and editor of the *Journal of Wave Motion*, and member of the editorial board of the *Proceedings of the National Academy of Sciences* (2003–04). He served on several NAE and NRC committees, including the Committee on Membership (1997–2001), Mechanical Engineering Peer Committee (1995–96; vice chair, 1996–97; chair, 1997–98), National Materials and Manufacturing Board (1994–97), Committee on Application of Expert Systems to Materials Selection During Structural Design (1991–95), and Committee on Army Basic Scientific Research (1982–88).

Jan was extensively honored for his myriad contributions. In addition to his NAE election in 1982, he was elected to the National Academy of Sciences in 1992 and a fellow of the American Academy of Arts and Sciences in 1994. He became a corresponding member of the Royal Dutch Academy of Arts and Sciences in 1999, and an honorary foreign member of the National Academy of Sciences of the Republic of Korea in 2010.

In 2003 he was awarded the US National Medal of Technology and Innovation for engineering research and education in the use of ultrasonic methods, and in 2005 he received the US National Medal of Science for pioneering the field of quantitative nondestructive evaluation. Both were presented by President George W. Bush at the White House.

Other honors include the ASME Timoshenko Medal (1992), SES William Prager Medal (2001), ASCE Raymond D. Mindl Medal (2009) and Theodore von Karman Medal (2010), and ASME Medal (2012) and honorary membership (2002). He became a fellow of the AAAS, the Japan Society for the Promotion of Science, ASA, and AAM. He received honorary doctorates from Zhejiang University (2011) and Clarkson University (2017), and was recognized as an honorary professor at the Beijing Institute of Technology in 2012.

For his teaching and mentoring, he was elected to the *Chicago Tribune* All-Professor Team in 1993, and in 2004 he received the Tutorial Citation Award from the American Society for Nondestructive Testing. In 2014 Sigma Xi recognized him with the Monie A. Ferst Award for his "notable contributions to the motivation and encouragement of research through education."

It was on a blind tennis date at Stanford that Jan met his future wife, Marcia Fee; they married in 1961. Both were born abroad, Jan in the Netherlands and Marcia in the Philippines, where her father held a position with Standard Oil, and both were affected by WWII, which ignited in Jan a passion for aviation and in Marcia a drive to help others. They dedicated their lives to service in the public interest—Jan as a scientist and engineer and Marcia as a social worker and community servant.

The couple was very active in the Northwestern community. As they said, Northwestern "has given us lifelong education, culture, music, travel, and other benefits." Their combined efforts culminated in the establishment of the Jan and Marcia Achenbach Chairs at Northwestern University. They left their entire estate to the university; the planned gift will establish two endowed professorships in mechanics of materials and solids in the Department of Mechanical Engineering and the Department of Civil and Environmental Engineering.

Jan and Marcia found especially enriching their time with family and Jan's students, many of whom were from China, Japan, and Korea. They also enjoyed traveling, the symphony, lyric opera, and theater.

Marcia passed away July 25, 2019, after 58 years of happy marriage.

ISAMU AKASAKI

1929–2021

Elected in 2008

"For contributions to the development of nitride-based semiconductor materials and optoelectronic devices."

BY HIROSHI AMANO

ISAMU AKASAKI, Special Distinguished Professor of Meijo University, and Distinguished University Professor and emeritus professor of Nagoya University, pioneer of blue LEDs, and Nobel Laureate in Physics, passed away from pneumonia April 1, 2021, at the age of 92.

He was born January 30, 1929, to Suguo and Sumi Akasaki; his father was a Buddhist altar craftsman. His elder brother, Masanori Akasaki, became a plasma physicist, a professor at Kyushu University, and president of Fukuoka Institute of Technology.

When he was a child, his father gave him many ore specimens, each a different luster and color. The boy was soon taken with the charm of ore. This early experience may have inspired him to enter the field of crystal growth research.

His birthplace, Chiran, is famous for an Army Special Attack Unit Base during World War II. He experienced student mobilization and many air raids during his middle school years. He said he even saw the face of a pilot firing a machine gun from the airplane. Those experiences led to his strong belief that war must not occur anymore.

After graduating from Kyoto University with a BS degree in 1952, he joined Kobe Kogyo Co., Ltd. to develop CdS-based fluorescent materials at the surface of a cathode-ray tube—his first encounter with "luminescence." His boss was Tetsuya Arizumi. Both men went to work in the Department of Electronic Engineering when it was established at Nagoya University in 1959.

At Nagoya University, Professor Akasaki concentrated on vapor-phase epitaxial growth and thermodynamic analysis of germanium (Ge). He found the "semiconductor" and its "crystal growth" attractive.

In 1964 he received his doctorate of engineering degree from Nagoya University—the title of his thesis was "Vapor phase epitaxial growth of Ge"—and moved to Matsushita Research Institute Tokyo, Inc. (formerly Tokyo Research Lab, Matsushita Electric Industrial Co., Ltd.). There he devoted himself to research on a series of III-V compound semiconductors including gallium arsenide (GaAs), gallium phosphide (GaP), and gallium nitride (GaN), and encountered light-emitting diodes (LEDs).

He initially concentrated on growing highly pure GaAs by vapor-phase epitaxy on a GaAs substrate grown by the horizontal Bridgman method for Gunn diode application. His group grew both GaAs substrates and high-purity epitaxial layers by themselves. As for the crystal growth of GaP, he experienced several hydrogen explosions. The GaP high-pressure furnace for red and green LEDs is displayed at the Akasaki Institute of Nagoya University.[1]

He started nitride research in 1967. In the early 1970s several research groups around the world were trying to fabricate blue LEDs with GaN; these included RCA Laboratories and Bell Labs in the United States, Lund University in Sweden, Philips in France, and the University of Tokyo.

[1] The institute was established in 2006 "with the purpose of introducing and disseminating the achievements of University Professor Isamu Akasaki and his worldleading research and development of high-brightness blue-light-emitting diodes (LEDs)…to the community at large" and "communicating the results of scholarship and research to the global community as an important base for cooperation between academia, government, and industry."

Professor Akasaki started growing GaN crystals by the molecular beam epitaxy (MBE) method, overcoming objections from others around him about the choice of MBE, which grows crystals in a vacuum. In 1974, in a test project by the Ministry of International Trade and Industry, he observed only blue cathodoluminescence from the MBE-grown GaN. Later, he shifted his focus to vapor-phase growth using halogens and succeeded in prototyping a MIS-type blue LED. This blue LED research followed that developed by Jacques Pankove (NAE 1986) of RCA.

After this initial success, he wanted to continue this research. So when the manager of the company decided to stop the blue LED research, he left for Nagoya University in 1981 and started a new crystal growth method, metalorganic vapor-phase epitaxy. At the time, almost no other organizations were continuing GaN research. Most researchers considered that it was very difficult to grow single crystals and that p-type GaN growth was impossible, so they abandoned GaN and started ZnSe research. According to Professor Akasaki, his situation was like “going alone in the wilderness.”

After a very fruitful career at Nagoya University, in 1992 he accepted a position as Special Distinguished Professor at Meijo University, where he remained actively engaged until his passing.

His achievements in the demonstration of p-type GaN and many other innovations led to extraordinary awards and honors: the Japanese Association for Crystal Growth Prize (1989), Heinrich Welker Gold Medal (1995), Medal with Purple Ribbon (1997); five honors in 1998—the Inoue Harushige Prize, C&C Prize, International Organization for Crystal Growth Laudise Prize, IEEE Jack A. Morton Award, and British Rank Prize; in 1999 both the ECS Gordon E. Moore Medal for Outstanding Achievement in Solid State Science and Technology and the Toray Science and Technology Prize; the Asahi Prize (2001); in 2002 the Takeda Award, Fujihara Award, and Order of Rising Sun; the President’s Award from the Science Council of Japan (2003); designation as a Person of Cultural Merit (2004); in 2006 the TMS John Bardeen Award and Outstanding Achievement Award from the Japanese Association for Crystal Growth; the Kyoto Prize (2009); in 2011 the IEEE Edison Medal and Order of Culture and Person of Cultural Merit; the Nobel Prize in Physics (2014, together with the author and Shuji Nakamura [NAE 2003]); Charles Stark Draper Prize (2015, with M. George Craford [NAE 1994], Russell Dupuis [NAE 1989], Nick Holonyak Jr. [NAE 1973], and Nakamura); UNESCO Medal (2016); and Queen Elizabeth Prize for Engineering (2021).

He was also a member of numerous academies and societies: fellow of the Institute of Electrical Engineers of Japan, Institute of Electronics, Information and Communication Engineers, and Japan Association for Crystal Growth; foreign member of the US National Academy of Engineering; member of the Engineering Academy of Japan, American Physical Society, Materials Research Society; honorary member of the Japan Society for Applied Physics, Science Council of Japan, Chemical Society of Japan, Physical Society of Japan, and Japan Academy; and life member of the Electrochemical Society and IEEE.

He actively supported researchers and generously donated several monetary prizes to Nagoya University, Japan Society for Applied Physics, and Japan Association for Crystal Growth. The Akasaki Awards have encouraged many researchers.

Professor Akasaki always tried to convey his experience to the younger generation, including through the establishment of consortiums and international conferences. In 1981, for example, when he moved from Matsushita Giken Co., Ltd. to Nagoya University, he started the Semiconductor Electronics Research Society and was instrumental in revitalizing the electronics industry in the central area of Japan near Nagoya.

In 1995 the Topical Workshop on Nitride Semiconductors was held. This was during the nascent period of blue LEDs using GaN, and the laser diode was on the verge of oscillation, so there was a lot of attention from the media. Amid the hustle and bustle, Professor Akasaki very effectively led the organizing and international advisory committee members, who hailed from Japan, the United States, Europe, and Asia.

Nitride semiconductors have since developed rapidly around the world, giving rise to the International Conference on Nitride Semiconductors, International Workshop on Nitride Semiconductors, and International Symposium on Growth of Nitrides. In addition, an international symposium was held at the Akasaki Research Center, established at Nagoya University from part of the patent fee income from 2002, to widely introduce research results to the world. Invited foreign researchers said that it was like receiving a medal to be invited by Professor Akasaki.

The "wilderness" in which Professor Isamu Akasaki pioneered is now a prosperous and fruitful field where many researchers all over the world gather and bring happiness to the people of the world. Through his work, the fusion of luminescence, semiconductor, and crystal growth has contributed to the potential for illuminating 1.5 billion people around the world who do not have infrastructure such as power plants. We thank this pioneer for his efforts and leadership, and pray for his soul.

He is survived by his wife Ryoko and their two daughters, Reiko Miwa (Yuichiro) and Junko Akasaki (Kazuaki Takahashi).

CLARENCE R. ALLEN

1925–2021

Elected in 1976

"Contributions in evaluating seismicity and fault movements leading to sound engineering practices and codes in earthquake-prone regions."

BY PAUL C. JENNINGS

CLARENCE RODERIC ALLEN passed away January 21, 2021, at the age of 96. He was born February 15, 1925, in Palo Alto, where his father, Hollis Allen, was attending graduate school. His father became a leading educator and assistant superintendent of schools in San Bernardino and professor at Claremont Graduate School.

Clarence had three siblings: an older brother Roland and two younger sisters, Constance and Margaret. His mother, the former Alfreda Delight Wright, died from complications of childbirth with Margaret's delivery, when Clarence was in the 6th grade. Several years later his father married Janet Maie Drake. Although much involved with and beloved by his extended family, Clarence himself never married.

After high school he enrolled at Reed College but interrupted his studies to serve in the Army Air Corps during World War II (1943–46), as a navigator on B-29s in the Pacific theater. After the war he returned to Reed and graduated with

The author acknowledges use of information and insights in Clarence Allen's oral history (*Connections: The EERI Oral History Series, Vol. 10: Clarence R. Allen, Stanley Scott Interviewer,* Earthquake Engineering Research Institute, Oakland, CA, 2002), which complemented, enlarged, and verified his own knowledge and information from other sources.

a BA in physics in 1949. He then earned an MS in geophysics (1951) and PhD in geology (1954), both from the California Institute of Technology. After a year (1954–55) as an assistant professor at the University of Minnesota, he returned to Caltech for the rest of his career, progressing from assistant professor (1955–59) to associate professor (1959–64) and then professor; he became professor emeritus in 1990. He also served in administrative roles, including as interim director of the Seismological Laboratory (1965–67) and acting chair of the Division of Geological Sciences (1967–68). In 1970 he was elected chair of the faculty.

A distinguished scientist, Clarence made significant contributions in several areas, but in particular to the relationship between earthquake seismology and the geology of faults. This is an important scientific topic, but it is also one of great interest to engineers working on earthquake hazard assessment and earthquake-resistant design. Clarence was very aware of this interest and his greatest contribution to engineering was in the way he could assess geological and seismological data and research in terms of its relevance to earthquake performance and engineering design criteria and communicate that knowledge to engineers, owners, and politicians. He was twice asked to speak on this subject to the Structural Engineers Association of California and his efforts were exemplified by his 1995 Distinguished Lecture to the Earthquake Engineering Research Institute.[1]

Another important example of this work was his studies of reservoir-triggered earthquakes, a problem brought to attention by the damaging 1967 earthquake associated with the filling of Koyna Dam in India. Clarence's research showed that most, if not all, of the largest reservoir-triggered earthquakes were in areas where there was evidence of geologically recent faulting, a result that showed how to approach this problem.[2]

[1] Allen CR. 1995. Earthquake hazard assessment: Has our approach changed in light of recent earthquakes? *Earthquake Spectra* 11:357–66.

[2] Allen CR. 1982. Reservoir-induced earthquakes and engineering Policy. *California Geology* 35(11):248–50.

In addition to communicating relevant scientific results to the engineering community, Clarence served on consulting teams on many major engineering projects, including the proposed Auburn Dam in California, the Aswan High Dam in Egypt, the Seismic Safety Reevaluation of the Diablo Canyon Nuclear Power Plant in California, and projects in New Zealand and South America. I had the privilege of working with him on the Seismic Safety Evaluation of the Proposed Liquefied Natural Gas Facility in Point Conception, California, and can attest to the knowledge and wisdom he brought to these tasks. He was a very effective consultant and was highly respected by his engineering colleagues, including George W. Housner (NAE 1965, NAS 1972), who noted his significant work in improving communication between scientists and engineers.

Clarence also devoted a lot of effort to public service. As chair of the Consulting Board for Earthquake Analysis of the California Department of Water Resources (1965–74) he worked with engineers and scientists, as in 1972 on the Governor's Earthquake Council (precursor to the California Seismic Safety Commission). He also was appointed to the California State Mining and Geology Board in 1969 and chaired it in 1975. As part of the National Earthquake Hazards Reduction Program, he was among the group that wrote the 1970 *Report of the Task Force on Earthquake Hazard Reduction*, published by the Office of Science and Technology Policy. One of his most important contributions was chairing the National Academy of Sciences committee looking at the initial scientific and engineering lessons from the 1971 San Fernando earthquake.[3]

Clarence served on a number of other NASEM committees as well, just a few of which are noted here. He was a member (1984–87) and chair (1987–89) of the Committee on Scholarly Communication with the People's Republic of China, vice chair of the Committee on Advanced Study in China (1980–85), and a member of the Committee on Global and International

[3] National Research Council. 1971. *The San Fernando Earthquake of February 9, 1971: Lessons from a Moderate Earthquake on the Fringe of a Densely Populated Area*. Washington: National Academy Press.

Geology (1982–87), Committee for the Symposium on Practical Lessons from the Loma Prieta Earthquake (1992–94), Study of NSF Decisionmaking on Major Awards (1992–94), and Board on Radioactive Waste Management (1985–90).

He chaired the National Earthquake Prediction Evaluation Council (1979–84) and the Earth Sciences Advisory Panel for the National Science Foundation (1967–68). He was vice chair of the American Seismological Delegation to the People's Republic of China (1974), one of the first scientists to visit that country after the Cultural Revolution. He also was elected president of both the Seismological Society of America (1975–76) and the Geological Society of America (1973–74).

Of his many publications, one of particular importance to engineering is *The Geology of Earthquakes*, coauthored with Robert S. Yeats and Kerry Sieh (Oxford University Press, 1997). In his chapter, Clarence brought together his expertise in seismology and geology and his experience in interacting with the public sector to address the assessment of seismic hazard.

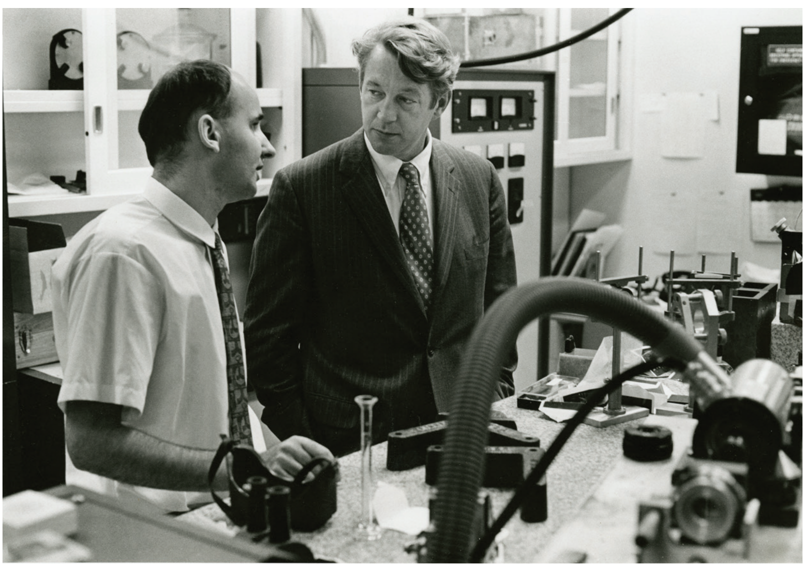
He received many recognitions and awards, beginning with the G.K. Gilbert Award from the Carnegie Institute of Washington in 1960. He was elected a fellow of the American Academy of Arts and Sciences in 1974, and in 1976, in a remarkable coincidence, he was elected independently to both the National Academy of Engineering and the National Academy of Sciences. The California Earthquake Safety Foundation awarded him the Alfred E. Alquist Award for public service in 1994 and he received the Harry Fielding Reid Medal from the Seismological Society of America in 1996. In 2001 he was awarded the George Housner Medal by the Earthquake Engineering Research Institute.

Beyond his considerable professional expertise, Clarence's interests in aviation and navigation, acquired during his military service, continued throughout his life. When flying, he strongly preferred to sit by the window, often with air navigation maps, and enjoyed following the course of the plane and studying the geology. He took pride in knowing where the plane was at any time.

Many of his professional and personal activities were deeply influenced by his love of the outdoors. Camping, hiking, and fishing were part of his family activities from early on; after careful planning, his father once took the family from Claremont to Eugene, Oregon, by car without once driving on a paved road! During his lifetime Clarence fished in the Yellowstone area and the High Sierras in California as well as in Colorado, Chile, and Tibet. He often fished with his Caltech colleagues; I enjoyed fishing with him in New Zealand as well as on many day trips to streams in the mountains of Southern California.

In addition to his substantial contributions to the profession, Clarence left a bequest of nearly $1.6 million to the Seismological Society of America, and a bequest of $800,000 to the Earthquake Engineering Research Institute, ensuring a robust future for the fields that sustained his intellect and his career.

Many are grateful for the time spent with him and the adventures he brought, and are honored to call him colleague, friend, and family. He is greatly missed.



ARTHUR G. ANDERSON

1926–2021

Elected in 1975

"Contributions and leadership in computer technology."

BY NICHOLAS M. DONOFRIO

ARTHUR GEORGE ANDERSON, retired vice president, International Business Machines, died peacefully in his sleep August 31, 2021, at age 94. An icon in the technical community, his technological leadership in IBM Research and Development was legendary. Wherever technology was on the move, from hard disc drives to semiconductors, as deployed throughout IBM's vast array of Compute Systems and Storage Systems, across the United States and around the world, Art was involved and engaged.

Art was born to Margaret (Bree) and Arthur Gustav Anderson on November 22, 1926, in Evanston, Illinois. He grew up in the Chicago area and briefly worked as a commercial radio engineer with an extra class amateur radio license, call sign w9kvq. He joined the Navy in July 1944 and served on the USS *Menard* as captain's yeoman. Upon discharge from the service, he attended the University of San Francisco, graduating with a BS degree in physics in 1949. He went on to postgraduate studies, receiving an MS in mathematics at Northwestern University in 1951 and a PhD in physics from New York University in 1958.

Art's 33-year industrial career at IBM began in 1951 as an engineer in applied mechanics at Poughkeepsie, NY, focusing on the development of high-speed computer technology and the design of prototype hardware. In 1953 he transitioned to a position at IBM's research lab at Columbia University while he completed his doctorate at NYU, performing research in solid-state physics aimed at understanding magnetic phenomena in metals.[1]

His brilliance as a researcher and manager quickly became apparent, as he continued research and began management activities shortly after completing his PhD. In 1961 he was named manager of the IBM Research Laboratory in San Jose, California. While there, he established and provided direction for a combined materials and process engineering activity that provided the basic technology for the IBM copier. His unique contribution was recognition of the need for a project-oriented activity involving engineers, physicists, and chemists, a need not generally recognized at the time. He was also instrumental in establishing a group in control theory that made major advances in computer control of traffic and electric power grids. He provided strong leadership in this effort to bring advanced control theory to bear on immediate engineering problems.

Returning to the East Coast in 1965, Art became assistant director of research at the IBM T.J. Watson Research Center in Yorktown Heights, NY. In addition to being responsible for day-to-day operations of the IBM Research Division, he provided direction and support for a major engineering effort devoted to realizing a trillion-bit memory. Under his leadership, the feasibility of major features of this memory, including electron beam recording on photographic film and file handling through vacuum seals, was established.

This assignment was followed by a stint at IBM in Armonk, NY, where he was responsible for staff support of the Corporate Technical Committee, a group concerned with the overall technical posture of IBM. In this position, he had a major role in the development of a more comprehensive method of forming

[1] His son Ivan Heninger reports that Art's work in nuclear magnetic resonance "was top of mind in his last weeks of life as he recreated those memories to confirm his own fitness following hip surgery."

long-range technical plans to identify areas and issues of primary importance to the future of the corporation.

Returning to Yorktown Heights in 1967 as director of research at Watson Research Center, Art was responsible for IBM's research on information-handling concepts and technologies conducted at laboratories in Zürich, New York City, San Jose, and Yorktown. This was followed in short order by his ascension in 1969 to vice president and director of research, where he had a major impact on IBM's technical effort by vigorously seeking to overcome the two main problems of industrial research laboratories: isolation from mainstream pure research in the universities, and isolation from nuts-and-bolts engineering problems in the company's development laboratories. He greatly increased interchange between IBM Research and universities through a program in which about 20 tenured professors each year spent their sabbaticals at IBM Research and a similar number of IBM research staff served as visiting professors at universities. He also established a postdoctoral program at IBM Research.

Art increased the interaction between research and development activities in IBM by bringing development and manufacturing groups into the research environment. By their location and interchange of personnel, the coupling between these groups increased dramatically. Other contributions included the emphasis in IBM Research on advanced uses of computers, particularly in large-scale scientific computations but also in laboratory automation, and broad conversational terminal computation using advanced languages and advanced techniques such as interactive graphic terminals, all pathbreaking at the time.

He emphasized the importance of broad areas of research that relate to the use of computers, including computer languages, displays, terminals, and other engineering challenges associated with optimizing the human-machine interface. At the IBM Yorktown Laboratory, he made enormous computing power readily available to everyone, thus presiding over the early days of making computers and computation an essential element of forefront research.

In 1970 Art spent a year as a visiting fellow at the Center for the Study of Democratic Institutions in Santa Barbara, CA, and this confirmed a strong sense of duty and civic participation as key values, which he acted on especially during his retirement. He also learned to fly.

At the conclusion of his sabbatical Art remained in California, serving as vice president and director of technical assessment in the Data Processing Product Group (1971–72), and then vice president and president of the General Products Division (1972–79), both in San Jose. This was followed by other senior leadership positions at IBM until his retirement in 1984 as senior vice president.

Art was ultimately responsible for the IBM businesses that drove high-end and high-performance systems, storage, and software. His legacy lives on as these products continue to drive success and value for IBM and its clients.

For the National Research Council, he served on the Board on Telecommunications/Computer Applications (1982–85).

Being both self-assured and self-aware is a gift and Art was truly blessed. Alongside his acclaimed and well-recognized technical leadership skills were his thoughtful interpersonal skills and keen business instincts. As bright and technology savvy as Art was, he was equally thoughtful and engaging.

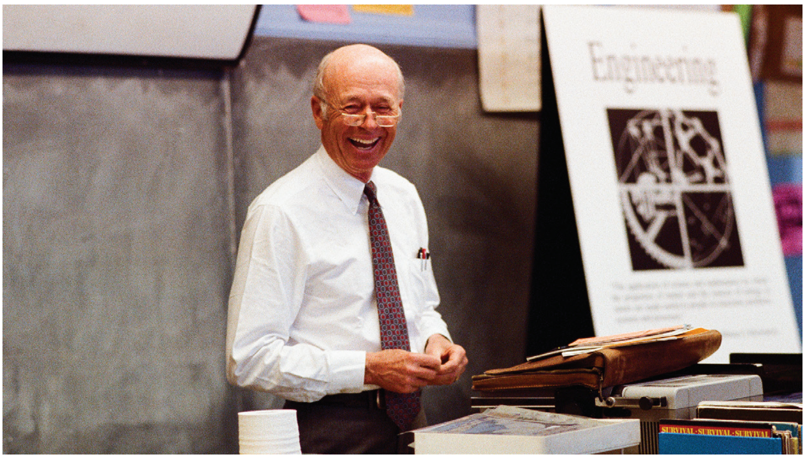
During his retirement Art consulted for the University of California to help revitalize the engineering curriculum. In preparation for this project, he sat in for a semester of undergraduate engineering classes at the California Polytechnic University at San Luis Obispo, including completing the homework assignments. He also worked with the University of Nevada and the Desert Research Institute leading development of the Nevada Award, the state's highest scientific honor. These efforts led to an honorary doctorate from the University of Nevada.

Also in retirement, Art began writing poetry, adding to his lifelong admiration of and participation in the arts. It was with poetry that Art communicated his last wishes to his family.

Among many prestigious awards for his contributions to science, the management of scientific research, and civic society, his favorite was the inaugural George Pake Prize (1984), awarded by the American Physical Society to recognize "outstanding work by physicists combining original research accomplishments with leadership in the management of research or development in industry." The prize is endowed by the Xerox Corporation, one of IBM's major competitors at the time, and Mr. Pake was Art's contemporary leading Xerox's research organization.

After retirement, Art and his wife Eliza (née Chavez Moran; they married in 1975) spent many years living in or near Monterey Bay, CA; Lake Tahoe, NV; Prescott, AZ; Durham, NC; and Puerto Vallarta, Mexico, where they flew, hiked, camped, skied, boated, and enjoyed life to its fullest.

Art is survived by Eliza; children Joseph (Susan Williams) in Flagstaff, AZ; Robin (Kirstin Summers) in San Pedro, CA; Jennifer in Red Bluff, CA; Diane Heninger (Autumn Doucet) in Wenatchee, WA; David (Tammy) Heninger in Morgan Hill, CA; and Ivan (Jacquelyn) Heninger in Selma, NC; 13 grandchildren; and seven great-grandchildren.


Engineering

STEPHEN D. BECHTEL JR.

1925–2021

Elected in 1975

"Leadership of engineers in the design and construction of energy related facilities."

BY BARBARA RUSINKO

STEPHEN DAVISON BECHTEL JR., former National Academy of Engineering chair, patriarch of the Bechtel family and its global group of companies, pioneer in engineering and construction, devoted husband, father, grandfather, and great-grandfather, and lifelong Boy Scout, died peacefully at his home in San Francisco on March 15, 2021, at the age of 95.

"Steve Jr." was born May 10, 1925, in Oakland, California. He was the son of Laura A. Peart and Stephen D. Bechtel Sr. and grandson of Warren Bechtel, founder of engineering and construction giant Bechtel Group Inc. Steve Jr. was the company's third chair and CEO; his son Riley P. Bechtel was the fourth, and his grandson Brendan P. Bechtel is now the sixth.

Steve enlisted in the Marine Corps Reserve after high school, did officer training at the University of Colorado, graduated from Purdue University with a BS in civil engineering in 1946, and earned an MBA from the Stanford University Graduate School of Business in 1948.

It was then that his father convinced him to join a Bechtel pipeline project in Texas as a field engineer. Over the next 12 years, Steve Jr. worked his way up the ladder to become president and then CEO in 1960, retiring as CEO in 1990 after 42 years of company service and as a nonexecutive director in 2018 after 70 years of service. Under his leadership from the historic Beale Street office in San Francisco, Bechtel's sales improved 11-fold, its workforce grew 5-fold, and the number of major projects soared from 18 to 119. An engineer licensed in 10 states, he extended the firm's footprint and took on efforts of increasing sophistication.

He also used his personal values to create a corporate culture based on honesty, merit, teamwork, and fair dealing. As he put it,

> "To be personally successful, as I define 'success,' I believe one should:
>
> have an outstanding character;
>
> continuously strive to improve your personal performance;
>
> be a team player;
>
> be a positive, constructive influence, and be involved in activities around you, both inside your company and in your community;
>
> be open-minded, objective, and realistic—accept change as a reality, recognizing that it offers opportunities;
>
> be a visionary—focus on areas where experience and abilities can be matched by few others, strive to foresee the industries and geographic areas that will offer the greatest opportunities for long-term profit, develop a competitive, innovative mentality, and create something new, uniquely suited to your company's strengths;
>
> be a hardworking participant; and
>
> enjoy your work and show your enthusiasm for it. It will be infectious to those around you."

The Bechtel group built iconic infrastructure on six continents and pioneered new technologies, engineering and construction methods, and socioeconomic development in low-income countries, often working in very difficult logistical situations and remote, forbidding environments. Signature projects of Steve Jr.'s tenure include the Bay Area Rapid Transit system (BART) in northern California; the James Bay hydroelectric project in Canada; LNG plants in Algeria, the United Arab Emirates, and Indonesia; nuclear power plants throughout the United States; Jubail Industrial City and King Khalid International Airport in Saudi Arabia; and the Channel Tunnel connecting Great Britain and France.

Over and above his responsibilities with the Bechtel Group, Steve Jr. was CEO of the Fremont Group of Companies until his retirement in 1995. Fremont became a prosperous developer and manager of real estate in California, Texas, and other US locations. Through its venture capital arm, Trinity Ventures, it was an early investor in Starbucks and other successful startups. Today, it owns and operates businesses in the United States and Europe, manages a fund of funds, and is building a portfolio of valuable, publicly traded equities.

He also served as a director of several leading companies, including General Motors, IBM, and Southern Pacific Railroad; chaired the Conference Board and the Business Council; and contributed his wisdom in advisory roles at the California Institute of Technology, Purdue, MIT, and Stanford and its Hoover Institution.

He was selected to serve on six presidential commissions for three US presidents: Lyndon Johnson appointed him to the President's Committee on Urban Housing; Richard Nixon named him to the National Industrial Pollution Control Council, the National Commission on Productivity, the Labor Management Advisory Committee, and the National Commission for Industrial Peace; and Gerald Ford asked him to serve on the President's Labor-Management Committee.

Steve Jr. was well recognized for his contributions, honored with numerous national and international awards, including the Ernest C. Arbuckle Award for excellence in management leadership, from the Stanford Graduate School of Business (1974); the Hoover Medal (1980), recognizing him as a "Distinguished worldwide engineering leader, for his contributions in the fields of natural resources, energy, government affairs and human needs, and for his contributions to the enrichment of the lives of his fellowmen in urban housing, curtailment of industrial pollution, labor management relationships, and realistic progress in developing countries"; the National Medal of Technology and Innovation (1991), bestowed by President George H.W. Bush, "For his outstanding leadership in the engineering profession with special recognition for his contributions to the development and application of advanced management techniques to world-class industrial projects"; and the NAE Founders Award (1999), "For decades of exceptional accomplishments in civil engineering, corporate management, and civic, educational and professional development, all of which have been of great benefit to people in the United States and around the world." He also received honorary degrees from Purdue University, the University of Colorado, and the Colorado School of Mines.

In addition to his NAE membership, he was elected to the French Legion of Honor (1979), Royal Academy of Engineering (UK; foreign fellow, 1986), and American Academy of Arts and Sciences (fellow, 1990). He served two terms as NAE chair (1982–86) and was a member of the NAE Industry Advisory Board.

A lifelong Boy Scout, he achieved Eagle rank in 1940 and was recognized by the Boy Scouts of America with the Distinguished Eagle Scout Award and the Silver Buffalo Award. With 40,000 other scouts he attended the 2013 National Jamboree at the BSA Summit Bechtel Reserve, which he helped create years earlier with a significant donation.

Steve Jr. was an avid outdoorsman and sportsman. He and his PGA Tour partner made the Sunday cut in the 1989 AT&T Pebble Beach Pro-Am. He trekked to base camp at Mount Everest, hiked the John Muir and Yosemite trails, and logged more than 100 fishing and 219 bird-hunting trips around the world. He was an avid and excellent fly fisherman who not only had a favorite fly (a "yellow deer hair") but would use it, with success, in any river no matter what time of year or what a guide had recommended. His bird hunting was not just about hitting his target but also about shots/bird.

In 1957 he established his first foundation. It and successors have distributed more than $1 billion in grants, largely to science, technology, engineering, and math education and environmental or conservation causes. He subsequently seed-funded foundations for each of his children and grandchildren.

He is remembered as a great conversationalist and a man who generously shared his time—enjoying life and the company of others whether over a meal or coffee, hunting, fishing, golf, or tennis.

Steve Jr. is survived by his wife of 75 years, Elizabeth Mead Hogan; their children Riley Bechtel, Gary Bechtel, Shana Johnstone, Lauren Dachs, and Nonie Ramsey; 16 grandchildren; and 30 great-grandchildren.

DAVID T. BLACKSTOCK

1930–2021

Elected in 1992

"For fundamental contributions to the principles of propagation of finite amplitude sound, and their application in various engineering fields."

BY JOSEPH J. BEAMAN AND MARK F. HAMILTON

DAVID THEOBALD BLACKSTOCK died at the age of 91 on April 30, 2021, in Austin, Texas, where he was born, raised, and spent most of his life. He was known internationally as an eminent scholar in acoustics, a mentor to both junior and senior acousticians, and an extraordinarily caring man.

He was born February 13, 1930, to Leo and Harriet Blackstock in Austin and grew up mostly in the Hyde Park neighborhood with his older brother Mathis. After receiving BS and MS degrees in physics at the University of Texas (UT) at Austin, David served 2 years in the US Air Force, then joined Frederick V. Hunt's group at Harvard University and earned a PhD in applied physics in 1960. He wrote his dissertation on the subject of nonlinear acoustics, a field in which he continued to work throughout his career.

After 3 years at General Dynamics and 7 years as associate professor of electrical engineering at the University of Rochester (NY), in 1970 David returned permanently to UT. Initially he worked at the university's Applied Research Laboratories, a leading research center in underwater acoustics, until in 1987 he became professor of mechanical engineering, a position he retained until 2000, when he retired with the title E.P. Schoch Professor Emeritus.

David's most important contributions were in nonlinear acoustics, which involves sound so intense that waveforms distort as they propagate; examples are explosion waves and intense sound beams used in therapeutic ultrasound. His seminal work in the 1960s, in parallel with work by academician Rem Viktorovich Khokhlov at Moscow State University in the former Soviet Union, established a foundation for nonlinear acoustics that is still employed today.

David popularized the use of the Burgers equation for modeling the nonlinear propagation of sound, an approach that permits the effects of nonlinear distortion and energy loss to be combined. He also developed a consistent framework that incorporates models for waveform steepening and weak shock theory developed by others in a way that permits analytical solutions for a variety of practical cases.

Among other theoretical contributions in the 1960s, David developed a solution revealing that a limit for the amplitude of a sound wave exists no matter how powerful the sources. The phenomenon is called acoustic saturation, a notable example of which is the limit on intensities that can be used in underwater sonar.

He also showed how two well-known and seemingly unrelated classical solutions derived in the 1930s—one for waves of finite amplitude in the preshock region, the other for sawtooth shock waves—are limiting cases of a single, more general solution for the propagation of finite amplitude sound. This overarching theory came to be known as Blackstock's bridging function.

Beginning in the 1970s, David performed research with his graduate students that combined theoretical, experimental, and computational approaches to a wide range of applications in nonlinear acoustics, including sonar, jet noise, parametric arrays, sonic booms, sound-sound interaction, and therapeutic ultrasound. For example, by implementing David's formulation of weak shock theory in a computer code, doctoral student Mike Pestorius became the first to model the propagation of high-intensity noise fields containing shocks. The remarkable agreement they achieved with their measurements of waveform distortion, shock formation, and shock coalescence remains a benchmark contribution to nonlinear acoustics in general and the jet noise community in particular.

Then in the mid-1970s, with master's student Mary Beth Bennett, David proved the existence of the parametric array phenomenon in air, which involves the use of inaudible ultrasound to generate superdirectional audio frequency sound. Audio parametric arrays in air, now called audio spotlights, are encountered in venues ranging from museums to trade shows, wherever transmission of speech with laser-like directionality is desired.

David's reputation extended far beyond the United States, even impacting Soviet scientists working in acoustics beginning in the 1970s, when mere communication with that community was challenging at best. He nevertheless managed to support their work and facilitate interaction with their counterparts in the West. As a result, in the 1990s after the fall of the Berlin Wall, a steady stream of the most famous Russian scientists working in nonlinear acoustics visited UT Austin.

In the 1980s David began receiving national recognition for his contributions in acoustics. These included, from the Acoustical Society of America (ASA), the Silver Medal in Physical Acoustics (1985), Gold Medal (1993), and Rossing Prize in Acoustics Education (2007); election to the NAE in 1992; and in 2015 the Per Brüel Gold Medal in Noise Control and Acoustics from the American Society of Mechanical Engineers.

He served as president of the ASA, which was his professional home, and also as chair of the International Commission for Acoustics, the "united nations" for acoustical societies around the world. For the National Academies of Sciences, Engineering, and Medicine and National Research Council, he served four terms on the Ford Foundation Diversity Fellowships Predoctoral Review Panel on Engineering. He was also a member of the Ford Foundation Fellowships Review Panel on Engineering (2017–18) and an ex officio member of the US Liaison Committee for the International Union of Pure and Applied Physics.

Beyond David's intellectual contributions to acoustics, his teaching and graduate student supervision are legendary. He could succinctly and lucidly explain complex phenomena to students of varying abilities, not only in the classroom but also in his widely used textbook, *Fundamentals of Physical Acoustics* (John Wiley & Sons, 2000).

He was also known for precise grading, and he would even correct grammar on homework assignments. The seemingly unending corrections of doctoral dissertation chapters in his signature green ink taught students to think logically and write clearly, resulting in dissertations that are models of perfection. His strong drive to build a sense of community among students ranged from playing soccer with them at lunchtime to a program in which he organized lunch dates for students to meet with senior researchers at ASA meetings.

In fact, despite all the international recognition David received, he felt most honored when the ASA Student Council in 2019 renamed its David T. Blackstock Mentor Award (he had been the first recipient of the Student Council Mentor Award in 2004). His reaction showed his humility and the importance he placed on helping young acousticians achieve their dreams.

Since the late 1990s one of David's greatest pleasures was acting as a scientific advisor for a National Institutes of Health project grant on lithotripsy, a nonsurgical procedure that disintegrates kidney stones with shock waves. The multidisciplinary talent in this group appealed greatly to David's scholarship and scientific curiosity. His attendance at the annual review meeting in January 2020 was David's last participation in a scientific conference.

David's wife of 64 years, Marjorie (née Goodson), died December 8, 2019. They had met while he was on a tour of duty at Wright Patterson Air Force Base. His remarkable career would not have been possible without her support. They are survived by their four children, Silas, Susan, Stephen, and Peter; six grandchildren; and five great-grandchildren.

NED H. BURNS

1932–2016

Elected in 2000

"For contributions to development and education in prestressed concrete including unbonded tendon building slabs and high-performance concrete bridges."

BY JAMES O. JIRSA, JOHN E. BREEN, AND MICHAEL ENGELHARDT

NED HAMILTON BURNS, born November 25, 1932, in Magnolia, Arkansas, died peacefully in his sleep November 5, 2016, at age 83. An outstanding teacher, administrator, and structural engineering researcher, he served the University of Texas at Austin for nearly 40 years.

Ned was the youngest of six children born to Andrew Louis and Ila Mae (née Martin) Burns. He graduated as valedictorian from Texas High School in Texarkana, where he was active as a trumpet player in the band. He earned a bachelor of science degree in architectural engineering from the University of Texas in 1954. As important as his college education was to his future career, meeting his lifelong love, Martha Ann Fontaine, at the university led to a marriage that lasted 61 years.

Ned's interest in prestressed concrete—on which he became widely recognized as an outstanding authority—began in 1955 when he was serving in the US Army at Fort Lewis, Washington. While there, he contacted Art Anderson (NAE 1977), president of Concrete Technology in Tacoma, to expand his professional horizons. Meeting on weekends, Ned

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Adapted from the authors' memorial resolution published by the University of Texas at Austin.

received numerous tutelage sessions on prestressed concrete design and construction from a pioneer in the industry.

After 2 years in the Army, Ned completed a master's degree at the University of Texas in 1958, working with Phil Ferguson (NAE 1973), and a PhD in civil engineering at the University of Illinois at Urbana-Champaign in 1962, working with Chet Siess (NAE 1967). He then returned to UT as an assistant professor, became a professor in 1972, and was named Zarrow Centennial Professor in 1983. He also served as associate dean of academic affairs for engineering (1989–93) and director of the Ferguson Structural Engineering Laboratory (1994–97).

Ned's career was marked by close identification with and numerous contributions to the study of prestressed concrete. For 40 years he taught the prestressed concrete course at UT, educating many leaders in the design, construction, and research community. And he was known internationally as coauthor of the classic Wiley text *Design of Prestressed Concrete Structures* (first published in 1963), with T.Y. Lin (NAE 1967; of UC Berkeley).

Under the sponsorship of the Reinforced Concrete Research Council and the Post-Tensioning Institute, Ned carried out the definitive tests of multipanel, unbonded flat slabs that became the basis for design provisions for the American Concrete Institute building code. The entire unbonded slab industry grew into a major construction market force on the basis of this code.

Ned was a pioneer in supervising the experimental studies that formed the basis for the analysis of posttensioned segmental box girder bridges—providing, again, the technical background for the standards that launched a significant new technology. He led one of the nation's most successful high-performance concrete pretensioned bridge design-and-construction demonstration projects (the North Concho River Overpass on US Route 67 in San Angelo, Texas). And in 2003 he demonstrated the feasibility of precast, posttensioned pavement slabs in a significant full-scale field project on I-35 in Texas.

Ned's work was recognized as sound, innovative, and important. His research on anchoring prestressing steel in concrete received the Precast Concrete Institute's Martin P. Korn Award (1993) and the T.Y. Lin Award (1994) from the American Society of Civil Engineers. And in 2000 he was elected to the NAE.

He also received numerous awards over the years for his exceptional teaching and advising at both the undergraduate and graduate levels. Among these were the General Dynamics Award for Excellence in Teaching (1965), Student Engineering Council Teaching Achievement Award (1977), Amoco Teaching Excellence Award (1983), Haliburton Education Foundation Award of Excellence (1983), American Concrete Institute Joe W. Kelly Award (1990), UT Blunk Memorial Professorship (1996), and Prestressed Concrete Institute Distinguished Professor Award (2000).

More than his numerous teaching, administrative, and research accomplishments, Ned was a person of great human interaction. He took deep personal interest in the welfare of not only the students in his classes but also those he came into contact with as a graduate advisor, associate dean for student affairs, and administrator of the Engineering Loan Committee. At the end of each semester, he would share his philosophy of engineering and life with students: "The truly great man is he who plants shade trees that he will never sit under."

He was a dedicated member of Highland Park Baptist Church, where he served as a deacon, Sunday school teacher, and in various other positions and sang in the choir as a second tenor. He was a wonderful family man who cheerfully attended Girl Scout and Boy Scout campouts, cochaired the Johnston Band Parents Association along with Martha, served as PTA copresident, and attended countless piano recitals, dance performances, and band concerts. He enjoyed woodworking and furniture building, and he and Martha enjoyed travel throughout the United States and Canada with other trips to Peru, Brazil, Europe, China, Thailand, and Japan.

Ned is survived by Martha; their children Kathryn Burns of Chapel Hill, NC, Stephanie Burns Wechsler (Dan) of Atlanta, GA, and Michael Burns (Katherine) of Austin, TX; three granddaughters; and many other loving family members and friends.

MAX W. CARBON

1922–2021

Elected in 2012

"For establishing engineering educational programs for nuclear reactor design and safety."

BY MICHAEL CORRADINI

MAX WILLIAM CARBON, a major force in establishing nuclear engineering educational programs, died June 23, 2021, at his home in Middleton, Wisconsin, at the age of 99.

He was born January 19, 1922, in Monon, Indiana, the son of Joseph William and Mary Olive (née Goble) Carbon. He attended Purdue University, where he earned his bachelor's degree in mechanical engineering in 1943. He met Phyllis Camille Myers, an undergraduate at Indiana University, on a blind date and they married on April 13, 1944.

After graduation Max joined the US Army as a corporal. During World War II he served in the Ordnance Department in New Guinea, the Philippines, and Japan (1943–46) before retiring to the US Army Reserve as a captain. He returned to Purdue and, as a DuPont Fellow in mechanical engineering, earned his master's degree in 1947 and PhD in 1949.

From February 1949 until September 1955, he worked at the General Electric Company's Hanford Works in Richland, Washington, producing plutonium for atomic and hydrogen bombs used for national defense. His primary duty was as head of the heat transfer group, which was responsible for the safety analysis, operating limits, and cooling technology that allowed for increased plutonium production and extended reactor lifetimes. As group head, Max played a significant role in increasing production by a factor of four over initial design.

He subsequently joined the Avco Manufacturing Corp. as head of its thermodynamics section, successfully designing the nose cone for the Titan intercontinental ballistic missile.

Max came to the University of Wisconsin–Madison in 1958 to establish a nuclear engineering program as part of a growing postwar research emphasis on designing better, more efficient nuclear power plants for generating electricity. In 1961, as the program grew, he became the first chair of the new Department of Nuclear Engineering and led in establishing bachelor's, master's, and PhD curricula; its academic programs were soon consistently ranked among the nation's highest.

As department chair, he considered it a critical component of his responsibilities to recruit, hire, and mentor top faculty and staff—many of whom ultimately were elected to the National Academy of Engineering. In addition, he strongly supported the practice of "research teaching"—in which students learn research techniques and methods and how to study and work independently of an advisor—as a necessary complement to formal classroom instruction. He was one of the major advisors for undergraduates in nuclear engineering at Wisconsin and supervised more than a dozen master's and PhD students. He also oversaw construction of the university's research and training nuclear reactor, which achieved initial criticality in early 1961.

Max served as department chair for 34 years, until his retirement in 1992, when he was named professor emeritus. During his tenure he oversaw the addition of plasma physics to create today's Department of Engineering Physics.

Max helped to define, advance, and champion the field of reactor safety and heat transfer not only in the technical community but also with the public, in educational efforts about the importance of nuclear power. He headed a Ford Foundation project developing college-level engineering education programs in Singapore (1967–68), and authored *Nuclear Power: Villain or Victim? Our Most Misunderstood Source of*

Electricity (Pebble Beach Pub., 1997). Written for nontechnical audiences, the book clearly explains the benefits and risks of nuclear power; now in its fifth printing, it has been translated into three other languages.

Max served on the Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards (1976–88), and as chair in 1979. He consulted for the nuclear power industry in several capacities throughout his career with a focus on safety. For example, he chaired the University of Chicago Review Committee on the Integral Fast Reactor (1983–95); the IFR was a pioneering design by Argonne National Laboratory that evolved into the GE Prism and Terrapower Natrium reactor designs.

Max's honors include being named a fellow of the American Nuclear Society in 1975 and elected to the National Academy of Engineering in 2012.

On the lighter side, Max enjoyed countless fishing trips to Canada and Alaska with friends and family members; walleye and salmon were favorites. He and Phyllis traveled the world extensively, and were especially fond of Australia, New Zealand, and countries in Asia. As they got older, they continued to enjoy their annual vacations in Costa Rica (but not until after the Super Bowl game) and on the coast of Maine, eating lobster, blueberry muffins, and strawberry pies and listening to crashing waves. Max and Phyllis were champion bridge and duplicate bridge players, and he enjoyed cards of any sort with anyone bold enough to challenge him. He won his last game of rummy the day before he passed away.

Phyllis, Max's bride of 76 years, preceded him in death by one year. They are survived by their children Ronald, Jean Dabel (John), Susan Carbon (Larry Berkson), David (Danhong Chen), and Janet Corradini (Michael). They were loved by 13 grandchildren and 12 great-grandchildren.

CHUN-YEN CHANG

1937–2018

Elected in 2000

"For contributions to Taiwanese electronics industry, education, and materials technology."

BY MIN-CHIUAN WANG
SUBMITTED BY THE NAE HOME SECRETARY

CHUN-YEN CHANG, who created Taiwan's first integrated circuit and is known as the country's semiconductor pioneer, died October 12, 2018, on his 81st birthday.

He was born October 12, 1937, in the Fengshan District of Kaohsiung, a city in southern Taiwan, during the Japanese occupation. His father, Mu-Huo Chang, was a farmer who relied on his own efforts to become a teacher at Fengshan Elementary School and later at Kaohsiung Middle School; his mother, Shu-Yu Cheng, was the daughter of a rich family in Fengshan. Chun-Yen had five siblings.

The first 10 years of childhood were happy for Chun-Yen Chang. That changed in 1947 with the February 28th Incident in Taiwan. His father was arrested and, although lucky enough to be released, lost his position as a high school teacher. The Chang family moved to Gushan in Kaohsiung, where his father made a living selling timber. Later the family moved to Madou District in Tainan City, where Chun-Yen finished his schooling. Because of the war and political turmoil, the boy attended seven schools.

In May 1950, when Chun-Yen Chang was in the sixth grade, the Madou incident (an event of the "White Terror") occurred, and his father was arrested again and put in jail; 4 months later, he was shot. At the age of 12, Chun-Yen accompanied his mother on a train to Taipei to collect his father's ashes.

After that, the Chang family fell into abject poverty, relying on the mother's strong will to bring up Chun-Yen and his five brothers and sisters.

Despite the dramatic changes in family circumstances, Chun-Yen Chang maintained excellent grades and entered Tainan First High School, one of the best high schools in southern Taiwan. He regarded Albert Einstein as an idol and encouraged himself with accounts of Einstein's troubled early life. He was most interested in physics and wanted to study in the Department of Physics at National Taiwan University in Taipei. But because of the family's difficulties and a desire to assist his mother in raising the family, he decided to study electrical engineering at Cheng Kung University near his home. He graduated in 1960.

He then entered the National Chiao Tung University (NCTU) in Hsinchu and studied at the Institute of Electronic Engineering, obtaining a master's degree in 1962. After graduating, he briefly worked for General Instruments, a US manufacturer, until the company wanted to send him to the United States for an internship; his application to the government to go abroad was rejected. Only then did he realize that his status as a family member of a political victim made it impossible for him to study abroad. Fortunately, under the assurance of NCTU president Si-Mou Li, he returned to his alma mater to work as a lecturer.

Within a few years he established Taiwan's first Semiconductor Research Center at NCTU and served as its first director. Also in 1965, the university's transistor research team successfully built the first bipolar transistor in Taiwan. In 1970, after he had been promoted to full professor, Chun-Yen Chang passed the oral examination of the doctoral dissertation by the Ministry of Education and became the first engineering PhD in Taiwan. He transferred to National Cheng Kung University in Tainan in 1977.

In the 1970s Professor Chang's masterpiece was research on the charge conduction mechanism of a metal-semiconductor junction. In the 1980s he published an innovative process for using triethylgallium to grow gallium arsenide in a low-pressure metalorganic chemical vapor deposition system. He was also committed to the development of new semiconductor components.

In 1988 Professor Chang transferred his research base back to National Chiao Tung University. After that, in addition to continuing the development of III-V material and devices, he initiated three new research areas: development of silicon germanium semiconductor compound technology, thin-film transistors, and development of innovative metal-oxide-semiconductor field-effect transistor devices.

Professor Chang became NCTU president in 1998 and served in that position for 8 years. During his tenure he doubled the university's research funding, and NCTU was selected by the Ministry of Education as one of the country's key research universities.

He promoted the National Si-Soft [silicon software] Project in 2001 to push for the transformation of Taiwan's semiconductor industry from manufacturing to design services. The project nurtured many integrated circuit design talents, allowing the semiconductor industry to support the vigorous development of the information and communications technology industry.

After retiring, Professor Chang returned to research and led graduate students to study new inventions of various semiconductor components, devoting the most in-depth attention to the negative capacitance transistor and cladding-type gate electrode 200 without a junction transistor.

As a family member of the victims of the White Terror, Chun-Yen Chang was hindered in his early education and employment. But with his tireless efforts and strategic initiatives, he became the first national PhD of engineering in Taiwan and internationally recognized for his outstanding work, with election in 2000 as a foreign member of the US National Academy of Engineering. During his commendable career he promoted the establishment of the first national semiconductor research center to drive the development of Taiwan's semiconductor industry and cultivated leaders of that industry.

Professor Chang is survived by his wife, Shen-Mei Li; sons Wei-Heng, Wei-Ren, and Wei-Lun; and many grandchildren.

HSIEN K. CHENG

1923–2007

Elected in 1988

"For original contributions to hypersonic flow theory and to the aerodynamics of three-dimensional wings in subsonic and transonic flows."

BY DANIEL WEIHS

HSIEN KEI CHENG, Emeritus Distinguished Professor of Aerospace and Mechanical Engineering at the University of Southern California's Viterbi School of Engineering, died in his sleep on July 11, 2007. He was 84.

Born in Macao, China, on June 13, 1923, Cheng received a bachelor of science degree in aeronautical engineering from Chiao Tung University in 1947. He continued his studies in aeronautical engineering at Cornell, where he earned a master of science degree (1950) and PhD (1952).

HK, as he was generally known, started his career working as a research aerodynamicist for Bell Aircraft Corp., where he gained invaluable experience in realizing theoretical concepts in aerodynamics. In 1959 he returned to Cornell Aeronautical Laboratory (now Calspan) to work as principal aerodynamicist, until 1963, when he moved to Stanford for a year as visiting professor. He then accepted a position as special lecturer in the Graduate Department of Aerospace Studies at the University of Southern California. The next year he was appointed full professor in USC's Department of Aerospace Engineering, and stayed almost 30 years, until his retirement in 1994. He maintained close ties with USC and other colleagues long after.

Cheng was an early and major contributor to various areas of aerodynamics. In 1963 he published a groundbreaking paper[1] on hypersonic flow that was crucial to the design of ultra-high-speed aircraft, an area now at the forefront of aeronautical science. His work was essential to the understanding of reentry phenomena including nonequilibrium gas dynamics.

He also made outstanding contributions to theories of three-dimensional wings in subsonic and transonic flows, including slender wings and bodies and the leading-edge vortex phenomena of swept and delta wings. Other areas in which he published significant work were theoretical and computational fluid mechanics, geophysical fluid mechanics, interaction of sonic booms on seas, biofluid dynamics, and the hydrodynamics of swimming propulsion.

Cheng's pathbreaking contributions were recognized by his election as an NAE member and a fellow of the American Institute of Aeronautics and Astronautics. He received the USC Viterbi School's Engineering Faculty Research Award in 1984 and was a member of the Phi Tau Phi Honorary Scholastic Society. In 2007 the USC Viterbi School's Astronautics and Space Technology Division named its annual keynote lecture in his honor.

Everyone knew HK as a warm, outgoing person, who gave freely of his immense store of knowledge, time, and mathematical intuition.

Cheng was survived by his wife, Wai L. Cheng, and daughter Linda Cheng.

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[1] Cheng HK. 1963. *The Blunt-Body Problem in Hypersonic Flow at Low Reynolds Number.* Cornell Aeronautical Laboratory Report No. AF-1285-A-10.

MALCOLM R. CURRIE

1927–2021

Elected in 1971

"Major innovations in electron devices and contributions to large systems in research and development."

BY YANNIS C. YORTSOS AND C.L. MAX NIKIAS

MALCOLM RODERICK CURRIE, engineering physicist and former chair and CEO of Hughes Aircraft Co., died April 18, 2021, at the age of 94. A defense and aerospace industry giant, he was best known for his work at the helm of Hughes Aircraft in the wake of the defense contractor's acquisition by General Motors. His distinguished career in electronics and weapons research and development included public service as undersecretary of defense research and engineering in the US Department of Defense. He also served as national armaments director. He was elected to the NAE in 1971.

Currie was born March 13, 1927, in Spokane, Washington, to Genevieve (née Hauenstein) and Erwin Caster Currie. He enlisted in the Navy during World War II, but the war ended before he could complete flight training. He took a discharge to earn his bachelor's degree in physics and doctoral degree in engineering physics from the University of California, Berkeley.

He began his career as a research scientist at Hughes Aircraft Research Laboratories in 1954, and quickly rose to director of

The authors gratefully acknowledge the assistance of Barbara Currie in preparing this tribute. The text also includes material from the USC announcement "Aerospace industry pioneer and USC Trustee Malcolm Currie, 94" by USC writers Gustavo Solis and Lynn Lipinski.

the company's research and development engineering division. There, he led projects such as the first digital airborne radars, laser systems, parameter amplifiers, electric propulsion, early satellite communications electronics, and ion beam semiconductor implantation. He authored or coauthored numerous technical papers and patents. Many in the scientific and aerospace communities took note of his achievements. Among them was renowned scientific instrument inventor Arnold Beckman (NAE 1967), who recruited Currie to head research and development for his company, Beckman Instruments, a biomedical product developer and manufacturer. Currie was vice president for product development and was involved in the first commercial DNA sequencer, peptide synthesizers, and other scientific instruments.

His abilities and accomplishments soon earned him another honor, this one from the federal government. In 1973, two years after joining Beckman, Currie was appointed undersecretary of defense research and engineering, responsible for planning, managing, and guiding the Defense Department's weapons research, development, and acquisition programs. In his concurrent role as national armaments director for NATO, he started and guided pioneering programs on the global positioning system and cruise missiles. He spearheaded many systems, from stealth aircraft and cruise missiles to turbine-powered M1 tanks, the Global Positioning System for satellite navigation, night vision, and smart weapons. He also chaired the DOD's Intelligence Research and Development Council.

Four years later, he returned to Hughes and steadily rose through its ranks to become chair and CEO in 1988. He led the company for 5 years until his mandatory retirement at age 65 in 1993. He is credited with leading its strategic diversification from defense into such areas as commercial satellite communications and private business network products. He also pioneered early research in traveling-wave tubes, lasers, millimeter waves, electric propulsion, and applications of electron and ion beams.

Currie served on the University of Southern California's Board of Trustees since 1989 and as chair from 1995 to 2000, overseeing a period of growth and success that included the near-doubling of the university's endowment and its selection by the *Time/Princeton Review College Guide* as College of the Year in 2000. In honor of his service, he received the university's highest honor, the Presidential Medallion, in 2001. He also served, until his death, on the USC Viterbi School of Engineering Board of Councilors.

In recognition of their investment in USC's biomedical research and education, a new Health Sciences Campus residence hall that opened in 2016 was named the Malcolm and Barbara Currie Residence Hall. Their generosity to USC also includes the 2008 endowment of the Malcolm R. Currie Chair in Technology and the Humanities, USC's first endowed faculty position honoring exceptional achievements in both realms. In an interview at the time, Currie said that he and Barbara wanted to "recognize that many of our most effective leaders of the future will have a depth of understanding of the technologies that are changing our world as well as the breadth of vision and perspective that come from study and love of the humanities."

In service beyond USC, he was president (1994) of the American Institute of Aeronautics and Astronautics and a fellow of the Institute of Electrical and Electronics Engineers (IEEE). For the National Academies of Sciences, Engineering, and Medicine, he served on the Naval Studies Board's Advisory Council for the Study on Technology for Future Naval Forces (1996–97) and the Government-University-Industry Research Roundtable (1992–94).

His many honors included Distinguished Service Medals in national and foreign intelligence and from both DOD and NASA, all in 1977, as well as the 1993 Goddard Astronautics Award and 1995 IEEE Founder's Medal, 1993 Goddard Astronautics Award, and 1995 IEEE Founder's Medal. In 1992 the US Air Force Academy presented him with the Thomas D. White National Defense Award for outstanding contributions to the national defense and security of the United States. He held the rank of commander in the French Legion of Honor and was inducted into the Space Technology Hall of Fame in 1998 for his work on the global positioning system.

Mal Currie was a remarkable engineer and innovator with a very entrepreneurial spirit. He held many patents and published numerous papers on topics from lasers to space propulsion. Not one to rest in retirement, he founded Currie Technologies, a developer and distributor of electric bikes and scooters, demonstrating his confidence in what he told *The Wall Street Journal* in 2000 was "the coming electric revolution."

He and Barbara shared a love of rare horse breeds. For 3 decades they studied horse breeding history and bloodlines and visited farms around the world to import, breed, and raise Pure Spanish Horses (Andalusians) on their ranch in Agoura Hills, California. They also enjoyed USC football and regularly attended games, cheering the Trojans.

Barbara reminisced about Mal and contributed the following:

While at the Hughes Research Labs, he shared an office with Murray Gell-Mann, a physicist who later won the Nobel Prize (1969) for work on theory of elementary particles. Dr. Gell-Mann spoke 13 languages fluently and was a student of Southwestern US archaeology in his spare time. Mal didn't learn any more languages from Dr. Gell-Mann, but started the lifelong habit of surrounding himself with the most brilliant people he could find.

He trusted his instincts about technology and in that respect gambled. He trusted the science when he was at Hughes and won for the company the multibillion-dollar contract for the AMRAAM missile, having spent untold millions on the development. As chairman of Hughes, he supported the expense and many-year corporate deficit of the commercial satellite program that became DirecTV.

While under secretary of defense, he convinced the Army to put the 105MM cannon on the M1 Abrams Main Battle Tank and to change from diesel engines to the gas turbine engine, eliminating the tell-tale trail of exhaust. Also, as DDR&E, he called all the services together, discontinued all their programs for the precursor of the GPS and assigned DARPA and the Air Force to develop the military version. The military version was opened to the public (modified to only an accuracy of 100 meters) by President Reagan, and the fully accurate version was released by President Clinton.

He trained as a Navy pilot (bi-wing Stearman) and often wondered what his life would have been if he had continued in the Marine Corps (he had the option after completing Navy basic training to select Navy or Marines). Because of his love of flying, as DDR&E one of his great joys was flying (second pilot) in the B-1, the B-2 Stealth bomber, the Harrier, and the Swedish Viggen, among others. He also tested the German Leopard tank on their test course in Germany—and was embarrassed to have taken a sharp turn and knocked down a tree. The general who was his escort assured him that he did a fine job, as a French general had done much more damage the week before.

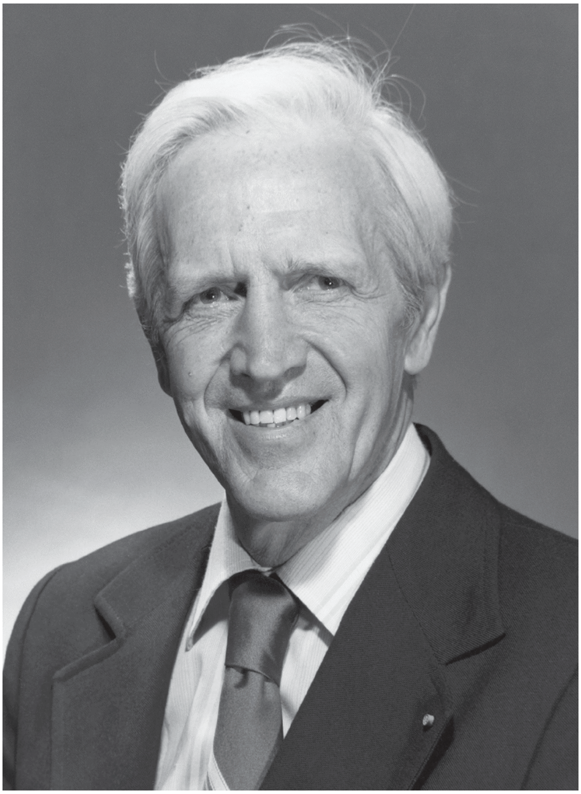
General Motors had just bought Hughes and Mal was involved with the SunRaycer program. Paul MacCready (NAE 1979) designed it and GM built it, as a precursor to all the modern electric and hybrid vehicles, and probably feeding into Mal's forever love of hybrid power. It raced across Australia (from Darwin to Adelaide, 1950 miles) and there was a whole caravan of "helpers," scientists, repair people, etc. Each night they camped along the way, sleeping in tents that they pitched themselves. In looking at pictures, we all giggled, because even though Mal had done all sorts of outdoor things with his family, his tent was always the one (and only one) that was somewhat tilted. Mal was thrilled with the battery technology and was a happy participant in the team that went ahead of the SunRaycer actually sweeping the surface of the road to get rocks out of the way. The GM SunRaycer won the race a full 2½ days ahead of the second entrant, Ford. I think the SunRaycer is now at the Smithsonian.[1]

Important to the DOD was the House Appropriations Committee, and particularly its chairman, George Mahon (D-TX), who also headed the Defense Subcommittee. Whenever the chairman would call, he, of course, was greeted

[1] It is in the Smithsonian's National Museum of American History (https://americanhistory.si.edu/race-cars/gm-sunraycer-1987).

by "Yes, Mr. Chairman, if I possibly can, Mr. Chairman,…" One day, Chairman Mahon called and asked Mal to meet with two men from his district who had a machine that could revolutionize weaponry, and, possibly, the world, and they, being great Americans, wanted to offer it first to DOD. Mal set up a time that day to see the men. They arrived with a small suitcase in hand and proceeded to tell Mal about the wonderful machine in the suitcase that solved the problem of generating electricity—it was a perpetual motion machine. Mal asked how this might relate to the laws of thermodynamics, drew blank stares from the men, and they said "let us give you an example." They started to open the machine to plug it in and Mal said, "Wait…do you have a patent on this?" No. "You must get one before you show this even to me, because you know that someone in the government will try to steal this great invention of yours and leave you without any ownership at all." So, alas, another perpetual motion machine lost, but Chairman Mahon was pleased, so the world continued.

Mal is survived by his wife of 44 years, Barbara (née Dyer); children Deborah Currie, David Currie, and Diana Currie-Hull, from his marriage to the former Sunya Lofsky; and two grandchildren.



C. CHAPIN CUTLER

1914–2002

Elected in 1970

"Fundamental contributions to microwave electronics and to space engineering and applied science."

BY PING KING TIEN

CASSIUS CHAPIN CUTLER developed his character during the tumultuous years of the Great Depression (1929–34) and World War II (1941–45) and led a successful career of research in communication science for more than four decades. His inventions in radio, radar, signal coding, imaging, and satellite communications earned him more than 80 patents, numerous awards, and a worldwide reputation. He was an enthusiastic collaborator, and remained humble throughout. He was quoted in the spring 1992 issue of the *WPI Journal*, "I don't think I'm really that smart. I just think my imagination got turned on at an early age and that gave me tremendous motivation."

Chapin was born December 16, 1914, in Springfield, Massachusetts, to Paul A. and Myra (Chapin) Cutler. He was raised in a small-town environment and educated in the public school systems. His resourcefulness and ingenuity had their roots in his youth and later in his education at Worcester Polytechnic Institute (WPI).

At age 14 Cutler played with elementary crystal receivers and his grandfather's three-tube radio, mostly listening to the broadcasts. Radio technology was a mystery to him. When

Adapted with permission from *Biographical Memoirs of the National Academy of Sciences* (www.nasonline.org/memoirs).

school started that fall, he went to the library to look for books on radio. Eventually a friend gave him a copy of *Radio Craft* magazine, with an article titled "The Junk Box Radio." Cutler later wrote in his journal, "This, I believe to be the most crucial event of my life."

"That's how I started," he said, "I built the junk box radio receiver using parts from a defunct broadcast set. I screwed the parts onto a pine board and used a single old vacuum tube. I salvaged even the wire and the solder from the old radio and used my dad's soldering iron heated on the kitchen stove." When the radio was built he heard "dit, dit, dit, dah, dit, dit, dah" from a station in Mexico City, and he was forever hooked on radio.

Shortly after, his father took him to a popular talk, "The Wonders of Radio and Communication," by a visiting scientist from the newly established Bell Telephone Laboratories. The speaker modulated a neon bulb, talked over a light beam, and demonstrated inverted speech. That was when Cutler decided what he wanted to do with his career. Experimentation with electronics soon became his avocation, and he supported his hobby by baking beans and selling them to neighbors.

He graduated from Springfield Technical High School in 1933 but, although his parents were determined that he should go to college, no one in the family had college experience or any idea of how to go about enrolling. One day he was stopped by a neighbor, a graduate student at WPI, who encouraged Cutler to apply and gave him an application form. A week later he visited the campus, was interviewed, and learned that he was accepted provided he did well in the first semester. His whole family was elated.

Because these were the Great Depression years, however, finances were a problem. The money Cutler had saved from selling beans was less than $100. His mother gave him $300 from Grandfather Chapin's estate, and his father obtained a loan from an insurance policy. Cutler thus had enough to start for the first year: $135 for room, $270 for board, $350 for tuition, and some money for supplies.

He learned of the WPI Scholarship for Yankee Ingenuity, endowed in 1928 by WPI 1895 alumnus Henry J. Fuller.

Seeking to secure one of these scholarships, Cutler worked day and night cleaning up his radio station, photographing and writing up the project. He did not win but was runner-up, and so received special attention at WPI from professors and employers.

The Worcester Tech Wireless Association, later named the WPI Radio Club (call sign W1YK), is reputed to be the oldest college radio station in the United States. Cutler joined the club and, partly because he was the only ham with a two-letter call, was elected to chair the Transmitter Committee; later he was elected club vice president and president. As committee chair, he was charged with getting the radio station on the air. He redesigned the station, and the school provided a pair of high-power (100 W) transmitter tubes.

Having successfully completed his freshman year, in the summer of 1934 Cutler worked as a chauffeur for T. Hovey Gage, a lawyer in Worcester, for $105 a month. On Memorial Day weekend he drove Mr. Gage to his summer residence in Waterford, Maine. It was a 180-mile, eight-hour trip, with a top speed of 12 mph on backroads, sometimes dirt roads. On entering the town, Cutler observed two attractive girls, and that evening, at a party of young people at the Wilkins Community House, he got to meet them. The most attractive of the two was Virginia Tyler.

That summer Cutler drove often to Maine, where Mr. Gage provided a room for him at a local inn, the Lake House. He got to know Virginia and they enjoyed time and some adventures together. They got married in Waterford on September 27, 1941.

Cutler graduated in 1937 with distinction (seventh in his class) with a degree in general science. He applied for employment at Bell Telephone Laboratories, but jobs were scarce in 1937—the economy had not quite recovered from the Depression, and the laboratories, to reduce costs, were open only four days a week. There were no openings in the research departments in New York City, but Cutler was offered a position at a branch laboratory in Deal, New Jersey, where research and development centered on shortwave radio, high-power transmitter tubes, new antenna designs, and ionospheric radio propagation—all areas close to Cutler's interests. His subdepartment head and later department head was John C. Schelleng, and among his close associates was James Wilson McRae, a recent PhD graduate from Caltech.

Cutler and McRae shared an office and transmitter lab. Assigned to design a high-power transmitter at 23 MHz using 25 kW experimental tubes, they used a feedback amplifier configured as the transmitter stage. Cutler called his first invention the "self-neutralized amplifier" because it balanced the internal tube capacitances, plate to cathode and grid to plate, against each other to prevent capacitive feedback. The grid and cathode were driven by the signals opposite each other in the optimum ratio. It proved to be stable, gave sufficient radio frequency feedback, improved linearity, and provided reasonable input impedance.

After gaining experience on the 25 kW transmitter tubes, Cutler and McRae embarked on the development of a 200 kW transmitter to operate at frequencies switchable from 4 MHz to 23 MHz with feedback over four stages of amplification. The objective was to provide 12-channel, single-sideband, multiplex telephony between the United States and England. They worked for two years until 1940, when Bell Labs was diverted to military work in preparation for war.

In 1940 Schelleng asked Cutler to work on the proximity fuse. The idea was to install a radio circuit in an explosive shell that would be shot from the ground toward an enemy airplane. The circuit would sense the proximity of the plane and send a signal to the ground to detonate the shell. Cutler designed the circuitry and tested the fuse at Aberdeen Proving Ground and Indian Point, both in Maryland. The project was shortened by the success of a self-contained triggering circuit.

Late in 1941 McRae and Cutler were asked to design and build waveguide plumbing for an X-band aircraft antenna. With advice from a number of experts, Cutler successfully built waveguide elbows, rotating joints, and connectors.

At that time one had to build one's own testing gear, including power supplies. McRae built the assembly according to their design and mounted one antenna on the second floor of the main building and another in a remote location. They were able to measure the directivity pattern and field intensity versus elevation angle and azimuth. They obtained good pattern in the E or H plane but had to adjust the structure between measurements. The beam width was about three degrees as required, but side lobes were one-tenth as strong as the main beam in one plane or the other, not close to the one-half percent power level required. Cutler hastily constructed more apparatus for measurements of amplitude, phase, and polarization of the radiation from the antenna feed. He tried various configurations of the assembly. Nothing seemed to work.

In the midst of this work McRae was called to Washington to guide the Army Signal Corps into the new age of radar. Cutler was left alone with the antenna project. "Late in the night, abed," he wrote in his notes, "it all came together in my mind. In the morning, I slapped my vision together with copper foil, solder, and sealing wax, and I had quite a different horn structure and a good radiation pattern. I slimmed down the waveguide and channeled the energy into two relatively narrow slots on each side of the guide. I called it the Waveguide Splitting Head. By varying its shape and size, I found a simple way to match the impedances."

It was indeed a novel, ingenious design of the antenna feed. The two slots were located exactly half a wavelength apart. The radiations from the two slots reduced the energy in the side lobes and reinforced the energy in the main beam. He used a screw in the splitting head to adjust field distributions in the two slots. It was simple—and reliable.

The waveguide antenna system, dubbed the "Cutler feed," was produced by the thousands and was aboard every Allied bomber in the latter part of World War II. Overnight Cutler became known as a radar expert and was consulted on various antenna designs. In the meantime he invented a variety of antenna feeds, including the corrugated waveguide, later used in microwave devices. When radar was unveiled to the public in 1945, an artist's rendition of the Cutler feed appeared in the August 20 issue of *Time* magazine.

In March 1944 with the war winding down, work began on the huge backlog that had accumulated in the telephone plant. AT&T announced a crash program to build an intercity microwave relay system from New York to Boston for both television and telephone signals. The system involved the construction of a series of radio relay stations about 30 miles apart with 3 MHz of bandwidth in 4 GHz channels. The close-spaced triode was selected for the repeater amplifier.

Cutler was then asked to study the circuit problems of the traveling wave tube (TWT; invented by Rudolph Kompfner [NAE 1966]) and to move his laboratory to the newly constructed research center in Murray Hill, NJ. The TWT faced several difficult technical problems, and there was a flurry of activities designed to overcome them. John R. Pierce (NAE 1965, NAS 1955) started the analysis and Cutler started the measurements.

For years TWTs had been made in a specialized shop where it took weeks to construct a single tube. Cutler longed to be able to make his own tubes. He studied vacuum systems and built his own pumping station. It was not easy. He used a thoriated tungsten cathode button heated white-hot by electron bombardment from another electrode in the tube. In a matter of hours he could open the vacuum chamber and change the parts.[1]

Calvin F. Quate (NAE 1970) joined Bell Labs in 1950 and Rudi Kompfner in 1951. By then Cutler was department head reporting to Pierce, who was now director.

Pierce deduced that noise on the electron beam due to thermal emission of electrons should appear as waves on the beam. It was not obvious at the time that anything as random as noise could propagate in the form of waves. Cutler and Quate set up an experiment to verify Pierce's theory. They projected an electron beam through the center of a toroidal resonant cavity in the newly designed pumping station; the cavity moved along the beam. They measured noise level excited in

[1] Cutler CC. 1951. The calculation of traveling-wave-tube gain. *Proceedings of the IRE* 39(8):914–17.

the cavity and found the waves predicted by Pierce. That was the famous Cutler-Quate experiment.[2]

Cutler learned about the digitization of prefiltered TV signals using pulse coding modulation up to seven or eight bits per sample. Because each picture amplitude sample was very much like the preceding one, he thought that if the difference in signal amplitudes were coded, it would require only a fraction of eight bits per sample—a substantial saving. He concluded further that if one quantized the difference between signals, some of the quantizing error would be compensated to yield a more accurate representation. Based on those ideas he invented differential pulse code modulation (DPCM), from which many coding schemes were derived over the years—predictive coding is used in digital TV transmission, fax machines, and medical imaging systems. Cutler then extended his work to pulse heterodyne radar, stereoscopic radar, and stereothermography.

The 1957 launch of Sputnik generated, at Bell Labs as elsewhere, a great deal of activity and enthusiasm for rocketry and spacecraft guidance and control. Cutler wrote a technical memorandum, "A Space Vehicle Communication System" and organized an ad hoc committee to study the components that would be necessary for a long-life radio repeater in an orbiting satellite. Their frequent meetings paved the way for the Telstar experiment,[3] soon followed by Project Echo.

Early in 1958 NASA was planning to orbit a 100-foot-diameter aluminized Mylar balloon to measure the density of the atmosphere in near space, and the agency was receptive to a passive communication experiment in space using the balloon for the reflector. Suddenly Project Echo was underway. The experiment required setting up a transmitter-receiver station at Bell Labs in Crawford Hill, NJ, and an identical station

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[2] Cutler CC, Quate CF. 1950. Experimental verification of space charge and transit time reduction of noise in electron beams. *Physical Review* 80(5):875–78.

[3] Crawford AB, Cutler CC, Kompfner R, Tillotson LC. 1963. The research background of the Telstar experiment. *The Bell System Technical Journal* 42(4):747–51.

at the Jet Propulsion Laboratory Earth Station in Goldstone, California. The balloon would orbit in low altitude with regular passes over North America. Radio signals would be sent from one station into space, reflected by the balloon, and received by the other station. Dozens of people were involved at Bell Labs, JPL, NASA, and NRL.

By mid-1960 they had a commercial 60-foot-diameter paraboloidal transmitting antenna, a novel 20-foot horn reflector receiving antenna, and a 10 kW Varian Klystron tube for the transmitter for each ground station. The newly invented maser was used for the first time as the low-noise amplifier. On August 12, 1960, *Echo 1* was launched into space, with a plan to transmit and receive a recording of President Dwight Eisenhower's voice during the first pass of the balloon. It was a day filled with excitement. "I remember starting the tape with my own fingers," Cutler said later in the *WPI Journal*, "It was probably the most exciting period in my life, because everything had to be done on the second. We had to have that antenna pointed exactly right, because this thing is whizzing from horizon to horizon in just 20 minutes." Goldstone reported back, "It was coming in loud and clear." There were excited cheers from those in the control room. They had succeeded with the first experiment in space communication![4]

After Project Echo and the Telstar experiment, the world was ready for commercial satellite communications. The federal government created a semipublic corporation, the Communications Satellite Corporation, as the sole owner of this business.

Cutler was promoted to assistant director of electronics research (1959) and then director of electronics systems research (1963–71) and of electronics and computer systems research (1971–78). Over the years hundreds of scientists reported to him. He hung the organization chart upside down in his office to remind himself that those at the bottom of the chart were the important ones. After a 40-year career at Bell Labs he retired in 1979.

[4] Cutler CC. 1961. Radio communication by means of satellites. *Planet and Space Science* 7:254–71.

In 1975, as Quate and his students worked on the acoustic microscope, he invited Cutler to spend time at Stanford. The acoustic microscope, a novel device, operated on the same principles as the optical microscope except that acoustic waves at microwave frequencies were used instead of visible light. The image from the microscope was taken with a single on-axis spherical lens with limited numerical aperture. Cutler wanted to circumvent the limit imposed by the small numerical aperture of the single lens; he suggested a multibeam arrangement with several off-axis lenses distributed over a wide angle. The wavelets emerging from the lenses acted constructively to form a coherent beam with a large numerical aperture according to the Huygens principle.[5] The difference in the images with and without Cutler's arrangement was striking.

After his retirement from Bell Labs, Cutler became a professor of applied physics at Stanford University, where he continued to work on acoustic imaging. He also was active as a member of Sigma Xi and a fellow of the American Association for the Advancement of Science and IEEE. He chaired the IEEE Awards Board (1975–76) and was editor of *IEEE Spectrum* (1966–67).

For his extraordinary contributions he was elected to the National Academy of Engineering in 1970 and the National Academy of Sciences in 1976. From the Institute of Electrical and Electronics Engineers (IEEE) he received the Edison Medal (1981), Centennial Medal (1984), and, for "the invention and development of predictive coding of pictures and picture sequences," Alexander Graham Bell Medal (1991). He was awarded an honorary doctor of engineering degree by the Worcester Polytechnic Institute in 1975 and received its Robert H. Goddard Alumni Award for Outstanding Personal Achievement in 1982.

Cutler greatly enjoyed physical activity, was a Boy Scout leader, and loved taking his children on adventures, teaching

[5] Bond WL, Cutler CC, Lemons RA, Quate CF. 1975. Dark-field and stereo viewing with the acoustic microscope. *Applied Physics Letters* 27(5):270–72.

them survival skills and the virtues of the compass. With family members, colleagues, and friends he skied and hiked much of the Appalachian Trail, climbed Mt. Rainier and Mt. Katahdin, and, with a Swiss team, ascended to the top of the Matterhorn. Most winters he spent skiing on the slopes of New England, often near the vacation property he acquired in Waterford.

He passed away December 1, 2002, in North Reading, MA, two weeks short of his 88th birthday. He was survived by his wife, Virginia; their children C. Chapin Cutler Jr. and Virginia Raymond; and four grandchildren.

Chapin Cutler was admired for his passion to discover and his unbounded energy for work. He will always be a role model cherished by all of us who work in science and engineering.

Acknowledgments

I was asked by Andreas Acrivos (NAE 1977, NAS 1991) to write this memoir for the National Academy of Sciences and was overwhelmed by the help I received. Most of the materials were collected from Cutler's personal notes supplied to me by the family. Several pieces were written by his close associates, Calvin Quate, William C. Jakes, and Herwig Kogelnik (NAE 1978). Searching through his old records, John R. Whinnery (NAE 1965, NAS 1972) found a nine-page text written by Cutler on his early experiences at the labs. Kogelnik retrieved a collection of email messages between Cutler and Nick Sauer discussing the lab at Deal. Roger N. Perry Jr. provided the information about Worcester Polytechnic Institute back in the 1930s and 1940s. Bruce Wooley made Cutler's files at Stanford University available. Gary Boyd and Susan Feyerabend helped to locate Cutler's old papers left in the lab. I also obtained files from the Lucent Archives and the IEEE History Center. My daughter edited the English of the first draft; Quate edited the final version of the text. I thank in particular Patricia A. Tier, who assisted me in every phase of this project.

JOHN E. DOLAN

1923–2018

Elected in 1980

"Engineering, innovating, and constructing technically advanced facilities in generation, transmission, and distribution for a major US privately owned electric system."

BY JAMES J. MARKOWSKY

JOHN EDWARD DOLAN, a leader in the development and construction of technically advanced facilities in generation, transmission, and distribution of the largest privately owned electric system in the United States, died March 17, 2018, at the age of 94.

John was born May 9, 1923, in Woodside, a neighborhood of Queens, New York. A devout Catholic, he graduated from Bishop Laughlin High School, enlisted in the Army in 1942, and was quickly selected for officer training and the Air Corps. First Lieutenant John Dolan was awarded multiple air medals for service in World War II as a B-17 pilot, completing 24 combat missions in the European theater with the 8th Air Force.

After the war he went to Columbia University on the GI bill and graduated in 1950 with a BS with highest honors in mechanical engineering; he also received the university's Illig Medal, awarded by the faculty to a member of the graduating class for commendable proficiency in his or her regular studies.

He joined American Electric Power (AEP) Service Corporation in 1950 as a junior engineer and, after a distinguished career, retired in 1988 as vice chair of engineering and construction. His early work involved the development of the industry's first commercial nuclear power plant, Dresden Plant Unit 1 in Illinois. He also served as project manager on a 150 megawatt gas-cooled nuclear reactor study in Florida, and worked with Philip Sporn (NAE 1965, NAS 1962), AEP's president (1947–61), on a water desalination project in Israel. The Israeli activities involved the design of a 6000 kilowatt plant and a 1,000,000-gallon-a-day seawater conversion unit.

He rose to become head of the Design Division in 1961 and chief mechanical engineer in 1966. He was elected vice president and chief engineer the following year and in short order rose through a number of positions of increasing responsibility before being named director of the parent American Electric Power Company in 1981.

Throughout his tenure at AEP John had significant responsibilities for, made major contributions to, or directed the engineering, design, and construction of 58 generating units totaling more than 25,000 megawatts of capacity as well as the development and installation of over 2000 miles of 765,000 volt transmission lines. Following are some of the major projects on his watch:

- 31 fossil units of 200,000–600,000 kW and five supercritical double reheat 800,000 kW units that were the largest in the world at the time;
- two 1100 MW nuclear units;
- the first major combination pump-storage and run-of-river hydro project; and
- seven 1300 MW units, the world's largest, including one involved in the unprecedented conversion from nuclear to coal-fired operation.

With John Tillinghast (NAE 1974), he continued and expanded on AEP's philosophy of the series concept of building units to meet system load in the most economical fashion. Dolan was responsible for development of the integration of single steam turbine–driven feed pumps in large generation units, and for the sliding steam pressure concept (for which he received a patent) and its application on supercritical pressure generation units, allowing them to maintain a higher generating efficiency at part load, resulting in major fuel and cost savings. The succession from 600,000 kW to 800,000 kW and finally 1300 MW represented the most advanced technology and largest available units at the time.

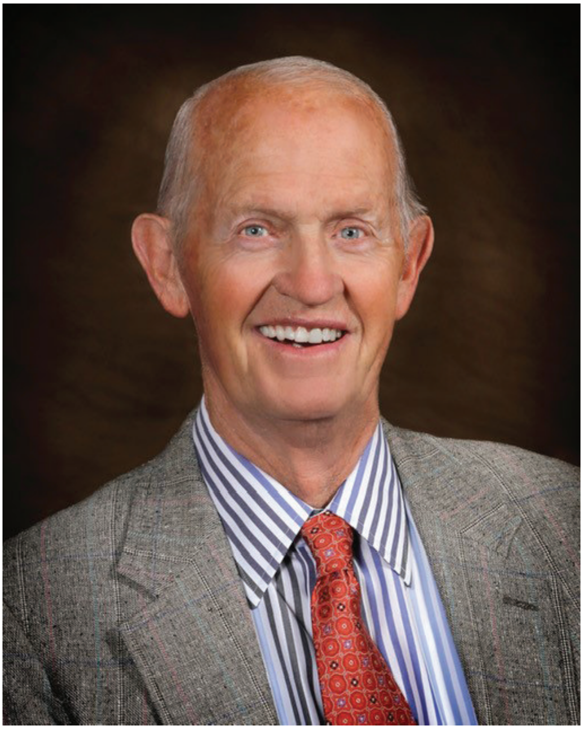
Late in John's career at AEP, defects were found in the nuclear steam supply system and containment structure of the nearly completed, jointly owned 800 MW William H. Zimmer Nuclear Power Plant. Correction of the problems would have required the owners to spend substantial sums to redesign, rework, and modify the plant, with no assurance of full compliance with the nuclear regulations or of approval for commercial operation. Because an attempt to correct the deficiencies was thus a very high financial risk, John and his engineers explored alternatives. The breakthrough alternative that John presented to AEP chair Willis S. (Pete) White Jr. (NAE 1983) was to convert the unfinished nuclear plant to a 1300 MW coal-fired power plant. The conversion—made possible by the existing turbine generation and the fact that the low end of the cycle was the same as a 1300 MW unit—was completed on time and within budget.

John wrote numerous publications on the technologies whose development he led for use in large power generating units, and chaired committees for the Association of Edison Illuminating Companies, East Central Nuclear Group, and Edison Electric Institute.

He was made a fellow of the American Society of Mechanical Engineers (ASME) in 1974 and elected to the NAE in 1980. He received ASME's Outstanding Leadership Award (1979); Nadai Medal (1984), which recognizes significant contributions and outstanding achievements that broaden the field of materials engineering; and James N. Landis Medal (1990), which is presented for outstanding personal performance in the design, construction, or management of major steam-electric stations using nuclear or fossil fuels. AEP honored him by naming a state-of-the-art engineering laboratory after him, the John E. Dolan Engineering Laboratory, which began operation in the summer of 1987.

Upon retirement in 1988, John and his wife moved to Largo, Florida, where they spent many happy years with family and friends.

His wife of nearly 66 years, Anne Margaret (née Youngberg, from his hometown) predeceased John in January 2018. They are survived by seven of their eight sons: Bryan (Joyce), Vincent (Lorene), Robert (Paige), Raymond (Virginia), Philip, Lawrence (Allison), and Paul (Janis), along with 18 grandchildren and 7 great-grandchildren. Sadly their eldest son John (Cathy) predeceased his parents.



DAVID A. DUKE

1935–2017

Elected in 1992

"For outstanding contributions in research, development, and commercialization of innovative glass and ceramic products."

BY DAVID MORSE AND PAMELA F. STROLLO

DAVID ALLEN DUKE died October 9, 2017, at the age of 81, in Salt Lake City, Utah, which is where he was born November 26, 1935, the youngest of six children of Beatrice (née Taylor) and Otto Duke. He attended Bryant Junior High and Salt Lake East High before enrolling at the University of Utah in 1953. He married his high school sweetheart, Hanne Jensen, in 1955 in the Salt Lake City Temple of the Church of Jesus Christ of Latter-day Saints.

After earning his bachelor of science in geology (1957), master of science in geoceramics (1959), and PhD in ceramics (1962), he accepted a position at Corning Glass Works as a research scientist and moved his family to Corning, New York. He was recognized as a brilliant researcher and talented manager during his long career with the company, which in 1968 sent him to Harvard Business School's Advanced Management Development Program. Upon his return, he was given the opportunity to grow and run several of Corning's businesses.

In the early 1970s he was the general manager of Corning's Industrial Products Business, where he ran a management team with Dick Dulude and Charles "Skip" Deneka. These leaders were tasked with capitalizing on Corning's new extrusion process, which produced the honeycomb ceramic structure ultimately named Celcor.

They took on multiple challenges to make Corning the solution of choice for automakers rushing to meet new US emissions regulations for their 1975 models: first ramping up production in time to capture business, then successfully demonstrating that the ceramic substrate provided the function that prospective customers needed, and, finally, ensuring that Corning could produce millions of units each year reliably and at an affordable price.

An around-the-clock development effort ensued, with an estimated three-quarters of Corning's Research and Development Center at Sullivan Park dedicated to Celcor. With no customer commitment, Corning broke ground in 1973 on a production plant in Erwin, NY. The bet worked. The facility shipped its first products in 1974, just months ahead of automakers' deadlines, and the rest was history. Celcor accounted for more than $100 million in profitable sales in its first year. It is the technology of catalytic convertors, diesel soot filters, and gas particulate filters worldwide to this day.

Not long after this success, Dave became general manager of Corning's new Telecommunications Products Division, which had six employees, virtually no sales, and the goal of creating an optical waveguide business. Dave oversaw some big risks to commercialize what would become Corning's optical-fiber business. However, the company needed to invest significantly in perfecting its manufacturing process. Mirroring the path they took with Celcor, Dave and others decided to move from a pilot operation to a full-fledged plant before Corning ever received a sizable order for fiber. The orders did come, Corning continued honing its capabilities under great pressure, and this area became one of its largest businesses. Optical communications via fiber networks led to the internet and all the changes in communications and data transfer that changed the world.

After 10 years focused on fiber commercialization, Dave became vice chair, directing Corning's R&D organization. He applied what he had learned from the experience with Celcor and optical fiber to help the company establish and maintain a focus on anticipating and innovating for the future.

By the time he retired in 1996, as vice chair of the board and chief technology officer, Dave had 10 patents, including for products such as Corelle dinnerware. He had also, on behalf of the company, accepted the 1994 National Medal of Technology and Innovation from the president of the United States.

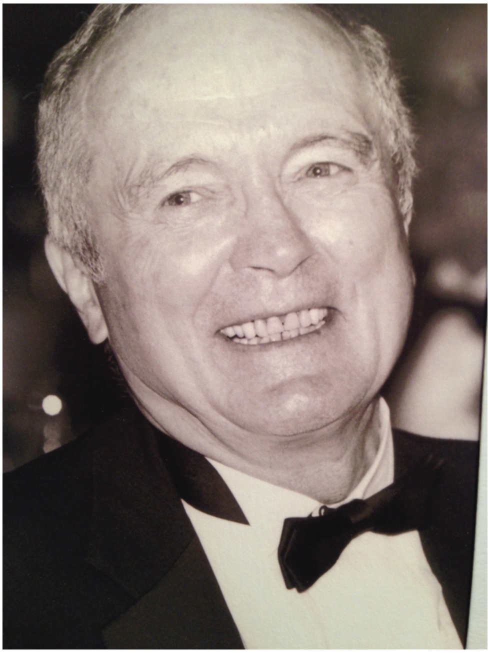
He was elected to the NAE in 1992, and in 1997 received the Earle B. Barnes Award in Chemical Research Management from the American Chemical Society. He was a member of the Engineering National Advisory Committee of the University of Utah College of Engineering, and for the National Academies served on the Committee on Japan (1993–99) and the Competitiveness Task Force: Strategies for Maximizing US Interests in Scientific and Technological Relations with Japan (1993–97).

Dave was an active member of the Church of Jesus Christ of Latter-day Saints, serving in the church throughout his life, including as president of the Elmira, NY, branch; bishop of the Elmira ward; and president of the Durban, South Africa, mission (1998–2001).

He was known for his love of others, making lifelong friendships with nearly everyone he met. He served tirelessly to help others, mentor colleagues at work, counsel families, and encourage youth to achieve personal and professional success through education, goal setting, and life planning.

Dave was active and athletic throughout his life. He developed a love of golf as a youth working as a caddy and groundskeeper at the Salt Lake Country Club and golfed to the very end, including at Augusta National. He also loved to fish. In Corning he played on intramural and city league teams in basketball, fast-pitch softball, volleyball, tennis, swimming, horseshoes, and bowling, and coached many youth sports teams.

He is survived by his wife of 62 years, Hanne; their four children: Katherine (Robert) Shumway, Michael (Catherine), Deborah, and John (Cessily); and 20 grandchildren.



PETER S. EAGLESON

1928–2021

Elected in 1982

"Leadership in the theoretical foundations of modern hydrology."

BY DARA ENTEKHABI

PETER STURGES EAGLESON, an accomplished and influential hydrologist who helped revolutionize the field, died of natural causes January 6, 2021, at the age of 92. He was an emeritus professor at the Massachusetts Institute of Technology.

He was born in Philadelphia on February 27, 1928, to Helen (née Sturges) and William Boal Eagleson and spent his childhood growing up in a suburb of the city. He attended Lehigh University, where he received his bachelor's degree in 1949, before moving on to MIT for his master's in 1952 and doctorate in 1956, all in civil engineering. Soon after, he joined the MIT faculty in the Department of Civil and Environmental Engineering, where he later served as department head (1970–75). In 1992 he was recognized with the James R. Killian Jr. Faculty Achievement Award, MIT's highest faculty honor.

Peter Eagleson was a pioneer in the field of hydrology. He expanded the scope of the field to encompass both engineering applications with important societal value and science investigations of the global water cycle, with broad and deep impacts on understanding of how the Earth system works. His 1970 book, *Dynamic Hydrology* (McGraw-Hill), provided a radically new perspective on the movement and storage of water in the environment. The water cycle interface with the climate system and biogeochemical cycles and its interactions with the biosphere were hallmarks of his new vision.

Later in the 1970s, in a series of seven papers under the main title *Climate, Soil, and Vegetation*—in a single issue of the journal *Water Resources Research* (14(5):705–76)—he demonstrated the potential of this new thinking for solving some longstanding disciplinary and interdisciplinary challenges.[1]

In 1991 the National Research Council published *Opportunities in the Hydrologic Sciences*, the report of a committee chaired by Eagleson that recommended a new vision for the field of study built on his pioneering ideas. The so-called "Blue Book" established the hydrologic sciences as pillars alongside other geosciences that collectively support understanding of the Earth system and guide stewardship of the planet. It was also the impetus for creation of the National Science Foundation's Hydrologic Sciences Program.

His other National Academies activities included serving as vice chair of the US National Committee for the International Union of Geodesy and Geophysics (1984–87) and as a member of the Water Science and Technology Board (1982–85), Commission on Physical Sciences, Mathematics, and Resources (1988–90), Commission on Geosciences, Environment, and Resources (1990–94), and Board on Global Change (1991–93).

After his retirement from MIT, he continued to produce inspiring new ideas. He published two books—*Ecohydrology: Darwinian Expression of Vegetation Form and Function* (Cambridge University Press, 2002) and the AGU-published *Range and Richness of Vascular Land Plants: The Role of Variable Light* (2009)—that ushered in yet another transformation of the discipline by bridging the fields of hydrology and ecology.

He was deeply engaged with the American Geophysical Union (AGU), and expanded the impact of his ideas across the geoscience community through his service and scientific contributions. He was the union's Hydrology Section president

[1] The paper titles and details of Eagleson's work and influence are provided in remarks by Ignacio Rodríguez-Iturbe, posted in the blog of Riccardo Rigon (University of Trento, Italy), About Hydrology, http://abouthydrology.blogspot.com/2021/01/peter-eagleson.html.

(1982–84), AGU president (1986–88), and received the organization's Robert E. Horton Medal (1988) and William Bowie Medal (1994).

He was recognized and respected nationally and internationally. In addition to his election to the NAE (1982), he received the International Hydrology Prize (1991), Stockholm Water Prize (1997), and the John Dalton Medal (1999) from the European Geosciences Union. To honor his long-lasting contributions to hydrology, the Consortium of Universities for the Advancement of Hydrologic Sciences established in 2008 the Peter S. Eagleson Lecture in Hydrologic Sciences.

Peter Eagleson led a rich life outside of the academic world as well. Known as "Pete" to his friends, he was an avid baseball fan and a Red Sox diehard.[2] He was an adoring husband to his wife, Beverly; they traveled together, collected modern art, and attended the Boston Symphony regularly.

He is survived by children Helen (Dale), Peter Jr., and Jeffrey (Judy) (from his 1949 marriage to Marguerite Anne Partridge); stepchildren William (Roberta) Rich, Robert (Robyn) Rich, Nancy Rich, and Cynthia Rich (Glenn); 13 grandchildren; and two great-grandchildren. His wife of 47 years, the former Beverly Grossmann Rich, died October 21, 2021.

[2] Jeff Dozier remembered that "At one of the meetings of the committee that produced the Blue Book, we opened with a moment of silence for the Boston Red Sox who had just lost the American League Championship to the Oakland Athletics" in 1990.

DEAN E. EASTMAN

1940–2018

Elected in 1988

"For early work in photoemission measurements and interpretation, and for subsequent leadership in process and packaging technologies."

BY FRANZ J. HIMPSEL, JOSEPH E. DEMUTH,
ELLA MAE EASTMAN, PETER E. KING, AND THOMAS N. THEIS
SUBMITTED BY THE NAE HOME SECRETARY

DEAN ERIC EASTMAN'S father emigrated from Sweden during the Great Depression to seek an opportunity in the iron-mining industry of Michigan's Upper Peninsula. Born January 21, 1940, to Eric and Mildred Benson Eastman in Oxford, Wisconsin, Dean spent his youth, with three brothers and a sister, in the small town of Stambaugh, MI, with a population under 2000 and a total high school enrollment of about 300 students. Dean played on the basketball, baseball, and tennis teams.

Dean's academic options shrank after 8th grade, when his father purchased a small farm two miles out of town. The farm was in a different school district, where he had to attend an even smaller school of about 30 students. Fortunately, for his junior and senior years he attended the Stambaugh high school—where the faculty immediately realized they had a special student in their midst. As a junior, Dean took over teaching the physics course from a teacher who recognized that he himself was unqualified to do it properly. Dean was then given an IQ test, which he had missed when transferring schools. The score was not made public, but word got around

Adapted with permission from *Biographical Memoirs of the National Academy of Sciences*, available online at www.nasonline.org/memoirs.

that it was off the charts, and the faculty became intimidated by this transfer student.

Of course, intelligence is no shield from the harsh realities of life. The summer before his senior year, the mine and steel workers went on strike, leaving Dean's father unemployed for a time. Like many of his classmates, Dean joined his father cutting pulpwood in the forest. The backbreaking work paid $5 a day, much-needed income for the families.

Dean (and the rest of America) got a shock of a different sort when the Soviet Union launched Sputnik. The following day, the high school chemistry teacher told students he was glad he was old and would soon die, and that he pitied the students because they would likely spend their lives living under communist rule!

Dean began constructing a rocket for a science club project together with one of the authors (PEK) and another student; PEK recalls the ensuing events as follows: We built a solid-fuel projectile and successfully tested it in a vertical flight in the spring, but we had ambitions to reach the maximum possible flight distance. As science club members and "mature" honor students, we were allowed to work independently on our project in the chemistry lab. But we were running out of time—graduation (in June 1958) was only a week away. Under the circumstances, we decided to simplify logistics by doing our second launch right out of the laboratory window—conveniently assuming that nothing could possibly go wrong!

We set up the launch pipe at a 45° tilt and ignited the fuel. But instead of the anticipated blast-off, the rocket jammed in the unstable tube and the exhaust gases filled the laboratory. It burned for what seemed an eternity, but probably on the order of a minute. We scrambled around the room, opening all the windows and turning on the hood fans. This was not an effective response, and moreover the chemistry teacher caught us red-handed.

That night, the three rocket musketeers held a clandestine meeting to plan our damage-control strategy, but we conceded that in all likelihood we'd be expelled. The next day we were tasked with repairing the lab floor, which had been charred from the hot exhaust gases. But to our surprise, we were not summoned to the principal's office. Every day that week we waited for the call, but nothing! They let us sweat it out right up to the graduation ceremony, in which Dean served, as planned, as valedictorian. The rocket fiasco was apparently forgiven.

So college was still in our future. Dean planned to attend Michigan Tech, with its affordable in-state tuition. His academic horizons broadened, though, when his College Board exam scores landed him a full national merit scholarship and his acing of the Michigan Mathematics Exam resulted in a second scholarship to cover his additional expenses.

Given the distraction of the rocket fiasco, it was only a month after graduation that Dean belatedly applied to MIT. He was accepted, and the national merit scholarship was increased to reflect MIT's greater costs.

He earned his BS in electrical engineering (EE) in 1962. Drawn to a professor who had a much broader view of EE—encompassing, for example, the scientific understanding of materials used in electronic devices—than other faculty, Dean did his senior project on ferrite memory devices and wrote his BS thesis on this topic. He went on to a master's degree (1963), with a thesis on high-speed pulse transmission in strip-line arrays. His theses, together with his high grades and class participation, undoubtedly helped attract the attention of IBM.

At the time, IBM was greatly expanding its R&D efforts, having just established the Thomas J. Watson Research Center in 1963. A major part of this expansion was the recruitment of young scientists, recently graduated from top-tier universities, who had been trained to think broadly and who would be willing to tackle problems that eluded solution by standard engineering methods. IBM anticipated that some of these young recruits would join top management later in their careers and help steer the company in the right direction.

Dean was seen as an unusually promising prospect for IBM. The company hired him while he was still a graduate student and supported him until he finished his PhD (1965). His clearly defined research topic—ultrasonic study of magnetoelastic and inelastic properties of yttrium iron garnet—allowed him to finish quickly and start work at IBM, on what became a steep career path.

When he arrived at the Watson Research Center, a solid state theory group had just been formed there. The researchers were using large-scale first-principles calculations to probe and predict the electronic structure of solids, starting with metals. Given Dean's interest in the fundamentals of materials, he was attracted to the emerging technique of photoelectron spectroscopy, which he thought would complement the theoretical work.

He applied photoelectron spectroscopy to a wide range of topics, pioneering the characterization of electrons in a variety of materials. In addition to bulk materials he studied surfaces, using a combination of ultra-high-vacuum technology and ultraviolet photons. Careful control of surfaces enabled him to demonstrate how photoemission could reveal the molecular nature of chemisorbed molecules on a metal surface. Since then, such experiments have been used widely to study chemical reactions at surfaces, such as in catalysis.

He also explored the energy levels at clean surfaces of metals[1] and semiconductors. His work on the efficient emission of electrons from the diamond surface generated continued interest over the years in the search for a chemically stable electron source. He was particularly interested in magnetism, and he managed to resolve the magnetic exchange splitting,[2] which causes a material to become ferromagnetic.

To characterize electrons in solids completely, one needs to measure not only their energy but also their momentum (in all three directions). The ultimate goal is to determine the relationship between energy and momentum (often called the energy band dispersion), and angle-resolved photoelectron spectroscopy is uniquely suited to pursuing that

[1] Eastman DE. 1970. Photoelectric work functions of transition, rare-earth, and noble metals. *Physical Review B* 2(1).

[2] Eastman DE, Himpsel FJ, Knapp JA. 1978. Experimental band structure and temperature-dependent magnetic exchange splitting of nickel using angle-resolved photoemission. *Physical Review Letters* 40(23):1514.

goal. Dean designed a special instrument for this purpose, which he called the ellipsoidal mirror display analyzer.[3] The device not only selected the energy but also displayed two components of the momentum simultaneously. The third momentum component was more difficult to obtain because it required photons with continuously variable energy. Such photons were provided by using synchrotron radiation, the area in which Dean had arguably his largest impact.

Synchrotron radiation was ideal for photoelectron spectroscopy, given that it was tunable, orders of magnitude brighter than traditional UV lamps and X-ray tubes, and could produce polarized photons. These features made it possible to extract the complete information about electrons in solids. Dean became known for his push toward continuously variable photon energy by means of synchrotron radiation. Because this radiation was generated by high-energy accelerators and storage rings, he and other early users had to travel to particle physics centers to get access to it in the so-called "parasitic" mode. Since then, these parasites have become major players at their hosts. Many dedicated synchrotron radiation sources have been built worldwide. Dean's efforts in using synchrotron radiation started with a sabbatical to the MIT Cambridge accelerator in 1974.

Having contributed so much to IBM research's reputation as a center of excellence in science and technology, he was named an IBM fellow—the highest honor that can be bestowed on an IBM technical employee—in 1974. This status, which comes with substantial freedom and funding to pursue new ideas, allowed Dean to expand his operation in photoelectron spectroscopy by establishing his own IBM beamline at the Tantalus electron storage ring of the Synchrotron Radiation Center (SRC) near Madison, Wisconsin.

The IBM beamline, together with beamlines from Bell Labs and collaborations between universities and national labs,

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[3] Eastman DE, Donelon JJ, Hien NC, Himpsel FJ. 1980. An ellipsoidal mirror display analyzer system for electron energy and angular measurements. *Nuclear Instruments and Methods* 172:327.

attracted researchers from all over the world. Many of them went on to careers in synchrotron radiation, sometimes as leaders of their own synchrotron light sources. The Tantalus storage ring is now a Historic Site of the American Physical Society.[4]

Dean's pioneering experiments made him famous at a young age. He was a sought-after speaker at international conferences, impressing audiences with his magisterial style of presentation and his insights into future research avenues.

In 1980 he received the Oliver E. Buckley Prize, the highest honor in solid state physics, awarded by the American Physical Society. He shared it with Bill Spicer, his long-time competitor. The two were cited for "their effective development and application of photoelectron spectroscopy as an indispensable tool for study of bulk and surface electronic structure of solids."

In 1981 Dean decided to switch from research to technology development—a more direct way, he thought, of contributing to IBM's business successes. He moved up rapidly in management, simultaneously leading R&D in compound semiconductor devices, lithography, and "packaging" (the sophisticated manufacturing processes for the assembly of semiconductor chips to build complete computing systems). In 1986 he became vice president for logic, memory, and packaging and vice president and director of product development.

Eventually, he moved from the IBM Watson Research Lab to IBM headquarters in Armonk, NY, where he led the Department of Hardware Development and Reengineering.

As a leader in technology development, Dean took on the enormous challenges facing IBM at the time. And because he pushed farther and harder toward solutions than anyone else, in the end he either won big or lost big.

One such challenge was the development of X-ray lithography for semiconductor manufacturing. The project addressed

[4] The Synchrotron Radiation Center (SRC) in Wisconsin: A historic site of the APS. 2018. Online at https://www.aps.org/programs/honors/history/historicsites/synchrotron.cfm.

a perceived obstacle to the continued miniaturization of digital electronics: the inability of optical lithography to pattern devices with critical dimensions smaller than 1 micrometer. To replace the established optical lithographic tools and processes and deliver the necessary manufacturing throughput, a very bright X-ray source would be necessary.

Dean and his team favored X-ray contact lithography. Under his informed technical leadership and confident direction, they assembled, tested, and largely demonstrated a compact synchrotron source at IBM's East Fishkill (NY) manufacturing site. However, a series of innovations, some unforeseen, extended the established optical lithographic processes far beyond 1 micrometer to today's critical dimensions measured in tens of nanometers. While X-ray contact lithography had some important niche applications, it never much contributed to the development of digital electronics or to IBM's business.

By contrast, Dean's forceful advancement of another exploratory project had great positive impact for IBM. The enterprise began when one of the authors (TNT) briefed Dean on test results indicating that in the scientific and technical computing arena, IBM's new engineering workstations based on the emerging RISC (reduced instruction set computing) architecture could deliver some 60 percent of the performance of IBM's mainframes at about 5 percent of the cost. Within days, Dean had assembled a small team of semiconductor packaging experts, led by Janusz Wilczynski (NAE 1987), to prototype a high-performance scientific computer based on harnessing many RISC processors in a modularly expandable system.

Thinking Machines, a noted company at the time, was already selling scientific supercomputers that harnessed multiple processors, but these were based on expensive proprietary processor designs. The IBM team used workstation processors that were manufactured in high volume and thus had a low per-unit cost.

With Dean's encouragement and support, a prototype piece of hardware was very quickly built, and this helped to kick-start a larger effort in the IBM Research Division.

Selling the concept to the product divisions as well as potential customers, however, was an uphill battle involving many people over several years, but the inexpensive modular architecture gradually prevailed. The company's ultimate influence in this arena may be seen by the racks of interchangeable computers that now fill every modern server center. The crash execution of the kick-start project and its contribution to a greater success set a precedent for other IBM researchers confronting the company's looming financial crisis of the early 1990s. Their attitude was: Be bold, and you can make a difference!

Years before, Dean had foreseen some of the company's problems and voiced his conviction that extraordinary measures would be necessary to address them. In particular, he understood that the exponentially compounding miniaturization of semiconductor electronic devices would greatly reduce the part count for even the most complex and powerful computing systems. He predicted that this development would reduce the value of IBM's lead in chip-packaging technology and render much of the associated manufacturing capacity extraneous. When Dean was appointed director of hardware development and reengineering in 1994, his job was to identify and develop plans to address this new direction and other structural problems that plagued the company. Where other executives hesitated, Dean usually prescribed action, and he was very effective in this role.

In 1996 Dean was tapped by the US Department of Energy to lead the Argonne National Laboratory. He left in 1998 to start a second career as professor of physics at the James Franck Institute of the University of Chicago. In a return to his past, he initiated a synchrotron radiation experiment at the SRC with one of the authors (FJH), at the Aladdin storage ring. Dean impressed the local staff with his attention to the details of the experiment, making valuable suggestions to improve the setup.

Dean further shared his expertise through service on committees of the National Research Council. In the early 1980s he cochaired, with Frederick Seitz (NAS 1951), a committee that outlined the future of major facilities for materials research.[5] The committee's recommendations led to the construction of the Advanced Photon Source and Advanced Light Source, which respectively became the premier X-ray and UV light sources in the United States. He also chaired the Condensed Matter and Materials Research Committee (1976–83) and served on the Board on Physics and Astronomy (1983–86) and Commission on Physical Sciences, Mathematics, and Resources/Applications (1986–92).

For his contributions in applied physical sciences and engineering, Dean was elected to the National Academy of Sciences in 1982 and the National Academy of Engineering in 1988. He was also a member of the American Academy of Arts and Sciences.

In 2000 Dean took up a new challenge: renovation of Frank Lloyd Wright's Coonley House in Riverside, a suburb of Chicago. He liked designing things, particularly buildings. During his life he moved into a variety of houses in need of repair and completely redid them, waxing especially proud when he managed to improve on a contractor's design. He oversaw building projects at homes in New York, Maine, and Chicago. The Coonley House was his ultimate challenge.

Dean and his wife Ella Mae purchased the "public wing" of the sprawling former Coonley estate in 2000 and restored it with exquisite attention to detail, chasing down old photographs of the original design, doing an analysis of the original paint, and dealing with the onerous constraints encountered and permits required for renovating a building listed in the National Register of Historic Places. He was on the site daily in order to monitor progress and be available for quick decisions.

His restoration earned him the admiration and praise of preservationists, the 2004 Wright Spirit Award from the Frank Lloyd Wright Building Conservancy, and recognition as an honorary member of the American Institute of Architects. In

[5] Major Materials Facilities Committee of the Commission on Physical Sciences, Mathematics, and Resources. 1984. *Major Facilities for Materials Research and Related Disciplines*. Washington: National Academy Press.

a kind of victory lap, but primarily to reveal the secrets of his success for the benefit of other such projects, he wrote a book about his restoration efforts: *Frank Lloyd Wright's Coonley House Estate: An Unabridged Documentary* (self-published, 2014).

Dean also really liked cars. After he moved to a house with a three-car garage, he started collecting them—first a truck, then a big white Cadillac convertible with a huge engine, a Camaro (with a comparable engine), a BMW, and a classic Corvette. There was also a newer Corvette model, which he purchased because it was a deal he couldn't pass up (he was always keenly conscious of value and a lover of bargains).

Riding on the highway with Dean in his BMW could be a rather hair-raising experience. He kept a radar detector on the dashboard, and while cruising at high speed would quickly brake at the slightest alert. His passengers would worry about getting rear-ended, but this was not an issue because he was going so fast. He also had the unsettling habit of facing his passengers when talking to them—even those in the rear seats.

Colleagues and students enjoyed the annual Christmas party hosted by Dean and Ella Mae. As Dean became a wine connoisseur, he offered excellent wines at the event.

Dean was a lighthearted and jovial person, but would focus intensely on a technical problem or managerial issue. He could be a demanding manager, but also took time to provide detailed suggestions on how to accomplish a task. He appreciated smart people who worked hard and helped their careers in various ways. "Picking smart people's brains" was his efficient way of becoming familiar with the gist of a new topic. He quickly grasped the heart of a problem and was articulate in stating it. He also was an excellent writer and speaker, expressing things clearly and with uncanny insight.

He died March 4, 2018, at the age of 78. He is survived by his wife of 38 years, Ella Mae (née Staley).

ROBERT W. FARQUHAR

1932–2015

Elected in 2012

"For deep space missions to asteroids and comets and for leading the NEAR mission to Eros."

BY DAVID M. VAN WIE

ROBERT WILLARD FARQUHAR, a national expert in deep-space mission and trajectory design and executive for space exploration at KinetX Aerospace, died October 18, 2015, at the age of 83.

He was born Robert Greener on September 12, 1932, in Chicago, where he was raised by his mother Ruth C. Boyens Greener (after her divorce) with support from his grandmother, Rose Boyens. His mother married Frank Farquhar when Bob was 13 years old, and Bob took on the surname in high school after he was formally adopted by Frank.

Before college, Bob joined the Army and served in Japan and Korea during the Korean War. Upon returning, he attended the University of Illinois Chicago, where, pursuing his longstanding interest in aviation, he earned his bachelor's degree in aeronautical engineering in 1959. He worked briefly on interplanetary trajectories at the RAND Corporation before going on to get his engineering master's degree (1961) at the University of California, Los Angeles, and—after working at Lockheed Missiles and Space Company in Sunnyvale—a PhD in astronautics (1968) at Stanford University.

Bob married the former Bonnie Gail Johnson and they had a daughter, Patricia Lee. Bonnie died in 1992. In 2004 Bob married Irina (Irene) Vostokova and they had a daughter, Anna (Anya).

Building on his PhD work studying the use of libration orbits, Bob is credited with coining the term halo orbit for the class of periodic three-dimensional orbits that exist near Lagrange points in three-body orbital mechanics. Throughout his career, he maintained a strong interest in mission and novel trajectory design for missions to the Moon, libration points, comets, asteroids, and planets.

After obtaining his PhD, Bob worked at NASA's Goddard Space Flight Center (1969–90) and in supporting assignments at NASA headquarters (1978–90). Among his many responsibilities during these years, he served as the flight dynamics manager and flight director for the International Sun-Earth Explorer 3 (ISEE-3) mission, which was the first mission to a libration point. It was renamed the International Cometary Explorer (ICE), and the spacecraft made a textbook pass through the tail of comet Giacobini-Zinner on September 11, 1985. Bob was also instrumental in creating the NASA Discovery Program, which is aimed at modest cost for solar system explorations missions.

He joined the Johns Hopkins University Applied Physics Laboratory (JHU/APL) in 1990 and worked there until 2007. He was mission director for the Near-Earth Asteroid Rendezvous (NEAR) Shoemaker mission that intercepted, explored, and, following his intricately designed trajectory, successfully landed on 433 Eros; the MESSENGER (Mercury Surface, Space Environment, Geochemistry and Ranging) mission, the first to orbit and conduct an extensive exploration of Mercury; and New Horizons, the first mission to Pluto and its moon Charon.

Bob left JHU/APL to serve as the Charles A. Lindbergh Chair for Aerospace History at the National Air and Space Museum in Washington (2007–08). In 2008 he joined KinetX as executive for space exploration, focusing on the development of new architectures for human spaceflight beyond low Earth orbit (LEO). These architectures envisioned reusable vehicles, deep-space habitats, libration-point staging, and an innovative phasing-orbit rendezvous (PHOR) technique. Bob was driven to find economically realistic ways to carry out human missions in deep space.

In service to the National Academies, he was a member of the Committee on Priorities for Space Science Enabled by Nuclear Power and Propulsion: A Vision for Beyond 2015 (2004–06).

Over his career, he received awards and honors too numerous to mention. They include the Mechanics and Control of Flight Award (1981) from the American Institute of Aeronautics and Astronautics (AIAA), the Dirk Brouwer Award (1984) from the American Astronautical Society (AAS), a letter of commendation from President Ronald Reagan (1984), a NASA Medal for Exceptional Engineering Achievement (ISEE-3/ICE) (1988), the Space Pioneer Award from the National Space Society (2001), the Diplôme d'Honneur (2001) from the Fédération Aéronautique Internationale, the 2002 Laureate Award for Space from *Aviation Week & Space Technology*, the NASA Medal for Exceptional Engineering Achievement (NEAR) (2002), and the Grainger College of Engineering Alumni Award for Distinguished Service (2013). In addition to his NAE election in 2012, he was elected to the AAS (1986), International Academy of Astronautics (1996), and AIAA (2004). Asteroid #5256 was named Farquhar in his honor in 1988.

Bob was a prolific writer in the space exploration community, with over 200 publications. His book *Fifty Years on the Space Frontier: Halo Orbits, Comets, Asteroids, and More* (Outskirts Press, 2010) provides unique insights into his efforts and contributions.

In parallel with his passion for space exploration, Bob compiled an exhaustive world-class collection of stamps from Manchuria and Manchukuo over a 50-year span. A portion of his collection was documented in his book *Manchuria in Transition 1925–1934: Chang Tso-lin to Emperor Kang Teh* (John Bull Stamp Auctions and Causeway Bay Post Office, 2006).

Family was hugely important to Bob. He suggested to the discoverers of minor planet 5947 that it be named after his first wife and it was subsequently named 5947 Bonnie in her memory. And on Valentine's Day in 2000, he persuaded the International Astronomical Union to name an asteroid after the woman who became his new wife: it is named 5957 Irina.

In addition to Irene, Bob is survived by their daughter Anna and four grandchildren. He was predeceased by his first wife and by his daughter Patricia Lee, who died in 2011.

HANS K. FAUSKE

1935–2021

Elected in 2016

"For contributions to nuclear and chemical reactor safety."

BY ROBERT E. HENRY

HANS KARE FAUSKE died September 27, 2021, at age 85. He was born to Marie and Ivar Fauske on December 7, 1935, in Bergen, Norway.

His undergraduate degree was in chemistry from the Norwegian Institute of Technology (1958), and he completed his education with an MSc (1959) from the University of Minnesota, under the guidance of Professor Herb Isbin, and a DSc (1963), both in chemical engineering, from the Norwegian Institute of Technology.

Upon completion of his studies, Hans joined the staff at Argonne National Laboratory (ANL), where he provided thesis supervision of master's and PhD students doing research through a collaboration of universities such as the University of Chicago, University of Minnesota, University of Notre Dame, and Northwestern University.

Before leaving ANL in 1980, he served for two years as director of the DOE Fast Reactor Safety Technology Management Center; he was responsible for the planning and management of the US programs and recognized as a world authority on fast breeder reactor safety. During this period he also chaired the Argonne National Laboratory Committee A, which was responsible for the hiring and promotion of scientific and engineering staff.

In 1980 he left ANL, along with Michael A. Grolmes and the author of this tribute, to establish Fauske & Associates Inc. (FAI), which in 1986 became a Westinghouse Electric Company. He was president of FAI from 1980 to 2012 and then the company's regent advisor through 2019.

FAI achieved a national and international reputation and is considered a global leader in nuclear and chemical process safety. Dr. Fauske himself was involved in projects covering a wide range of safety issues in both the nuclear power and chemical process industries. His career included roles involving many aspects of both chemical and nuclear reactor safety:

- He was senior consultant to the Nuclear Industry Degraded Core Rulemaking program that followed the accident at the Three Mile Island Unit 2 plant. He had a leadership role in initiating the MAAP computer code that is used by utilities around the world to assess possible accident behavior, and how to counter that behavior, for commercial water-cooled nuclear power plants.
- He was senior technical advisor to the Clinch River Breeder Project with responsibility for developing the severe accident energetics evaluations. This eventually led to the licensing of the liquid sodium-cooled Clinch River Breeder design.
- He provided technical direction for the AIChE Design Institute for Emergency Relief Systems (DIERS), which is sponsored by 28 domestic and international chemical firms. These activities resulted in state-of-the-art methods and laboratory tools that have been used to design relief systems for individual chemical recipes involved in both storage and process equipment throughout the world. These studies of possible chemical vulnerabilities were employed at the US Hanford high-level waste tanks to support containment-in-place as a viable long-term alternative strategy that has been used effectively.

Dr. Fauske's important contributions were recognized with myriad honors. He was elected a member of the NAE (2016) and was also a fellow of the American Nuclear Society (ANS) and American Institute of Chemical Engineering (AIChE). Over the decades he received the first University of Chicago Medal for Distinguished Performance at Argonne National Laboratory in the field of Reactor Technology (1975), the ANS Tommy Thompson Award in the field of reactor safety (1982) and Thermal-Hydraulics Division Technical Achievement Award (1991), the AIChE Donald Q. Kern Award (1992) for Heat Transfer and Fluid Flow Technology and Robert E. Wilson Award (1996) for ensuring nuclear and chemical industries safety, the University of Minnesota Outstanding Achievement Award (2004) for worldwide impact on nuclear and chemical reactor safety, and the ANS George C. Lawrence Pioneering Award (2012) for nuclear safety in recognition of his lifetime of pioneering contributions toward the enhancement of nuclear safety.

He served on the editorial boards of the *Journal of Loss Prevention in the Process Industries*, the *International Journal of Multi-Phase Flow*, and the *AIChE Process Safety Progress Journal*.

He published more than 200 scientific articles and held numerous patents in the areas of nuclear and chemical process safety. He coauthored the book *Experimental Technical Bases for Evaluating Vapor/Steam Explosions in Nuclear Reactor Safety* (with the tribute author; ANS, 2017). Following are just a few of his other notable publications:

- On the mechanism of uranium dioxide-sodium explosive interactions. *Nuclear Science and Engineering* 51:93–101 (1973)
- Summary on accident energetics, including coolant dynamics, cladding and fuel relocation, and molten-fuel-coolant interaction. *Proceedings of the International Meeting on Fast Reactor Safety and Related Physics* (Oct 5–8, 1976, Chicago), Conf-761001, vol 1:316–24 (1977)
- Managing chemical reactivity – Minimum best practice. *Process Safety Progress* 25(2):120–29 (2006)

He continued actively writing and publishing into his 80s.

Dr. Fauske spoke seven languages, and recently became a US citizen, something he carefully weighed for many years. He was generous with his time, a patient mentor, and modest despite his substantial accomplishments. When not engaging with his family, his favorite place to be was solving problems at his white board, continuously writing equations for understanding and predicting important physical phenomena.

He was immensely proud of the achievements of his children and grandchildren, and he adored his wife Judi (née Gerdes), his "very pretty lady" whom he married February 8, 1964. She survives him, as do their children Hans Kristian (AnnMarie) and Kirk Ivar (partner Tori Harmon), and five grandsons.

JOHN E. FFOWCS WILLIAMS

1935–2020

Elected in 1995

"For contributions to the theory of jet noise, and other aspects of aeroacoustics and hydrodynamics."

BY ANN P. DOWLING

JOHN EIRWYN FFOWCS WILLIAMS, Rank Professor of Engineering at the University of Cambridge (1972–2002) and master of the university's Emmanuel College (1996–2002), died suddenly of a brain hemorrhage on December 12, 2020, aged 85.

John, known to all his friends as Shôn, was born May 25, 1935, into a Welsh-speaking family in Llangadog, Wales. Eirwyn means "snow white" because it snowed the day he was born, a rare event in May—even in Wales. His father Abel was a preacher, poet, and writer. His mother Elizabeth died in 1940, and Shôn would later recount that he and his two brothers "had a lovely time running wild with dad looking after us." After his father's remarriage, Shôn was sent at age 10 to a boarding school, the Great Ayton Friends' School, far away in North Yorkshire, some 2 days' journey from his home. Shôn spoke almost no English when he arrived at the school. He soon learnt, 'though he then tended to speak Welsh with a Yorkshire accent.

He left school at age 16 and became an engineering apprentice at Rolls-Royce Ltd. in Derby, England, while continuing his studies at Derby Technical College (now part of the University of Derby). He won the Spitfire Mitchell Memorial Scholarship (1955–60), which funded his studies at the University of Southampton. His time there was transformational. He took the aeronautical BSc degree in just 2 years, obtained a PhD in 1961, was president of the Students' Union (1957–58), and met his future wife, Anne Beatrice Mason. They married in 1959 and went on to have three children: Awena (born 1966), an adopted son, Aled (1970), and Gareth (1980).

Shôn's PhD, supervised by Elfyn John Richards, a Welsh aeronautical engineer, was on the noise of high-speed turbulent jet flows, which was increasingly important because of the high-velocity turbojets that were beginning to power commercial aircraft. He showed how the aircraft's forward motion and the high-speed convection of the turbulent eddies in the jet modified the intensity and directivity of the generated sound, correcting an error in Sir James Lighthill's 1952 paper ("On sound generated aerodynamically. I. General theory"). The error was subtle, the result of a reduction in the effective correlation volume of the turbulent eddies due to the variation in retarded time[1] over an eddy whose convection speed is non-negligible in comparison with the speed of sound.

Sir James supported and agreed with Shôn's conclusions and communicated his paper describing this work for publication in the *Transactions of the Royal Society*.[2] The paper demonstrated what became characteristic of Shôn's style—it addressed a technologically important problem, presented detailed mathematics but also gave a clear physical description of the underlying reason for the result, and backed up the theory by a comparison of its predictions with experimental data. The two men became close friends.

After leaving Southampton, Shôn continued his research in high-speed jets as a research fellow in the Aerodynamics Division of the National Physical Laboratory (1960–62) in Teddington, England, and at Bolt, Beranek, and Newman Inc. (1962–64) in Cambridge, Massachusetts. At BBN his research covered all speed ranges, from the noise of supersonic rocket

[1] The time from when sound leaves a source to be heard by a distant observer.

[2] Ffowcs Williams JE. 1963. The noise from turbulence convected at high speed. *Philosophical Transactions of the Royal Society of London, Series A* (255):469–503.

jets to turbulent boundary layer flows over a submarine, whose pressure fluctuations could interfere with the sonar system.

Shôn and Anne returned to the United Kingdom in 1964 when Shôn became a reader in applied mathematics and subsequently the Rolls-Royce Professor of Theoretical Acoustics at Imperial College London.

He viewed aeroacoustics as a branch of fluid mechanics. Sound is usually a byproduct of unsteadiness in flow, perhaps due to turbulence or another flow instability. But the energy in sound is so small that the source flows are often unaffected by the noise they produce. Indeed the pressure fluctuations in the sound are typically many orders of magnitude smaller than local pressure fluctuations in the source flow, and can be expressed in terms of integrals of the flow field over the source region. Lighthill's (1952) theory showed how that could be done for a turbulent flow in unbounded space, and Shôn, working with student David L. Hawkings, showed how that could be extended to the sound generated by surfaces in motion. The Ffowcs Williams-Hawkings (FfW-H) equation[3] expresses the far-field sound from moving surfaces in terms of integrals of pressure and velocity over the surfaces. Use of this equation has become ubiquitous as a means of predicting the noise from helicopter and propeller blades, turbomachinery, and many other applications where determination of surface pressure and velocities is a basic part of the design. The FfW-H equation enables the sound field to be readily calculated from this information.

In 1966 David G. Crighton joined Shôn as research assistant and PhD student, sponsored by the US Office of Naval Research to work on underwater acoustics. Sound travels long distances underwater and sonar is used to detect submarines by passively listening to the sounds they generate as they move through the oceans. Submariners would sometimes emit a screen of bubbles to mask their presence, thinking that the bubbles would scatter

[3] Ffowcs Williams JE, Hawkings DL. 1969. Sound generation by turbulence and surfaces in arbitrary motion. *Philosophical Transactions of the Royal Society of London, Series A* (264):321–42.

sound and conceal their noise signature. But the analysis by Crighton and Ffowcs Williams[4] showed that the high compressibility of the air bubbles could lead to strongly radiating monopoles in the inhomogeneous mixture not present in water alone. These could actually greatly enhance the sound generated by the turbulence—by some 50 dB for a 1 percent air/water concentration and by 70 dB for a 10 percent concentration. So rather than the cloud of bubbles disguising the noise of a submarine, it dramatically increased it. It is said that this result led to an immediate change in operational procedures!

As director of the Concorde Noise Research Unit and chair of the Concorde Noise Panel (1965–75), and an executive consultant to Rolls-Royce, Shôn led work to address Concorde's noise problem. Concorde was the first commercial aircraft to fly supersonic, reducing the travel time from London to New York to just under 3 hours. But the design of its engines, powered by turbojets with afterburners needed at take-off, was inherently very noisy. Shôn led attempts to reduce the noise, but it was too late in the project to make radical design changes, and the ejectors and mixing lobes tested had only a marginal effect. The main improvements came through enhanced operations, such as a very rapid initial climb.

In 1972 Shôn moved to Cambridge as the inaugural Rank Professor of Engineering, taking the Concorde Noise Research Unit with him. Abbreviated as CNRU, it became known as the Cambridge Noise Research Unit.

The following year Shôn became head of the university's Division of Energy, Fluids, and Turbomachinery. He used to say that his main achievement was to persuade very good research students to tackle important but interesting problems.

To his many PhD students he was an inspiring supervisor who brought his enthusiasm, curiosity, and creativity—and sense of fun—to every project. The research he led was wide ranging, and his former students went on to leadership roles across university disciplines that include mathematics,

[4] Crighton DG, Ffowcs Williams JE. 1969. Sound generation by turbulent two-phase flow. *Journal of Fluid Mechanics* 36:585–603.

engineering, computer science, and biomechanics, and in technological industries that range from automotive and aviation to electronics and chip design, bioengineering, and ship building.

Shôn's work helped make "anti-sound": the introduction of suitably phased sound to cancel unwanted noise—a practical option. In particular, he realized the power of feedback systems involving acoustic waves to stabilize aeromechanical systems. One branch of applications, pursued in collaboration with colleagues at the Massachusetts Institute of Technology, was the control of instabilities of turbomachinery, particularly compressors. Through a series of theoretical studies, complemented by laboratory and full-scale demonstrations, the teams showed the feasibility and benefits of "smart" engines. These are engines with modern sensors and feedback controllers driving actuators that enable the engines to operate in conditions where they would otherwise be unstable (for example, extending the operating range of compressors by artificially delaying the onset of surge or rotating stall).

Shôn enjoyed the interdisciplinary nature of the Cambridge community, which sometimes took him into completely different areas of research. An inquiry from clinicians who hoped that anti-sound might eliminate the annoyance of snoring led Shôn and his PhD student Lixi Huang to investigate the mechanisms that cause snoring. There are several. Anti-sound was not going to be effective, but preventing the sound source was possible, at least in the laboratory. The surgeons and their patients were ready to try out the engineers' suggestions.

The first intervention was to drill a small hole in the soft palate to reduce its tendency to vibrate due to pressure differences on its two sides. It worked brilliantly—and continued to work even when the hole had healed and closed up! The remaining scar stiffened the palate sufficiently to prevent flutter. This led to a minimally invasive procedure in which a surgical laser beam was used to cause scarring and change the dynamics of the soft palate.[5] This was a huge step forward

[5] Huang L, Quinn SJ, Ellis PD, Ffowcs Williams JE. 1995. Biomechanics of snoring. *Endeavour* 19:96–100.

because before Shôn and Lixi's work the surgical solution was a uvulopalatopharyngoplasty, an operation involving removal of much of the soft tissue in the palate.

Shôn was an early Cambridge entrepreneur and in 1979, with Jack Lang, founded the successful startup company Topexpress Ltd., focused on software development, research, and consultancy. The UK Ministry of Defence was a major customer, particularly AUWE (the Admiralty Underwater Weapons Establishment). Topexpress was eventually sold to the VSEL Consortium plc, essentially becoming its advance research lab. Shôn subsequently joined the board of VSEL as a nonexecutive director.

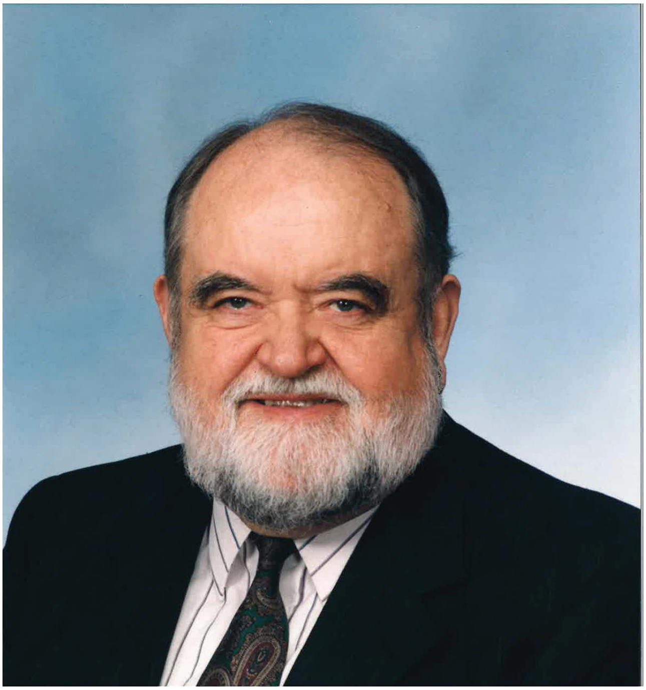
In 1977, for his many achievements in establishing the field, Shôn was awarded the Aeroacoustics Medal from the American Institute of Aeronautics and Astronautics (AIAA), followed by the Rayleigh Medal from the Institute of Acoustics (1984), the Silver Medal of the Société Française d'Acoustique (1989), and the Gold Medal (1990) from the Royal Aeronautical Society (RAeS). He received an ScD degree from the University of Cambridge in 1986 and was a fellow of the RAeS, the Institute of Mathematics and its Applications, the Institute of Physics, the Acoustical Society of America, and the AIAA. He was elected a fellow of the Royal Academy of Engineering in 1988, and received its Sir Frank Whittle Medal 2002 for "outstanding and sustained achievement" and "lifelong dedication to understanding the properties of sound, which has enabled huge innovation in international transport." He was a foreign honorary member of the American Academy of Arts and Sciences since 1989 and elected a foreign member of the National Academy of Engineering in 1995.

Shôn had been a fellow of Emmanuel College since his arrival at Cambridge in 1972. He enjoyed its convivial community, which included playing bowls after a very pleasant lunch. In 1996 he accepted the invitation to became the college master and said it "changed my life completely." Shôn, Anne, their schoolboy son Gareth, and their dogs moved into the master's lodge to succeed Lord St. John of Fawsley, a very different character. As Shôn was to say, "The College dominated our life, my interest then being much more to ensure the College's academic success than in my own work." He was a hard-working, convivial, much-loved master and, together with Anne, made the master's lodge a welcome place for fellows and students. He placed particular emphasis on inclusive admissions, high academic standards, and generating a community spirit across the college. The college enjoyed his lively company and thrived under his leadership.

When Shôn retired in 2002, he was the longest-serving professor at the University of Cambridge. He and Anne moved to his family's home in Eglwysbach. They were delighted when Gareth and his wife Ewa joined them in North Wales where Gareth, a keen cyclist, runs a cycle shop and tackles challenging mountain routes.

John Ffowcs Williams is survived by Anne, Gareth (Ewa), and two granddaughters. Awena, a psychiatrist, predeceased him, but he remained devoted to his son-in-law Andrew and grandson Ieuan, who is a musicologist. Shôn would be delighted that the study of some form of sound and vibration continues in the family.

He is greatly missed by family and friends throughout the world.



FRANCIS B. FRANCOIS

1934–2021

Elected in 1999

"For engineering and policy leadership in surface transportation infrastructure and research."

BY THOMAS B. DEEN AND E. DEAN CARLSON

FRANCIS BERNARD FRANCOIS, long-time executive director of the American Association of State Highway and Transportation Officials (AASHTO), died February 17, 2021 at his home in Chicago at age 87. An engineer and patent attorney, he was well known for his support of technical innovation and his leadership in improving transportation policies.

Frank was born January 21, 1934, in Barnum, Iowa, a village near Fort Dodge. Growing up on a farm in Webster County endowed him with an appreciation for hard work and basic values of ethics and integrity. He had a wide variety of interests and as he approached college age considered a number of possible careers, including professional magician or the priesthood. In the end he graduated from Iowa State University in 1956 with a bachelor's degree in engineering.

He moved to Washington, DC, and began his career as a patent examiner in the US Patent Office. An ambitious young man, he enrolled in night classes at George Washington University Law School. In 1959 he became a patent advisor for the Applied Physics Laboratory at Johns Hopkins University.

During this period he met and fell in love with Eileen Mary Schmelzer, a local student living in Hyattsville, Maryland. They married just before Frank received his law degree in February 1960. He passed the Maryland bar later that year and practiced patent and trademark law (1962–80) with the firm of Bacon and Thomas.

Frank and Eileen shared an interest in public service and it wasn't long before Frank joined the local Democratic club and got interested in running for office. In 1962 he became an elected official in Prince George's County, MD, a populous jurisdiction just east of Washington, serving first as chief judge of the Orphan's Court, then as a county commissioner, and finally as an elected member of the county council. He was a strong advocate for civil rights, fair employment for African Americans, community development, improved fiscal management, education, and the needs of senior citizens and the handicapped.

As a council member, Frank represented Prince George's County on the Washington Metropolitan Council of Governments (COG; chair, 1969, 1976; president, 1971) and Washington Metropolitan Area Transit Authority (WMATA), for which he chaired the joint Policy and Steering Committee on the Washington Alternatives Analysis Project. At the time Washington was in the throes of construction of major portions of the interstate highway system as well as significant parts of the rail transit system known as Metro. These assignments whetted Frank's growing interest in both transportation technology and engineering along with the difficulties in balancing the benefits of improved mobility with the environmental and social costs associated with such changes. He supported and helped coordinate the DC Air Pollution Act in 1968 and was present for the signing of the bill alongside President Lyndon Johnson and DC mayor Walter Washington.

By 1978 he considered running for county executive but decided against it; when his decision was announced, the *Washington Post* referred to him as the council's "philosopher-historian," "maverick," and "ambassador to the outside world."[1]

Frank was a big man with a strong resonant voice, and his political skills were evident as he became a force in a number

[1] Maraniss DA. 1977. Francois won't run, says so in 10 pages. *Washington Post*, Nov 24.

of national organizations, including election as president of the National Association of Regional Councils (twice) and of the National Association of Counties (NACo; 1979). As NACo president he touted county government as the most important and elective local government in America.

In 1980 he resigned from the Prince George's County Council to serve as executive director of AASHTO. During his nearly 20-year tenure, he reasserted and strengthened the association's role as the premier technical organization for issuing highway standards and specifications, many of which continue to have worldwide application.

He emphasized the need for multimodal transportation and developed agency expertise in policy activities. Because the association's board is made up of the directors of each state's transportation agency, Frank had, in effect, 50 bosses. He was a significant influence in national debates about transportation policy, and his experience in politics was crucial in his ability to reach consensus positions among the AASHTO directors. Such consensus played a major role in the passage of major transportation legislation in 1981, 1986, 1991, and 1996, during the presidencies of Ronald Reagan, George H.W. Bush, and Bill Clinton. He also marshalled state transportation departments' advocacy for several major highway and transit bills, capped by the 1998 Transportation Equity Act for the 21st Century (TEA-21).

In addition, he cultivated AASHTO's expansion into international activities, recognizing the potential mutual benefits of working cooperatively with global transportation organizations such as the International Road Federation, Permanent International Association of Road Congresses, and World Road Association. He co-led the Scanning Tour on Transportation Agency Organization and Management cosponsored by AASHTO, the US Federal Highway Administration (FHWA), and industry leaders; the tour included meetings with transport agencies in Australia, New Zealand, Sweden, and the United Kingdom. He also served on the National Academies' Committee for the 10th International Conference on Low-Volume Roads (2008–11).

While directing AASHTO, Frank supported other transportation organizations in their efforts to encourage innovation. He served on the executive committees of the National Academies' Transportation Research Board (TRB) and National Cooperative Highway Research Program (1980–99), and worked tirelessly with TRB and the FHWA to support research that would lead to improved highway planning, design, construction, and maintenance activities. He was an active advocate for the Strategic Highway Research Program (SHRP) and convinced state transportation agencies that they should finance the program out of their own budgets and support the research by building segments of their highways as test sections. Many products of SHRP have been accepted as standard practice in such diverse areas as asphalt pavement design and winter maintenance.

He supported transportation research with an eye to the future. He was a cofounder and chair of the Intelligent Transportation Society of America (ITSA) and was made an honorary life member of its board. ITSA is the seed organization for the development of autonomous vehicles that interact with highways to provide for driverless vehicles. For the National Academies he served on the Committee on the Metropolitan Planning Organization, Present and Future: A Conference (2006–08), Committee for a Future Strategy for Transportation Information Management (chair; 2004–06), and Committee for a Study for a Future Strategic Highway Research Program (1999–2002).

Other National Academies service included his appointment to the Committee on Weather Research for Surface Transportation: The Roadway Environment (2003–04) and Science and Technology for Countering Terrorism: Panel on Transportation (2001–02), among others. For the NAE he served on the Audit Committee (2002–05).

Frank received many awards and honors. In 1973 he was recognized as Washingtonian of the Year by *Washingtonian Magazine*. TRB presented him with its W.N. Carey Jr. Award (1989) for his leadership in transportation research and Frank Turner Medal for Lifetime Achievement in Transportation

(2007). The Institute of Transportation Engineers gave him the Theodore M. Matson Memorial Award in 1993 and in 2002 made him an honorary lifetime member of its board. In 2003 Iowa State University (ISU) awarded him the Marston Medal and in 2004 the American Road and Transportation Builders Association named him one of the top 100 private-sector design and construction professionals in the United States in the 20th century. In 2000 AASHTO created the annual Francis B. Francois Award for Innovation, presented to state departments of transportation that have developed innovative projects. He was elected to the National Academy of Engineering in 1999, and posthumously inducted into the Hall of Fame of ISU's Department of Civil, Construction, and Environmental Engineering.

Frank had important impacts beyond his chosen professional field. For example, he was the patent attorney for two boyhood friends who got a patent for a breakaway basketball goal. Several professional and college games had been halted by broken glass backboards from what some called the thunder dunk. The breakaway goal solved the problem of broken glass backboards, and so the dunk and hanging from the rim were allowed again and kept the excitement in the sport. Frank wrote a book memorializing the invention, *Two Guys from Barnum, Iowa, and How They Helped Save Basketball* (Archangel Press, 2008).

In 2011 he published his memoirs in a book that featured deep family ties to his native Iowa, titled *Me? I'm from Iowa: Memoirs of an Iowa Farm Boy Who Went to Washington* (lulu.com, available on Amazon).

In retirement Frank moved to Chicago to be close to family. He was married to his beloved wife Eileen for 43 years; she died in 2003. They are survived by their children Joseph, Marie, Michael, Monica, and Susan, and seven grandchildren.

WILLIAM L. FRIEND

1935–2021

Elected in 1993

"For leadership in the development of new technologies and their application in commercial facilities."

BY BABATUNDE A. OGUNNAIKE

WILLIAM LOUIS FRIEND, retired executive vice president and director of Bechtel Group, Inc., died January 27, 2021, at age 85, from complications due to covid-19. He was a passionate and practical engineer who believed in the power of engineering to change the world for the better.

Born June 17, 1935, in Queens, New York, Bill went to Stuyvesant High School and then studied chemical engineering at Polytechnic University, graduating summa cum laude in 1956. He then attended the University of Delaware, where he received an MS degree in chemical engineering in 1958. In 2005 Polytechnic University conferred on him the degree of Doctor of Engineering, Honoris Causa.

Bill served in the US Air Force Reserve in 1959 and then went on to enjoy a distinguished career in a variety of positions in engineering and construction, both as a practicing engineer and as an executive. He began as a regional manager of international operations and process engineering for the Lummus Company in the late 1950s, with field assignments abroad in Germany, Holland, Mexico, and Spain, and stateside in San Francisco, New York, Houston, and Puerto Rico. In 1972 he went to work at J.F. Pritchard in Kansas City, Missouri, rising to become president and chief executive officer.

In 1977 he joined the Houston office of Bechtel, the global engineering, construction, and project management company. He was elected a partner of the privately held firm in 1981 and to the board of directors 2 years later. He retired as executive vice president of Bechtel Group in 1998. The company's chair and CEO Brendan Bechtel had this to say about Bill: "He believed our ability to manage large, complex undertakings could add real value when applied to the US government missions in defense, space, nuclear security, and environmental cleanup. He helped to create a new government services unit, Bechtel National, Inc., in 1986, and led the organization until 1992. Today, that business is one of our four core businesses, a tribute to Bill's vision and leadership."

Barbara Rusinko (NAE 2018), who worked with Bill for Bechtel at the US Department of Energy's Savannah River site, recalls, "Bill created a work environment that was focused on quality and continuous improvement; he empowered us to keep up with advances in the profession and in our own areas of expertise. The talent that we have today…is an enduring legacy of his leadership years."

Bill was passionate about diversifying the engineering workforce, and in this he was a visionary leader far ahead of much of corporate America. He served as Bechtel's representative to the National Action Council for Minorities in Engineering (NACME) and chaired its board of directors (1992–96). "Bill was a strong advocate for our work to build an engineering workforce that looks like America," said NACME CEO Michele Lezama. "He was especially focused on our *Math Is Power* campaign, one of our first outreach efforts to precollege students and their parents." LeeAnne Lang of Bechtel's Corporate Affairs added: "Bill was very excited about it, so you can bet that all the schools within a 100-mile radius of Bechtel's San Francisco office were well aware of *Math Is Power*."

Bill's commitment to education and engineering research motivated much of his volunteer work, earning him a well-deserved reputation as one of the most admired and most generous members of the community. When Stan Sandler (NAE

1996), then chair of the Chemical Engineering Department at the University of Delaware, decided to establish a departmental advisory council in 1982, he chose Bill to be one of the cochairs. "As a new department chair in 1982, I found Bill's sincere interest in the department, his industrial insights, and his history of the department extremely valuable," said Sandler.

In addition, Bill was a trustee of Polytechnic University, his undergraduate alma mater, and chaired the university board's Committee on Trustees. He chaired the University of California President's Council on the National Laboratories, Los Alamos, Lawrence Livermore, and Berkeley. And after his election to the National Academy of Engineering in 1993 he served as treasurer, member of the NAE Council, and member of the Governing Board of the National Research Council. He was also active in other National Academies programs, including the Board on Energy and Environmental Systems (2009–11), Committee on Setting Priorities for NSF-Sponsored Large Research Facility Projects (2003–04), and NAE Committee on the Diversity of the Engineering Workforce (1999–2005). He was a fellow of the American Institute of Chemical Engineers.

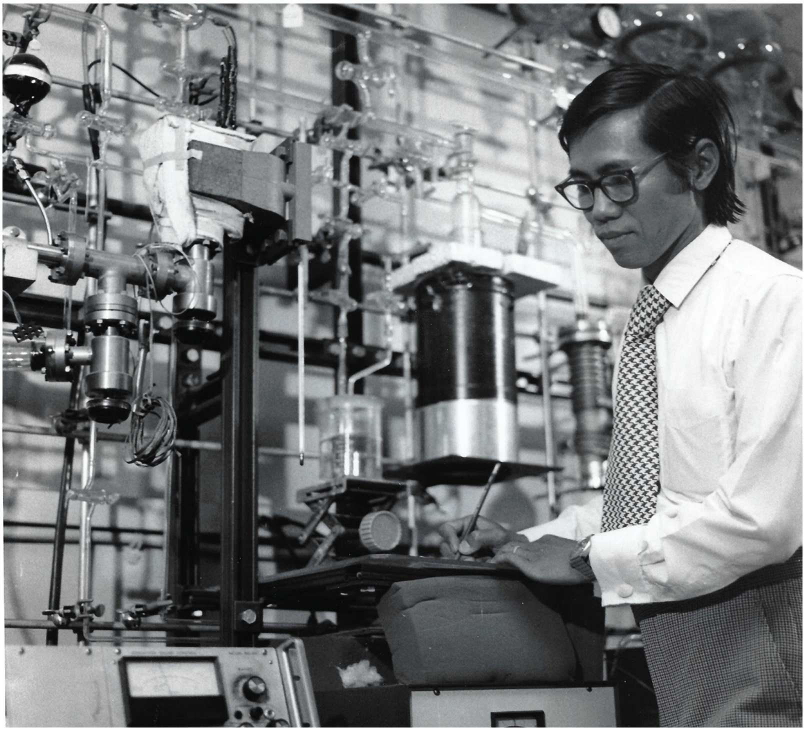
As generous as Bill was with his time and talent, he was even more so with his treasure, supporting—frequently and generously—a remarkable number of initiatives at the institutions from which he obtained his degrees. On a personal note, in 2004, through a very generous gift to the University of Delaware (UD), Bill created the William L. Friend Endowed Chair in Chemical Engineering, which I hold. In 2018 Bill and his wife, Mary Kay, were named inaugural members of UD's highest giving society, the Founders Society.

As Mary Kay noted, "Bill and I were very fortunate to have been introduced to each other in 1995 by long-time friends. We both felt, even at our first meeting, that this could be something special, and, indeed, it was. We had 26 wonderful years together, traveling frequently, sharing our beach house with dear family and friends, and simply enjoying time with each other. Bill was a truly good man—honest, generous, trustworthy, supportive, and loving—and while I will grieve for him, I will also be so very grateful for him and the life we had."

Michael Mislock, a stepson, added: “Among the many lasting impacts Bill had on people’s lives, one that stands out to me is his commitment to education. He backed up his beliefs through large donations to universities and the establishment of several scholarships for minorities and young people who could not otherwise afford to attend a university. He and my mother also established trust funds to pay for higher education for each of their 14 grandchildren. This generous gift is something my wife and I will always be thankful for and we will use it to emphasize the importance of education to our children, and help them remember their Grandpa Bill.”

He supported sports teams wherever he lived, was an avid tennis player, and enjoyed lifelong friendships.

Bill is survived by his wife Mary Kathryn Friend; his sons and their wives and families: Walter and Kimberly Friend and John and Jennifer Friend, as well as Michael and Whitney Mislock, Steven and Kim Mislock, Timothy and Deenie Mislock; and 14 grandchildren and 1 great-grandson.



SHUN CHONG FUNG

1943–2021

Elected in 2007

"For the investigation of factors underlying the deactivation and reactivation of catalysts, and for application of the findings in commercial practice."

BY THOMAS F. DEGNAN JR., TEH C. HO, AND STUART L. SOLED

SHUN CHONG FUNG, a retired research chemical engineer, passed away in Bridgewater, New Jersey, on July 21, 2021. He was 78 years old.

Born January 28, 1943, in Guangdong province, China, Shun was raised in Hong Kong and attended the Chinese University of Hong Kong in 1960, before transferring to the University of California, Berkeley and graduating with his BS in chemical engineering in 1965. He continued his education at the University of Illinois at Urbana-Champaign, where he received his MS (1967) and PhD (1969), both in chemical engineering. He then spent his entire 34-year career working in ExxonMobil's Corporate Research organization. He retired from ExxonMobil Research and Engineering in 2003 as a senior research associate at the company's Clinton, NJ, laboratory.

Shun Fung is best known for his fundamental work in elucidating the mechanistic chemistry involved in the redispersion of noble metal catalysts. He effectively used these insights to develop commercially important methods for regenerating deactivated platinum, palladium, and other supported metal catalysts. His regeneration and metal redispersion techniques have been applied globally to most of the world's catalytic reforming units, which produce high-octane gasoline through dehydrogenation and dehydrocyclization reactions. These reformers are also a critical petrochemical source of aromatics, including benzene, toluene, and mixed xylenes.

Noble metal catalysts are the mainstay of the gasoline reforming process. Unfortunately, these catalysts lose their activity over time because of the accumulation of carbonaceous deposits (i.e., coke) and poisons that are intrinsic to the hydrocarbon sources. Removing the coke and poisons by combustion with air—a process called oxidative regeneration—restores much of the catalyst activity. However, over time, the regeneration step causes the "dispersed" metal particles to agglomerate, permanently damaging the catalyst's activity.

By studying the agglomeration process and the effects of coke combustion, Shun discovered several techniques for "redispersing" the metal on the surface of the inorganic support, thereby restoring the regenerated and redispersed catalyst to its initial (fresh) activity. The discovery proved to be of immense importance to the petroleum refining industry.

In Exxon's Corporate Research Laboratory, Shun worked closely with John Sinfelt (NAE 1975), who led the development of advanced reforming catalysts. The two men were primarily responsible for Exxon's emergence as the global leader in catalytic reforming process technology.

Shun also applied his knowledge and insights in coke combustion to other refining processes, including fluid catalytic cracking. These led to improvements in the catalyst as well as the process. He was a pioneer in researching the deactivation and reactivation chemistry of zeolitic methanol-to-olefin (MTO) catalysts. Exxon began its research into the MTO process in 1990, but the first process was not commercialized until 2010. By building on his earlier work, Shun also discovered how to redisperse platinum in the zeolite L catalyst (commercially known as EXAR), a key enabler for direct hexane aromatization.

Shun was the named inventor or coinventor on 78 US patents. He was also the author of nearly 50 peer-reviewed journal articles.

In recognition of his contributions to refining process innovation, he received the Excellence in Catalysis Award from the Catalysis Society of Metropolitan New York (1999) and the American Chemical Society's Industrial Innovation Award (2002), and he was elected to the National Academy of Engineering in 2007.

Shun enjoyed traveling with his family—they visited more than 30 countries across four continents. Cruises to exotic venues were among his favorite vacations, and he was particularly drawn to countries that had historical and cultural significance. He loved gardening and developed a special interest in trees; around the family home he planted maples, weeping cherry, and weeping apple trees, which dot the central New Jersey community where he raised his family.

As a college student, he worked for a time in Yosemite National Park. He would tell his colleagues that his "Yosemite experience" was the source of his deep appreciation for nature and his love of the outdoors. He frequently reminisced about a 3-week trip with his family to Yellowstone and Grand Teton National Parks in 1994.

Two of his other hobbies were cooking and astronomy. To the delight of his family and guests, he often experimented in the kitchen with great gastronomical success. In particular, he was well known for his Cantonese cuisine and his Asian-inspired barbecue.

With his family in tow, Shun frequented observatories/planetariums and visited both the Kennedy and Johnson Space Centers. He was deeply interested in astrophysics and closely followed the publications and radio and TV broadcasts of Michio Kaku and Neil DeGrasse Tyson. The family television was tuned to the Science Channel whenever there was a telecast concerning astronomy.

Shun is survived by his wife, Juliana Fung, whom he married in 1972; their children Allen Fung (Kaori Ihara) and Carina (Benson) Yang; and two granddaughters.

RICHARD J. GAMBINO

1935–2014

Elected in 2004

"For the discovery of magnetic anisotropy, the enabling technology of magneto-optical recording."

BY SANJAY SAMPATH AND HERBERT HERMAN
SUBMITTED BY THE NAE HOME SECRETARY

RICHARD JOSEPH GAMBINO was born May 17, 1935, and passed away August 3, 2014, at the age of 79. He was a beloved professor and revered advisor of students, a highly respected researcher and scientist, and a warm and devoted family man. His valued presence and contributions to Stony Brook University's Materials Science and Engineering Department, and in particular the Center for Thermal Spray Research, are integral to the university's history and standing. He was also instrumental in establishing the New York State Center for Advanced Technology on Sensors and setting up a comprehensive magnetics measurement facility while at Stony Brook.

Dick received a BA degree in chemistry from the University of Connecticut in 1957 and MS degree in inorganic chemistry from the Polytechnic Institute of New York in 1976. He worked at the US Army Signal Research and Development Laboratory in Fort Monmouth, New Jersey (1956–60) and at Pratt & Whitney Aircraft Division, United Aircraft Corporation, in Middletown, CT (1960–61) before joining the IBM Thomas J. Watson Research Center (Yorktown Heights, NY) in 1961.

Adapted with permission from *IEEE Transactions on Magnetics* 51(2). © 2015 IEEE.

During his 3-decade career at IBM, he rose to become manager of amorphous magnetism. His main research interests while there were in crystal growth, magnetic and superconducting properties of alloys and intermetallic compounds, sputtering, galvanomagnetic and magneto-optic effects, amorphous magnetic films, quasicrystals, and high-temperature oxide superconductors.

In 1993 he made a career shift and accepted a position as research professor of materials science at Stony Brook, supported by the IBM Technical Academic Career Program, which is designed to assist outstanding IBM employees' transition to university teaching and research. At Stony Brook he did research on materials for electronics and for magnetic, temperature, and strain sensors, initiated research programs, established a facility, and developed collaborations. He taught both graduate and undergraduate students, served as major advisor to 16 PhD and 9 MS graduates of the Materials Science and Engineering Department, and was still working with grad students until the time of his death.

In 1996 the Stony Brook Center for Thermal Spray Research was established through the National Science Foundation Materials Research Science and Engineering Center (MRSEC). Dick joined the university's center in 1998 to enable the expansion of thermal spray applications to functional materials (e.g., magnetic materials, sensors) and introduce sensor applications for direct write thermal spray. This effort ballooned to a multimillion-dollar initiative resulting in multiple patents and publications.

In 1999 he became part of the Defense Advanced Research Projects Agency's Mesoscale Integrated Conformal Electronics (MICE) program in the MRSEC. The MICE project introduced thermal spray into the arena of electronic circuits and sensors and led to the formation in 2002 of MesoScribe Technologies, which Dick cofounded (with SS, Robert Greenlaw, and Jon Longtin) and led as president and chief technical officer. Under Dick's scientific leadership, the company enabled commercialization of direct write thermal spray sensors, which continue to impact critical applications such as embedded sensors for harsh environment applications, flexible electronics, and printed antennas on complex geometries. The technology received an R&D 100 Award in 2007.

Dick was awarded 45 patents, authored 160 publications, and, with Takao Suzuki, edited *Magneto-Optical Recording Materials* (IEEE Press, 2000).

His contributions throughout his career were recognized with a number of awards and honors. In 1992 he and IBM colleagues Praveen Chaudhari (NAE 1988, NAS 2003) and Jerome J. Cuomo (NAE 1993) received the IEEE Morris N. Liebmann Memorial Award for their discovery of amorphous magnetic films used in magneto-optic data storage systems. In 1995 they were honored by President Bill Clinton as recipients of the National Medal of Technology and Innovation "For the discovery and development of a new class of materials—the amorphous magnetic materials—that are the basis of erasable, read-write, optical storage technology, now the foundation of the worldwide magnetic-optic disk industry."

In addition, Dick was elected a fellow of the IEEE (1995) and member of the National Academy of Engineering (2004), and in 2007 he was inducted into the Long Island Technology Hall of Fame. He received the State University of New York Medallion of Distinction and, after his official retirement, was awarded an honorary doctorate from Stony Brook in 2013.

To quote Jerry Cuomo, "Dick's work in material science has been so prolific that to view its depth and scope from the perspective of any one person would not do justice to its multifaceted content, which included notable contributions in magnetism, synthesis, processing, and applications, and involved collaborations with many prominent US and international scientists. Although he achieved outstanding recognition for his work in amorphous magnetic materials with uniaxial magnetic anisotropy, the entire compendium of his work was fundamentally and technologically significant."

Beyond his avid technical engagement, Dick had a passion for sailing, painting, reading, history, and, especially, family. He married his high school sweetheart, Patricia Podmore, and they raised four children: Jeffrey, Janice (1958–2011), Pamela, and Donna. Dick and Patricia spent 45 happy years together until her passing in 2004. In 2009 he married Pamela F. Carr and gained "bonus children" (as he called them) Lisanne, Michelle, and Daniel. His daughter Donna said he was "doubly blessed to find true love once again." He is survived by Pamela and their blended family, including eight grandchildren.

Dick was a gifted and natural teacher. Whether it was science, sailing, or painting, he loved to share these gifts with all around him. His kindness, humility, warmth, inspiration, and enthusiasm for life were contagious, and he is greatly missed by all whose lives he touched.

CHARLES M. GESCHKE

1939–2021

Elected in 1995

"For contributions to the development of desk-top publishing."

BY JOHN E. WARNOCK

CHARLES MATTHEW GESCHKE was born in Cleveland, Ohio, on September 11, 1939, to Matthew William and Sophia Krisch Geschke. He attended Saint Ignatius High School and then Xavier University, where he earned an AB in classics (1962) and an MS in mathematics (1963). He married Nancy (Nan) McDonough in 1964.

In his first job, he taught mathematics at John Carroll University (1963–68). In 1972 he completed his PhD studies in computer science at Carnegie Mellon University under William A. Wulf (NAE 1993). He was a coauthor of Wulf's 1975 book *The Design of an Optimizing Compiler* (published by American Elsevier).

Chuck began his career at Xerox's Palo Alto Research Center (PARC) in October 1972. His focus was on programming languages and tools used for the Alto workstations that were designed at PARC and used by all the center's computer researchers.

In 1978 he formed the Imaging Sciences Laboratory, which focused on research in graphics, optics, and image processing. I was hired at PARC that year, and Chuck worked with me and other PARC researchers on Interpress, a printing protocol intended for Xerox laser printers. Unable to convince the company's management to adopt Interpress as the Xerox standard, we became frustrated and left to start Adobe Systems Inc. in December 1982. Adobe went public in 1986.

At Adobe, Chuck and I wanted to build a company with an open environment where all employees would like their jobs. As he said in a 2008 interview, "When we began, John and I wanted to build a company that we would like to work in. Why would you build a business you didn't want to work in?"

Chuck was a great manager and together we hired the smartest people we could find. He served as Adobe's chief operating officer (1986–94), president (1989–2000), and cochair of the board (1997–2017). He retired from the board of directors in 2019.

In 1982–87 Xerographic printers became popular as computer printers, and at Adobe we felt we could succeed with a very different appoach from the Xerox Interpress. We developed PostScript, a protocol (programming language) designed to express the contents of a printed page. PostScript became the industry standard worldwide in the years that followed.

Adobe's success was broadly recognized by the industry and institutions, as were Chuck's contributions. He received numerous awards and honors, among them the Association of Computing Machinery (ACM) Software System Award (1989), American Electronics Association Medal of Honor (2006), Marconi Prize (2010), and William K. Bowes Lifetime Achievement Award from the Commonwealth Club of California (2016). In 2009 Chuck and I received from President Barack Obama the National Medal of Technology and Innovation, "for their pioneering technological contributions that were central to spurring the desktop publishing revolution and for their role in changing the way people create and engage with information and entertainment across multiple mediums including print, video, and the Web."

In addition to his election to the NAE in 1995, Chuck was recognized as an Ernst & Young Entrepreneur of the Year (1991, 2003), ACM fellow (1999), honorary member of the Institute of Electrical and Electronics Engineers (2001), and fellow of the Computer History Museum (2002), American Academy of Arts and Science (2008), and American Philosophical Society (2012).

He received honorary doctorates from Xavier University and John Carroll University, both in 2012.

Chuck recognized that the internet was not an unalloyed good. In 2013 remarks for the Markkula Center for Applied Ethics, he observed—somewhat presciently—that "Today on the internet…anybody can distribute content in a way that appears to be factual and accurate but is not…. [W]e're apt to find ourselves reacting to information that is totally inaccurate and making decisions that could impact both our personal lives, our family's lives, and in fact the life of the country in terms of political campaigning."[1]

Over and above his professional pursuits, Chuck served on the computer science advisory board at Carnegie Mellon University and the board of the San Francisco Symphony, National Leadership Roundtable on Church Management, Commonwealth Club of California, Tableau Software, Egan Foundation, and Nantucket Boys and Girls Club. In service to the National Academies, he was a member of the Government-University-Industry Research Roundtable (1997–2000), National Forum on Science and Technology Goals: Harnessing Technology for America's Economic Future (1997–99), and Computer Science and Telecommunications Board (1993–96).

Chuck had an unusually traumatic experience in 1992. On the morning of May 26, as he was arriving for work, he was kidnapped at gunpoint from the Adobe parking lot by two men. The FBI monitored the kidnappers' phone calls to Chuck's wife, and one of the men was arrested after he picked up the $650,000 ransom that Chuck's daughter left at a drop-off point. The man brought the authorities to a bungalow in Hollister (about 60 miles south of the Adobe office in Mountain View) and Chuck was, fortunately, released unharmed.

Charles Geschke died April 16, 2021, at the age of 81. He is survived by his wife Nan; their children Peter, John, and Kathy; and seven grandchildren.

Chuck is greatly missed.

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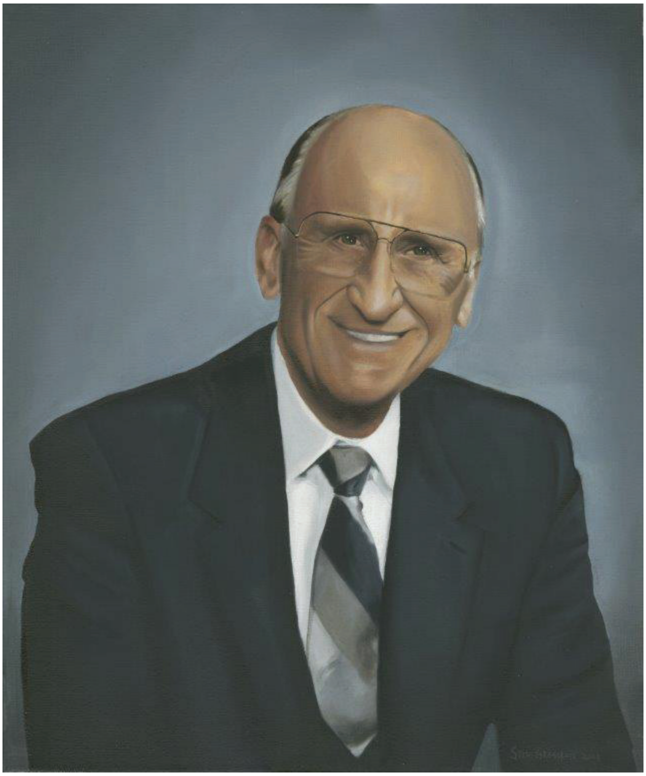
[1] Available at https://www.youtube.com/watch?v=ySZT8gtPXcw&t=2s.



EARNEST F. GLOYNA

1921–2019

Elected in 1970

"Leadership in engineering education, water resources management, and environmental engineering."

BY DESMOND F. LAWLER, DAVIS L. FORD, GARY A. POPE, AND C. MICHAEL WALTON

EARNEST FREDERICK GLOYNA, who served as dean of the College of Engineering (now the Cockrell School of Engineering) at the University of Texas, Austin, from 1970 to 1987, passed away January 9, 2019, at the age of 97.

Dean Gloyna transformed the College of Engineering from a good engineering school to one of national and international prominence for both its education and research. His vision was to build excellent facilities and hire superb faculty, knowing that these two ingredients would attract the necessary third: top-notch students. That vision became reality thanks to his shrewd leadership and excellent management skills.

Earnest was born June 30, 1921, to Herman Ernest and Johanna Bertha (née Riethmayer) Gloyna, in the small town of Vernon, Texas. He grew up on the family farm and enrolled at Texas Tech University, where he earned a BS in civil engineering in 1942, just as the country was entering the Second World War. Having been in the Reserve Officers' Training Corps, he was commissioned as a second lieutenant in the US Army upon graduation. He participated in the D-Day invasion at Omaha Beach, where he helped build airfields for allied troops and,

Adapted with permission from the University of Texas. Readers may also be interested in his biography, *Reflections of a Soldier and Scholar*, by D.L. Ford (University of Texas Press, 2009).

through this and other campaigns in the 820th Engineering Battalion, rose to the rank of major. He remained proud of his military accomplishments, but always wary of the devastating effects of war.

In February 1946 he married Agnes Mary Lehman, whom he had known since childhood. They were married 65 years, until Agnes' death in June 2011, and had two children.

Earnest worked in industry briefly, at the Magnolia Petroleum Company in Dallas, and then, after a summer appointment with the Atomic Energy Commission (in Oak Ridge, Tennessee), enrolled in the master's degree program in civil engineering at the University of Texas at Austin. He completed his degree in 1949 and accepted an appointment to the UT faculty in civil engineering, but took a leave of absence to obtain a doctorate in sanitary engineering (now environmental engineering) and water resources at the Johns Hopkins University (1953). He then returned to UT, as an assistant professor, and spent the rest of his career there until his retirement in 2001, when he was recognized as the Bettie Margaret Smith Chair Emeritus in Environmental Health Engineering.

Focusing on the evaluation and improvement of water quality, his early work was on technology for treating municipal and industrial wastewaters (oxidation ponds). His book *Waste Stabilization Ponds* (World Health Organization, 1971) was translated into many languages and used all over the world for several decades. His 1991 paper "Generalized Kinetic Model for Wet Oxidation of Organic Compounds," coauthored with Lixiong Li and Peishi Chen, was his most highly cited work.[1]

Over the decades he both taught graduate classes on and consulted widely on the treatment of industrial waste, working on international projects with the World Health Organization and the World Bank. As an example, he was one of two foreign consultants invited to provide environmental oversight for China and the World Bank on the Yangtze River Three Gorges Dam project.

[1] Published in *AIChE Journal* 37(11):1687–97.

His external consulting projects supported his academic work with students, as he believed that an engineering professor teaches best when exposed to real-world problems and solutions. His involvement in such projects also effectively represented his interest in engineering to provide accessible approaches to health problems in developing countries and his belief, more broadly, that development should be associated with promoting, not impairing, the health and well-being of people and other living things.

He stepped down as dean at the age of 70 and had a highly productive research career for the next 10 years, primarily investigating the possible use of supercritical water oxidation as a treatment process for highly recalcitrant organic compounds present in industrial wastes.

In addition to his considerable academic and research contributions, he served on the Council of the National Academy of Engineering (1981–86) and the NAE's Academic Advisory Board (1995–98), whose purpose was to "serve the goals of the NAE as they relate to strengthening and maintaining currency in engineering education."

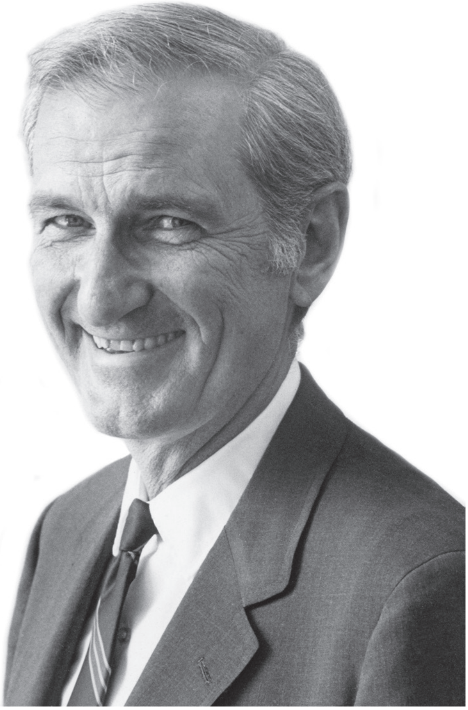
Earnest's professional accomplishments led to awards and achievements too numerous to list. Among the most important were his NAE election (1970), chairmanship of the US Environmental Protection Agency's Science Advisory Board (1981–83), and presidency of the (national) Water Pollution Control Federation (now the Water Environment Federation) (1983–84). He was a founding member of what is now known as the Association of Environmental Engineering and Science Professors, a distinguished member of the American Association of Civil Engineers (ASCE), and a member of the American Academy of Environmental Engineers (president, 1983) and the Academy of Medicine, Engineering and Science of Texas (TAMEST). In 2003 he received ASCE's OPAL Award in Education. Honored by professional organizations throughout the world, in both developed and developing countries, he was particularly pleased to be designated a distinguished alumnus of his three alma maters—Texas Tech (1973), UT Austin (1992), and Johns Hopkins (1993).

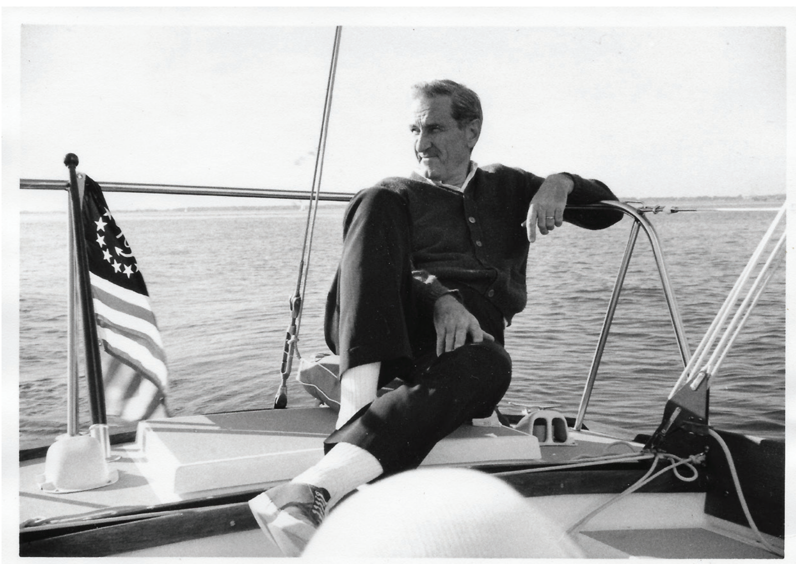
In his later years he enjoyed spending time at the Little G Ranch, near Burnet, Texas, where he and Agnes hosted friends and colleagues.

In all his endeavors, Earnest was a strong leader with exemplary ethics and professionalism. As dean he led initiation of UT's Equal Opportunity in Engineering program, and under his leadership the school saw a significant increase in the number of minorities and women who enrolled in engineering programs.

He demanded a lot from all who worked in the College of Engineering, but no more than he demanded of himself. His relentless pursuit of greatness for professional engineering (he was a registered PE in the state of Texas), the College of Engineering, and the entire University of Texas allowed that vision to be realized during and following his tenure as dean. Few faculty members have impacted UT Austin like Earnest F. Gloyna.

He is survived by son David Gloyna (Sue), daughter Lisa Gloyna, three grandchildren, and three great-grandchildren.





WILLIAM E. GORDON

1918–2010

Elected in 1975

"Pioneering in radar telescope design, and development of tropospheric and ionospheric wave-scattering concepts leading to improved radio communications."

BY MARSHALL H. COHEN AND NEAL F. LANE
SUBMITTED BY THE NAE HOME SECRETARY

WILLIAM EDWIN GORDON was born in Patterson, New Jersey, on January 8, 1918. His father, James William Gordon, was born in England in 1878 and immigrated to the United States around 1905; his mother, Mary Scott Williamson, was born in Patterson in 1883 to parents who had emigrated from Scotland. James Gordon worked as a sales representative for the Waterman pen company, whose office was in New York City, and his territory included areas in nearby New Jersey.

Bill attended public schools in Totowa Borough and then enrolled at Montclair (NJ) State Teachers College, where he obtained a BA in mathematics (1939) and an MS in educational administration (1942), and taught in junior high schools in the northern NJ towns of Mendham and Oradell. At Montclair State, he met Elva Freile, who had grown up in nearby Teaneck. They were sweethearts throughout college and married in June 1941.

Adapted with permission from *Biographical Memoirs of the National Academy of Sciences* (available online at www.nasonline.org/memoirs), where his tribute includes more technical detail. The authors thank Kenneth Bowles, Dale Corson (NAS/NAE), Donald Farley, Nancy Ward, Paul Cloutier, and the Woodson Research Center of the Fondren Library at Rice.

Bill enlisted in the Army Air Corps in 1942 and was assigned to study meteorology at New York University, from which he earned a second MS in 1946. He ended his service as a captain in the Air Corps in Austin, Texas, where he and his family stayed so he could continue to work on radio wave propagation. In 1948 they moved to Ithaca, NY, as Bill pursued studies in electrical engineering (EE) at Cornell University. The Gordon family grew to include two children, Larry and Nancy.

After studying with Edwin Hamlin and Henry Booker (NAS), Bill received his PhD degree in 1953 and became an associate professor in Cornell's School of Electrical Engineering. In 1959 he was appointed professor, and in 1965 he was named the Walter R. Read Professor of Engineering.

In his early years Bill was de facto the leader of the tropospheric research program, and part of a lively group of EE students and professors who met in a weekly seminar on radio wave propagation. In a seminar in April 1958 he presented his ideas for what became the Arecibo radar—the first public presentation of the concept of a large ionospheric scatter radar.

That summer Bill assembled a group to study the radar, and in December they published a report with design parameters and a brief discussion of experiments and observations that the 1000-ft radar could support.[1] The report also discussed sinkholes in karst regions that might serve as a natural bowl to support a large reflector.

Gordon led the design team in 1958, and also promoted the dish in Washington. The Advanced Research Projects Agency (ARPA) had just been formed, and its mission included support of studies of the ionosphere. In late 1959 ARPA provided funds for an engineering study of the radar and, in June 1960, funds for construction. Excavation at the site in Puerto Rico, 12 miles south of Arecibo, started in September.

Bill moved with his family to Arecibo to manage the construction. A few other families joined the Gordons, and the

[1] Gordon WE, Booker HG, Nichols B. 1958. Engineering report of the School of Electrical Engineering, 3, Cornell University.

group became and remained very close. The development effort at the site was intense, but balanced by swimming and shell collecting at nearby undeveloped beaches, along with trips around Puerto Rico and to other Caribbean islands.

The radar was dedicated in November 1963 as the Arecibo Ionospheric Observatory, and Bill became its first director and leader of the ionospheric research group. Within five years he had invented, promoted, and overseen the design and construction of the world's largest scientific radar and radio astronomy system. He later said these were the best five years of his life.

The Arecibo Observatory has always been regarded as an engineering marvel. In 2003 it was designated both a Milestone in Electrical Engineering and Computing by the IEEE and a Historic Mechanical Engineering Landmark by ASME. In 2008 it was listed on the National Register of Historic Places by the National Park Service.

In 1965, having exceeded Cornell's extended leave for faculty, he reluctantly moved back to Ithaca. Just one year later he was recruited by Rice University president Kenneth Pitzer to serve as dean of science and engineering and professor of space science. Pitzer had a vision for Rice that included its development as a major research university of international stature, with strength in the arts and humanities as well as science and engineering, and with excellent graduate as well as undergraduate programs. Bill was intrigued by the chance to be part of Rice's transformation, and the move eliminated the strains of dealing with Arecibo management issues at Cornell.

He had no way of knowing how challenging his new task would turn out to be, and how quickly he would be tested in his new job. The ambitious research vision for Rice was not shared by all of the university's board of trustees, many of whom were concerned that Rice would lose its focus on quality undergraduate education by diverting resources to graduate study and research. When Pitzer left to accept the presidency of Stanford University, the board appointed an executive committee to run the university while a search was conducted to find the new president. Bill was named chair of that committee and essentially functioned as interim president. A faculty committee was formed to consider candidates and make recommendations to the board. Unfortunately, the board chose and named a new president without consulting the faculty committee, resulting in a major faculty protest. Bill, having been at Rice only a short while, found himself in a very difficult position but never wavered in his judgment that the board had indeed acted improperly. In March 1969 the board dissolved the executive committee and appointed an acting president. Bill was appointed vice president (one of four) and remained dean of engineering and science. In the view of Rice faculty who were there at the time, Bill's determination to follow through on Pitzer's vision was a turning point for the university. After a second presidential search, this time with faculty involvement, the board announced that chemist Norman Hackerman (NAS) would be Rice's fourth president.

Bill continued as dean of science and engineering, and then dean of natural sciences (now the Wiess School of Natural Sciences) after engineering was split off as its own school. In 1980 President Hackerman named Bill as provost and vice president, a position he held until his retirement in 1986.

During his two decades of service in the administration, Bill was a major force in Rice's rise to a leading national research university. As dean and provost he used his legendary powers of gentle persuasion, and financial incentives where appropriate, to increase the faculty ranks of women and members of other underrepresented groups, especially in science and engineering. He enhanced interdisciplinary research, insisted on fair and balanced evaluation of faculty for promotion and tenure, ensured that faculty in non–science and engineering fields were appropriately recognized for their scholarship and other creative endeavors, strengthened the undergraduate curriculum and teaching (he felt communication skills should receive greater emphasis across the curriculum), and eased Rice through the transition from expensive mainframe computers to personal computers.

He also stressed the importance of science and engineering majors studying the arts, humanities, and social sciences to better understand the proper role of technology in society. And in an effort to encourage dialogue across the intellectual boundaries of the campus and foster a true community of scholars, he created the Provost's Lecture Series and encouraged faculty to discuss their research and scholarly activity with those in other fields as well as the broader Rice community. To this end, he established the Rice faculty organization Scientia, brainchild of mathematics professor Salomon Bochner (NAS), to broaden the conversation across traditional intellectual cultures. Now called the Scientia Institute, it remains a vital organization.

Besides his very effective administrative skills, Bill's productive scientific and technical career spanned different fields over the decades, starting with his focus on radio wave propagation (1942–57). At the University of Texas in Austin, he investigated anomalous radio propagation due to vertical stratification, or ducting, and tropospheric radio wave propagation. He developed the idea that atmospheric "blobs," or turbulence, with corresponding fluctuations in the refractive index of air were responsible for some of the peculiar radar echoes that he saw. He remained interested in turbulence and its effect on radio wave propagation throughout his career.

Bill's PhD thesis was on atmospheric turbulence and the resulting scatter propagation of radio waves.[2] This work was restricted to the troposphere, the part of the atmosphere below about 10 km, where water vapor is important and the maximum range for scatter communications is about 700 km. Longer-range propagation was due to scattering in the stratosphere, the dry region above about 10 km, but few direct measurements of the dielectric constant in the stratosphere existed. Theoretical reasoning was used to estimate the fluctuations and the scattered power, and successfully explained scatter propagation from the troposphere, to distances of about 1000 km at frequencies from 100 to a few thousand MHz.

[2] Gordon WE. 1955. Radio scattering in the troposphere. *Proceedings of the IRE* 43:23–28.

Scatter propagation via the ionosphere was also of interest. Scattering on field-aligned irregularities in electron density was important for a number of phenomena, including echoes from the aurora, and for radio wave propagation to 2000 km. The ionospheric region responsible for these effects was from about 70 to 300 km above the Earth. Gordon considered the possibility of getting sufficient scatter from higher levels, but concluded that the signals would be too weak to allow long-range communication. At that point apparently he had the idea to stop thinking in terms of eddies or irregularities established by turbulence, and to think instead of scattering from the individual electrons acting incoherently. He calculated the strength of the forward-scattered signal to be expected with this mechanism, and found that the signal would be much too weak for communications. But then he took the crucial step of estimating the signal to be expected if the antenna were directed vertically, rather than horizontally, as in applications to over-the-horizon communications. The signal was still weak but strong enough to detect with sufficient averaging, and this could give the electron density in the scattering region.

This was the birth of incoherent scatter radar, an area in which Bill was particularly active in 1958–65. His first estimate of the signal to be expected from the incoherent scattering of radio waves on electrons in the ionosphere was made early in 1958. He worked out the required properties of a radar that could measure the density and temperature of the electrons in the ionosphere to a height of 1000 km. Using readily available components at a frequency of a few hundred MHz, the antenna would need a diameter of about 1000 ft (305 m). The main assumption was that the electrons scattered the incoming radiation according to the Thomson formula, and the elementary scattered waves added independently to form the total echo. The density was obtained from the strength of the echo and the temperature from the width of the spectrum of the echo, as each elementary echo contained a frequency (Doppler) shift according to the vertical component of the electron's velocity.

Bill published an article in late 1958[3] that described the radar and its capabilities. His ideas were largely confirmed by Kenneth L. Bowles, who showed that Gordon's calculation gave roughly the correct back-scattered power—but that the width of the spectrum was narrower than expected, allowing for a much greater range of experimentation.

The radar of the Arecibo Ionospheric Observatory was designed to measure density and temperature up to 1000 km, and for three decades (1966–97) Bill and his students exploited the system in ionosphere experiments. They verified the theoretical calculations showing that for a certain range of the ratio of the radio frequency wavelength to the Debye length (the "screening distance" around a charged particle), the echo was concentrated in a narrow "ion line" controlled by the ion mass and not the electron mass. This meant that in this range the system was two orders of magnitude more sensitive than had originally been thought, and this opened up many avenues of research into the ionospheric plasma.

An upward radio wave in the ionosphere, at a frequency below the critical (penetration) frequency, will be partially absorbed near the level where the wave frequency equals the local plasma frequency. If the wave is strong enough, substantial heating can occur, and parametric instabilities will induce large fluctuations in the densities of both ions and electrons. To study these effects a 100 kW transmitter at 5.6 MHz was added to the Arecibo system in 1967. Larger and more versatile transmitters were later added, and in 1980 a new heating facility consisting of a powerful transmitter and an array of log-periodic antennas was built at Islote, Puerto Rico, 4 miles northeast of the observatory. The high-frequency wave (3–30 MHz) heats the plasma, while the 430 MHz radar is used as a probe to study the heated region. With students and collaborators, Gordon conducted heating experiments using this equipment and published papers spanning the years 1971 to 1991.

[3] Gordon WE. 1958. Incoherent scattering of radio waves by free electrons with applications to space exploration by radar. *Proceedings of the IRE* 46:1824–29.

In addition to his research, teaching, publishing, and administrative leadership, throughout his career Bill consulted with industry, served as an advisor to federal agencies and national and international scientific organizations, and in other ways served the professional community and public. His many professional service activities included work with the International Union of Radio Science (URSI; international vice president, honorary president), Institute of Radio Engineers (chair, Professional Group on Antennas and Propagation), Upper Atmosphere Research Corporation (chair, 1971–72, 1973–78), University Corporation for Atmospheric Research (chair, board of trustees, 1979–81), Cornell University Board of Trustees, and more than 60 advisory and review committees for the National Science Foundation (NSF), Stanford Research Institute, US Information Agency, National Academy of Sciences (NAS), National Academy of Engineering (NAE), and National Research Council (NRC).

His NRC service included the Committee on the Modernization of the National Weather Service (1994–97; vice chair, 1997–99), Panel for a Joint NAS-Bulgarian workshop on Introducing Research Results into Practice: The Educational Dimension (chair, 1988–89), Office of International Affairs (chair, 1986–90), International Space Year Planning Committee (chair, 1986–89), Panel for the US-India Science and Technology Initiative (chair, 1984–87), and Advisory Committee for the International Council of Scientific Unions (1981–86), among many others.

In recognition of his engineering and scientific accomplishments, and for his numerous public services, Bill was elected to and received awards from many organizations. He was elected to the NAS in 1968 and served as foreign secretary (1986–90), and elected to the NAE in 1975. He was a foreign associate of the Engineering Academy of Japan and a fellow of the American Academy of Arts and Sciences, American Association for the Advancement of Science, American Geophysical Union, and Institute of Electrical and Electronics Engineers.

He received URSI's Balthazar van der Pol Gold Medal (1966) for "Development of the incoherent scatter technique for ionospheric studies," the American Meteorological Society Medal (1969), the NAS Arctowski Medal (1984) "For his pioneering development of theory and instrumentation for radar backscatter studies, which opened a broad field of research in the high altitude ionosphere," a Medal Commemorating 100 Years of International Geophysics from the USSR Academy of Sciences (1985) for distinguished contributions in international geophysical programs, and the Centennial Medal of the University of Sofia (1988).

Bill thought about science beyond the boundaries of his own work. In a lecture to Rice alumni in 1977 he discussed scientific creativity. Creativity, he said, usually results from a confluence of factors:

- the problem is available and the time is right;
- youthful spirit, a mix of logic and emotion;
- preparation, hard work, insight, intuition;
- combination of approaches;
- realization that thinking is a lonely, individual process, but colleagues are essential;
- joy of discovery; and
- beauty of the product.

He explained the role of technology to the Society of Rice University Women in 1984:

> Technology is an art, an art of converting in a systematic way the work of scientists and engineers into products and processes that materially enrich civilization. The scientist's goal is knowledge, the engineer's goal is design, i.e., applying knowledge in a useful practical way, the technologists are the artists who efficiently and economically produce, in the needed quantities, the products or processes.

Bill was one of the most highly principled people any of us are ever likely to meet. His honesty and integrity were legendary on matters large and small. And he was in all things a gentleman. After a trip with a group of Rice alums to observe and talk about Halley's Comet, he received a letter penned by a member of the group with the heading "Tribute to Professor William Gordon from the Travel Group." The letter said it all:

> We could scarcely ask for a better companion, or a more qualified teacher. From my short experience here I am confident Bill is the kind of teacher Shakespeare had in mind when he wrote in *Henry VIII*: 'He was a scholar and a good one; exceeding wise, fair-spoken, and persuading…(and) to those that sought him, sweet as summer.

Bill was also well known and highly respected in federal policy circles, largely through his service on many advisory committees and as NAS foreign secretary. He had opportunities to hold high-level positions with the federal government but his heart was in academia. In a 1993 letter to NSF director Ed Knapp, who had expressed interest in recruiting Bill to an important position at the foundation, Bill wrote:

> Were you to offer and I to accept a position…for a few years, I would find myself then ready to retire from academic life but having lost my already tenuous grip on an active career as a scientist.… In contrast if I continue as professor and administrator, I don't lose my grip on a continuing career as an experimentalist and I find myself with something to retire to, not something to retire from.

Bill was a model civic scientist, not only because of his many services to the science and engineering community and federal agencies but also by virtue of his public outreach and speaking to community organizations, churches, and schools. In addition to talking about his passion—space and atmospheric physics, and Arecibo in particular—he addressed pressing national concerns such as energy and climate change.

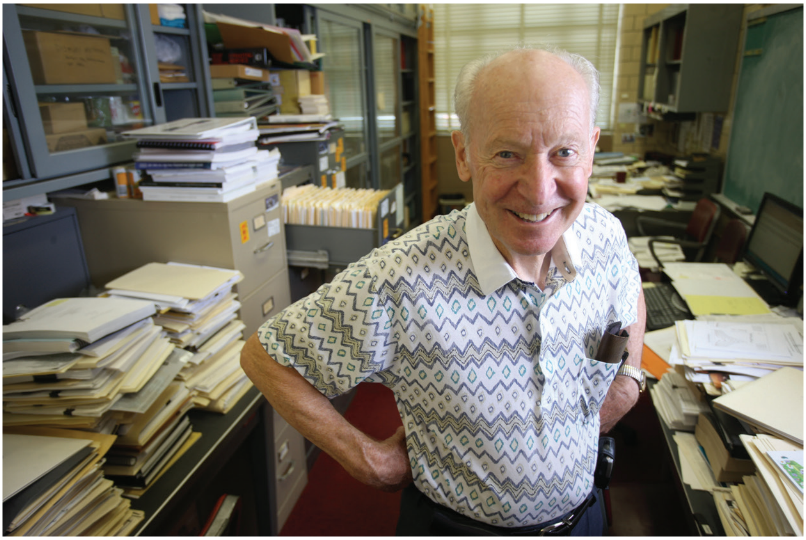
In the 1970s he began to alert fellow scholars and especially business and community leaders to the potential impacts of climate change, warning that while the threat was long term, it was time to start paying attention. As the years passed with little policy progress Bill became convinced that the problem of global warming and climate change was becoming urgent. In a lecture to the Rice faculty in November 1986, he asked,

> The world we live in, will it survive? Are we abusing it in ways that may not be reversible?… Man's economic and technical activity, even providing his food, fuel, and housing, contributes to significant global changes. The enemy is us.

Bill liked to raise tropical plants he discovered in Puerto Rico and sail his boat *Dulcinea* on Galveston Bay. The family spent many summers at their lakeside cottage on Cape Cod, where they enjoyed sailing and the visits of friends and relatives.

Elva died in February 2002. In 2003 Bill married Mary Elizabeth (Liz) Bolgiano and moved to Ithaca, where she had lived for over 50 years. Bill and Elva had been friends with Liz and her husband, Ralph, who had been on the engineering faculty at Cornell and was now also deceased. Liz was a wonderful partner for Bill in their adventures and travels, until his passing February 16, 2010, at age 92.

Liz died in 2015. Bill is survived by his son Larry (Christine) and daughter Nancy Ward (George), four grandchildren (two of whom attended Rice: Amanda Gordon graduated in 1998 and George Ward in 2001), and three great-grandsons.



KARL A. GSCHNEIDNER JR.

1930–2016

Elected in 2007

"For contributions to the science and technology of rare-earth materials."

BY VITALIJ K. PECHARSKY
SUBMITTED BY THE NAE HOME SECRETARY

KARL ALBERT GSCHNEIDNER JR., an international authority in rare earths and former Anson Marston Distinguished Professor of Engineering at Iowa State University of Science and Technology (ISU), died April 27, 2016, at the age of 85.

He was formerly senior scientist and group leader at the US Department of Energy (DOE) Ames Laboratory, chief scientist at the Critical Materials Institute (a US DOE Energy Innovation Hub), founder and former director of the Rare Earth Information Center at Ames Laboratory, and founder and former senior editor of the *Handbook on the Physics and Chemistry of Rare Earths*.

Karl was born in Detroit on November 16, 1930, into a family of German immigrants who had come to the United States shortly after World War I and settled in Michigan. In 1952 he received his bachelor of science degree in chemistry, with minors in physics and mathematics, from the University of Detroit (now University of Detroit Mercy). He then moved west to continue his education at Iowa State College (now ISU) in Ames, under the supervision of Frank H. Spedding (NAS 1952) and Adrian H. Daane. He completed his thesis, entitled "The Rare Earth–Carbon Systems," and received his PhD degree in physical chemistry, with minors in physics and metallurgy, in 1957.

While at Iowa State, Karl met Melba Pickenpaugh. They married just before his graduation and spent their honeymoon in Texas (Big Bend) and then went west to move to the Los Alamos Scientific Laboratory (now Los Alamos National Laboratory) for Karl's first full-time job.

After working at Los Alamos as a staff member (1957–61) and section leader (1961–63), Karl returned to Ames to become an associate professor of metallurgy at ISU and a group leader at the US Atomic Energy Commission (now US DOE) Ames Laboratory. He and Melba called Ames home for the rest of Karl's life.

In 1967 Karl was promoted to full professor at ISU. He became a Distinguished Professor in Sciences and Humanities in 1979 and in 1986 was named Anson Marston Distinguished Professor of Engineering, ISU's highest faculty honor, in recognition of his exemplary performance in research and his national and international reputation in materials science of rare-earth elements and alloys.

He served concurrently as a program director for metallurgy and ceramics at the US DOE Ames Laboratory (1974–79) and directed the Rare Earth Information Center (1966–96). In 2013 he became the chief scientist at the Critical Materials Institute. He also remained a group leader at the Ames Laboratory, retiring from the lab and ISU in January 2016, just a few months before his death.

Rare-earth elements and, especially, lanthanides (counting only those that may or do have 4*f* electrons)—the fraternal 15, so named by Karl—were his lasting passion. Realizing their importance to basic science and their potential to revolutionize technology—long before rare earths became essential components of the strongest permanent magnets, brightest luminescent compounds, most versatile catalysts, and many other materials regarded today as critical to the nation—Karl shared his enthusiasm about the lanthanides with everyone who asked.

He used an imaginary Rare Earth Drive, a neighborhood with 15 nearly indistinguishable houses, to describe the nature of the elements from lanthanum to lutetium in simple terms. He likened every house and the family that lived there to a specific lanthanide. The first house was occupied by the Lanham family with no children, for lanthanum has no 4*f* electrons. Next was the Cerro family, who had one boy, representing cerium, which has one 4*f* electron with spin +½, then the Prases with two boys (for praseodymium), and so on. After the Gads with seven boys—because gadolinium has seven 4*f* electrons with identical spins +½—each of the next families added a girl, representing a 4*f* electron with spin −½, until the last house, of the Lus, where there were seven boys and seven girls for lutetium.

Using a simple fact of life, where little kids make no family decisions but influence and often manipulate family lives both in- and outside the house, Karl explained that 4*f* electrons are like the kids on Rare Earth Drive. The witty allegory was that even though 4*f* electrons are located deep in the electronic core and are not directly responsible for chemical bonding, they interact with their parents, siblings, and neighborhood kids (for hybridization of 4*f* electrons with their own 5*d* and 6*s*) as well as with valence and conduction electrons of neighboring atoms. They thus strongly influence both the structure and properties of lanthanides and their alloys and compounds.

In 1966 Karl founded the Rare Earth Information Center (RIC) and directed it for the next 30 years. Supported jointly by ISU and Ames Laboratory and by contributions from hundreds of corporate and individual members, RIC quickly grew to become a unique and important resource of information about rare earths at the time, when now-common online tools were nonexistent. RIC responded to tens of thousands of requests for scientific information related to rare earths, and published and distributed quarterly and monthly newsletters, *RIC News* and *RIC Insight*, written personally by Karl. When the center closed in 2002, its one-of-a-kind database had over 100,000 records—practically every published piece related to rare-earth science and technology was easily accessible to those interested.

Karl's contributions to the science of rare earths and his leadership in gathering, systematizing, and disseminating information through RIC laid the groundwork for the *Handbook on the Physics and Chemistry of Rare Earths*. With his friend LeRoy Eyring, he edited the first volume, published in 1978. The original four-volume monograph was so successful that Karl knew it had to continue. The *Handbook* quickly became an authoritative series, publishing reviews on all aspects of the science and technology of rare earths, with one or two new volumes printed every year. Karl retired from the *Handbook* editorship in 2011 after editing 41 volumes, with a total of 251 chapters and over 20,000 printed pages.

Karl made numerous other innovative contributions to materials science and engineering. Using his expertise in the rare-earth family of the elements, he added much-needed predictive power to the alloy theory. In a seminal paper published in 1985, he carefully analyzed the experimentally known phase diagrams of 21 intralanthanide binary systems.[1] By grouping them into 13 distinct types, he derived a generalized phase diagram for easy predictions of phase relationships in any of the 91 possible binary intra-rare-earth alloy systems of trivalent lanthanides and yttrium. A number of subsequent experimental studies have confirmed Karl's predictions. He also discovered a family of fully stoichiometric intermetallic compounds of rare earths that are extraordinarily ductile, opening up a new area of research on the mechanical behaviors of solids.[2]

In the early 1990s Karl started research related to magnetocaloric effect, which is detected as reversible temperature changes that occur in magnetic materials when they are exposed to varying magnetic fields. He knew that the magnetic moments of rare earths, which are the largest known in nature, hold promise to support very large entropy changes—the key reason for the emergence of strong thermal effects.

His leadership and efforts led to important breakthroughs: the discovery of the giant magnetocaloric effect in a rare-earth

[1] Gschneidner KA Jr. 1985. Systematics of the intra-rare-earth binary alloy systems. *Journal of the Less-Common Metals* 114(1):29–42.

[2] Gschneidner KA Jr, Russell A, Pecharsky A, Morris J, Zhang Z, Lograsso T, Hsu D, Lo CHC, Ye Y, Slager A, Kesse D. 2003. A family of ductile intermetallic compounds. *Nature Materials* 2:587–91.

compound[3] and the first successful demonstration of a near-room-temperature magnetocaloric refrigerator device.[4] These publications showed that magnetocaloric solid-state cooling may in time become a viable alternative to the ubiquitous vapor-compression systems. Further, they triggered worldwide interest, with numerous groups investigating the phenomenon, discovering a number of new materials exhibiting giant magnetocaloric effects, and designing systems making use of large and reversible temperature changes in efficient, environmentally friendly solid-state caloric cooling devices. The magnetocaloric effect remained the top priority for Karl—the field of science and engineering in which he published more than a hundred original research articles and reviews.

Karl was well recognized for his scientific contributions. In addition to his NAE membership (2007), he was elected a fellow of the Minerals, Metals and Materials Society (TMS; 1990), American Society for Materials (1990), American Physical Society (2002), Materials Research Society (2011), and American Association for the Advancement of Science (2011). Among other honors, he won the TMS William Hume-Rothery Award (1978), the Frank H. Spedding Award (1991) for distinguished contributions in the field of rare-earth science from Rare Earth Research Conferences Inc., the Russell B. Scott Award (1993) for the Best Research Paper of the Cryogenic Engineering Conference, the David R. Boylan Eminent Faculty Award in Research (1997) from ISU College of Engineering, Science Alumnus of the Year (2000) from University of Detroit Mercy, and the Acta Materialia Gold Medal (2008) for demonstrated ability and leadership in materials research.

Karl's legacy is alive in many ways. The *Handbook on the Physics and Chemistry of Rare Earths* remains an important resource of information about rare earths, with two of his

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[3] Pecharsky VK, Gschneidner KA Jr. 1997. Giant magnetocaloric effect in $Gd_5(Si_2Ge_2)$. *Physical Review Letters* 78:4494–97.

[4] Zimm C, Jastrab A, Sternberg A, Pecharsky V, Gschneidner K Jr, Osborne M, Anderson I. 1998. Description and performance of a near-room temperature magnetic refrigerator. *Advances of Cryogenic Engineering* 43:1759–66.

colleagues serving as editors and 60 volumes published to date. His contributions to the alloy theory have led to broad acceptance that the theoretically predicted binary phase diagrams of rare-earth metals are correct, with the corresponding databases listing them as "experimental" without actual experimental verification. The field of magnetocaloric materials and caloric cooling research that Karl helped to usher into the mainstream is blossoming with promising materials and devices that will bear fruit in the foreseeable future. And the Critical Materials Institute[5] that Karl helped to establish and build from the ground up as its chief scientist—following the testimony he gave in March 2010 before the Space, Science and Technology Committee of the US House of Representatives—is still going strong.

Known to his friends and colleagues as Mr. Rare Earth, Karl was characteristically humble. He rode his bike to work every day, rain or shine, adding up to roughly 100 miles every week. An avid gardener, he planted seeds of everything that could grow in Iowa, and shared the fruits of his labor when he had extra. He protected his plants from rabbits and raccoons using live traps, releasing the animals into the wild miles away from his and others' gardens.

At work, he was the main cheerleader and a perfect coach, sharing his massive knowledge and experiences. A natural leader, he led by example and always let others show the way when he thought they were ready. He stayed focused yet he was consistent in looking for new opportunities. When anyone needed help or advice, his office and his home were always open. Karl's voice, his jokes, and his contagious chuckle are irreplaceable. He is greatly missed by all privileged to have known him.

Karl is survived by Melba, his wife of 58 years; their children Tom (Nina), Dave (Helen), Ed (Martha), and Kathy; four grandchildren; and two great-grandchildren.

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[5] https://www.energy.gov/articles/ames-laboratory-lead-new-research-effort-address-shortages-rare-earth-and-other-critical

WILLIAM J. HALL

1926–2020

Elected in 1968

"Contributions to structural engineering, structural mechanics, and soil dynamics."

BY DAVID E. DANIEL AND ROBERT H. DODDS JR.

WILLIAM JOEL HALL, an eminent structural engineer, university teacher, and scholar, died June 9, 2020, at the age of 94 in Urbana, Illinois.

He was born in Berkeley, California, on April 13, 1926, the eldest son of Eugene Raymond and Mary F. (Harkey) Hall, who both hailed from Kansas, where they had met at the University of Kansas (KU). Bill's father earned a PhD in zoology from the University of California, Berkeley, and went on to become curator at the university's Museum of Vertebrate Zoology. Bill's mother held a master's degree in botany from KU and was active in the Girl Scouts.

In Bill's early childhood, the family moved to a 12-acre ranch in Lafayette, just east of Berkeley. The ranch had a water well, chickens, cows, and numerous fruit trees. Bill learned everything needed to maintain the ranch and developed a strong work ethic. As a teenager, he worked occasionally as a cowboy on other ranches in the area.

He attended UC Berkeley for a year, planning to study mechanical engineering, but left to join the Merchant Marines when World War II began. He served on a Victory-class cargo ship in the Pacific and survived attacks by Japanese bombers.

The authors appreciate input from Doug Nyman and Bill's son Jim Hall.

After the war he joined his family who had returned to Lawrence, Kansas; he enrolled at KU and graduated with his BS in civil engineering in 1948. While there, he met Elaine Frances Thalman, who earned a degree in music; they married in 1948.

After graduation, Bill joined the SOHIO Pipeline Company, part of Standard Oil of Ohio. He soon had his first experience with problems of applied dynamics—a pump station vibrating so strongly it caused unacceptable vibrations at a home 4 miles away. He traced the problem to an issue involving geology (the house was built on the same strata of rock as the station) and the synchronous operation of multiple pumps, and solved it by changing the pump operation to avoid their synchronous vibrations.

A year later, Bill entered graduate school at the University of Illinois at Urbana-Champaign (UIUC) and was assigned to be a research assistant for Nathan M. Newmark (one of the 25 founding members of the National Academy of Engineering), an assignment he described as "one of the luckiest things that ever happened to me in my whole life."[1] Their research, funded by the military, concerned problems of structures and dynamics with a focus on blast effects. Bill earned his master's degree in 1951 and, when he got his PhD in 1954, Newmark convinced him to join the UIUC faculty.

Professor Hall rose rapidly through the faculty ranks and taught a variety of structural engineering courses. He was the principal investigator on a number of earthquake engineering projects sponsored by the National Science Foundation. His research spanned a range of topics in structural engineering, from evaluation of design and performance issues of steel structures to shock and blast effects on structures and military equipment, and earthquake engineering studies of structures and equipment.

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[1] Quoted in *Connections, The EERI Oral History Series: William J. Hall* (2015) – interview by Robert D. Hanson and Robert Reitherman, with an appendix on Nathan M. Newmark (https://www.eeri.org/images/oralhistory/hall.pdf). This detailed personal account is a trove of information about Hall's life and includes a number of photographs.

He served as department head from 1984 through 1991; in 1990 the department was ranked first nationally by *US News and World Report*. He led a very successful, major transformation of the faculty during his tenure as head and, with his many decades on the faculty, was an invaluable resource to foster connections across multiple generations of faculty and alumni, especially as the transition from the postwar faculty accelerated in the 1980s.

After his formal retirement in 1993 he remained very active as a consultant, in professional activities, and in the daily life of the UIUC Civil Engineering Department. As new department heads came on board, Bill booked regular meetings with them to offer support and advice when called upon.

In the mid-1970s Bill served as a consulting specialist and technical advisor for the design and construction of the Trans-Alaska Pipeline System (TAPS). His contributions included the development of earthquake hazard mitigation concepts for the aboveground pipeline and pump station and marine terminal facilities.

He also led a unique experimental research program in the UIUC Structural Engineering Laboratory to understand the behavior of aboveground support piles for TAPS. Large refrigerated structures, several stories tall, were fabricated in the lab to load-test the piles embedded in frozen soil. The implementation of these design elements was tested during the magnitude 7.9 Denali fault earthquake of 2002, which caused no damage to the pipeline.

Concurrent with his academic career, Bill engaged in major consulting engineering projects, individually and as a collaborator with Newmark (until his death in 1981), in the areas of new design criteria for hardened protective structures. These jobs spanned missile facilities, military physical vulnerability studies, vibration studies of NASA missile test stands, reactor containment analysis and design studies (including seismic considerations), field test studies on nuclear blast effects, development and review of seismic design criteria for structure and equipment, and review of seismic designs of some 70 nuclear power plants for the US Atomic Energy

Commission and US Nuclear Regulatory Commission (US NRC).

In 1990–92 he aided SAIC in an investigation into the design of hardened facilities using advanced high-strength cementitious materials. Other notable consulting projects included the Foothills Alaska-Canada gas line and Western LNG Terminal at Point Conception, CA (1980–83), the Yukon Pacific Corporation (CSX) for a proposed trans-Alaska gas pipeline and LNG facility (1989–92), and the Defense Nuclear Facilities Safety Board on engineering matters for DOE facilities (1989–2000).

His expertise also put him in high demand to serve on study and advisory committees for many organizations, including NSF, the Department of Defense, and Department of Commerce, among others. A particularly noteworthy assignment was in 1982 when Bill served on the Defense Science Board Task Force on Closely Spaced Basing for the MX missile system, the so-called Townes Committee, reporting to the Secretary of Defense. Bill was especially proud to serve his country on these high-visibility and critical military challenges at the height of the Cold War.

Bill was an active member of professional organizations and societies. For the National Academies, he was appointed to the Committee on Earthquake Engineering (1983–86), Advisory Committee for the International Decade of Hazard Reduction (1987–88), and Committee on Feasibiltiy of Applying Blast-Mitigating Technologies and Design Methodologies from Military Facilities to Civilian Buildings (1994–95). For ASCE he served on the Structural Division's executive committee (1971–75; chair, 1973–74) and research committee (1960–64), executive committee of the Technical Council on Lifeline Earthquake Engineering (1980–84; chair, 1982–83), and Central Illinois Section (secretary-treasurer, vice president, president, and director, 1956–68).

He was the author or coauthor of more than 220 articles, books, and book chapters, covering topics in the fields of structural engineering, structural mechanics and dynamics, soil dynamics, earthquake engineering, plasticity, fatigue, brittle fracture mechanics, civil defense, and education.

His research earned him numerous honors: UIUC's A. Epstein Memorial Award (1958), ASCE's Walter L. Huber Civil Engineering Research Award (1963), the Adams Memorial Membership Award of the American Welding Society (1967), election to the NAE[2] (1968, at the age of 42), ASCE's Newmark Medal and E.E. Howard Award (both in 1984), the KU College of Engineering Distinguished Engineering Service Award (1985), the first C. Martin Duke Award (1991, given by the ASCE Technical Council on Lifeline Earthquake Engineering), ASCE's Norman Medal (1992), and the Housner Award from the Earthquake Engineering Research Institute (1998). He was also a member of the honor societies Tau Beta Pi, Sigma Tau, Phi Kappa Phi, Sigma Xi, and Chi Epsilon.

Always deeply immersed in his work, Bill was similarly involved in the lives and welfare of his students and faculty colleagues as well as staff and professional colleagues worldwide. He was dedicated to helping others whenever possible. As a testament to his commitment to teaching, he and his wife created the William J. and Elaine F. Hall Endowed Professorship in Civil and Environmental Engineering.

One of Bill's and Professor Newmark's best lessons—taught by example—for all their students was the understanding that, whatever their career choice (and many became professors, department heads, and deans), they were engineers first and were trained to solve engineering problems. Because of their leadership and inspiration, their students carried on in this tradition and the engineering world has clearly benefited from their example.

For many who came to know Bill Hall, the most treasured memory is that of one-on-one engagement with him and the support and encouragement that he selflessly offered. Bill was simultaneously a serious man with almost encyclopedic recall of people and details and, at the same time, a warm, caring person who was interested in others and could smile and laugh with ease. The combination of his wealth of knowledge,

[2] His brother Benjamin D. Hall (1932–2019) was elected to the National Academy of Sciences in 2014.

tremendous story-telling ability, caring heart, and sense of humor made him not only a giant in civil engineering but a giant as a human being as well.

Bill's wife of 71 years, Elaine, died November 23, 2020. They are survived by their three children: Martha (Matt) Sigler of Dublin, Ohio; James (Melody) Hall of Thompson's Station, Tennessee; and Carolyn (Larry) Vandendriessche of Bentleyville, Ohio; four grandchildren; and four great-granddaughters.

DELON HAMPTON

1933–2021

Elected in 1992

"For outstanding contributions to education and practice in geotechnical and transportation engineering, and for leadership in engineering education for minorities."

BY DAVID E. DANIEL AND PERCY A. PIERRE

DELON HAMPTON, an exceptionally talented engineer, role model, and visionary leader in civil engineering education and practice, died at his home in Potomac, Maryland, on January 14, 2021, at the age of 87.

He was born in Jefferson, Texas, on August 23, 1933, the son of Charles and Alzadie Douglas. His birth mother, who died shortly after he was born, had asked her sister, Elizabeth Hampton, to raise Delon should something happen to her. Elizabeth and her husband Uless took the baby to their home in Chicago and raised him there.

Uless Hampton worked at the Tuthill Company, which made bricks, pumps, meters, and other materials and equipment used in the construction industry. His formal education had ended in 8th grade, but he had a collection of classic books by Shakespeare, Churchill, and Plato, which Delon devoured; an avid reader, he also became a frequent visitor to the local library. The neighborhood was rough, but, after Uless left, Elizabeth Hampton scraped by financially and was attentive to her new son's upbringing. Perhaps most importantly, she instilled in Delon a desire for a better life.

The young boy had a close group of friends who did everything together—football, basketball, and baseball, and building things such as forts, soapbox cars, and scooters from scraps—but more than anything, Delon desired to learn and to succeed as an adult. He decided to leave the poor-quality high school in his neighborhood and transferred to Englewood High School, farther south in Chicago, even though it meant more than an hour and two streetcars for his daily commute. He succeeded at Englewood, actively participated in sports, and made friends. When he graduated at age 16 he attended career fairs at the Illinois Institute of Technology, where he discovered an interest in architecture and civil engineering.

He decided to attend the University of Illinois at Urbana-Champaign and enrolled in the Department of Civil Engineering in January 1950. There he was inspired by the teaching of Ralph B. Peck (NAE 1965), and what became a lifelong interest in soils and geotechnical engineering blossomed. He was also active in campus activities and developed a passion for bridge. Unfortunately, he also experienced discrimination when he sought summer jobs with civil engineering firms.

After graduating in 1954 he headed to Prairie View A&M University for a teaching job, which lasted less than a year because he was drafted into service in the US Army. He served 2 years[1] and decided, upon discharge in 1957, to attend Purdue University for a master's degree, which he received in 1958. In part because engineering practice at the time was largely closed to African Americans, he stayed on to get his PhD in civil engineering. He completed his doctorate in June 1961 and decided to spend the summer in Europe. A highlight of the trip was attending the International Conference on Soil Mechanics and Foundation Engineering in Paris that July.

He returned from Europe ready to start working in the private sector. Though highly qualified, he received no job offers. But he was an optimist and a "can do" person.

With an introduction from a friend, he was offered a teaching position at Kansas State University. After a successful year there, he was offered and accepted a 1-year appointment as interim head of the soil mechanics research program at the US Air Force Shock Tube Facility in Albuquerque, New Mexico.

[1] He later served in the US Naval Reserves (1968–71).

This position allowed him to continue studying soil dynamics, which had been the focus of his graduate research. In 1963, at the end of the short-term appointment, he returned to Kansas State, where he found that the new chair of the Department of Civil Engineering did not like the fact that this young faculty member had spent the previous year on leave. Dr. Hampton realized that he had no future at Kansas State and began contemplating his next move.

He was offered a teaching position at the Illinois Institute of Technology (IIT) in his hometown of Chicago. He accepted and began teaching and conducting research in 1964. His time at IIT was successful, but it wasn't long before a prime opportunity presented itself.

Howard University recruited him vigorously. Walter T. Daniels[2] was chair of the Department of Civil Engineering and the two men had met at professional events; Daniels wanted the young scholar to come to Howard to teach and increase research in the department. In 1968 Dr. Hampton decided to accept the university's offer and moved to Washington.

He excelled at Howard as a teacher, a researcher, and a professional engineer. He served on the faculty for some 25 years and later on the College of Engineering advisory board.

Teaching the soil mechanics course required of all civil engineering students, he was known as extremely demanding but also fair. At the beginning of the year, he told the students exactly what they would have to know at the end of the course and gave them a list of questions they would have to be able to answer. When the time came he tested them on exactly what he had taught them. His course was hard, but no one complained that it was unfair.

Dr. Hampton was not only an effective teacher but also one of the most active researchers in the department. By the end of his first year, he had built the laboratory Dr. Daniels had promised him. He brought in some of the department's first

[2] Daniels, who received his PhD in civil engineering from Iowa State University in 1941, is recognized as the first African American to receive a PhD in any field of engineering.

research grants, including, in that first year, a research contract from the US Forest Service to study the soils and rocks of an area called the Idaho Batholith.

As a registered professional engineer in the District of Columbia, Maryland, Indiana, and Virginia (and eventually also in Alabama, California, Colorado, Delaware, Florida, Georgia, Illinois, Iowa, Michigan, Mississippi, New York, Tennessee, and West Virginia—16 states), Dr. Hampton had increasing opportunities to consult on engineering projects. He seized an opportunity to manage a small, local engineering office on a part-time basis and soon developed a close working relationship with two preeminent Chicago-based engineers, Clyde N. Baker Jr. (NAE 2004) and John P. Gnaedinger, who invited him to join them in an engineering partnership. The firm of Gnaedinger, Baker, and Hampton Associates (GBH) was established in Washington in 1971, with Dr. Hampton as president with a majority interest. The business prospered.

Dr. Hampton learned that building a successful engineering firm required not only strong engineering skills but, very importantly, excellent client relationships as well. Leading an engineering company was an enterprise for which he had, in effect, been preparing his entire life: from his resourceful childhood days of creating usable items from scraps to his passion for school and learning the craft of engineering, and his lifelong skills at building and nurturing relationships.

In 1973 he sold his interests in GBH to the two partners and chartered his own firm, Delon Hampton & Associates (DHA), at a time when there were few Black-owned engineering firms. DHA's first big job was a project for the Washington Metropolitan Area Transit Authority (WMATA) to design two rail service and inspection shops. The firm delivered, and WMATA returned repeatedly for engineering services.

DHA added program and construction management services to its capabilities and grew throughout the 1980s to provide nationwide services. Major projects included the Archer Avenue heavy rail transit station, a tunnel and reservoir project, and renovations to Soldiers Field and Comiskey Park, all in Chicago; the Omni Rail Transit Station of the

Metropolitan Atlanta Rapid Transit Authority; multiple stations for the Los Angeles Light Rail System and improvements to LA International Airport; the Baltimore Convention Center; and the Capitol Visitors Center, Nationals baseball park, and the Verizon Center and adjacent Gallery Place in Washington. Today DHA is counted among the top 360 engineering design firms in the United States.

In the course of his career Dr. Hampton published more than 40 technical papers. He also chronicled his experiences and challenges as an aspiring African-American engineer in his autobiography *A Life Constructed: Reflections on Breaking Barriers and Building Opportunities* (cowritten with Bob Keefe; Purdue University Press, 2013).

He made major contributions to the engineering profession through his engagement in and leadership of a number of engineering associations. Perhaps the highlight was his election as the first Black president (2000) of the American Society of Civil Engineers (ASCE). During his term he led the society to establish the Outstanding Projects and Leaders awards program, known as OPAL, to recognize and celebrate civil engineering standouts. He was also very active in the following organizations:

- ASCE: board of direction (1991–94; president, 2000)
- ASCE Capital Section: board of directors (1976–78), president (1984–85), chair, Scholarship Board of Trustees (1992–93)
- American Road and Transportation Builders Association: board of directors (1977–87)
- American Public Transit Association: associate member, board of governors (1982), board of directors (1985), chair, board of directors (1993), chair, business member board of governors (2006)
- Consulting Engineers Council/Metropolitan Washington: president (1986–87)
- American Consulting Engineers Council: vice president (1987–89)
- American Association of Engineering Societies: chair, public affairs council (1989–90)

- Civil Engineering Research Foundation: corporate advisory board (1989–92)
- National Science Foundation Engineering Advisory Committee (1992).

In addition, he was exceptionally involved in studies and operations of the National Academy of Engineering and National Academies:

- Task Force to Review Guidelines for Construction Management Developed for the Urban Mass Transportation Administration (chair, 1988–89)
- Committee for Peer Review of Program Plans, University Transportation Centers Program (1990–91)
- FHWA Research and Technology Coordinating Committee (1991–95)
- Building Research Board (1992–94)
- Panel on Transit Cooperative Research Program Strategic Planning Process and Strategic Plan (chair, 1993)
- Transportation Research Board: executive committee (1994–2000)
- NAE Civil Engineering Peer Committee (1995–98; chair, 1997–98)
- NAE Audit Committee (1995–96; chair, 1998–2000)
- NAE Committee on Membership (1997–98 and 2005–07)
- NAE Civil Engineering Section (secretary, 1997–2000)
- NAE Council (1997–2003)
- Board on Infrastructure and the Constructed Environment (1997–99)
- Committee for the Assessment of Upper Mississippi River-Illinois Waterway Navigation System Feasibility Study (2000–01)
- NAE Executive Compensation Committee (2000–03)
- Transit Research Analysis Committee (2004–06)
- Panel for Building and Fire Research (2004–05)
- Committee on New Orleans Regional Hurricane Protection Projects (2005–09).

Purdue University recognized Dr. Hampton as a distinguished engineering alumnus in 1982. The University of Illinois at Urbana-Champaign honored him with distinguished alumni awards from the Department of Civil and Environmental Engineering (1990) and College of Engineering (2000). The National Society of Black Engineers presented him with its Distinguished Engineer Award, and the American Academy of Environmental Engineers designated him a diplomate in 1990. ASCE selected him for the Edmund Friedman Professional Recognition Award (1988) and James Laurie Prize (1997), and designated him a distinguished member in 1995. He was elected to the NAE in 1992, and posthumously inducted in November 2021 to the American Public Transportation Association (APTA) Hall of Fame.

Recognizing the importance of his education, in 2012 he made a generous donation of $7.5 million to Purdue's Department of Civil Engineering, and the university's Civil Engineering Building was renamed the Delon and Elizabeth Hampton Hall of Civil Engineering.

To those who knew Delon Hampton, he was a very special, memorable, extraordinary individual. He was easy-going, always seemed to have a smile, and was interested in getting to know others. His leadership style emphasized hard work, building trusted relationships, and appreciating the good things about life's experiences.

One of his most important contributions was his advocacy for fairness and opportunity for Black engineers. Dr. Hampton suffered from closed doors and unavailable opportunities at numerous points in his life, but he never let that discrimination dampen his desire to succeed. Though he was undoubtedly proud to have been selected as the first Black president of ASCE, he was likely equally disappointed that, so far, he is the only one.

He succeeded beyond all reasonable odds to create a highly successful engineering firm, but he was quick to point out that there are still no more than a handful of Black CEOs of major engineering or construction companies in the United States. It was his belief that we can solve this problem only if *all* people know that if they work hard and prove their abilities, every position—including CEO—will be open to them. In his candid but constructive way, he consistently pointed out that we have much work to do if this openness is to become a reality. Dr. Hampton believed that commitment was key and that leadership matters.

He led by example. Even after he started DHA, he remained affiliated with Howard University for 25 years, serving as a role model, mentor, and source of inspiration to innumerable students. With them and others, he was frank while offering constructive advice on how they might advance themselves and their careers. His own life story of achievement put him in an ideal position to help others rise to their full potential.

As an engineer, role model, and inspirer of others, few have outshone Dr. Delon Hampton. The world—and not just the engineering world—is a better place because of him.

He is survived by his wife of 27 years, Sonia M. Hampton, with whom he traveled the globe and shared joyous adventures.

WILLIAM R. HEWLETT

1913–2001

Elected in 1965

"Electronics engineer."

BY ROBERT J. SCULLY AND MARLAN O. SCULLY
SUBMITTED BY THE NAE HOME SECRETARY

WILLIAM REDINGTON HEWLETT passed away January 12, 2001, at age 87. The Silicon Valley miracle was in large part fostered by him and David Packard (NAE 1971). Indeed, the ideas and ideals of the Hewlett-Packard Corporation set a high standard for the industry.

During his life Hewlett was recognized by his profession, his country, and his peers as the hero that he was. He was president of the (now) Institute of Electrical and Electronics Engineers in 1954 and was elected to membership in the National Academy of Engineering in 1965 and the National Academy of Sciences in 1977. President Ronald Reagan awarded him the National Medal of Science in 1983 for "his pioneering accomplishments in the creation and manufacturing of electronics and semiconductor devices and electronic test instruments." In 1987 he was awarded the Degree of Uncommon Man by Stanford University, its most prestigious award granted to alumni.

William was born May 20, 1913, in Ann Arbor, where his father, Albion W. Hewlett, was a doctor who taught medicine at the University of Michigan. When Will was 3, his dad moved the family back to their native California to teach at

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Stanford University. Will, who had dyslexia, attended the prep school Lowell High. He excelled in math and the sciences, but had problems with everything else. He dealt with his reading disability by learning to memorize and repeat subject matter over and over to himself. Life's future obstacles would similarly be dealt with; they were intriguing challenges begging a solution. From his early work on electronic oscillators to the development of the HP pocket calculator, Will Hewlett was a problem-solving pathfinder.

At an early age he began his engineering career the way many others do: blowing up things. His preferred method was stuffing doorknobs full of explosive. Aside from this hobby, he was a good and well-behaved kid. He developed a love for the outdoors as an avid mountain climber with a penchant for camping.

When Will was 12, his father died of a brain tumor. Deeply troubled by this loss, the boy sought refuge in the school science lab and solace in the mountains. To help the family cope with the tragedy Will and his sister Louise were moved to France for a year. While there he was tutored by his mother and grandmother.

High school would not prove him to be an outstanding student. Nevertheless he had his sights set on attending Stanford University. The principal initially refused to recommend him to the university, until she learned that his father had been Albion Hewlett. The surprised principal exclaimed, "He was the best student I ever had." The letter of recommendation that followed allowed Hewlett to open the doors to a new world of technology.

He received his BA (1934) from Stanford and MS (1936) from the Massachusetts Institute of Technology (MIT), both in electrical engineering, and in 1939 he was awarded the degree of electrical engineer from Stanford.

He immediately formed his own company. He had become close friends with David Packard while an undergraduate at Stanford. They had many things in common, apart from the social scene. Both liked to blow up things. Both loved outdoor activities—hunting, fishing, skiing, and mountain climbing were the early trademarks of the future fathers of Silicon Valley. And both had a passion to discover, develop, and invent.

So it was that Hewlett-Packard came into being in 1939: in their garage with an investment capital of $538. The lingering Depression didn't make things easy for the new company, but it did push the two partners to perform. Hewlett recalled, "In the beginning we did anything to bring in a nickel. We had a bowling lane foul line indicator. We had a thing that would make a urinal flush automatically as soon as a guy came in front of it. We had a shock machine to make people lose weight."

Over the next two years Hewlett-Packard inventions became more practical. One notable early achievement was the development of an audio frequency oscillator. At the time electronics was a new field, half science and half art. The resistance-tuned oscillator was a new idea that had been stymied by inherent stability problems. Hewlett came up with an ingenious solution: he invented a variable frequency oscillator that was stabilized by a small light bulb. This simple addition to the circuit made the device an inexpensive, reliable instrument. They called it the 200A, because calling it, say, 1A, might reflect inexperience to potential customers.

The new product was used to calibrate the sophisticated sound systems of the large studios. Walt Disney purchased eight for use in the film *Fantasia*. The success of these and other devices helped set the stage for Hewlett-Packard's future and presented missions for research and development. Although they were pioneers in new research, many of the technologies they fielded were testing and calibrating equipment for technological equipment already in existence.

The spring of 1941 saw the young company thrust into World War II. Will had been a ROTC cadet in college and was called to active duty. He originally worked in the Aviation Ordnance Department; it wasn't a good use of his technical skills but rather a result of his ROTC training. Packard, meanwhile, was making contacts in the defense sector, and his technological breakthroughs in the young company were earning him friends in high places. As such, he wrote to Colonel Roger

B. Colton of the Signal Corps and explained the benefits of having Hewlett transferred there. Thus Will was moved to the Signal Corps at Fort Monmouth, where he put his electrical engineering skills to good use. But not for long: that summer Hewlett-Packard went from a partnership to a corporation and the government now recognized Hewlett as an essential employee. He was released back to Palo Alto for a couple of months, only to be called back to Washington after Pearl Harbor.

Hewlett had more energy and ambition than the army required. In the nation's capital he learned, among other things, the bureaucratic ways there. He was unaccustomed to working less than 12 hours a day, but was forced to as the bureaucrats around him insisted on locking the safe at six o'clock each night, so that's when he had to hand over his documents and call it a day. Although he found this frustrating, his new wife, Flora (née Lamson), a biochemist whom he married in 1939, was delighted. She accepted the fact that her husband spent most of his time away from home, but was becoming quite busy herself, taking care of their growing number of children.

Will was transferred to a staff job, working for General James E. Wharton in the new products division, and late in the war he was sent to the Philippines, where he helped with assimilating new technologies into the frontline units of the military.

At about the time of the Japanese surrender he was given an intelligence assignment that took him, with a team, to Japan. He suspected that part of the purpose was to discover what the country had been doing with the atomic bomb. He met a man named Yagi, the civilian head of research and development. Yagi was helpful and knew the right directions in which to steer the investigators. He also explained to Hewlett, who recalled that the Japanese government had announced the development of a "death ray," that it was nonsense but that he had to appear to work on developing one anyway.

Hewlett found the Japanese electronics to be underdeveloped and primitive. Contrary to popular opinion, there was little if any cooperation between the Japanese army and navy or between the government and the civilian research and development community. Hewlett observed that the Japanese navy had been around the world for 10 years before the war; they knew what was out there and what the country was getting into. On the other hand the army had spent the previous 10 years occupying Manchuria in China, where they met ill-equipped, untrained forces. Will noted the result was that the army believed it could defeat the world. It was a fitting insight for the lieutenant colonel on which to end a military career.

He returned to Palo Alto in 1945. If he did not get shell shock in combat, he certainly got a shock when he came home. The company was no longer garage-based but a thriving industry of over 200 employees and it was growing at 100 percent per year. And as if David hadn't done enough, Will learned that his friend had thought it unfair to stay home and make more money than his buddy who went off to war, so he kept his salary lower than Will's service pay.

Hewlett was named vice president. As a leader he saw humanity as a raw resource of power that could grow only when left alone and encouraged from the sidelines. As such he brought a unique style of management to his company. Like his designs, it is simple and straightforward. Based on compassion, trust, and loyalty, it is backed by enthusiastic and loyal employees who extend the frontiers of technology while adding economic wealth to the nation. Will didn't manage by directive; his style was "management by walking around."

Will himself best illustrated the Hewlett-Packard way. The company had earned a reputation for making quality printers, but a quality problem with one of its models exposed HP to warranty problems in the tens of millions of dollars. When the serious situation was described to the board, Hewlett listened and finally asked what had been learned from the experience. He then simply said, "Make sure your number one responsibility is to take care of our customers."

As the company expanded to become the backbone of Silicon Valley, Will seems to have realized that his role was changing. He was now one of the richest men in the world, and, together with Flora, turned his attention to philanthropy.

He was particularly interested in the fields of medicine and education. He served as director of the Drug Abuse Council in Washington, DC (1972–78) and on the boards of numerous colleges and hospitals.

In 1995 he donated $70 million to the Public Policy Institute of California, which studies economic, social, and political issues facing the state. Silicon Valley had brought enormous growth and prosperity to northern California, but with it came challenges such as overpopulation, massive immigration, and destruction of once plentiful forests. William contributed to the conglomerate he had laid the foundation for with compassion and understanding—and with the hope that the next "Silicon Valley" would be a more perfect organization, not just a group of for-profit companies but a society of people from all walks of life who would live and work together with dignity and respect.

Will retired from HP in 1987 and in the late 1990s experienced a series of debilitating strokes that left him in a wheelchair. But the HP Way remained alive and in full force. William Hewlett's influence did not end on January 12, 2001. His enduring and legendary contributions continue to enrich us all.

Flora died of cancer in 1977 at age 62. The following year Will married Rosemary Bradford; she died in 2010. Bill is survived by his children Eleanor Hewlett Gimon (Jean-Paul), Walter, William, James, and Mary Hewlett Jaffe; 5 stepchildren; and 12 grandchildren.

GERALD D. HINES

1925–2020

Elected in 2001

"For global leadership in engineering advancements that set the standard for innovative and efficient design in the commercial building industry."

BY RONALD KLEMENCIC

GERALD DOUGLAS HINES, founder and chair of the Houston-based international commercial real estate firm Hines, died August 23, 2020, of cancer at age 95, surrounded by family at his home in Greenwich, Connecticut.

Started as a one-person operation in Houston more than 60 years ago, the firm's portfolio of work today includes nearly 1000 developments and more than 100 high-rise buildings around the world, many of which were built in collaboration with some of the most renowned architects. At the time of Hines's passing, his firm employed more than 4800 people in 225 cities, more than 25 countries, on five continents, and managed nearly $84 billion in investment assets.

He was born August 15, 1925, and raised in Gary, Indiana. His mother, Myrtle, was a teacher and homemaker, and his father, Gordon, was an electrician at Gary Works, US Steel's largest manufacturing plant. At age 14 Gerry worked part-time in the plant, chipping billets, hammering steel bars into small pieces, and quickly learning that this kind of hard, manual labor was not in his future. "I saw the inside of that steel mill, and I said, 'There is no way I want to work here for my career,'" Hines told his biographer, Mark Seal.[1] "So, you

[1] Seal M. 2016. *Raising the Bar: The Life and Work of Gerald D. Hines*. Bainbridge Island WA: Fenwick Publishing.

learn what you do not want to do. It was terrible being in the steel mill. It was grimy, and the language was pretty awful."

As a boy he had marveled at downtown Chicago's Wrigley Building—with its soaring north and south towers (21 and 30 stories, respectively), delicate terra cotta tiles, and intricate Beaux-Arts architectural style—and told himself, "Someday, I'd like to build one of those."

Between 1943 and 1946 Hines served as a lieutenant in the US Army Corps of Engineers, stationed in Fort Lewis, Washington. He then enrolled at Purdue University, and graduated in 1948 with a degree in mechanical engineering.

He went to work in the Houston office of Detroit-based American Blower, an industrial furnace and air conditioning manufacturer. He lived with Purdue fraternity brothers at a local chapter of the YMCA. Soon after that he was hired as a sales representative at Texas Engineering Company, which manufactured mechanical systems for commercial and industrial buildings.

It was while working at Texas Engineering, in 1951, that Hines made his first foray into real estate. He purchased for $16,000 the small home out of which the company operated, and in 1957 he sold the house for twice that amount. Thus, his eponymous firm, with himself as the sole employee, was born.

Hines developed roughly a dozen small warehouses and ordinary office buildings in Houston during the firm's earliest years. By 1967 the firm employed 35 people and had amassed a portfolio of nearly 100 office, parking, residential, retail, and warehouse projects in Houston. He burnished his reputation in the early 1970s with three flagship projects in the city:

- The Galleria: An upscale shopping center built on former prairie land and opened in 1970. It drew Texas's first Neiman Marcus department store outside of Dallas. Hines insisted that the shopping center include an ice skating rink despite the added costs; he believed, correctly, that it would draw visitors and increase basement-floor rental rates.

- One Shell Plaza: Upon completion in 1971, the 50-story, 715-foot-tall office tower, designed by Skidmore, Owings & Merrill, was the tallest building in Texas. According to Hines, “Winning the opportunity to build One Shell Plaza in downtown Houston almost five decades ago charted the course for our firm.”
- Pennzoil Place: The project’s distinctive 36-story, twin-trapezoidal towers were built with celebrated architects Philip Johnson and John Burgee and opened in 1975. Pennzoil Place was named Building of the Year by *New York Times* architecture critic Ada Louise Huxtable, who added, “It successfully marries art and architecture and the business of investment construction.”

These successes allowed Hines to expand his company to markets in the rest of the United States and throughout the world. Over the next 50 years the firm opened offices in Atlanta, Barcelona, Beijing, Berlin, Chicago, Copenhagen, Frankfurt, Greece, Hong Kong, London, Mexico City, Milan, Moscow, Paris, Prague, San Francisco, São Paulo, Seoul, Warsaw, and other parts of the world.

Colleagues, friends, and family members recalled that Hines—always modest, humble, and soft-spoken—had unique, almost quirky, characteristics. He was known to keep an old-school slide rule handy, and during meetings would pretend to use it so that others wouldn’t call on him to speak.

With an early background selling HVAC systems for Texas Engineering, he was particularly interested in his projects’ ventilation systems. He fretted over the tiniest details and was never above testing hinges, handles, and doors. As he told *Forbes* in 2000, “[Customers] like to feel that heavy hardware. Just like a good Mercedes or Lincoln door—when you slam it, it sounds good.” Jeff Hines reports that when his father met with Shell executives to discuss building the 50-story One Shell Plaza in Houston in 1970, he brought along pieces of hardware to demonstrate what he planned for the building’s level of finishes.

Some of the firm's most notable developments include Salesforce Tower in San Francisco (designed by architect César Pelli), D.Z. Bank in Berlin (Frank O. Gehry), Tour EDF in Paris (Pei Cobb Freed & Partners), Columbia Square (Henry N. Cobb) and City Center (Sir Norman Foster) in Washington, DC, and Diagonal Mar Centre in Barcelona (Robert A.M. Stern).

Hines formed a rewarding, long-term working relationship with Philip Johnson and John Burgee. The trio designed and constructed more than a dozen buildings, including two of the five tallest buildings in Houston—the 64-story Williams Tower and 56-story T.C. Energy Center—as well as 24-story One Post Oak Central. Around the country, they designed and built the 23-story 580 California Street and 48-story 101 California Street buildings in San Francisco, the 34-story building at 53rd and Third in Manhattan (nicknamed the "Lipstick Building" because of its curving, elliptical exterior and tapered form), the 25-story 500 Boylston Street building in Boston, the 45-story Comerica Tower in Detroit, and the 50-story Wells Fargo Center in Denver, among other structures.

In 2001 Hines and Johnson were honored by the American Institute of Architects (AIA) during a celebration that drew more than 350 guests to the Solomon R. Guggenheim Museum in New York City. "I had heard about Philip Johnson and how ornery he was," Hines told a *Houston Chronicle* reporter. "A mutual friend introduced us, and I didn't find him to be ornery at all. I thought he was very cooperative." For his part Johnson said, "I have only learned from Gerry. I don't learn from the books or school. I learn from the builders."

Hines also worked with the celebrated architects David M. Childs, Art Gensler, Bruce Graham, A. Eugene Kohn, Richard Meier, Charles W. Moore, Jean Nouvel, William E. Pedersen, I.M. Pei, Jon Pickard, and Kevin Roche, as well as the firm Skidmore, Owings & Merrill.

The reasoning behind partnering with blue-chip architects was simple, according to Stephen Fox, an architectural historian and lecturer at Rice University and the University of Houston. "If you make a building that is distinctive, there are tenants that will pay extra to have their offices there," Fox told the *Houston Chronicle*.[2] "That was kind of the Hines breakthrough—to understand and respect the power of architecture to create structures [that] potential clients would want to identify with. He put Houston on the map in terms of architecture by his imaginativeness and his business discipline in understanding how he could work with the best architects of the world within the economic constraints of real estate development and construction."

In addition to developing projects with the world's top architects, Hines's projects are recognized by the US Environmental Protection Agency, US Green Building Council, Global Green USA, and other leading environmental organizations.

Beyond day-to-day business activities, Hines shared his knowledge and experience with emerging industry leaders. Professionally and philanthropically, he supported real estate, architecture, and urban planning programs at Harvard University, Rice University, the University of Houston, Yale University, the University of Pennsylvania's Wharton School, and other educational institutions.

He also earned industry awards and honors throughout his career. In 1997 the University of Houston named its School of Architecture after Hines. Five years later, he received the Urban Land Institute (ULI) Prize for Visionaries in Urban Development—and donated the honorarium and additional funding to inaugurate the ULI Gerald D. Hines Student Urban Design Competition. In 2008 Harvard Design School presented its first Visionary Leadership in Real Estate Development Award to Hines.

He was named an honorary fellow of the AIA, earned honorary doctorates from Purdue University and the University of Houston, and was inducted into the North Texas Commercial Real Estate Hall of Fame. In addition, he received the National Building Museum's Honor Award, the Lynn S. Beedle Award from the Council on Tall Buildings and Urban Habitats, the

[2] Sarnoff N. 2020. Gerald D. Hines, developer who shaped Houston's skyline, dies at 95. *Houston Chronicle*, Aug 24.

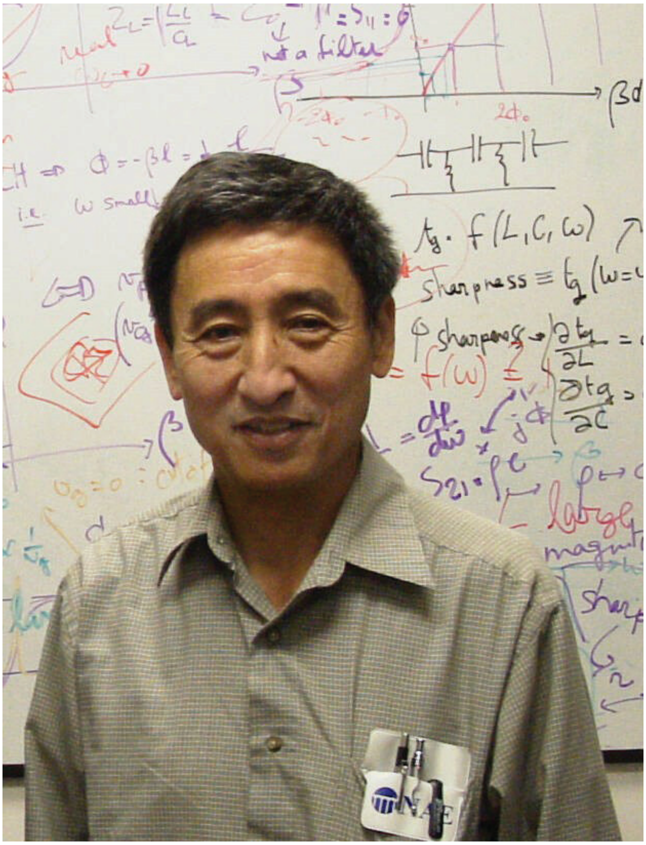
Good Design Is Good Business Patron Award presented by *Architectural Record* and the American Architectural Foundation, the Cornell Real Estate Industry Leader Award, and the History-Making Texan Award from the Texas State History Museum Foundation.

When Hines was 50, doctors told him he would need heart bypass surgery. Instead, he adopted a healthy diet and rigorous exercise program, often cycling 25 miles before breakfast. He also enjoyed climbing expeditions, backcountry ski trips, and sailing. He was an avid skier into his 90s, and developed the Aspen Highlands ski area as a coowner of the Aspen Ski Company. He owned homes in Houston, Aspen, New York City, and Greenwich. He celebrated his 90th birthday in 2015 at the Gerald D. Hines College of Architecture on the University of Houston campus. The event drew more than 2000 guests.

Hines is survived by his wife Barbara (née Fritzsche), sons Jeffrey and Trevor, daughters Jennifer Hines Robertson and Serena Hines, 15 grandchildren, and one great-grandchild. Jeffrey joined the firm in 1981 as an assistant project manager; he was named president in 1990 and chair and CEO in 2020.

In the 2016 biography, Hines offered some insight into his career success:

> When opportunities come to you, don't take more than the ones you can be successful at. If you're successful at one of them, then other opportunities will come. But if you're not successful because you took on too many things, then opportunities will have a harder time showing up. So be successful one opportunity at a time.



TATSUO ITOH

1940–2021

Elected in 2003

"For advances in electromagnetic engineering for microwave and wireless components, circuits, and systems."

BY YUANXUN ETHAN WANG
SUBMITTED BY THE NAE HOME SECRETARY

TATSUO ITOH, distinguished professor of electrical and computer engineering in the Samueli School of Engineering at the University of California, Los Angeles, passed away at home on March 4, 2021, at the age of 80. He led breakthroughs in the use of microwave and millimeter-wave frequencies of the electromagnetic spectrum for electronics and communication technologies.

In an illustrious career that spanned more than 50 years, Itoh was a prolific researcher who was among the world's most influential in his fields of study. He headed the UCLA Microwave Electronics Laboratory, which conducts theoretical and experimental projects in micro- and millimeter waves for components of integrated circuits and in metamaterials. He authored or coauthored 48 books and book chapters, as well as nearly 1500 research publications in peer-reviewed journals and conference proceedings. His works have been cited more than 63,000 times, according to Google Scholar.

This tribute is adapted from the author's original version published in *IEEE Antennas & Propagation Magazine*, Jun 2021 (p. 159). Readers may also be interested in a tribute published in *IEEE Microwave Magazine*, Jun 2021 (https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9423722&tag=1).

Born in Tokyo on May 5, 1940, Itoh studied at Yokohama National University, where he earned his bachelor's and master's degrees in electrical engineering in 1964 and 1966. He moved to the United States to continue his education at the University of Illinois at Urbana-Champaign, and earned his PhD in electrical engineering in 1969. During his PhD study, he discovered the spectral domain method, a technique that allows quick solutions of micro- and millimeter-wave waveguide properties and is now often implemented in electromagnetics software.

Upon completion of his doctorate he remained at Illinois until 1976, when he accepted a research post at the Stanford Research Institute in Palo Alto, California. The next year he moved to the University of Kentucky as an associate professor and in 1978 to the University of Texas at Austin, also as an associate professor. He was named the Hayden Head Centennial Professor of Engineering in 1981 and led a research lab that made several major breakthroughs in micro- and millimeter-wave research. Many of his designs have influenced researchers exploring terahertz frequencies.

In 1991 he joined UCLA as the TRW Professor of Microwave and Millimeter Wave Electronics, and in 2003 he was named the Northrop Grumman Professor of Electrical Engineering. He continued to lead groundbreaking research in micro- and millimeter waves and their applications. In addition, he and his research group were among the first to exploit metamaterials (artificial materials that offer electronic properties not found naturally), in particular a class known as composite right-/left-handed structures, for miniaturized antennas and other components in communication chip technologies. The versatile antennas offered high transmission efficiency and low power consumption.

Beyond UCLA he served the community as editor of *IEEE Transactions on Microwave Theory and Techniques* (1983–85) and founding editor in chief of *IEEE Microwave and Guided Wave Letters* (1991–94). For the National Academies of Sciences, Engineering, and Medicine, he was very active on the US National Committee for the International Union of Radio

Science, as an ex officio member (1988–96, 2009–11), delegate (1990), and member (2005–07); he was also appointed to the NIST Board's Panel on Electronics and Electrical Engineering (2007–09) and the Committee on Army Basic Scientific Research (1984–88). And as an NAE member he served a 3-year term on the Electronics, Communication and Information Systems Engineering Peer Committee (2006–09).

Itoh received numerous international accolades for his accomplishments, including election to the US National Academy of Engineering (2003) and National Academy of Inventors (2013), and an honorary doctorate from the Universitat Autònoma de Barcelona. He was a life fellow of the Institute of Electrical and Electronics Engineers (IEEE), and received its Third Millennium Medal (2000) and later Electromagnetics Award (2018) for "contributions to electromagnetic modeling, artificial materials, microwave electronics, and antennas." The IEEE Microwave Theory and Techniques Society, for which he served as president (1990), named an annual best journal paper award in his honor and bestowed upon him the Microwave Theory and Techniques Distinguished Educator Award (2000) and Microwave Career Award (2011).

In 2014 the IEEE *Transactions on Terahertz Science and Technology* published an overview of Itoh's life that covered his childhood in postwar Japan, his early interests in electrical engineering, his journey to the United States, and the evolution of his career.[1] After his death, the society created an online tribute for colleagues and friends to share their memories of him.[2]

Professor Itoh encouraged his students to think big and work hard, to venture out of their comfort zone, to keep up with the newest technology trends, and to appreciate both the history and the state of the art. He was advisor to more than 80 PhD graduates, 60 of them at the Samueli School of Engineering, where he was a beloved faculty member. Many

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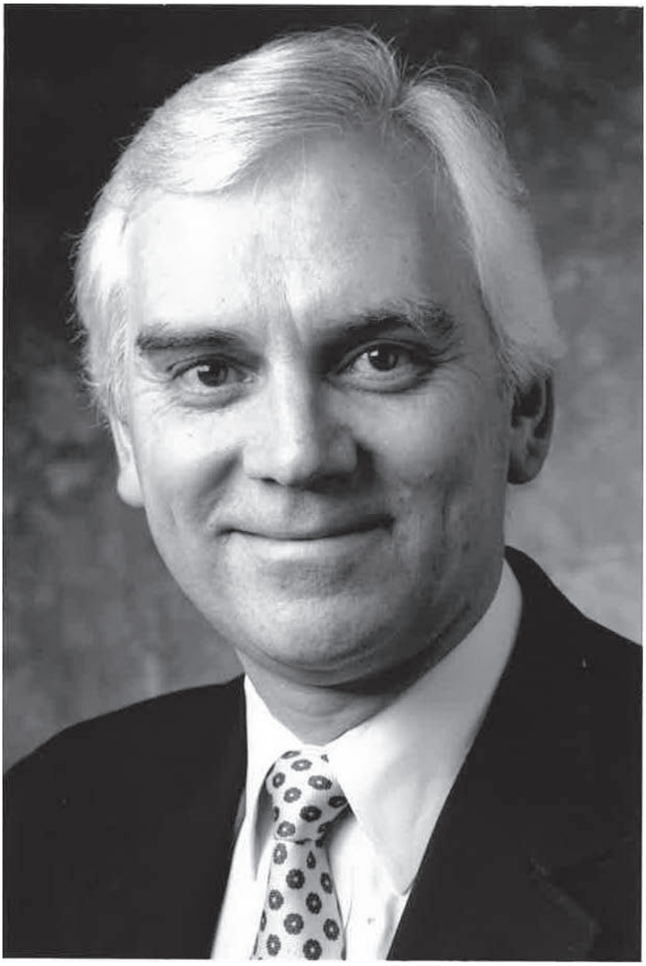
[1] Siegel PH. 2014. Terahertz pioneer: Tatsuo Itoh "Transmission lines and antennas: Left and right." *IEEE Transactions on Terahertz Science and Technology* 4(3):298–306.

[2] https://www.kudoboard.com/boards/jEirvuFv/slideshow

of his former students are faculty members at institutions worldwide, continuing his legacy as educators themselves.

His students particularly appreciated his advice that "it is never possible for anyone to be a full-time worker as it is not possible for a person to work 24 hours a day, 7 days a week." He was also open minded and applauded his students' innovations. In a workshop organized to honor his achievements, he said, "The best thing about being a teacher is that he can learn from his students without paying tuition." Despite his giant presence in the community, he showed remarkable humility.

Itoh is survived by Seiko, his wife of 51 years; son Akihiro; daughter Eiko; and three grandchildren.



STEPHEN C. JACOBSEN

1940–2016

Elected in 1990

"For engineering artificial kidneys, the Utah artificial arms, robots, and micro-motors and for successful commercial implementation of advanced products."

BY EDMUND Y.S. CHAO

With his prolific creativity, ingenious inventions, exquisite design concepts, and futuristic mind, STEPHEN CHARLES JACOBSEN was peerless in his chosen fields of mechanical and bioengineering. He was the biomechanical engineer behind a number of medical firsts: the first artificial heart successfully implanted in a human (the Jarvik-7), the first artificial wearable kidney, and the Utah Artificial Arm, which amputees could precisely control with tiny twitches of a chest or shoulder muscle. He died April 3, 2016, at age 75.

Steve was born in Salt Lake City on July 15, 1940. His mother was an elementary school teacher and his father was a commercial artist and amateur inventor. He grew up around tools and had a passion for taking things apart to see how they worked. "As a teenager, he completely disassembled an MG sports car in our basement, then painstakingly put it back together again," said his sister, Charlyn Dalebout.

He majored in mechanical engineering at the University of Utah, but at the end of his junior year administrators asked him to leave because of poor grades and an unfortunate practical joke that resulted in a large explosion in the engineering building. He was given a second chance by Wayne Brown, the dean of engineering, who called him into his office and said, "Steve, you are the smartest kid I have ever had the privilege of teaching. If you can keep a 'B' average, we'll get you back into school and get you a degree."

Jacobsen graduated in 1967 and went on to get a master's degree (1970), also in mechanical engineering, under the mentorship of surgeon Willem J. Kolff (NAE 1989) and engineer-physician Clifford Kwan-Gett. Both were doing pioneering work on mechanical hearts and kidneys in a new division of artificial organs at the University of Utah. Jacobsen did early prototyping of what eventually became the Jarvik-7.

Jacobsen was accepted into the mechanical engineering PhD program at the Massachusetts Institute of Technology under the direction of Robert Mann (NAE 1973), the renowned mechanical engineering professor who recognized the importance of the new discipline of biomedical engineering and started work on the first electromechanical artificial limbs for lower-limb amputees. I got to know Steve very early in my career since Mann was my mentor too. Steve and I were engaged in the exciting fields of simulation and virtual reality and competed in a Defense Advanced Research Projects Agency (DARPA) call for project submissions. Among several very high-powered groups around the country, Steve was the final winner with his gravity-powered exoskeleton brace to aid soldiers carrying backpacks of more than 60 pounds.

I subsequently established one of the first gait analysis laboratories, at the Mayo Clinic in Rochester, Minnesota, and shared the experimental data with Woodie Flowers (NAE 1994). At the time Woodie was an investigator in Mann's laboratory—where Jacobsen was learning the complex algorithms for robotic control theory and how to apply them to the design of artificial limbs for amputees to recover near-normal limb function. Steve shared an office and design ideas with Woodie, who marveled that "Steve could see so many things at once. He saw parallels that crossed domains. His limit-pushing was infectious."

Steve joined the faculty of the University of Utah in 1983 as a research professor for the Department of Bioengineering, accepted a joint appointment in the Department of Computer Science in 1992, and in 1996 was designated a Distinguished

Professor of Mechanical Engineering. He was also director of the Center for Engineering Design (1973–2007). He authored or coauthored 170 technical publications and 276 technical presentations, and was named on more than 200 US patents, 123 foreign patents, and 50 trademarks.

At the same time, he founded a number of companies—Sterling Research Corp., Sarcos (now Raytheon-Sarcos), Micro-Drugs Inc., Eye-Port Corp., Motion Control Inc., IOMED Inc., MicroJect Corp., and Precision Vascular Systems Inc.—and designed animatronic pirates for the Pirates of the Caribbean ride at Disney theme parks and, for DARPA, a pole-climbing, robotic snake with a spy camera intended for remote surveillance in enemy territory. He enjoyed assembling teams of engineers, prototype builders, programmers, and artists to come up with creative approaches and applications.

He also volunteered his expertise for the National Academies, as a member of the Keck Futures Initiative Smart Prosthetics Steering and Program Committees (2006–07), Committee on Human Exploration (1998–2000), and Manufacturing Studies Board (1992–95). For the NAE he served twice on the Mechanical Engineering Peer Committee (1993–96, 2004–07).

His impact was recognized through many national and state awards. He was elected to the National Academy of Engineering and Institute of Medicine—both in 1990—and the American Academy of Orthotists and Prosthetists. He won the Leonardo da Vinci Award from the American Society of Mechanical Engineers in 1987; the Utah Governor's Medal for Science and Technology in 1990; and the Pioneer of Robotics Award from the Institute of Electrical and Electronic Engineers in 2007, "In recognition of outstanding contributions to the design and control of leading edge robots and other animate machines." In 2012 he received one of five "Most Prolific Inventor Awards" from the University of Utah's Technology Commercialization Office for having more than 200 inventions, the Utah Genius Lifetime Achievement Award, and the University of Utah Distinguished Innovation and Impact Award.

Steve's personality, wit, and willingness to help others made him a beloved member of the community. His loss is greatly felt by friends and colleagues.

He is survived by his wife, Lynn; their children, Peter Jacobsen and Genevieve Boyles; and two grandchildren.

DAVID JENKINS

1935–2021

Elected in 2001

"For theoretical and practical contributions to improving water quality worldwide through applied research on biological waste-water treatment processes."

BY R. RHODES TRUSSELL AND GEORGE TCHOBANOGLOUS

DAVID JENKINS, who died March 6, 2021, at age 85, had a brilliant mind, an engaging personality, a passion for humor, and a will to persevere rarely found. He is missed by a broad network of family, friends, and colleagues with whom he actively engaged right up to the last month of his life. The international community of environmental engineers and scientists has lost one of its most respected and beloved advisor-counselors.

David was born in Shropshire, England, on October 4, 1935, to Samuel H. and Olive Jenkins. Samuel Jenkins was himself accomplished in the field of water quality of treatment.

In 1960, at age 24, when David finished his PhD in public health engineering at the University of Durham, King's College, he emigrated to California to make his way in the world, taking a job with Percy McGauhey (NAE 1973), director of the Sanitary Engineering Research Laboratory in Richmond. It didn't take long for the faculty at the University of California, Berkeley, to recognize David's talent, and in 1963 he joined the Department of Civil and Environmental Engineering, where

Readers may also be interested in "A remembrance of Prof David Jenkins (1935–2021)" prepared by the International Water Association's Specialist Group on Microbial Ecology and Water Engineering; available at https://iwa-network.org/wp-content/uploads/2021/10/A-Remembrance-of-Prof-David-Jenkins-1935-2021.pdf.

he remained until his retirement in 1999. He rose to become one of the most highly regarded members of the department, an honorary member of its Academy of Distinguished Alumni, and in 2001 a member of the NAE.

David's major areas of research were biological treatment processes for wastewater and sludge, and water and wastewater chemistry and microbiology. A distinctive feature of his studies was the use of the modern tools of science to find a deeper understanding. In biological treatment, he focused on the causes and controls of activated sludge solids separation problems and the chemical and biological methods of nutrient removal. As a practicing engineer, he specialized in the upgrading and troubleshooting of wastewater treatment plants and in environmental and process problems using his expertise in chemistry and microbiology.

He contributed immensely to understanding of the mechanisms of chemical and biological phosphorus removal in wastewater systems. A few notable accomplishments along his journey of discovery are the identification of geosmin and methylisoborneol, the most recalcitrant causes of off flavors in drinking water; elucidation of the mechanism of solvent diffusion through plastic water pipes; recognition of the importance of mean cell residence time in the management of microbial populations in biological treatment processes; fundamental work on quantification of the many types of filamentous microorganisms in the activated sludge process and other environmental processes, their role in treatment, and their control; and development of methods for controlling *Nocardia* and foaming.

David badly injured his back playing rugby in college and suffered the consequences the rest of his life, although he never let it slow him down. He traveled with a special chair or brace, and many students remember him giving a lecture in the classroom while lying on his back on a chaise. He was beloved for his mentorship of undergraduate and graduate students and postgraduate fellows. He sought ways to nurture and bring out the best in each person he mentored, all of whom became lifelong friends and colleagues.

Throughout his career, he researched and published widely on a variety of environmental engineering topics. He was a great collaborator and interacted with a broad spectrum of the global environmental engineering community. Sought out because he was a problem solver, he generously shared his expertise in microorganism identification in workshops sponsored by a variety of state, national, and international wastewater management organizations, and his expertise in wastewater treatment and management with a number of public agencies, including the County Sanitation District of Los Angeles and the Public Utilities Board of Singapore.

He authored more than 250 publications and reports and coauthored four texts. His book *Water Chemistry* (Wiley, 1991; coauthored with Vern Snoeyink [NAE 1998]) remains popular, and the *Manual on the Causes and Control of Activated Sludge Bulking, Foaming, and Other Solids Separation Problems* (CRC Press, 2003; coauthored with Michael G. Richard and Glen T. Daigger [NAE 2003]) is the bible for activated sludge trouble shooters worldwide.

He was amply honored for his contributions. In addition to his NAE membership, he was designated a fellow of the Chartered Institution of Water Environment and Management in the United Kingdom and an honorary life member of both the Water Environment Federation (WEF) and the International Water Association (IWA). He received the WEF Eddy Wastewater Principles/Processes Medal for research three times (1974, 1985, 1988), the Camp Applied Research Award for contributions to wastewater treatment practice (1984), the Fair Distinguished Engineering Educator Medal for wastewater engineering education (1995), and the Gascoigne Medal for Wastewater Treatment Plant Operations Research twice (1989, 2001). He was selected for three IWA honors: the 1992 Outstanding Service Award (given in honor of Dr. Samuel H. Jenkins), 2001 Ardern-Lockett Award, and 2010 Global Water Award. David also received the 2010 Association of Environmental Engineering and Science Professors Frederick George Pohland Medal for work that bridges theory and practice, and the 1988 Simon Freeze Award and Lectureship, sponsored by ASCE.

David met Joan Van der Velde, who would become his life partner, in 1957 while participating in a musical production together at the University of Durham. In a busy autumn of 1960, they married, honeymooned, David defended his thesis, and they moved to the United States. They were a dynamic duo for over 60 years. Joan hosted countless spaghetti dinners for students and faculty and accompanied David at numerous events over the decades. She is well known and beloved by his vast network of professional friends and associates.

David had the great fortune of living a full and meaningful life exactly as he wished. He is much missed.

He is survived by Joan, their children Daniel Jenkins (Deanne) and Sarah Muren (Mark), six grandchildren, and a growing number of great-grandchildren.

STEVEN P. JOBS

1955–2011

Elected in 1997

"For contributions to creation and development of the personal computer industry."

SUBMITTED BY THE NAE HOME SECRETARY

STEVEN PAUL JOBS was born February 24, 1955, and died October 5, 2011, at age 56, his life cut short by pancreatic cancer. Only a handful of National Academy of Engineering members have had so much written about them or been so well known to the general public. His life was portrayed in a biography by Walter Isaacson published in 2011 and dramatized in a 2015 movie, both titled *Steve Jobs*, and he has an extensive Wikipedia page, all of which were sources for this piece. It may seem unnecessary to write yet another account of his life, except to acknowledge in this space that he was, in fact, a member of the NAE, elected in 1997.

He had no formal training as an engineer but tinkered with his father on electronics, took an electronics course in high school, read a lot about science and technology, had some early hands-on experience as a technician at both Hewlett-Packard and Atari, and helped Steve Wozniak create and sell a "blue box" to spoof the phone system to allow free long-distance calls. All of this gave him some feel for the technology creation and commercialization processes before he and Wozniak launched Apple in 1976, establishing themselves as pioneers in the personal computer revolution.

Steven Jobs was born to Joanne Schieble, an unmarried mother who put him up for adoption. His original adoptive parents, acceptable to his mother, backed out and he was adopted by Paul and Clara Jobs. His birth mother was not happy with their selection and launched a protracted lawsuit to have him returned, before eventually relenting. According to his biography, this was an origin story that continually troubled Jobs and may have contributed to his relentless drive to succeed. He was loyal to his adoptive parents and considered them his true parents. He eventually learned from his birth mother that she and his father had subsequently married for a time and had a daughter, named Mona Simpson, who became a successful novelist. Jobs eventually met her and they remained close until his death. He chose not to meet his biological father.

Jobs grew up in Mountain View and Los Altos, California. He attended Homestead High in Cupertino, where he nurtured an interest in electronics and his classmate and friend, Bill Fernandez, introduced him to Fernandez's neighbor, Wozniak. After graduation Jobs attended Reed College in 1972, but dropped out the same year in the belief that it was a waste of his parents' money.

In a series of steps one would not necessarily recommend as training for a future industry titan, he dabbled in hallucinogenic drugs, made an extended pilgrimage to India, lived in a commune in Oregon, and acquired both a lifelong appreciation for Zen Buddhism and a lifelong interest in strict dietary regimens, so much so that he opted for dietary control instead of surgery when confronted later with a cancer diagnosis.

The legend of Steve Jobs began in 1976 when he and Wozniak launched Apple in the garage of his parents' Los Altos home. Their first offering was the Apple I, of which only 200 were sold. This was followed by the Apple II in April 1977, featuring high-resolution color graphics, ample memory, and eight expansion slots. It was one of the first commercially successful microcomputers.

Over the next few years, as Apple was sustained by the great success of the Apple II, the company developed the Lisa and Macintosh computers. The Lisa was not a commercial success and was discontinued in less than 2 years. Steve led the development of the Macintosh computer, which, introduced in January 1984, was the first easy-to-use, affordable personal computer featuring a graphical user interface. The Macintosh was successful in the education market and pioneered new markets like desktop publishing, but was hampered at launch by an initial lack of applications.

By 1985 Apple was faltering and Jobs and CEO John Sculley, whom Jobs had brought to Apple as CEO, were in bitter disagreement about the company's future direction. Sculley favored the open architecture of the Apple II, whereas Jobs favored the complete control of a closed architecture. The Apple Board chose Sculley over Jobs, who left the company he and Wozniak had created, setting the stage for what would be one of the greatest comebacks in business history.

Following his resignation from Apple, Jobs founded NeXT Inc., which created a workstation aimed at the higher education market. The NeXT workstation was introduced in 1988 but was expensive, and after having sold only 50,000 machines, in 1993 NeXT transitioned to become a software company. This would appear to be yet another setback for Jobs, but the NeXT operating software was a modern UNIX-based system that would be his leverage to return to Apple, where it became the foundation of most of Apple's products. In 1996 NeXT introduced WebObjects for web application development; it was subsequently used to build and run the Apple Store and iTunes Store.

At the same time he was developing NeXT, in 1986 Jobs acquired the graphics group of Lucasfilm for $10 million, $5 million for company capital and $5 million for technology rights. His original interest was in the computer system that the group had developed, but he eventually embraced the artistry of the animated films that the company, renamed Pixar, would produce. Beginning with *Toy Story* in 1995, Pixar created a series of commercially successful films, distributed in partnership with Disney, several of which won Motion Picture Academy Awards. Even as he was reviving Apple, Jobs continued his involvement with Pixar, culminating in January 2006 when he sold it to Disney for $7.4 billion in Disney stock.

In December 1996, flirting with bankruptcy and with a sense of desperation, Apple announced plans to buy NeXT for $427 million, basically to get NeXT's technology, most notably NeXTSTEP, which evolved into the operating system Mac OS X. The deal was finalized in February 1997 and on September 16 Jobs was named interim chief executive ("interim" at his insistence). He became permanent CEO in 2000.

Just keeping Apple alive probably would have cemented Jobs' legacy, but, under his guidance, the company increased sales significantly with the introduction of the very successful iMac, characterized as unlike any personal computer that came before, and other highly successful new products, which restored Apple to the legendary status of its earliest days. With the releases of the iPod portable music player, iTunes digital music software, and the iTunes Store, the company made forays into consumer electronics and music distribution, spectacularly leveraging its computer expertise to break loose from the confines of being "just" a computer company.

The iPhone, introduced January 9, 2007, and released June 29, was described as "revolutionary." Started in 2004 with a team led by Scott Forstall, Tony Fadell, and Jony Ive, the iPhone was unlike any other phone or smartphone in existence, with a touchscreen and no keyboard. It defined the design and form factor for all smartphones to come, and changed the meaning and use of the smartphone from a business object into an essential personal one. More than 2.2 billion iPhones have been sold. The iPad was introduced January 27, 2010, and by April 2015 more than 250 million had been sold.

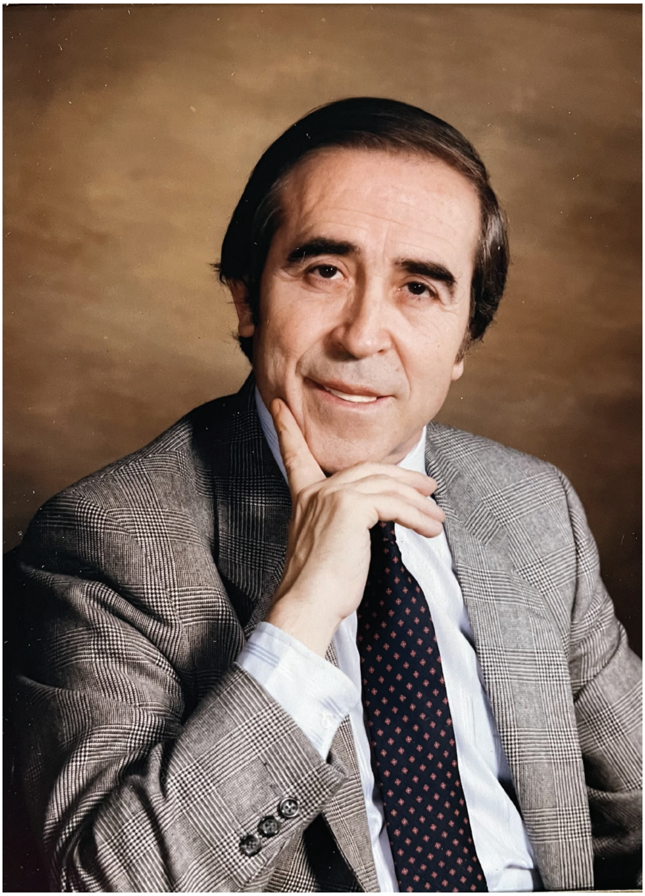
Jobs was skilled at orchestrating technological innovation, product design, marketing, and entrepreneurship. He had an eye for talented individuals and was deeply indebted to those who provided critical contributions to his success, including Wozniak for the original Apple designs, John Lasseter and Ed Catmull for animation creativity at Pixar, Joanna Hoffman for product marketing, Avie Tevanian for software management, Jony Ive for product design, Tim Cook for his overall leadership, manufacturing, and supply chain management, and many others, even occasionally his rival Bill Gates (NAE

1996). But it was Jobs' incredible creativity, passion, foresight, and tenacity that pulled it all together.

While the biography and the movie celebrate his accomplishments, an underlying theme in both was that Steve Jobs was not an easy man to work with or for. He believed that a company could excel only if it was populated by "A" players and he was apparently completely unforgiving of what he saw as less than an A performance. He always had a vision of what he wanted, and it sometimes flew in the face of what experienced people around him thought possible. His ultimate success is undeniable, but its toll in human terms for the Apple staff is unknown.

Jobs didn't just run companies, he created the canvas on which engineers could create masterpieces, which is an apt description of many Apple products launched by Jobs. He had avid interests in technology, literature, and music (especially Bob Dylan), and said he wanted to operate at "the intersection of humanities and science," which likely contributed to his success in making products that were so user-friendly and eagerly adopted by consumers who never knew they needed them. This is not to say that every product Jobs touched turned to gold, but many did, eventually making Apple the most valuable company in the world.

In October 2003 Jobs was diagnosed with pancreatic cancer and his health and ability to lead Apple waxed and waned from then on. He underwent a liver transplant in April 2009, but succumbed to the disease 2½ years later. He is survived by his wife Laurene Powell, whom he married in March 1991; their son Reed and daughters Erin and Eve; and his daughter Lisa from an earlier relationship.



ANGEL G. JORDAN

1930–2017

Elected in 1986

"For contributions to solid-state device research, and for innovative leadership in engineering education."

BY PRADEEP KHOSLA

ANGEL GONI JORDAN was born September 19, 1930, in Pamplona, Provincia de Navarra, Spain, and raised in the country's northern mountain region of the Pyrenees. He earned a degree in physics at the University of Zaragoza in 1952, with a 1-year research fellowship (1951–52) in Pittsburgh at the Mellon Institute of Industrial Research, where he conducted basic and applied research in semiconductor photodevices and solar cells.

Back in Spain, he went to work as a research engineer, doing basic and applied research in servomechanisms and electronics, in the Laboratorio y Taller de Investigación, Estado Mayor de la Armada (LTIEMA) in Madrid (1952–56). He introduced the foundations of semiconductor devices and semiconductor electronics in the country's naval research laboratory and produced a number of technical reports.

In 1956 he and his wife Nieves came to the United States to pursue their PhDs in electrical engineering at the Carnegie Institute of Technology (now Carnegie Mellon University, CMU). Upon completing his PhD in 1959 Angel was hired at CMU as a researcher and assistant professor of electrical engineering.

During his 4-decade career he made numerous scientific and technical contributions in semiconductor electronics and materials science and engineering. He distinguished himself in his work in tunnel diodes, junction devices, photodiodes, parametric amplifiers, high-frequency devices, behavior of semiconductor devices at low temperatures, noise in semiconductor devices, effects of imperfections in the electrical properties of semiconductors, radiation damage in semiconductors, thin films, gas detection devices, semiconductor metal oxides, and microprocessor-controlled systems. Later in his career he conducted research on high-definition television, intelligent sensors for robotics applications, technological innovation and management of technology, and studies of the computer industry.

During his tenure in the CMU Electrical and Computer Engineering Department (ECE) Angel attracted considerable government and industry funding and was instrumental in building one of the country's first and finest university laboratories in solid-state devices. His work enabled advances in the understanding and theory of semiconductor phenomena and devices, and contributed to technological developments with impacts on microelectronics, environmental monitoring and control, biomedical instrumentation, coal mining safety, and automated systems.

He taught several generations of undergraduate and graduate courses and supervised the doctoral work of 28 students, launching them and numerous master's students to become influential leaders in their fields. He is remembered fondly as a warm and engaging teacher.

As ECE department head (1969–79) he expanded areas in which the department was prominent; recognized and fostered new areas, such as computer-aided design, computer hardware, robotics, and optical electronics; initiated new interdisciplinary programs, such as magnetic technology and electronic materials; and propelled the department to a leading position in the country. Funded research support more than quadrupled and the level of enrollment and quality in both undergraduate and graduate programs increased substantially. He participated in the founding of CMU's Department of Computer Science, now recognized as nationally outstanding.

As dean of CMU's engineering college, Carnegie Institute of Technology (CIT, now the College of Engineering; 1979–83), he extended the scope of the Design Research Center; led all departments to higher levels of excellence; introduced manufacturing and automation in the research and educational programs of several engineering departments; was a leader, with Raj Reddy (NAE 1984) and Thomas J. Murrin (NAE 1984), in the formation of the Robotics Institute, encouraging participation from computer science, all engineering departments, and the Graduate School of Industrial Administration (this institute—which offered the first PhD program in robotics—is now the largest academic robotics research center anywhere); encouraged and supported the formation of the interdisciplinary Magnetics Technology Center (one of the few and the largest center of its kind in the nation, funded by industry and government agencies); fostered close cooperation among departments and centers; and led the college to a dramatic increase in funded research.

As CIT dean and then as provost of CMU (1983–91), he led the faculties of the CIT and Graduate School of Industrial Administration in putting together innovative curriculums in integrated manufacturing systems engineering and management to educate a new breed of manufacturing engineers and managers. All of the university's research programs expanded. By the last year of his term, research funding exceeded $125 million a year, of which 20 percent was from industry, one of the highest percentages in the country.

Under Dr. Jordan's leadership, in 1986 CMU attracted to its engineering college an NSF Engineering Research Center (ERC): the Engineering Design Research Center is based in the Design Research Center and the Robotics Institute, two programs also launched and nurtured during his tenure as dean. A second NSF-funded ERC, the Data Storage Systems Center based in the Magnetics Technology Center, was also established.

As provost he fostered close cooperation between the School of Computer Science and the rest of the university, particularly the College of Humanities and Social Sciences. For example, the Computational Linguistics Program, housed in the

Philosophy Department, comprises linguistics, philosophy, and computer science. The Center for Machine Translation, a large research institute based in computational linguistics and funded by government agencies and industry, reports directly to the provost because of its universitywide scope. The engineering college and the Graduate School of Industrial Administration collaborate in interdisciplinary programs in manufacturing and information technologies.

He was a leading force in the revitalization of the Mellon Institute, one of the first industrially sponsored research institutes in the country before it merged in 1967 with Carnegie Institute of Technology to form Carnegie Mellon University. In 1983 when Angel became provost, this institute was in a state of flux and in need of leadership. For two years he directed the institute from the provost's office and put it back on track before appointing a permanent director. The building that housed the Mellon Institute is now the home of Mellon College of Science, and over the years the programs of the original Mellon Insitute have dissipated or been absorbed in other parts of Carnegie Mellon.

In addition, Dr. Jordan participated in educational and search committees, inside and outside his department or college, and in universitywide committees with the administration. He was active in the development and fund raising for a campaign to raise $200 million for the university, and was instrumental in attracting a number of endowed professorships and gifts and grants from individuals, foundations, and corporations. In concert with the Development Office and the university president, he participated in a development campaign for the college to raise funding for renovations, construction, equipment, and facilities.

As a technology leader, Angel was a dynamic force in creating community and collaboration beyond the CMU campus. As department head, dean, and provost, he initiated and encouraged local, national, and international industry-university research partnerships. He was a pioneer in technology transition with the university acting as a catalyst for economic development in Pittsburgh and Western Pennsylvania.

In 1983 he founded, was the first chair, and later served on the board of directors of the Pittsburgh High Technology Council, an organization to help change the city from one of smokestacks to high technology. He also played an important role in the formation and implementation of the Enterprise Corporation (and served on its board of directors), the mission of which is to help start new companies in Greater Pittsburgh; participated in the conversion of the J & L Steel site to an industrial park, the Pittsburgh Technology Center, to help attract advanced technology companies to the city and to work with CMU; served on the Allegheny County Airport Advisory Commission for the construction and expansion of the Midfield Terminal; and worked with community groups in the area and around the state to foster economic development through education and technology.

As chair of the Association of Engineering Colleges in Pennsylvania and governor-appointed member of the Pennsylvania Science and Engineering Foundation, he was a leader in creating and launching the Ben Franklin Partnership Program and the state's Advanced Technology Centers, and served as director of the Western Pennsylvania ATC.

He was the orchestrator and driving force behind the effort to attract the Software Engineering Institute to CMU and Pittsburgh. This federally funded research and development center is meant to enhance the productivity of software production and set the standards of software engineering for DOD and industrial corporations. Together with CMU's School of Computer Science and College of Engineering, the SEI is a catalyst for spin-offs and magnets to attract software companies to Pittsburgh and Western Pennsylvania. In addition to spearheading the SEI's establishment in 1984, Angel served as acting director (2003–04).

For years he served on the board of directors of the Mellon Pittsburgh Corporation (MPC), including as vice chair (1985–87) and chair (1987–91). The corporation was established for collaborations between CMU and Pitt. Under the MPC umbrella the two institutions in 1986 formed the Pittsburgh Supercomputing Center, one of the original five supercomputing centers in the nation funded by the National Science Foundation. Because of its universitywide scope the center reports directly to the provost.

He fostered research collaborations between CMU and the University of Pittsburgh in areas where the two institutions complement each other—for example, in magnetic resonance and in cancer research between CMU's Biological Sciences and Computer Science Departments and Pitt's School of Medicine; and in biomedical informatics between CMU's Laboratory for Computational Linguistics and Center for Machine Translation and Pitt's Linguistics Department and School of Medicine.

As ECE department head he reorganized the interdisciplinary Biomedical Engineering Program in the College of Engineering and served as acting chair, fostering collaborations between the program and Pitt's medical school and between the program and Allegheny Singer Research Institute (the basic and clinical research branch of Allegheny General Hospital), for which he served on the research committee and board of directors. He continued fostering these collaborations as dean of engineering, and as provost he expanded them to include CMU's science and engineering colleges, Robotics Institute, and School of Computer Science. He also served on the board of directors of the Allegheny Heart Institute (a division of Allegheny General Hospital) and chaired its research committee.

He lectured at US universities and abroad on interdisciplinary education, industry-university relations, technology transfer, and strategic planning; fostered and participated in collaborative efforts between CMU and universities and research establishments nationally and abroad; and initiated a number of international research and educational programs in science and technology and in the humanities and social sciences. In parallel, throughout his faculty career he consulted (two days a month on average) with industry, universities, and government agencies nationally and abroad.

He published extensively in refereed journals, wrote a number of reports and monographs, and made numerous presentations at national and international meetings. He was a coauthor of a 1984 report by the Business–Higher Education Forum, *The New Manufacturing: America's Race to Automate*, that has been widely circulated and attracted national and international attention.

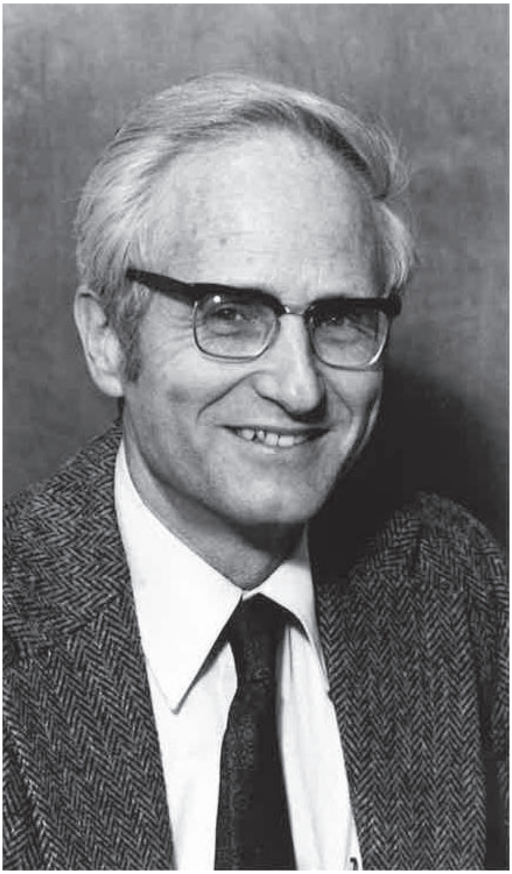
For the National Research Council, he was appointed to the Committee for the Study of Defense Industrial Mobilization (1988–90); and as an NAE member he volunteered on the Electronics, Communication and Information Systems Engineering Peer Committee (1987–89; chair, 1989–90) and Committee on Membership (1989–90).

Angel's contributions were well recognized. In addition to his NAE election, he was a fellow of the IEEE and American Association for the Advancement of Science and a member of the American Physics Society and American Society of Engineering Education. He was a Distinguished Fulbright Scholar, the 1987 Vectors Pittsburgh Man of the Year in Education, and selected to receive the Enterprise Award, presented by the *Pittsburgh Business Times*, "in recognition of his foresight and leadership in bringing the Software Engineering Institute to Pittsburgh." He was particularly pleased to have received honorary doctorate degrees from several higher education institutions in the country of his birth, including the Polytechnic University and Universidad Carlos III, both in Madrid.

In July 1991 Dr. Jordan stepped down as provost and returned full time to research and teaching as a University Professor of Electrical and Computer Engineering and Robotics, affiliated with the ECE Department, School of Computer Science, Robotics Institute, and Graduate School of Industrial Administration. He became professor emeritus in 2003.

He became an American citizen in the 1960s, and embraced his new "hometown" of Pittsburgh with pride—and enthusiasm for the Steelers, cheering the team in Spanish as he watched games with his family.

He died August 4, 2017, at the age of 86 surrounded by his loved ones. He is greatly missed by the CMU community and by his wife, Nieves; their three sons, Edward (Rina) of Utah, Xavier (Perlita Peret) of Washington, DC, and Arthur (Dana) of Upper St. Clair, PA; and six grandchildren.



JACK L. KERREBROCK

1928–2019

Elected in 1978

"Contributions in the development of propulsion and energy conversion systems design and research, education, and national service."

BY EDWARD M. GREITZER AND ALAN H. EPSTEIN

JACK LEO KERREBROCK, a world figure in aerospace propulsion, died at his home in Lincoln, Massachusetts, on July 19, 2019. He was 91.

His career was marked by insightful and pathbreaking research, technical innovation, eminence in education, and leadership and counsel for government and industry. His research included airbreathing propulsion, space propulsion, and turbomachinery; his inventions and innovations included the gas core nuclear rocket, the technology for transient turbomachinery testing, and many devices and techniques for diagnostics and improvements in jet engines; his educational contributions included a seminal book on gas turbine engines as well as decades of excellence and positive impact in teaching and mentoring students; and his advice to industry and government was widely recognized and highly sought.

Jack started his career as a theorist, where his combination of physical insight and mathematical abilities fueled contributions to propulsion and to magnetohydrodynamics (MHD), but he soon broadened his focus to a major emphasis on experimental research. This switch came about, he explained, because a theorist could only blame himself for a lack of progress while an experimentalist could always blame it on the equipment. In Jack's case, excuses were rarely needed because he combined extraordinary skills in both experimentation and theory. The term role model, in its best sense, could be used to describe him—someone to look up to not only for guidance but also for how an exemplary individual behaves and what we can learn from him or her.

Jack was born in Los Angeles on February 6, 1928, to Oscar and Florence (Hoy) Kerrebrock. He grew up in Oregon and obtained a BS (1950) at Oregon State University and then an MS (1951) at Yale University, both in mechanical engineering. His passion for aerospace took him to NACA Lewis Research Center (1951–53) in Cleveland, the forerunner of the NASA Glenn Research Center. During this period he met and married Bernice (Vickie) Veverka, who was then a comput*or*—i.e., a *person* who calculates or computes—at Lewis. In 1953 the Kerrebrocks left for Caltech, where Jack completed his PhD, also in mechanical engineering, in 1956. His thesis topic was the interaction of turbulence with shockwaves, and he worked with Frank Marble (NAE 1974, NAS 1989); they formed a close relationship that lasted throughout their careers.

Doctorate in hand, Jack went to Oak Ridge National Laboratory as a research engineer, but he returned to Caltech 2 years later as a senior research fellow. In 1960 he joined MIT as an assistant professor. When he applied for the position, he was courted by three departments: Aeronautics and Astronautics, which he joined, Mechanical Engineering, and Nuclear Engineering. Reportedly, the dean called the three department heads together and told them, “I don’t care which of you get him, but I’m not letting you bid against each other. I’m writing the offer.”

Jack spent his very fruitful career at MIT, aside from two stints away from the campus. Promoted to associate professor in 1962 and to full professor in 1965 (a rapid rise indeed), he founded the Space Propulsion Laboratory in 1962 and directed it until 1976, when it merged with the Gas Turbine Laboratory, of which he had become director in 1968. He was named the R.C. MacLaurin Professor in 1975, and in 1978 he accepted the role of head of the Department of Aeronautics and Astronautics. He also served MIT as associate and then acting dean of engineering. From 1983 to 1985 he was on leave from MIT as the NASA associate administrator for aeronautics and space technology, and he spent a year at Caltech as Sherman Fairchild Distinguished Scholar (1990–91).

He supervised 85 PhD and MS theses at MIT, sharing his love of, and enthusiasm for, propulsion and energy conversion with several generations of students. He was a mentor to faculty as well, including the authors.

Contributions to Space Power and Propulsion

Jack's work on nuclear space propulsion started when he went to Oak Ridge in 1956. There he conceived of the gas core nuclear rocket engine. Major challenges to the concept were fluid instabilities and vortex containment. His physical insight and mathematical prowess in these areas were later applied to many aeropropulsion and power fields.

In the early 1960s there was great enthusiasm for MHD generators for aerospace applications. At MIT he conceived of the nonequilibrium MHD generator and demonstrated it in a large-scale experiment. He later extended this concept to nonequilibrium MHD lasers, also demonstrated at MIT. He returned to space propulsion in the early 1990s, studying flow instabilities in particle bed nuclear reactors for space propulsion.

Contributions to Gas Turbine Technology

Jack's important contributions to gas turbine technology include basic conceptual features of compressor phenomena. One of these, referred to today as the Kerrebrock-Mikolajczyk effect, concerns the behavior of wakes in compressors, specifically the transport of a wake across a turbomachinery blade passage. It is the type of analysis that (i) can be explained, as he did, by simple geometric construction and that (ii) causes one to say "Of course—why didn't *I* think of that?" It resolved a widespread mystery that lurked in compressor data, and there were sessions devoted to it at technical meetings for some years, for turbines as well as compressors.

His paper explaining the effect[1] received the American Society of Mechanical Engineers (ASME) Gas Turbine Award (1970) for best gas turbine paper of the year. Another, very different, metric for the paper was that the MIT AeroAstro Department's doctoral exam used to have a section in which the students read a paper and then explained the ideas and conclusions to the examining faculty. We took considerable care in our choice of papers in terms of readability, ideas, intellectual nuggets (a Kerrebrock term), and importance, and Jack's paper was a charter member of this select group.

Jack's invention of the blowdown compressor pioneered the use of transient testing techniques to obtain data on transonic compressor behavior in a rapid and low-cost manner, without the large (several thousand horsepower) motors and other infrastructure used in industry and government laboratories. It made possible the investigation of aeroengine turbomachinery, at realistic conditions, in a university setting. The facility, and the results obtained from it, was the forerunner of a blowdown turbine later developed at MIT by one of the authors (AHE), and then, in a larger incarnation, a transient turbine facility commissioned at the Air Force Research Laboratory.

An important part of Jack's research included experiments on turbomachinery aeromechanics, particularly flutter, another topic not previously accessible at a university. To do the unsteady aerodynamic and aeromechanic experiments, he had to develop his own high-frequency response measurement techniques based on semiconductor pressure transducer technology, but he saw that as part of the challenge—and the fun. For some years, therefore, in contrast to the photographs in our department brochures of faculty looking directly into the camera, the photo of Jack was of the back of his head as he stared into a microscope while crafting the miniature probes he had designed.

[1] Kerrebrock JL, Mikolajczyk AA. 1970. Intra-stator transport of rotor wakes and its effect on compressor performance. *ASME Journal of Engineering for Gas Turbines and Power* 92(4):359–68.

Jack was the first to recognize and describe the coupling of different fluid dynamic disturbances that occurs because of the swirling flows inherent in turbomachinery and that creates (heretofore undescribed) three-dimensional motions. His paper on the topic,[2] when one of us read it in the mid-1970s, seemed a whole new way of thinking about inlet distortion in turbomachines, a departure from the two-dimensional analyses that were then the standard. As with wake transport, there was a clear and bright light of a new idea being presented, the essence of which Jack could sum up in one or two sentences (although the resulting algebra giving the detailed scientific explanation was not for the faint of heart—another type of Kerrebrock trademark tour de force that can be traced back to his PhD thesis). The ideas in his paper helped greatly in defining new research on this topic.

In later years Jack was the originator of vaporization cooling, a scheme to allow turbine blades to operate at a nearly uniform temperature, and of the aspirated compressor. In connection with the former, his work on heat transfer in internal passages, recognized by the ASME International Gas Turbine Institute as the best heat transfer paper of the year,[3] provided a first-of-a-kind clarification of the mechanism responsible for the heat transfer coefficients observed in rotating blade rows. The latter concept—involving the use of strategically designed suction (i.e., aspiration) to control the behavior of the viscous flow in compressor blading, thereby permitting higher aerodynamic loading and thus fewer stages than conventional compressors—was experimentally confirmed at MIT and then at NASA.

Contributions to Engineering Education

Beyond his eminence in research, Jack shone as an engineering educator. His gas turbine engine textbook, *Aircraft Engines and*

[2] Kerrebrock JL. 1977. Small disturbances in turbomachine annuli with swirl. *AIAA Journal* 15:794–803.

[3] Bons JP, Kerrebrock JL. 1999. Complementary velocity and heat transfer measurements in a rotating cooling passage with smooth walls. *ASME Journal of Turbomachinery* 121(4):651–62.

Gas Turbines (MIT Press, 1st ed., 1977; 2nd ed., 1992), is used around the world as the reference book of choice, setting the standard for rigorous exposition of gas turbine phenomena and their impact on design. It reaches beyond fluid mechanics to include other important aspects of the technology, such as structural design, aeromechanics, noise, and rotor dynamics. One of its strengths is treating propulsion as a system rather than a set of individual disciplines.

In person at MIT, his classes drew rave reviews from undergraduate and graduate students. The latter invariably finished their research excited about their work and enormously pleased to have had the opportunity to work with him.

In addition to Jack's gas turbine teaching, in the mid-1970s he and two MIT colleagues, Gene Covert (NAE 1980) and Jim Mar (NAE 1981), invented unified engineering, a new approach to undergraduate aerospace education that integrated and brought together four main aerospace disciplines. The subject carried twice the credit of a typical course and was thus roughly half the academic load of a typical student; it was given to the whole second-year class as a cadre. "Unified," as it is simply called, has been the foundation of the aeronautics and astronautics undergraduate curriculum for over 4 decades.

Jack's commitment to undergraduate education was also evident in the fact that he was asked to teach the undergraduate propulsion subject in the spring 2001 term before he "retired" (in name, but not in fact). In this last class at MIT, he received the Undergraduate Teaching Award given by the students.

His educational leadership extended beyond the classroom. As head of the Gas Turbine Laboratory, head of the Department of Aeronautics and Astronautics, and dean of engineering, Jack did much to maintain gas turbine engineering at the forefront of the department's engineering curriculum.

He was also the faculty leader of the department's Daedalus Project, a human-powered aircraft that, on April 23, 1988, flew 72.4 miles (115.11 kilometers) in 3 hours, 54 minutes, from Heraklion on the island of Crete to the island of Santorini. Daedalus still holds the world record for human-powered flight. The culmination of a decade of work by MIT students and alumni, the flight was the capstone of a wonderful experience for faculty, staff, and students, and it made a major contribution to the understanding of the science and engineering of human-powered flight.

Leadership in the Broader Aerospace Community

As the associate administrator for NASA Aeronautics and Space Technology, as well as in his many roles as an advisor to the government, Jack had an invigorating influence on national aerospace policy and played a key role in maintaining support for NASA aeronautics R&D.

He was a valued and sought-after advisor and consultant for both industry and government on broad policy and challenging technical barrier engineering issues. An illustrative selection of his service includes the National Commission on Space (a presidential committee), and many committees as part of the US Air Force Scientific Advisory Board, for which he chaired the ad hoc Committee on the Aeropropulsion System Test Facility, Science and Technology Advisory Group AF Systems Command, and Division Advisory Group of the Aeronautical Systems Division. For NASA, he served on the Space Station Advisory Committee and Advisory Board for Aircraft Fuel Conservation Technology. He was also a member of the Defense Science Board Task Force on National Aero-Space Plane Program.

For the National Academies and National Research Council, Jack was active in volunteer service as a board, committee, and panel member and chair. For example, he chaired the Committee on Hypersonic Technology for Military Applications (1987–88), Committee on the Space Station (1991–94), and Aerospace Industry Panel (1998–2000) of the Committee on Impact of Academic Research on Industrial Performance (on which he served as a member, 1997–2000). He was also vice chair of the Engineering Research Board (1984–86) and a member of the Committee on Aircraft and Engine Development Testing (1984–86), Committee on Requirements for Advanced Space Technology (1989–92), Committee on

Strategic Assessment of Earth-to-Orbit Propulsion Options (1991–92), Aeronautics and Space Engineering Board (1992–94; chair, 1994–95), and Committee on Engineering Challenges to the Long-Term Operation of the International Space Station (1998–2000), among others.

Characteristically, Jack viewed his role as not merely to critique programs and policies but to directly address and solve the problems (technical and organizational), cutting to the root difficulty of complex systems and pointing out elegant, often simple, solutions. He was noted for his insight and wisdom about complex problems, his high level of integrity, and as someone who would have a substantial positive effect on a wide variety of programs.

His contributions were recognized by a number of awards and honors, in addition to his election to the NAE. These include membership in the American Academy of Arts and Sciences and designation as an honorary fellow of the American Institute of Aeronautics and Astronautics (AIAA), AIAA Dryden Research Lecturer (1980), Sherman Fairchild Distinguished Scholar (Caltech), Distinguished Alumnus (Caltech), and honorary professor at Beijing University of Aeronautics and Astronautics (he was pleased that he was Number 007). After the 1970 ASME Gas Turbine Award, he received the Air Force Exceptional Civilian Service Medal (1981), NASA Exceptional Service Medal (1983), and 1992 AIAA Leland Atwood Award (for educational contributions).

Mentoring and Impact on Others

Jack hired both of the authors at MIT. One was a former student of his who used the opportunity to move into new areas, just as Jack had done. The other came from industry with no knowledge about how a university worked, let alone what he was supposed to be doing. From the beginning, Jack encouraged both of us, provided guidance about choice of research topics, and made sure that opportunities were given. The takeaway is that, no matter what the initial conditions, Jack was a thoughtful, encouraging, and immensely effective mentor.

This description of Jack is heard over and over from the numerous faculty and students that he helped, mentored, and encouraged over the years. The details may be different, but the overall result and the outpouring of gratitude for his help are invariant. One of his legacies is that many of his students have become leaders in government, industry, and academia. By the authors' count, at least 10 members of the NAE consider Jack a mentor and major influence on their careers.

In this context, one of Jack's great strengths was his focus on people. He had the gift of focusing on the individual. The person he was with at the time, no matter how junior, felt that Jack was really there for him or her, and he was. Also, from what appeared to be a casual chat, Jack could determine that a prospective graduate student from a not very highly ranked institution, or one with a less than stellar record, had the potential to excel at MIT. He then advocated for, and mentored, the student who might not otherwise have been admitted or prospered. In the hothouse of the MIT meritocracy, Jack was unusual in accepting people as they were, not as he (or others) might have wished them to be. A student with the ability to perform at only a B or C level was given as much attention, encouragement, and appreciation as an A+ superstar.

Inventing

Jack was a prolific inventor whose creations spanned the gamut from the everyday to the profound. In addition to those described above, examples include the Kerrebrock tractor, which he invented with his father and brother while in high school. It had a very narrow track, and a cursory search reveals several websites describing the tractor, one of which contains the quote: "That has to be the coolest tractor I have ever seen."

He also came up with numerous improvements to sailboats, combining two of his passions, sailing and inventing. His boats always had unusual, custom enhancements, many of them not obvious to the casual observer (and later removed as experience trumped enthusiasm).

Activities Outside Technology

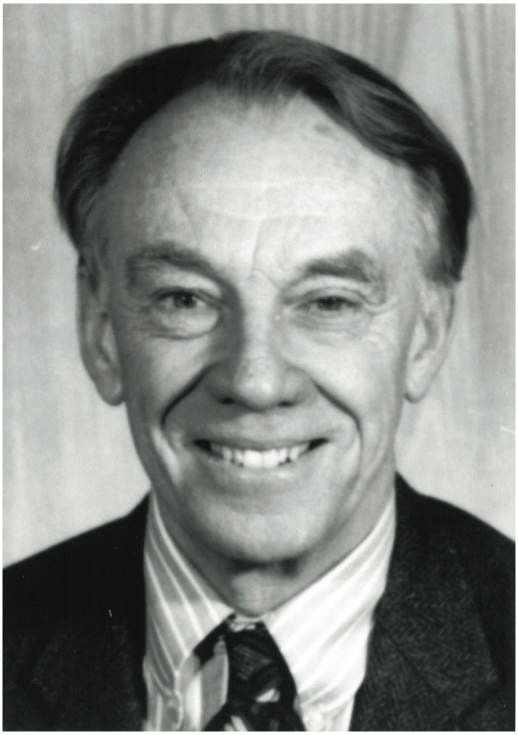
This tribute would not be complete without at least a brief mention of Jack's enthusiasm for the outdoors. He was perhaps never happier than when climbing a mountain, hiking a wilderness trail, or leading a group of youngsters through ice and snow to teach them independence and survival skills. His outdoor contributions earned him fellowship in the Explorers Club. He ran his first Boston Marathon in his early 50s on a whim and with no special training, and followed that with several more, including the Marine Corps Marathon in Washington, DC. He was still hiking in the White Mountains in his late 70s.

Jack's first wife, Vickie, passed away in 2003 after 50 years of marriage, and Jack married Rosemary "Crickett" (Keough) Redmond in 2007. Jack and Crickett traveled widely, to South Africa, Scotland, Tuscany, Paris, and a special trip to Cape Canaveral for one of the last space shuttle launches, where he was able to introduce Crickett to one of her heroes, Neil Armstrong.

In addition to Crickett, Jack leaves behind two children, Nancy Kerrebrock (Clint Cummins) of Palo Alto, and Peter (Anne) Kerrebrock of Hingham, MA, and five grandchildren. He was preceded in death by his son Christopher. He also is remembered fondly by the Redmond children, Paul J. Jr. (Joe Palombo), Kelly (Philip Davis), Maura, and Meaghan Winokur (James), and their two children.

Jack would occasionally tell the story of his work in a machine shop in high school, turning steel stanchions for Navy destroyers. He cranked up the lathe speed until the tool glowed red, to make his parts as fast as possible. An older machinist came over, put his arm around Jack's shoulders, and said, "Look around, nobody else goes this fast, what's your rush?" Jack never did slow down—as an engineer, a teacher, a human being.

The authors feel privileged to have had Jack Kerrebrock as a colleague, a role model, a mentor, and a friend. He changed our lives.



JUSTIN E. KERWIN

1931–2021

Elected in 2000

"For research and development of computational methods used in propeller design and in the prediction of sailing yacht performance."

BY DAVID S. GREELEY, SPYROS A. KINNAS, AND J. NICHOLAS NEWMAN

JUSTIN ELLIOT KERWIN, emeritus professor of naval architecture at the Massachusetts Institute of Technology and a pioneer in the development of computational methods, died at his home in Rockport, Massachusetts, on May 23, 2021. He was 90.

Known as Jake to his friends, colleagues, and students, he was born in New York City on March 24, 1931. His father, Matthew Kerwin, was an executive in the Standard Fruit and Steamship Company and his mother, Carlotta (Service) Kerwin, was a homemaker. The family lived in the Hague and London before World War II and then returned to the New York area. His uncle also worked in the shipping industry and owned a small schooner that Jake sailed on when he was young, inspiring his choice of a career in naval architecture.

He received his SB degree in 1953 from MIT, where he was a member of the varsity sailing team. This required a substantial commitment of time sailing on the Charles River and at other colleges and universities, but he was an outstanding student. He stayed for another year to get his master's degree, followed by a year as a Fulbright scholar at Delft University of Technology. After serving for 2 years as an officer in the Air Force, overseeing the design and construction of rescue boats, he returned to MIT as an instructor and part-time graduate student.

His return to MIT in 1957 coincided with the installation of an IBM 704, a mainframe computer given to MIT for general use. This was also when the first Fortran compiler was released, making it much easier to develop programs for engineering applications. After a short programming course Jake became one of the first users of the 704 and one of the first naval architects to take advantage of programmable computation. In addition to applying this technology in his research, he developed and taught a new subject devoted to numerical analysis and programming in the Department of Naval Architecture and Marine Engineering.

Jake received his PhD in 1961, with his thesis on "The solution of propeller lifting surface problems by vortex lattice methods."[1] Most of his subsequent research focused on propeller hydrodynamics, including analytical, experimental, and numerical aspects.

The blades of marine propellers are lifting surfaces with moderate aspect ratios and complex geometry. They rotate in nonuniform inflow fields, resulting in substantial unsteady effects, often accompanied by intermittent cavitation. These complications were included by Jake as his theories and programs evolved. He was the first to analyze them in a general unsteady manner in the time domain. In later work he treated more complex propulsors, including contrarotating propellers, stator/rotor combinations, ducted propellers, and waterjets.

He supervised innovative experiments in the MIT Marine Hydrodynamics Water Tunnel to guide and confirm theoretical and numerical developments. Measurements of the flow around propellers were made using laser Doppler velocimetry and led to better understanding of the trailing wake behind propellers and improved predictions of performance at off-design conditions. Studies of the flow around a stator/rotor combination confirmed the greater efficiency of this arrangement. In a "flapping foil" experiment measurements were made of the unsteady field around a stationary foil that was subject to the time-varying flow caused by two smaller flapping

[1] Available at https://apps.dtic.mil/sti/pdfs/AD0262648.pdf.

foils upstream. The latter results were used by several research groups to validate their computational techniques.

Jake and his students became the principal developers of propeller design and analysis techniques and related software, with funding from the Navy and other organizations. Their work provided computational solutions to practical problems that hitherto could only be analyzed based on physical experiments and measurements. The codes they developed are known for their robustness, accuracy, and computational efficiency and are used for propeller designs by the US Navy and industries worldwide.

He also applied his computational expertise to other problems in the field of naval architecture. One of his first papers was on the use of bivariate polynomials to represent the geometry of ship hulls.[2] Later he made extensive use of B-splines, not only for the geometry but also to represent the fluid velocity field; the resulting programs were more accurate and efficient, and better suited to integration with commercial CAD/CAM codes.

Jake was a partner in a small consulting company that developed software and performed routine hydrostatic calculations for naval architects and shipyards, before the time when they acquired their own computers.

In the 1970s he collaborated with one of us (JNN) on a research project to improve the handicap systems for sailing yachts in ocean races. One of the principal accomplishments was a velocity prediction program (VPP), in which the hydrodynamic forces on the hull and aerodynamic forces on the sails are balanced to predict the yacht's performance for a given wind velocity and direction. This requires a multidimensional optimization of the sails and orientation of the boat to maximize the velocity in the prescribed direction. In this program Jake was able to apply his sailing experience as well as his expertise in lifting surfaces and computing. The VPP revolutionized both the handicap systems used for

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[2] Kerwin JE. 1960. Polynomial surface representation of arbitrary ship forms. *Journal of Ship Research* 4(1):12–21.

ocean races and the optimization of sailboat designs by naval architects.

Jake served on the faculty at MIT for 41 years, teaching and mentoring numerous students and postdocs. Many are now leaders in their field in the United States and other countries. He retired as professor emeritus in 2001 but remained an active consultant to the Navy until 2017.

He was honored with the David W. Taylor Medal from the Society of Naval Architects and Marine Engineers (1992) "for notable achievements in naval architecture" and the Gibbs Brothers Medal (1998) from the National Academy of Sciences "for his outstanding contributions in the field of naval architecture, including the development of computational methods used worldwide in propeller design."

His keen interest in sailing continued throughout his life. His first boat was a 24-foot sloop that he assembled from a kit and raced in southern Massachusetts. His crew usually included graduate students. Later he bought a larger boat, which he owned for 50 years, racing and cruising with his family and students. He applied his engineering knowledge and craftsmanship to many boat projects.

Jake married Marilyn Peterson in 1969. Their daughter Melinda is a social worker and musician. Their son John is a systems engineer working on the development of medical devices. After Jake retired, he and Marilyn started a Dixieland jazz group with other retired MIT colleagues in ocean engineering, he on the piano and she on bass. The Ancient Mariners, as the group was called, played gigs throughout New England and as far away as Austin, Texas, often accompanied by Melinda on the fiddle. Sadly, and unexpectedly, Marilyn died less than a month after Jake.


2 5 '86

MAKOTO KIKUCHI (菊池誠)

1925–2012

Elected in 1987

"For pioneering contributions to research on semiconductor devices, and for leadership in introducing advanced semiconductor work into Japanese industry."

BY RUSSELL D. DUPUIS

MAKOTO KIKUCHI was born in Tokyo on December 6, 1925, and died, at age 86, on November 6, 2012. His father, Toyosaburo Kikuchi, was vice minister in the Ministry of Education and became president of Yokohama Municipal University. His mother often took her young son—at his request—to the National Science Museum in Ueno; as he explained, "I was extremely interested in the activities of scientists—not the science itself…. The most interesting thing for me was what the scientists were doing: experimenting, thinking, making some failures, and finally getting to [a] more correct understanding of the nature of things…. That is not only the fundamental activity of scientists but the fundamental activity of human beings."[1]

In Kikuchi's early education, he focused on literature, philosophy (including Goethe, Kant, and Hegel), and European art. In middle and high school, he learned to read German and French. During World War II, his family had to move twice because their home was destroyed by bombings.

[1] This and other quotations are from an oral history conducted May 27, 1994, by William Aspray, IEEE History Center, Piscataway, NJ, USA (https://ethw.org/Oral-History:Makoto_Kikuchi). The IEEE History Center has a collection of more than 800 oral histories in electrical and computer technology which can be accessed via http://ethw.org/Oral-History:List_of_all_Oral_Histories.

Food became scarce, but the family survived and he continued his education after the war.

He entered the University of Tokyo in 1945 to study physics. After graduating in April 1948, he took a research position in the newly established physics department of the Ministry of International Trade and Industry's Electrotechnical Laboratory (ETL) (now the National Institute of Advanced Industrial Science and Technology) and devoted himself to semiconductor research—an area that experienced a dramatic upswing after the announcement that same year of the invention of the transistor.

The scientists at ETL learned of the demonstration of the transistor from General Douglas MacArthur's headquarters and from the July 12, 1948, issue of *Time* magazine. A small group of about 10 researchers and technicians formed to begin investigations of the exciting new device. Although their work was hampered by the unavailability of pure semiconductors (e.g., germanium [Ge] and silicon [Si]), availability of only basic electronic equipment, and very limited access to technical articles describing the rapid developments in transistor technology, the highly motivated group persevered to educate themselves. Eventually Kikuchi developed a process for the creation of point-contact transistors, first with Si and then with Ge.

In 1960, invited by Jerome Wiesner (NAE 1966, NAS 1960), he was a visiting scientist in the research laboratory for electronics at the Massachusetts Institute of Technology. There he had better access to the latest publications on transistors and electronics and also began to take notice of the differences in how research organizations worked in the United States compared to Japan. During his many subsequent US trips (almost every year), he visited industrial electronics labs such as those at General Electric, RCA, and Bell Telephone Laboratories. During one such visit to Palo Alto, William Shockley offered him a position in his company; Kikuchi declined because he wanted to devote his efforts to improving the competitiveness of the electronics industry in Japan.

He eventually became a research manager at ETL but found the bureaucracy at the government laboratory more and more oppressive (as he put it, “Bureaucracy [is] the enemy of research activity.”). Also, he enjoyed the technical interactions with his research teams, which was more than management typically had with their teams at ETL. And finally, after 26 years working for the government, he wanted to broaden his experience to gain a new viewpoint with a greater range of ideas.

In 1974 he resigned from ETL and joined Sony Corporation—after being aggressively recruited by its president and cofounder, Masaru Ibuka (NAE 1976). As director of the central research laboratory Kikuchi was exhilarated by the company’s dynamic technology environment and rapid decision making, led by Ibuka and Sony’s other cofounder, vice president Akio Morita. For example, when Kikuchi wanted to develop the ion implantation process for silicon devices at Sony he needed approval for the purchase of equipment at a cost of about ¥100 million. He explained the need for the investment in a 17-minute exchange with Ibuka and Morita and it was approved on the spot.

Kikuchi was also instrumental in Sony’s development of the silicon charge-coupled device (CCD). After he and his research team greatly improved the CCD performance, he was instructed by Kazuo Iwama, the new vice president of Sony, to transfer the project from the research lab to production at the company’s Atsugi factory. Although Kikuchi initially questioned the transfer of the technology he and his staff had painstakingly nurtured, this turned out to be the right move as it became very successful for Sony and its CCD-based digital cameras and professional video systems.

In addition, Kikuchi championed the company’s development of III-V compound semiconductor materials and devices. He made the early choice to focus III-V materials development on metalorganic chemical vapor deposition (MOCVD) for compound semiconductor device production.

In 1984, after many years fostering the development of key technologies, including the semiconductor laser for the compact versatile disk (DVD), Kikuchi became managing director of Sony. In this role he recognized that managers needed to appreciate the technological importance of both revolution and evolution, that the "maturing of technology…[was] far more important than simply product development."

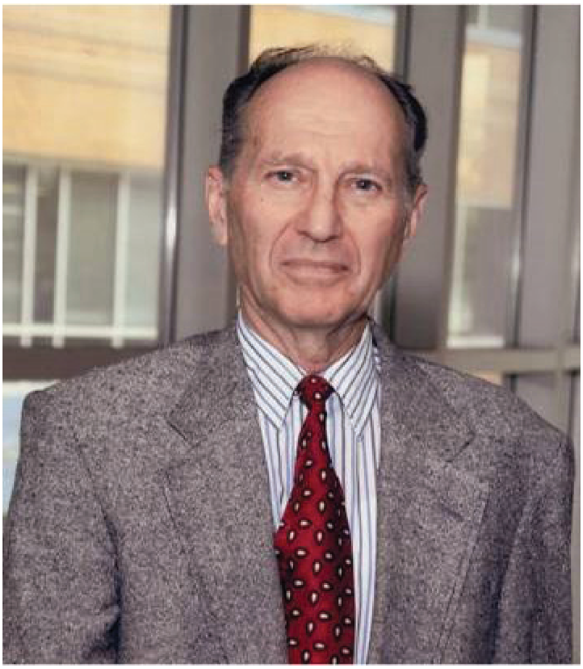
Then in 1990 he expanded his influence and experience as a professor in the Faculty of Technology at Tokai University, where he was designated in 2000 an honorary visiting professor, as he continued work with Sony as executive technical advisor and director of the Sony Education Foundation.

Besides many technical papers, he authored *Story of Semiconductors—Physics and Applications* (NHK Books, 1967), *Japanese Electronics—A Worm's Eye View of Its Evolution* (International Specialized Book Services, 1st ed., 1983; Simul International, transl.), *Japanese Semiconductors—Its 40 Years* (Chuko-Shinsho Publishing Co. Ltd., 1992), and *Semiconductors* and *Semiconductor Theory and Application—Half a Century History* (Shokabo Co. Ltd.). He also wrote a number of essays, such as "My Friends, Let's Talk about Science for the Future of the Younger Generation" (Kogaku-Tosho Publishing Co. Ltd., 2003).

In addition to his election to the NAE as a foreign member in 1987, he received the Kanagawa Culture Award in 1994. The award is presented to individuals (or groups) whose remarkable achievements have contributed to the improvement and development of the prefecture's culture.

Kikuchi was a pioneer of the semiconductor industry in Japan and his contributions to physics, technology, and the management of technology are still felt today. He is well known in Japan, Europe, and the United States for his efforts to improve worldwide technical interactions through international exchanges and to deepen relationships by fostering communication and collaborations and through educational activities. He had many friends throughout the world who remember his warm personality and technical insights.

He is survived by son Tsuneo Kikuchi. His wife Taeko Kikuchi died in 2016, and a younger son, Hiromi, died in 2019.



ROBERT M. KOERNER

1933–2019

Elected in 1998

"For the design and use of geosynthetics in the constructed environment."

BY DAVID E. DANIEL AND RUDOLPH BONAPARTE

ROBERT MICHAEL KOERNER, a guiding force and preeminent leader in civil engineering, died December 1, 2019, at the age of 85.

He was born December 2, 1933, in Philadelphia, the son of Michael H. and Cecilia (née Grahammer) Koerner. The family moved to Upper Darby, Pennsylvania, when Bob was 3 years old; the neighborhood was full of families and children, and Bob was very active in a variety of improvised outdoor games.

He attended West Catholic High School for Boys and chose the science curriculum. Upon graduation in 1951, he enrolled in the Drexel Institute of Technology (renamed Drexel University in 1970) and selected engineering as his major. The school's co-op program, where students studied for 6 months and worked for 6 months, was appealing to Bob. His first job in the co-op program was with a local water company where he conducted surveys to install underground water pipes. This introduced him to civil engineering, which would become his life's work. Subsequent assignments provided experience in the heavy construction industry and foundation engineering.

Bob graduated from Drexel in 1956 with a BS in civil engineering and went to work for 4 years at the James J. Skelly Company in New York City, rising quickly from assistant superintendent to the responsibility of construction superintendent of a 1½-mile-long section of the Cross Bronx Expressway.

He attended Columbia University for graduate work in the evenings. There he became acquainted with Prof. Donald Burmeister, who was well known in the field of soil mechanics and foundation engineering.

A series of construction-related jobs subsequently took Bob back to Philadelphia, where he met the love of his life, Pauline (Paula) W. Feuerer, at a Christmas party on December 25, 1958. They began dating, were married November 15, 1959, in Narberth, and started a family: Michael (1960), George (1962), and Pauline (1964).

The heavy construction work Bob was involved with at the time was dangerous, and he was badly injured on more than one occasion. The combination of a young family, the dangers of the construction industry, and Bob's own technical interests led him to contemplate a career shift, first to consulting with Dames & Moore and then to academics.

He took graduate courses at Drexel, where he earned his MSCE degree in 1963, and became keenly interested in foundations.[1] He decided to pursue a PhD in geotechnical engineering at Duke University beginning in 1965, conducting research under the guidance of Alexander S. Vesic. He obtained his degree in 1968 and returned to Philadelphia to teach soil mechanics and foundation engineering at Drexel beginning that September.

His first research grant, from the National Science Foundation, was related to deep foundations, but, working with colleagues at Drexel and especially with physicist Art Lord, Bob's interests shifted to emerging fields, including use of acoustic emission sensing techniques. Interest in acoustic emissions to detect phenomena such as cracking in soils, rocks, and concrete was intensifying among entities such as the US Bureau of Reclamation and US Army Corps of Engineers. The Environmental Protection Agency also became interested in

[1] He also studied law at Temple University (1963–64).

acoustic emissions and other nondestructive testing methods to locate buried drums containing waste.

Bob was promoted to associate professor at Drexel in 1971 and to professor in 1975. By 1978 his and Lord's research on acoustic emissions had advanced to a point that they were recognized as Researchers of the Year at Drexel. Bob was appointed H.L. Bowman Professor of Civil, Architectural, and Environmental Engineering from 1984 until his retirement in 2003, at which time he was designated the Harry L. Bowman Professor of Engineering Emeritus.

Notwithstanding his significant research contributions related to acoustic emissions and other topics, Dr. Koerner is best known for his research, contributions, and leadership in the field of geosynthetics engineering. By 1978 he had become interested in synthetic fabrics that might be used in geotechnical engineering applications, an interest piqued by several consulting jobs that involved subsurface filtration and drainage problems. He invited several speakers from industry to come to Drexel to talk about use of this new engineering material, then called "filter fabrics," in the subsurface.

At about the same time a friend, Joe Welsh of Intrusion Prepakt Co. (later Hayward-Baker Co.), told Bob that a publisher was interested in developing a book on the use of synthetic fabrics in civil engineering projects, and asked if Bob would be interested in writing such a book with him. Bob agreed, and the resulting book, *Construction and Geotechnical Engineering Using Synthetic Fabrics* (John Wiley and Sons, 1980), literally changed Bob's life. He was inundated with inquiries about this new engineering material.

He became immersed in researching and understanding the material that would soon be called "geosynthetics" and the new engineering discipline of "geosynthetics engineering." He taught six American Society of Civil Engineers (ASCE) courses on these subjects (1979–82), engaged in numerous industry-sponsored projects to test the new materials and develop design methods for them, taught the world's first formalized course on the subject in 1982, and authored or coauthored 15 papers on the topic in a 3-year period. In fact, Bob was a prolific writer. During his career he authored or coauthored 13 books, 20 book chapters, 186 refereed journal papers, 205 conference proceedings papers, and 120 other papers. He was also the editor of 27 conference proceedings.

His geosynthetics-related research accelerated quickly, as did research around the United States and worldwide. In the early 1980s much of the research was driven by new environmental regulations requiring that waste containment landfills and impoundments be underlain by geomembrane liners. As the engineering of these waste containment facilities became much more sophisticated and detailed, Bob pioneered the use of geosynthetic materials in them for liquid conveyance and drainage, filtration, and structural strengthening.

The geosynthetics field continued to evolve rapidly, with the development of new and better materials, testing and design methods, and the accumulation of lessons learned from constructed projects and sometimes field failures. When the Koerner-Welsh book became outdated, Bob pressed ahead with a more comprehensive volume: *Designing with Geosynthetics* (Prentice-Hall Publishing Co., 1986). This book exceeded all expectations and became the engineers' standard reference for information about geosynthetic materials, applications, and testing, analysis, and design methods.

Bob rigorously applied an essential principle in his writing: provide engineers with credible, theoretically sound, and fact-based methods for testing, designing, and constructing with geosynthetics. He fought against the propensity by some to view geosynthetics as a commodity, and insisted on a rigorous engineering approach in the selection of materials and design applications. The right way, he advocated, was to embrace and apply sound engineering principles. His leadership raised the standard of the profession and is one of his enduring contributions to it. *Designing with Geosynthetics*, now in its sixth edition, remains the seminal publication in geosynthetic engineering.

To better organize the rapidly evolving and growing discipline, Dr. Koerner decided to form a research institute in 1986, which by 1989 had become the Geosynthetic Research Institute (GRI). To accommodate a tremendous appetite among engineering designers for up-to-date information about designing with geosynthetics, he launched a series of short courses that took him, armed with multiple carousels of 35 mm slides, to locations across the country and around the world.

One of Bob's short courses took place October 29–30, 1986, in San Francisco, and was attended by Henry Haxo of Matrecon and Bob Landreth of EPA. At the time, EPA was beginning to require the use of geomembrane liners for hazardous waste landfills and impoundments, and Landreth, working out of the agency's Cincinnati Lab, was responsible for oversight of its research program. Haxo was the leading independent researcher investigating the chemical compatibility of geomembrane liners with the types of chemicals found in hazardous waste landfills and impoundments.

EPA realized the importance of sound engineering of the type advocated by Dr. Koerner. Thus began about 3 decades of steady research collaboration between GRI and EPA. This research formed the basis for development of new materials, new testing and design methods, and improved regulations for use of geosynthetics in EPA-regulated facilities. Some of this EPA-sponsored research was conducted in partnership with the authors of this tribute and led to publication of several EPA technical guidance and research documents as well as the book *Waste Containment Facilities: Guidance for Construction, Quality Assurance and Quality Control of Liner and Cover Systems* (ASCE Press, 1995).

What was unique about GRI was both the breadth of companies and institutions that supported it financially through annual commitments and the many years this support was maintained. At universities, the difficulty of sustaining industry support is well known—universities tend to be best at long-term, basic research; industry, on the other hand, usually needs immediate answers to pressing challenges. Bob managed to earn the support of nearly all the major geosynthetic manufacturers, despite the fact that he was sometimes researching problems with their materials. But he always approached a problem looking for a practical solution. If there was a problem with a certain type of geosynthetic material, he would study it and find a way to improve the material or find an alternative approach to resolve the problem. He would never ignore a significant problem—rather, he would apply the full force of his formidable team and research facilities to solve it.

His annual conferences became "must attend" events for anyone who wanted to keep abreast of the latest developments in the rapidly maturing field of geosynthetic engineering. The impact of GRI became so broad that Bob decided in 1998 that it was time to take the institute off the Drexel campus. He renamed GRI the Geosynthetic Institute (GSI) and moved it to a location near the Philadelphia airport where it could better serve the industry's changing needs, which had grown well beyond research alone.

GSI maintained a robust research capability with in-house equipment and through its ongoing connection to Drexel University, principally through Dr. Grace Hsuan, who was deeply involved in many of GRI's and GSI's most important projects. Over several years, GSI expanded its range of services to include accreditation of commercial geosynthetic testing laboratories, development of materials and specifications, training, and other services. By 2019, more than 73 organizations supported GSI, representing a broad range of geosynthetic manufacturers, installers, engineering consultants, and government agencies that use, design, test, or specify geosynthetics.

The geosynthetics industry was in its infancy when Dr. Koerner first became engaged in 1986; today it generates revenues for the materials alone in excess of $2 billion per year. The primary application areas of geosynthetics include highways, retaining walls, soil slope reinforcement, landfill and impoundment linings and cover systems, subsurface contaminated groundwater barrier walls, canal linings, erosion control systems, and waterproofing for dams and tunnels. The engineering functions provided are separation, reinforcement, filtration, drainage, and containment.

Bob had a special passion for education, engineering, and Drexel University. He was a teacher at heart, gifted with not only clarity of thought but also a unique ability to draw and illustrate in ways that made complex issues understandable. The Koerner Family Foundation is a permanent reflection of his commitment to education; it provides generous fellowships to students pursing advanced degrees in engineering.

Dr. Koerner received many honors for his work. In addition to his election as a member of the National Academy of Engineering and as an ASCE distinguished member, he was recognized as Philadelphia Civil Engineer of the Year (1989), designated an honorary member of the International Geosynthetics Society (2008), and selected for no fewer than 19 invited lectureships around the country and the world. He was also elected president of the Philadelphia Section ASCE (1975–76) and North American Geosynthetics Society (1989–91).

Bob's personal life revolved around two activities: running and time with family. His passion for running did not take root until he was 40 years old, when he began running with his sons Michael and George. This carried on for years and came to include daughter Pauline's husband, Doug, and innumerable marathons. At technical conferences, Bob would invite anyone within earshot to join him for a run before breakfast. That a man so full of energy would choose running as a pastime comes as no surprise—in a sense, he was always running, at everything he did.

Bob was a very engaging, friendly, and caring person. It has been said that he could get a group of strangers conversing with one another faster than anyone else. This characteristic was one of his most wonderful attributes for which so many will remember him. At countless conferences and meetings, a small group of people would assemble around Bob. He would start a conversation on a topic and a very lively discussion would take off from there. He had a way of bringing out the best in those around him, whether students or professional colleagues. He also was a very caring person. He and Paula hosted many visitors in their home and always made sure that social events were rich in conversation and laughter.

Paula, who also died December 1, 2019, was as remarkable as Bob. She not only took the lead in raising their children while Bob worked and attended school, but also played a very active role in the GRI and GSI. She helped to manage finances, communications, and events, often traveling with Bob. It is impossible to imagine Bob without Paula at his side. The two were an inseparable team, equally beloved by all who came to know them.

Bob and Paula are survived by Michael (Mary), George (Jamie), and Pauline Limberg (Douglas), and six grandchildren.

PRABHA S. KUNDUR

1939–2018

Elected in 2011

"For contributions to modeling and control techniques to enhance the stability and reliability of large electric power systems."

BY VIJAY VITTAL

PRABHA SHANKAR KUNDUR, an outstanding electrical engineer, visionary leader in the development of analytical tools, and industry consultant, passed away at the age of 79 on October 9, 2018. He made significant contributions to the understanding of the dynamic behavior of large power grids, enabling better analysis and control to avoid large-scale blackouts and enhance power system stability and reliability.

Prabha was born in Bengaluru, India, on March 18, 1939. He obtained his BE degree from Mysore University in 1959, his ME degree from the Indian Institute of Science, Bengaluru, in 1961, and his MASc and PhD degrees from the University of Toronto in 1965 and 1967, all in electrical engineering. Upon completion of his doctoral studies, he returned to India to teach at Bengaluru University before accepting a position as analytical engineer at Ontario Hydro, Canada, in 1969.

During his nearly 25 years at Ontario Hydro, he held senior-level positions, as head of the Systems Controls & Transient Section and manager of the Analytical Methods & Specialized Studies Department in the Power System Planning Division. In 1993 he joined Powertech Labs Inc., the research and technology subsidiary of BC Hydro, where he served as president and CEO from 1994 to 2006, when he retired; he was responsible for leading the development, application, and commercialization of a variety of new technologies for the energy sector. In September 2006 he founded and was president of Kundur Power System Solutions Inc., in Toronto.

With a passion for mentoring and guiding engineers, Dr. Kundur served concurrently as adjunct professor at the University of Toronto (1979–2017), Western University (1991–99), University of British Columbia (1994–2006), and University of Manitoba (2006–17). And he wrote *Power System Stability and Control* (McGraw-Hill, 1994), a classic reference for those in both academia and industry. In addition, he provided extensive international consulting on power system planning and design as well as advanced technical courses for utilities, manufacturers, and universities around the world.

In the technical community, he was an active participant in the Power and Energy Society (PES) of the Institute of Electrical and Electronics Engineers (IEEE) and in CIGRE (International Council on Large Electric Systems). He was responsible for the development of several standards and a key document, jointly published by PES and CIGRE, that presented a classification and definition for power system stability.[1]

Dr. Kundur pioneered important developments that advanced stability analysis of the electric power transmission grid, beginning with his original doctoral work. His contributions include digital simulation and analysis of power system dynamic performance, application of power system stabilizers, development of tools for dynamic reduction of large power systems for dynamic studies, and spearheading the development of a suite of commercial software tools that comprehensively examined three critical aspects of power system stability behavior—small-signal, transient, and voltage stability. His work directly enhanced the reliability of the electricity supply.

He was well recognized for his contributions. He was an IEEE life fellow and winner of the IEEE's 1997 Nikola Tesla

[1] Kunder P, Paserba J, Ajjarapu V, Andersson G, Bose A, Canizares C, Hatziargyriou N, Hill D, Stankovic A, Taylor C, Van Cutsem T, Vittal V. 2004. Definition and classification of power system stability: IEEE/CIGRE Joint Task Force on Stability Terms and Definitions. *IEEE Transactions on Power Systems* 19(3):1387–401.

award, 2005 PES Charles Concordia Power System Engineering Award, and, in 2010, Medal in Power Engineering, "For leadership in the development and application of analytical methods, tools and techniques for modeling, simulation and control of large-scale interconnected power systems." He also received CIGRE's 1999 Technical Committee Award and 2014 CIGRE Medal. In 2003 he was elected a fellow of the Canadian Academy of Engineering and in 2011 a foreign member of the NAE. He received honorary doctoral degrees from the University Politehnica of Bucharest (2003) and the University of Waterloo, Canada (2004). In 2012, in recognition of his technical leadership, the IEEE PES Prabha S. Kundur Power System Dynamics and Control Award was established in his honor.

To his family Prabha was a source of positivity, inspiration, and generosity. He was a loving and devoted husband to Geetha Kundur (née Halkatti) for 55 years, and great fun to his grandchildren, Linus and Ptolemy (Tolly), taking them on family vacations and bringing them gifts from around the world. He was especially proud of his daughter, Deepa Kundur, who in many ways followed in his footsteps—she is an electrical engineer and professor and chair in the Department of Electrical & Computer Engineering at the University of Toronto.

SAU-HAI LAM

1930–2018

Elected in 2006

"For contributions to aerospace engineering in the areas of plasma flows, combustion, turbulence, and adaptive controls."

BY CHUNG K. LAW, RICHARD B. MILES, AND ALEXANDER J. SMITS

SAU-HAI LAM, the Edwin Wilsey '04 Professor Emeritus at Princeton University, passed away October 29, 2018, at age 87. Harvey, as he was known, was a beloved member of the Department of Mechanical and Aerospace Engineering (MAE) and widely admired as a teacher and scholar, for his original and penetrating academic contributions, and for his razor-sharp intellect. As a wise counselor, a kind mentor, and an inspired teacher, he educated and nurtured generations of students.

During his 39 years on the Princeton faculty, he served as director of the Engineering Physics Program, MAE chair, and associate dean of the School of Engineering and Applied Science. He collaborated for many of those years with Seymour Bogdonoff (NAE 1977) and other members of the Gas Dynamics Laboratory, and participated in the creation of the Princeton Program in Applied and Computational Mathematics, which he cochaired from 1983 to 1986.

As an educator, he perfected the departmental pregeneral interview process, creating a deep and personal learning experience for generations of graduate students. He would generally start with "tell me something you know," and students quickly found out that knowledge requires understanding and reasoning and cannot be acquired by simply memorizing formulas. He was always approachable in spite of his "awesome intellect," and would patiently work with each student to explain and illustrate fundamental concepts. Prospective PhD students came out of his multihour interviews with a profound respect for him and an appreciation for this never-to-be-equaled educational experience. He further enriched graduate education by organizing the "Grand Canonical Ensemble" (inspired by a term from statistical mechanics), an informal group of students who gathered regularly to discuss current topics in science and engineering.

He was an early admirer of the new microcomputer revolution and, recognizing the potential impact of the new microcomputer technology on engineering, in 1978 introduced an undergraduate course on microprocessor programming.

He was also dedicated to providing opportunities for those who had not had them. In the mid-1960s, he and Bogdonoff organized and ran the first Princeton summer orientation program for disadvantaged students to prepare them for college math and physics. This included teaching many how to use a slide rule. The program continued successfully for decades. Later, he and his wife established the Patsy and Harvey Lam '58 Family Scholarship Fund and the Harvey S.H. Lam '58 Endowed Fund in Mechanical and Aerospace Engineering. Graduating seniors are recognized for outstanding academic achievement with the Sau-Hai Lam '58 Prize in Mechanical and Aerospace Engineering.

Harvey viewed himself as a "theorist" who focused on interesting theoretical and mathematical issues associated with engineering problems. His research included dynamics of ionized gases, thermionic energy conversion, reduced chemistry modeling of complex combustion systems, dynamics of boundary layers and turbulence, and nonlinear control theories. His 1965 paper, "Unified Theory for the Langmuir Probe in a Collisionless Plasma," remains a classic.[1] He viewed these problems as related by a single mathematical property common to them all, the existence of multiple time and length scales.

[1] In *Physics of Fluids* 8(1):73 (https://doi.org/10.1063/1.1761103).

He pioneered the methodology of computational singular perturbation for analyzing complex chemical reactions in fluid dynamics, which he first presented in 1985.[2] He followed those advances with contributions to modeling of plasma sheaths and thermionic power conversion. With his fertile and active mind, his interests extended well beyond plasmas and included modeling of collisional rotational energy exchange and the impact of CO_2 on climate—for the latter he collaborated on a 2007 paper with Robert Socolow.[3]

He had wonderful insights and a way of creating compelling analogies, such as imagining one person bucking the oncoming crowds in Times Square to help debunk weakly ionized "plasma magic." He believed in scientific literacy for everyone and taught a freshman seminar on how to estimate practically anything, from the number of leaves of grass in a lawn to the number of potentially habitable planets in the universe.

The youngest of nine siblings, Harvey was born December 18, 1930, in Macau and grew up in Shanghai. As a youth during World War II, he witnessed from his rooftop American B-29s flying overhead and P-51s and P-38s strafing the airport. He was admitted to the very competitive Shanghai Middle School. In his memoir he recalls that on the entrance exam one of the problems was to compute the square root of 0.4. "Of course, I immediately put down 0.2 (I did not know how to do square roots long-hand), and went on to do three more problems. When I found the rest were too difficult, I came back to check the answer I gave for this problem. I multiplied 0.2 by itself, and was shocked to discover that it gave 0.04. So I tried 0.3, then 0.6, then 0.7, and finally settled on 0.63. Apparently this was the make-or-break math problem of my life."

Later, with the civil war between the Nationalists and the Communists in full swing and the People's Liberation Army

[2] Lam SH. 1985. Singular perturbation for stiff equations using numerical methods. In *Recent Advances in the Aerospace Sciences*, ed. Casci C, Bruno C. New York: Plenum Press.

[3] Socolow RH, Lam SH. 2007. Good enough tools for global warming policy making. *Philosophical Transactions of the Royal Society A* 365(1853):897–934.

approaching Shanghai, he moved with his family to Hong Kong, where he completed high school. His education at the Shanghai school turned out to be "years ahead" of his peers in Hong Kong.

His older brother was then working in New York City and suggested he come to the United States. Harvey applied and was accepted to San Mateo Junior College in California, but when he arrived in 1949, his brother sent him to Lakemont Academy, a very small (enrollment 80) private (boarding) high school in the Finger Lakes region of the state of New York, to improve his spoken English. He excelled there and by the end of the year was speaking fluent English.

Harvey went on to undergraduate studies at Rensselaer Polytechnic Institute (RPI), supported in part by a dishwashing job during the academic year and by working for Montgomery Ward as a draftsman during the summer. He chose aeronautical engineering as his major, based on his fascination with the airplanes he had seen from his Shanghai rooftop.

When it became clear that returning to China was not an option, a friend convinced him to apply to graduate school. On the RPI Aeronautical Engineering Department's bulletin board, he saw a flyer about the Daniel and Florence Guggenheim Jet Propulsion Laboratories. There was one at CalTech with Professor H.S. Tsien and one at Princeton with Professor Luigi Crocco (NAE 1979). Tsien was well known to Harvey, but his brother assured him that Princeton was a good place and close to New York City. He applied, and Princeton gave him a Guggenheim Fellowship. He completed his PhD under Crocco in 1958. He spent the next year as a research associate at the Gas Dynamics Laboratory under Bogdonoff and then accepted a junior faculty position in aeronautics at Cornell, where he was mentored by William Sears (NAE 1968) and Nicholas Rott (NAE 1993).

After a year at Cornell as an assistant professor of aeronautics, Harvey came back to Princeton as an assistant professor in 1960 at the invitation of MAE chair Courtland Perkins (NAE 1969, past NAE president). He was promoted to associate professor in 1963, spent a sabbatical year at Stanford in 1966–67, and became a full professor at Princeton in 1968. In 1972 he was named the Edwin Wilsey ’04 Professor and director (until 1980) of the Engineering Physics Program, which he elevated to number one in national ranking. In 1981 he served as associate dean of the School of Engineering and Applied Science and in 1983 he succeeded Bogdonoff as MAE chair, serving in that capacity for 6 years.

After his retirement in 1999, he arranged to spend some time at Stanford, where he continued to teach, pursue his research, and reconnect with Rott. He also taught as a visiting professor at Tsinghua University in Beijing upon the invitation of one of the authors (CKL, NAE 2002).

He was a fellow of the American Institute of Aeronautics and Astronautics and a member of the American Society of Mechanical Engineers, American Physical Society, and American Society for Engineering Education. He received the Princeton University Engineering Council Teaching Award in 1993, and was elected to the National Academy of Engineering in 2006.

Harvey was skilled in Chinese calligraphy and accomplished as a clay sculptor. In the early 1980s, together with his younger son Philip, he created the “Princeton font” for mathematical formulas; it was later formally accepted by the American Mathematical Society for its manuscripts. Among his other interests were tennis and golf, and teaching himself new programming techniques on his computer.

Harvey Lam was admired for his consummate integrity, his ability to identify the truth in all situations, and the generous and insightful counsel that he provided to students and faculty. His dedication to education was remarkable and his intellectual contributions to the field were seminal. His dedication, insight, and guidance had a lasting impact on four generations of students and departmental colleagues and staff. He was an extraordinary man, universally respected for his scholarship, his humanity, his fairness, and his warmth and sense of humor.

He is survived by his wife of 59 years, Patsy, sons Nelson and Philip, daughter Karen, and seven grandchildren.

T. WILLIAM LAMBE

1920–2017

Elected in 1972

"Contributions to knowledge of soil structure and behavior, settlement control, foundation performance and earth structures."

BY W. ALLEN MARR

THOMAS WILLIAM LAMBE, 96, of Sarasota died peacefully March 6, 2017. He was born November 28, 1920, in Raleigh, North Carolina, the son of Claude Milton and Mary Habel Lambe.

He graduated from North Carolina State University in 1942 with a bachelor of science in civil engineering and worked for a while before beginning graduate study in 1943 at MIT, where he received a master's degree in civil engineering in 1944 and a doctor of science degree in soil mechanics in 1948. In July 1945 he was appointed an instructor at MIT and reached the rank of full professor in 1959. Ten years later he was appointed the first Edmund K. Turner Professor of Civil Engineering, a position he held until his retirement in 1981. He also served as director of the Soil Stabilization Laboratory and head of the Geotechnical Division in Civil Engineering. Under his leadership, soil mechanics at MIT achieved worldwide eminence.

After the premature death of Donald W. Taylor in 1955, Lambe became the senior soil mechanics professor at MIT, soon joined by a growing cadre that included Harl P. Aldrich (NAE 1984), Robert V. Whitman (NAE 1975), R. Torrence Martin, and Charles C. Ladd (NAE 1983). This period, which extended through the 1970s, saw an expanding influence of the MIT soil mechanics program on the profession worldwide, in both academic research and professional practice. Seminal among these contributions was the stress-path method, largely developed by Lambe and Whitman and summarized in their coauthored text. Lambe's 1973 Rankine Lecture, "Predictions in soil engineering,"[1] introduced the concept of types of engineering predictions based on the level of analysis and the timing of the forecast. This taxonomy remains in widespread use today.

The classification of predictive approaches was typical of Professor Lambe's research, with a close relation to engineering practice. Many remember the five workshops he organized and ran, in which colleagues from the world over were asked to make performance predictions that were later compared to the results of major field experiments. Another remarkable example of his ability to link benefits between research and practical engineering was the instrumentation of foundation work for many MIT buildings constructed during the 1960s—described in his 1970 Terzaghi Lecture[2]—and for Boston area subway construction, including the Red Line through Harvard Square.

The impacts of his work were fundamental and far-reaching. Of his many important contributions—including in soil chemistry, soil stabilization, and ground freezing—the stress path method and formalization of geotechnical predictions stand out. His textbooks *Soil Testing for Engineers* (Wiley & Sons, 1951) and *Soil Mechanics* (coauthored with Whitman; Wiley & Sons, 1969) were pathbreaking.

As a consultant, Lambe worked for clients not only in many parts of the United States but also in Egypt, Japan, Jordan, Libya, the Netherlands, Puerto Rico, Qatar, Turkey, and Venezuela. The projects involved earth dams for storage of water, oil, and mining waste; landslides; building foundations; foundations for an offshore storm surge barrier in the Netherlands; and hydraulic reclamation projects, among

[1] Published in *Géotechnique* 23(2):149–202.

[2] The Integrated Civil Engineering Project. *ASCE Journal of the Soil Mechanics and Foundations Division* 98(6), June 1972.

others. Many MIT geotechnical students were educated to become engineers through practice-oriented research and direct or indirect involvement in his consulting projects. He remained active as a consultant until he was in his early 90s.

Dr. Lambe's technical contributions were nationally and internationally recognized. He was a member of the National Academy of Engineering (1972), a fellow of the Institution of Civil Engineers (ICE), and an honorary member of the American Society of Civil Engineers (ASCE) and Southeast Asian Society of Geotechnical Engineering. His more than 100 publications earned him many awards, including ASCE's Norman Medal (1964), Karl Terzaghi Award (1975), and Wellington Prize (1984), and the NC State University College of Engineering Distinguished Engineering Alumnus Award (1982). NASA twice recognized his contributions to the Apollo program for which he shaped the exploration program for the surface of Earth's moon. For the National Academies, he was appointed to serve on the Committee on Natural Disasters (1983–87).

Bill enjoyed tennis, golf, badminton, skiing, equestrian sports, cattle ranching, boating, and fishing. A man of numbers—he often said the best adjective is a number—during his life he lived in 21 homes in seven states. After retirement from MIT, he participated in 14 reunions of his growing family in six US states and two Canadian provinces. He was also a member of the Longview Society in Sarasota, Florida, that met monthly to discuss a variety of national, international, and societal subjects.

His wife of 59 years, Catharine "Kit" Cadbury Lambe, preceded him in death. He is survived by their children—Philip (Catherine) in North Carolina, Virginia (Robert Guaraldi) in New Hampshire, Richard (Michele) in Washington, Robert (Judith) in Massachusetts, and Susan (Scott Clary) in Virginia—as well as 14 grandchildren and seven great-grandchildren.

LOUIS LANDWEBER

1912–1998

Elected in 1980

"Research, design, and educational contributions to modern naval architecture and marine engineering."

BY S.K. CHOW, ROBERT ETTEMA,
YU-TAI LEE, AND FREDERICK STERN
SUBMITTED BY THE NAE HOME SECRETARY

LOUIS LANDWEBER, professor emeritus of mechanics and hydraulics, Iowa Institute of Hydraulic Research (IIHR)–Hydroscience and Engineering, passed away January 20, 1998, at the age of 86. A distinguished and widely recognized leader and a theoretician whose insights extended well beyond the ordinary, he was the "Father of Ship Hydrodynamics" at IIHR, with a career that spanned decades of the 20th century critical to the development of naval ship hydrodynamics.

His contributions to the theory and practice of naval architecture and marine engineering were groundbreaking. Building on his formal education as a physicist and mathematician, his work bridged to engineering applications. Few engineers could match his understanding and elegant formulation of fluid mechanics as applied to water movement around bodies in water, from ships and submarines to drifting objects such as icebergs.

"Lou Landweber had a thirst for knowledge that never ran dry," noted the University of Iowa's Engineering Dean Alec Scranton during Landweber's induction to the Legacy of Iowa Engineering on April 25, 2017. He added, "Soft-spoken, Landweber was renowned for his problem-solving ability. He always offered any visitor a chair alongside his own, pulled out a writing shelf, positioned his pencil and writing pad, and gently talked his visitor through the problem, step by step."

Lou was born to Joseph and Lena Landweber in New York City on January 8, 1912. His father worked as a tailor, and his mother focused her energies on raising their four sons and managing the family. He attended the city's public schools and then enrolled at the City College of New York, where at age 20 he received his bachelor's degree in mathematics as well as the Ward Medal for Physics and the Belden Prize for Mathematics.

Upon graduation he went to work as a junior physicist at the US Experimental Model Basin at the Washington Navy Yard. He found his work fascinating, but recognized the need to deepen his knowledge of mathematics and fluid mechanics. Accordingly, he began graduate studies at George Washington University and in 1935 attained his master's degree in physics. Also that year, he married Matilda (Mae) Herschfeld, sister of one of his classmates.

Beginning in 1940 he led a group that distinguished itself in war-related research, primarily in resolving key hydrodynamic aspects associated with the way minesweeper ships handled mines. For this work he received the Navy's Meritorious Civilian Service Award in 1947.

Soon after the war the Navy expanded Landweber's research group to become the Model Basin's Hydrodynamics Division. While continuing to lead the group, his research led to his PhD in physics (1951) from the University of Maryland (where he also taught concurrent with his work and studies). His thesis, "An Iteration Formula for Fredholm Integral Equations of the First Kind with Application to the Axially Symmetric Potential Flow about Elongated Bodies of Revolution," initiated the so-called Landweber iteration, an algorithm to solve ill-posed linear inverse problems, which are ubiquitous in ship hydrodynamics (e.g., when formulating ship motions and ship waves). It has been extended to solve nonlinear problems with constraints.

While pursuing his PhD degree Landweber was promoted to head of the Hydrodynamics Division of the David Taylor

Model Basin in Carderock, Maryland (now called the Naval Surface Warfare Center, Carderock Division). This Navy lab has world-renowned naval ship technology testing facilities and research staff who study ship-related problems and design future naval ships—a line of work that fascinated Landweber for the rest of his life.

In 1954 he accepted an offer to work at the University of Iowa. Hunter Rouse (NAE 1966), IIHR director (1944–66), invited him as both researcher and full professor of mechanics and hydraulics. To sweeten the deal, the Office of Naval Research (ONR) funded the conversion of one of IIHR's basement river channels, built in 1919 as the original Hydraulics Laboratory, into a large ship towing tank—a narrow channel through which small-scale ship models would be pulled and assessed under various circumstances. This tank, at the time one of the few such facilities in the nation, solidified IIHR's capabilities to experimentally examine the motion of a ship.

Landweber immediately took over theoretical and experimental studies connected to naval architecture, ship hydrodynamics, and the fluid mechanics of body motion in water. Within a year, Rouse was very pleased that his new hire had quickly assumed most of the administrative responsibility for naval projects.

Landweber felt that academics suited him much better than civil service work, and he happily set to work at IIHR as a researcher, educator, and innovator. His impact was transformative and he developed a strong theoretical and experimental research program in ship hydrodynamics that continues. Under his guidance, IIHR became an international leader in research related to naval architecture and ship hydrodynamics, with ongoing financial support from ONR.

Landweber and his colleagues conducted research projects on analysis of wakes, drag of truncated bodies, ship vibration, ship rolling, added-mass considerations, resistance from waves, turbulence, and cavitation. He made major theoretical contributions to the prediction of waves around ship hulls, of resistance due to waves (using ideal-fluid theory), and of friction (using boundary-layer theory).

He was among the first to explore the potential of computational fluid dynamics (CFD), which is now the main thrust for solving complex flow problems, including ship hydrodynamics. These early efforts in the 1960s provided a foundation for later work at IIHR. Landweber laid out the problem—usually a classical equation-solving problem—and his associate or students would program it using their computer expertise. Together, they would solve the problems with Landweber's insightful understanding, keen mathematical sense, and trusty slide rule.

Throughout his career he addressed many mathematical aspects of ship hydrodynamics and fluid mechanics. For example, he focused considerable effort on the application of the Lagally theorem for estimating the forces and moments acting on a rigid body (e.g., a ship hull or an iceberg) moving through water treated as an inviscid and incompressible fluid. In addition, he helped enhance knowledge in the field by editing English translations of Russian texts on ship hydrodynamics.

Landweber not only was a first-class researcher but also possessed an ability to spot talent. In 1970 V.C. Patel was looking for a job; his position at Lockheed Martin in Georgia had ended. He and his wife liked life in the United States, but where to go next? He wrote three letters seeking a position—one of them to Lou Landweber. Landweber responded almost immediately with a handwritten note inviting him to come to IIHR to present a seminar. "Lou and his wife Mae picked me up at the airport," Patel remembered. "They took me to a Chinese restaurant—they made me feel so welcome." He gave a seminar about CFD with relation to aerospace. "Nothing to do with hydraulics or ships!" Patel laughed. But Landweber immediately saw how Patel's work on the boundary layers of airplanes could be applied to ships. He wrote a note to Patel promising to speak to then-IIHR director Jack Kennedy (NAE 1973) as soon as he returned from vacation. "Within a couple of weeks, I got a telegram offering me a job—from Jack Kennedy!" Patel says. He went on to serve IIHR for decades, culminating as director (1994–2004).

Landweber's career at IIHR was among the longest and most productive in the institute's history. Even after his retirement in 1982 at age 70 and well into his 80s, he continued to secure grant funding, conduct research, publish papers, and mentor graduate students, until 1995, when health problems restricted him to his home. He was the author, coauthor, or editor of some 150 technical papers, reports, monographs, and books in the fields of hydrodynamics and naval architecture. He ushered more than 50 MS and PhD students through their studies. They remember his integrity, warmth, support, and humor—characteristics that rival even his vast technical achievements in their recollection.

Through interactions with former students working in various industries, he expanded applications of his well-developed knowledge base beyond ship-related applications. A good example was his assistance to one of the authors (SKC; 1967 PhD) working on flow predictions for pumps at the Westinghouse Research & Development Center in Churchill, Pennsylvania. Landweber's potential theory was applied to a centrifugal pump and in 1978 their joint paper, "Calculation of Flow through Two-Dimensional Centrifugal Impeller by Method of Hydrodynamic Singularities," won the first Henry R. Worthington North American Technical Awards Competition, sponsored by the Polytechnic Institute of New York and Worthington Pump Inc. During the same time, another of the authors (Y-TL; 1978 PhD) started working in Chow's group, using the similar potential theory to predict both flows in three-dimensional centrifugal pumps and electromagnetic fields at end-regions of turbogenerators.

In addition to his NAE membership, Landweber was a fellow of the Society of Naval Architects and Marine Engineers (SNAME) and American Academy of Mechanics. Among his many honors, he was selected as the Fifth David W. Taylor Lecturer[1] and received SNAME's Kenneth S.M. Davidson

[1] His presentation, "On Irrotational Flows Equivalent to the Boundary Layer and Wake," is available at the online Defense Technical Information Center, https://apps.dtic.mil/sti/pdfs/ADA062002.pdf.

Medal for outstanding accomplishment in ship research, both in 1978; honored by a special session at the Third Engineering Mechanics Division Specialty Conference of the American Society of Civil Engineers in 1979; named Georg Weinblum Memorial Lecturer for 1981 ("Interactions between Viscosity and Ship Waves"); and honored at the Sixth International Conference on Numerical Ship Hydrodynamics, Iowa City, in 1993.

Although Landweber died more than two decades ago, he is remembered fondly by his many friends and colleagues at IIHR. Kind, calm, friendly, and unassuming, he had the ability to get along with everyone and always made time to meet and talk with visitors to IIHR. He was a generous mentor, freely offering his time and support to both colleagues and students. "He was a very dear man," Patel remembered with a smile. Landweber's successor in ship hydrodynamics at IIHR, Fred Stern, agreed. "He was a real sweetheart…. always a very helpful and kind fellow." Landweber's death was a loss that profoundly shook the entire IIHR family. Yet, as Stern said at the funeral, the pain was "somehow accompanied by simultaneous feelings of happiness, joy, and pride for having known—as a close friend, surrogate father, and mentor—such a man as Lou Landweber."

Mae passed away March 28, 2001. They are survived by sons Peter (born 1940), a mathematician, and Victor (born 1943), a photographic artist inspired in part by his father's lifelong hobby of photography, and four grandchildren.

GERALD J. LIEBERMAN

1925–1999

Elected in 1987

"For significant technical contributions to quality control and reliability, and for leadership as an engineering educator."

BY FREDERICK S. HILLIER
SUBMITTED BY THE NAE HOME SECRETARY

GERALD J. LIEBERMAN was born December 31, 1925, in Brooklyn, New York; his parents, Joseph and Ida, had come to this country from Lithuania. After attending high school in Brooklyn Jerry obtained an undergraduate degree in mechanical engineering from Cooper Union in 1948 and a master's degree in mathematical statistics from Columbia University in 1949. He then worked for a year at the National Bureau of Standards. It was there that he met his future wife, Helen Herbert; they married in 1950.

Jerry enrolled in the PhD program in the Department of Statistics at Stanford University in 1950 and did his doctoral dissertation on multistation inspection schemes. This and much of his later research on sampling inspection and quality control were subsequently incorporated into military standards.

With his background in engineering and engineering statistics, Jerry received a joint appointment as an assistant professor in Stanford's Departments of Industrial Engineering and Statistics, reflecting the Statistics Department's interest in having a link with the School of Engineering and the desire of

Additional details of interest are available in the Stanford bio of Dr. Lieberman, available at https://web.stanford.edu/~infanger/DantzigLieberman/Bio_GJL.htm.

the Industrial Engineering Department to strengthen its statistical activities. This was a good fit for Jerry and he rose from assistant professor in 1953 to professor in 6 years. It also was a great fit for Stanford students in these areas because Jerry was an outstanding teacher whose congenial and welcoming personality made him beloved by his students.

At the outset, Jerry's research and writing were largely in statistics. His first book (coauthored with Albert Bowker), *Handbook of Industrial Statistics*, was published by Prentice-Hall in 1955. A full-length Prentice-Hall textbook (again with Bowker), *Engineering Statistics*, followed in 1959, with a 2nd edition in 1972. This influential textbook was widely used for many, many years and Jerry also frequently taught a popular course on this topic.

During the mid-1950s Jerry became interested in the emerging field of operations research, a discipline that involves applying mathematical models and techniques to decision making. He soon introduced a new course, Introduction to Operations Research, and urged Stanford to take the lead in offering a curriculum in this relatively new field.

Thanks largely to Jerry's efforts, Stanford established an interdepartmental PhD program in operations research in 1962, with Jerry as its chair. With outstanding faculty from throughout the university, the program drew many exceptional students who went on to become leaders in the field. In 1966 Jerry succeeded in luring the renowned pioneer in the field, George Dantzig (NAE 1985, NAS 1971; commonly referred to as the father of linear programming), to join the Stanford faculty.

The following year the interdepartmental program became a full-fledged Department of Operations Research in the School of Engineering, adding a master's program and a few undergraduate courses. Jerry continued as chair for another 8 years, and the department was soon widely acclaimed as a leader in the field and a magnet for top students. For example, for many years at least half of the NSF fellows entering operations research chose to join the Stanford program.

Jerry turned his expository skills from engineering statistics to operations research. In 1967 he and I, his former student, published *Introduction to Operations Research* (Holden-Day Publishers); it immediately became the preeminent textbook in the field and still retains this status (the 11th edition was published in 2020 by McGraw-Hill). The book has been translated into more than a dozen languages and is estimated to have been used by over a million students around the world.

Even with his responsibilities as program and department chair, as well as his work on textbooks, Jerry remained a very active researcher. He did seminal work on the mathematic theory of system reliability, replacement policies, inventory control, and stochastic management problems.

After 13 highly successful years as chair of the Interdepartmental Program and then the Department of Operations Research, Jerry stepped down because the Stanford administration had bigger plans for him. He served as associate dean of humanities and sciences, vice provost and dean of research, vice provost and dean of graduate studies, chair of the Centennial Celebration, and chair of the faculty senate. He gained such confidence from the Stanford presidents that he was called on to serve as the provost or acting provost under three of them. He clearly was one of Stanford's most preeminent university citizens of his generation. At the same time, he managed to stay in close touch with his faculty colleagues in the Department of Operations Research, participate in department decisions, supervise doctoral students, and contribute to new editions of our coauthored textbook.

In addition to his extensive service to Stanford, Jerry had a broad record of national leadership in statistics, quality control, and operations research. He held national offices in four professional societies in these fields, including serving a term as president (1980–81) of the Institute of Management Sciences. He also served on the editorial board of three journals and was active in committees of the National Academies of Sciences, Engineering, and Medicine. He served on the Board on Mathematical Sciences (1988–94) and its Panel on Applied Mathematics Research Alternatives for the Navy (1981–89), the NIST Assessment Board's Panel for Computing and Applied Mathematics (1983–85; chair, 1986–89), and the

Committee on National Statistics Panel on Quality Control of Family Assistance Programs (1986–88), among others.

For his contributions, Jerry was honored with the 1972 Shewhart Medal of the American Society for Quality Control for his research on sampling plans and statistical quality control; election to the NAE (1987); the Institute for Operations Research and the Management Sciences (INFORMS) President's Award (1994), which is presented "to recognize, and thereby encourage, important contributions to the welfare of society by members of our profession at the local, national, or global level"; and the institute's 1996 George E. Kimball Medal for his exceptional service to the profession.

Tragedy struck in the 1990s when Jerry developed amyotrophic lateral sclerosis (Lou Gehrig's disease). He retired from Stanford in 1995, and this terrible disease took his life at the age of 73 on May 18, 1999.

Having described Jerry's spectacular academic career, I would be remiss if I did not acknowledge the remarkable personal qualities that enabled it. Jerry was my freshman advisor, undergraduate, graduate, and dissertation advisor, mentor, friend, and coauthor, and I can personally attest to these qualities. Beyond being a fine scholar, he had tremendous wisdom, integrity, and courage, and he gave generously to others. He was a congenial, good-natured man who engaged life fully and cheerfully. He was a kind and sympathetic man who listened well and was always ready to help. He also was a wise man who offered sage advice. He was a very special role model for both his colleagues and his students. He was a real prince of a man.

Upon the passing of both Jerry and the eminent George Dantzig, I had the privilege of leading a fundraising campaign to establish Stanford's Dantzig-Lieberman Operations Research Fellowships. The response was overwhelming, especially from the alumni of the Department of Operations Research (now part of the Department of Management Science and Engineering). This endowment fund now holds well over $4 million, supporting multiple fellowships each year. In addition, the university established 12 one-year Gerald J. Lieberman

Fellowships for graduate students who show potential for becoming the next generation of academic leaders.

Jerry is survived by Helen; their four children: Janet Lieberman Argyres of Castro Valley, CA, and Joanne Lieberman, Diana Lieberman, and Michael Lieberman, all of Palo Alto; and two grandchildren.

KUO-NAN LIOU

1944–2021

Elected in 1999

"For contributions in the theories of radiation transfer and light scattering, with applications to remote sensing technology and climate modeling."

BY PING YANG, YU GU, AND QIANG FU
SUBMITTED BY THE NAE HOME SECRETARY

KUO-NAN LIOU was a distinguished professor in the Department of Atmospheric and Oceanic Sciences and founding director of the Joint Institute for Regional Earth System Science and Engineering at the University of California, Los Angeles (UCLA). He passed away March 20, 2021, at the age of 76.

He was born November 16, 1944, in Taiwan. He received his BS degree from National Taiwan University in 1965, and then earned his MS (1968) and PhD (1970) in meteorology and oceanography at New York University. After postdoctoral research at the National Aeronautics and Space Administration, in 1975 he became a professor at the University of Utah, where he taught for 22 years before going to work at UCLA. He made seminal contributions to atmospheric science and education/mentoring, with a focus on atmospheric radiation, light scattering, remote sensing, and cloud/aerosol radiative forcing effects on the climate system.

Among his most fundamental contributions, he demonstrated that atmospheric radiation should no longer be

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Adapted from the *Bulletin of the American Meteorological Society* (August 2021, pp. 778–82), which includes more extensive technical discussion of his contributions.

consigned to the fringes of meteorology but instead should take a central place in climate science. He advanced the field with a quantum leap through his work on the theory of radiative transfer, investigation of radiative effects of clouds and aerosols, and development of methods for inferring atmospheric and surface parameters through remote sensing.

Clouds, which cover 60–70 percent of the globe, play an important role in atmospheric radiation. Liou's monograph, *Radiation and Cloud Processes in the Atmosphere: Theory, Observation, and Modeling* (Oxford University Press, 1992), coherently integrates radiative transfer and cloud physics and bridges the gap between radiation and climate processes in clouds. The volume contributed to the development of climate models for the investigation of global climate change and remote sensing techniques for the inference of cloud and aerosol properties.

In an earlier paper he demonstrated that cirrus clouds are ubiquitous, particularly in the tropics, and are critical to understanding the global energy budget and water cycle.[1] Their effect on climate was illustrated through a hierarchy of climate models with varying degrees of complexity. Since publication of this paper, numerous field experiments have been undertaken to collect data to quantify the impact of cirrus on the Earth's radiation budget and climate.

A 1971 paper by Liou and James Hansen (NAS 1996) on light scattering research may have been the first to systematically compare the geometric optics method and Lorenz-Mie theory.[2] The scattering of light by spheres can be solved by the Lorenz-Mie theory and computation performed accordingly.

Ice clouds in the atmosphere are composed almost exclusively of nonspherical ice crystals—such as solid and hollow columns, plates, bullet rosettes, aggregates, and dendrites—and ice particles have surfaces with varying degrees of

[1] Liou K-N. 1986. Influence of cirrus clouds on weather and climate processes: A global perspective. *Monthly Weather Review* 114(6):1167–99.

[2] Liou K-N, Hansen JE. 1971. Intensity and polarization for single scattering by polydisperse spheres: A comparison of ray optics and Mie theory. *Journal of the Atmospheric Sciences* 28(6):995–1004.

roughness. In the early 1970s Liou was the first to study cirrus cloud radiative properties by considering nonspherical ice crystals.[3] He developed the theoretical basis for the depolarization of the backscattered signal from nonspherical ice particles with a linearly polarized laser beam.[4] This work established the basis for cloud phase detection using ground-based, airborne, or spaceborne lidar.

In the 1980s he pioneered the study of the scattering of polarized light by nonspherical ice crystals by means of the principle of geometric optics. And in the 1990s he and one of his students developed an innovative physical-geometric optics method, referred to as the improved geometric optics method (IGOM), for light scattering by large particles.[5] The IGOM substantially overcame the shortcomings of the conventional geometric optics method for light scattering; in particular, it could for the first time depict the variation in extinction efficiency with particle size within the geometric optics framework, and it overcame the inherent singularity, called the delta transmission, associated with the ray-tracing technique for a particle with parallel surface facets.

The IGOM and its subsequent developments in synergistic combination with other methods for small-to-moderate particles provide advanced modeling capabilities for cirrus cloud optical property computations for downstream applications, as summarized in his coauthored text *Light Scattering by Ice Crystals* (Oxford University Press, 2016). The computations laid the foundation for fundamental datasets for ice cloud radiation parameterization schemes used in many climate models and for radiance simulations under ice-cloudy conditions in radiative transfer models.

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[3] Liou K-N. 1972. Light scattering by ice clouds in the visible and infrared: A theoretical study. *Journal of the Atmospheric Sciences* 29:524–36.

[4] Liou K-N, Lahore H. 1974. Laser sensing of cloud composition: A backscattered depolarization technique. *Journal of Applied Meteorology* 13:257–63.

[5] Yang P, Liou K-N. 1996. Geometric-optics–integral-equation method for light scattering by nonspherical ice crystals. *Applied Optics* 35(33):6568–84.

A theorist, Liou also pursued laboratory experiments in light scattering and cloud physics, primarily to test theory. His work in the area of light scattering was recognized in 1996 through a Creativity Award from the Atmospheric Sciences Division of the National Science Foundation for "Light Scattering by Ice Crystals: Theory and Experiment."

The Nobel Laureate Chandrasekhar had presented radiative transfer in plane-parallel (1D) atmospheres as a branch of mathematical physics and developed numerous solution methods. Liou followed the discrete-ordinates method developed by Chandrasekhar and in 1974 derived the first analytic solution for the four-stream approximation for radiative transfer.[6] On the basis of the delta-four-stream approach, he and a former student constructed the Fu-Liou radiative transfer model, which includes the correlated *k*-distribution method for the sorting of nongray gaseous absorption in scattering atmospheres and the scattering and absorption properties of hexagonal ice particles.[7] The Fu-Liou code has been adopted as a standard broadband radiative transfer model to study climate forcing effects of clouds and aerosols, and used by NASA for the retrieval of satellite-observed atmospheric and surface radiative energy fluxes.

Liou was a pioneer in the development of 3D radiative transfer theories based on the finite spherical-harmonics expansion of the intensity and scattering phase function. In particular, he developed a successive order-of-scattering approach for 3D radiative transfer that offers an innovative way of constructing a 3D cloud extinction coefficient field from satellite observations. This study corrected the conventional 1D approach to the evaluation of sunlight reflected and absorbed by clouds, which is essential to discussion of the role of clouds/radiation in climate and climate change. In addition, Liou and

[6] Liou K-N. 1974. Analytic two-stream and four-stream solutions for radiative transfer. *Journal of the Atmospheric Sciences* 31:1473–75.

[7] Fu Q, Liou K-N. 1992. On the correlated *k*-distribution method for radiative transfer in nonhomogeneous atmospheres. *Journal of the Atmospheric Sciences* 49(22):2139–56.

his associates worked on 3D radiative transfer over mountains[8] for high-resolution climate models, seeking to improve regional climate simulations by incorporating the 3D radiation configuration in mountains and snow-covered regions that are especially vulnerable to climate change and global warming.[9]

Liou developed a 1D cloud-precipitation-climate model to investigate the potential link between the perturbed cloud particle size distributions and precipitation produced by greenhouse warming/air pollution.[10] If more small particles are produced, precipitation could decrease, leading to more cloud water in the atmosphere, which implies more reflection of sunlight, leading to cooling and a potential offset of the warming produced by greenhouse gases. A reduction of cloud particle size of about 1 μm in eastern North America has been observed as a result of anthropogenic pollution. Liou's discovery linking cloud particle size and precipitation in climate change is now referred to as the second indirect climate forcing in aerosol-cloud feedbacks.

Over five decades Liou and his associates conducted numerical simulations involving the effects on precipitation of the increase of anthropogenic aerosols in China, using the UCLA atmospheric general circulation model.[11] They showed that increased aerosol optical depths in China led to a noticeable increase in precipitation in the southern part of the country in July due to the cooling in midlatitudes, producing

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[8] Liou K-N, Gu Y, Leung LR, Lee WL, Fovell RG. 2013. A WRF simulation of the impact of 3-D radiative transfer on surface hydrology over the Rocky Mountains and Sierra Nevada. *Atmospheric Chemistry and Physics* 13:11709–21.

[9] For a less technical perspective on Liou's work, see "Mapping the Frozen Sky: Study Looks at Clouds from Both Sides Now," published in *ScienceNews* in June 2002.

[10] Liou K-N, Ou S-C. 1989. The role of cloud microphysical processes in climate: An assessment from a one-dimensional perspective. *Journal of Geophysical Research* 94(D6):8599–607.

[11] Gu Y, Liou K-N, Chen W, Liao H. 2010. Direct climate effect of black carbon in China and its impact on dust storms. *Journal of Geophysical Research* 115(D7).

a precipitation pattern referred to as "north drought/south flooding" over the past 50 years. Moreover, black carbon and dust in China would heat the air column in the middle to high latitudes and tend to move the precipitation toward the Tibetan Plateau.

As the first to use long-term satellite data and a comprehensive cloud model to study ice clouds, Liou and colleagues also found compelling evidence that large quantities of ice nucleating particles (an important factor in the formation of ice clouds) are produced by human activities.[12] Because ice clouds play a central role in severe weather and climate change, adequate representation of this process is expected to significantly improve climate projections.

In addition to his accomplishments in radiative transfer, remote sensing, and climate applications, Liou enhanced understanding of microphysics, radiation, and turbulence interactions in clouds. In particular, he and a former student constructed a 2D model to understand the evolution of cirrus clouds.[13] This study represents the first effort to incorporate in a cirrus model all the pertinent physical processes involving ice crystal formation, radiative transfer in clouds, and second-order turbulence closure.

Liou was also active in service to the national and international science community throughout his career. To list a few, he chaired the Atmospheric Sciences Section Fellows Committee (2013–14) and Roger Revelle Medal Committee (2017–20) of the American Geophysical Union (AGU), the 1986 International Radiation Symposium, and the Committee on Atmospheric Radiation (1982–84) of the American Meteorological Society (AMS); and he was chair-elect of the AMS Atmospheric Research Awards Committee (2021–22). He was appointed to the National Academies' Committee on

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[12] Zhao B, Wang Y, Gu Y, Liou K-N, Jiang JH, Fan J, Liu X, Huang L, Yung YL. 2019. Ice nucleation by aerosols from anthropogenic pollution. *Nature Geoscience* 12:602–07.

[13] Gu Y, Liou K-N. 2000. Interactions of radiation, microphysics, and turbulence in the evolution of cirrus clouds. *Journal of the Atmospheric Sciences* 57:2463–79.

Evaluating NOAA's Plan to Mitigate the Loss of Total Solar Irradiance Measurements from Space (2013) and Advisory Panel for the International Satellite Cloud Climatology Project (1984–87). And he was quite involved in the work of the NAE, with extensive service in various roles for his section as well as appointment to the NAE Nominating Committee (2011–13) and Committee on Membership (2008–11).

He was also editor of the *Journal of the Atmospheric Sciences* (1999–2005) and *Journal of Geophysical Research* (1987), review editor for the *IPCC Report* (1998–99), and associate editor of the *Journal of Quantitative Spectroscopy and Radiative Transfer* (2011–21).

We would be remiss if we did not mention Liou's contributions to atmospheric education and mentoring. His iconic textbook, *An Introduction to Atmospheric Radiation* (Elsevier Science, 1980), was translated into Chinese, Russian, Japanese, and Arabic and educated several generations of researchers around the world in the disciplines of atmospheric radiation and remote sensing. The 2002 edition includes about 70 percent new material and is still frequently used by researchers in the areas of radiative transfer, light scattering, and remote sensing.

An important part of Liou's legacy is reflected by the number and quality of the graduate students he trained—he guided the completion of 33 doctoral dissertations and many master's theses. Many of his former students are now prominent researchers. He also mentored many early-career researchers who worked with him as visiting scholars.

Liou's significant contributions were well recognized. In addition to his election to the US National Academy of Engineering (1999), he was a fellow of the Academia Sinica (2004) and foreign member of the Chinese Academy of Sciences (2017). He received the AMS Jule G. Charney Medal (1998), Biennial William Nordberg Medal (2010) from the Committee on Space Research, International Radiation Commission Quadrennial Gold Medal (2012), AGU Roger Revelle Medal (2013), and AMS Carl-Gustaf Rossby Research Medal (2018), and was included in the Nobel Peace Prize bestowed on the

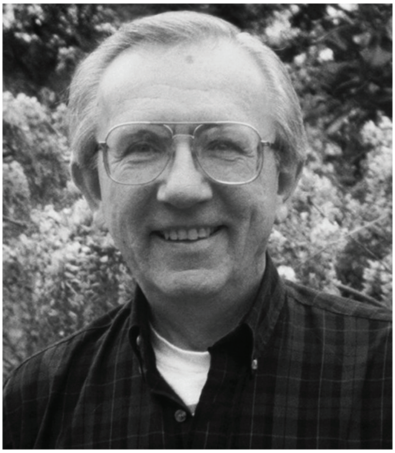
Intergovernmental Panel on Climate Change (IPCC) in 2007. He was a fellow of AMS, AGU, the American Association for the Advancement of Science, and the Optical Society of America.

The passing of Kuo-Nan Liou is a great loss to atmospheric science. He was an expert in many research areas, most significantly in atmospheric radiation. His remarkable scientific insight led to paradigm-shifting contributions to atmospheric science, and his teaching and mentoring exemplified his selflessness and generosity.

With his passion for science and pursuit of excellence in the three key areas of university faculty—teaching, research, and service—Liou was a role model for all. He was generous and supportive of others, and wrote numerous letters in support of colleagues' promotions and nominations for awards or recognitions. He liked to encourage early-career researchers by reciting an ancient Chinese poem: "The setting sun leans on the furthest mountains to disappear, the Yellow River flows into the sea. To see a thousand miles further, ascend another story."

In tribute to Liou for his extraordinary accomplishments in scientific research, his dedication to service for the science community, his integrity, and his generosity and kindness, we borrow from Margit Dirac's speech at the dedication of the Paul A.M. Dirac Science Library: "It is customary to praise those who are not with us anymore—often quite undeservedly, but not in this case. No praise will exaggerate or be too glowing."

Liou is survived by his wife Agnes, daughter Julia, son Cliff, and a granddaughter.



RAYMOND C. LOEHR

1931–2021

Elected in 1983

"International leadership in research, engineering analysis, education, and management practices for solution of waste disposal problems."

BY MICHAEL A. KOPLINKA-LOEHR
SUBMITTED BY THE NAE HOME SECRETARY

RAYMOND CHARLES LOEHR, the Hussein M. Alharthy Centennial Chair and professor emeritus at the University of Texas at Austin (UTA), died April 15, 2021, in Ashburn, Virginia. He was 89 years old.

He was born in Cleveland, Ohio, on May 17, 1931, to Clarence and Anastasia Vanniel Loehr. He obtained a BS in civil engineering (1953) and MS in sanitary engineering (1956) from Case Institute of Technology (now Case Western Reserve University) and his PhD, also in sanitary engineering, from the University of Wisconsin, Madison.

He began his lifelong teaching career as a professor of civil engineering at the University of Kansas, Lawrence (1961–68). He then moved to Cornell University (1968–85), where he became head (1972–80) of the Environmental Studies Program in the College of Agricultural and Life Sciences, associate director (1975–78) of the Office of Research and Agricultural Experiment Station of the College of Agriculture and Life Sciences, and the Liberty Hyde Bailey Professor (1981–85). He also established a multidisciplinary research program in agricultural waste management.

In 1985 he accepted appointment as the Hussein M. Altharthy Chair and Professor of Civil Engineering at UT Austin, where he continued his pioneering research on treatment of waste materials and launched graduate courses on that topic. He was also the founding director of the university's Environmental Solutions Program, which involved a consortium of industry sponsors of research, workshops, and other activities that addressed challenges in the industry and provided research support for faculty and students.

In 2003 he retired from full-time academic work, became professor emeritus at UT Austin, and moved to northern Virginia.

He was an expert on the treatment of industrial wastes, management of hazardous wastes, and remediation of sites contaminated with industrial and hazardous wastes. His research contributions led to improved biological methods to treat contaminated soils and a better understanding of the risks of organic chemicals found in sediments. He published over 300 peer-reviewed technical articles, and authored or coauthored 10 books. In addition, he was the major advisor for 10 PhD students and over 80 MS graduate students, and had a profound impact on the lives of his students.

Beyond his academic activities, he was an active member of the environmental engineering profession. He provided invited testimony to congressional committees and subcommittees, and was a consultant to industries, law firms, and engineering firms; a member of the board of directors of two engineering consulting firms; and a registered professional engineer in Texas, Ohio, and Kansas. To obtain practical experience helpful to his professional, academic, and research activities, on separate academic leaves of absence he worked for the US Environmental Protection Agency (EPA) and for a consulting engineering firm.

As an active contributor to the broader community, he was a member, diplomate, and president (2002–03) of the American Academy of Environmental Engineers, and chair or member of committees of the Department of Defense, Department of Energy, Los Alamos National Laboratory, and EPA. He served for over 25 years as a member of EPA's Science Advisory Board, including as chair (1988–93). As part of his EPA involvement, he chaired several independent evaluations and reports, such as the 1990 report *Reducing Risk: Setting Priorities and Strategies for Environmental Protection*, which helped set directions and action for the agency.

He provided nearly 2 decades of service on boards and committees of the National Academies of Sciences, Engineering, and Medicine. He was appointed chair of the Committee on Research Opportunities and Priorities for EPA (1995–97) and vice chair of the Committees to Review EPA's Research Grants Program (2002–03) and on Remediation of PCB-Contaminated Sediments (1999–2001), and was a member of the Committee on Research and Peer Review in EPA (1994–2000), Committee on Sustainable Water Supplies in the Middle East (1995–99), Board on Environmental Studies and Toxicology (1983–86 and 1995–98), Committee on Multimedia Approaches to Pollution Control (1986–88), and Advisory Committee on Technology Innovation (1984–87).

His research on biological treatment of wastes and his technology development efforts, particularly in surface treatment of wastes, were widely recognized. He was elected to the National Academy of Engineering in 1983 and received awards from 10 professional engineering and scientific organizations, including the Environmental and Water Resources Institute's 2007 Lifetime Achievement Award by the American Society of Civil Engineers; the 1995 Rachel Carson Award from the Society of Environmental Toxicology and Chemistry; the 1997 Camp Applied Research Award from the Water Environment Federation; and the 1969 ASCE Rudolph Hering Medal (with Robert W. Agnew). The UTA College of Engineering bestowed on Dr. Loehr the 1987 Engineering Foundation Faculty Excellence Award, the 1991 Billy and Claude Hocott Distinguished Centennial Engineering Research Award, and the 1992 Joe J. King Professional Achievement Award for his "exemplary service and demonstrated leadership in advancing the profession of engineering."

In honor of his 70th birthday, his family created the Raymond C. Loehr Scholarship for Environmental Science to recognize his lifetime of commitment to education. Scholarships are given to students in the Ithaca City School District (ICSD) to encourage and recognize interest in science, especially environmental science. The family also initiated the Raymond C. Loehr Award for Excellence in Science Teaching, given to an ICSD faculty member to recognize innovative methods for fostering interest in the sciences.

Ray loved country music, flowers, and his family, creating over 90 memory books for his loved ones. He leaves his wife of 67 years, Joan M. (Briggs) Loehr, and their eight children: Stephen (Amy Yale-Loehr), Michael (Carrie Koplinka-Loehr), Mary, and James (Caitlin) of Ithaca, NY; Mark (Catherine Tapsall) of South Sutton, New Hampshire; Kathleen (Kevin Coray), Daniel (Karen), and Anne (Neel Inamdar) of Reston, VA, as well as 19 grandchildren and 12 great-grandchildren.

TSO-PING MA

1945–2021

Elected in 2003

"For contributions to the development of CMOS gate dielectric technology."

BY ERIC R. FOSSUM AND A. STEPHEN MORSE

TSO-PING MA, the Raymond J. Wean Professor of Electrical Engineering and Applied Physics and much-loved faculty member at Yale University since 1977, died April 6, 2021, at age 75. He was an award-winning electrical engineer whose work with semiconductors and microchips placed him at the cutting edge of worldwide electronic and technological research.

Born November 13, 1945, in Lanzhou, China, TP (as he was known) fled with his parents to Taiwan following the Chinese Civil War and earned his BS in electrical engineering (1968) at National Taiwan University. He came to Yale for his graduate education, earning his MS (1972) and PhD (1974), both in engineering and applied science.

He worked 2 years at IBM and then returned to Yale, where he eventually became acting chair (1988) and then chair (1991–95) of the Department of Electrical Engineering. As a professor of electrical engineering and of applied physics, his research and teaching focused on semiconductors, MOS interface physics, ionizing radiation and hot electron effects, advanced gate dielectrics, flash memory device physics, and ferroelectric thin films for memory applications.

He studied semiconductors with his mentor, Richard C. Barker, whose research spanned solid state science and technology and who founded the Yale Center for Microelectronic

Materials and Structures. Ma and Barker were the inaugural codirectors of the center and served in that capacity for a number of years starting in the mid-1980s. The two men operated a joint research operation and comentored many Yale graduate students. One of the authors (ERF, PhD 1984) recalls that "It was like an extended family, affectionately known as the Ma-Barker gang, and together they provided complementary insight and guidance for all of us."

Beginning in the 1980s, Ma and his team studied the use of high-permittivity (high-*k*) silicon nitride for transistor scaling. The notion inspired the semiconductor industry and led to the adoption of advanced high-*k* dielectrics in today's highly miniaturized integrated circuits. In the 1990s Ma and his team pioneered research on memory devices based on ferroelectric materials.

He was called by one of his colleagues "the locomotive in driving microelectronics research at Yale." His seminal work on transistor gate dielectrics revolutionized the microelectronics industry, based on his engineering of the dielectric gate materials, which control the flow of electrons through a transistor. His discoveries allowed the transistors to be made extremely small—more transistors could be packed on an electronic chip, thereby increasing computing power.

One of Ma's pathbreaking discoveries began with a visit at Yale to the molecular biology lab of his wife, Dr. Pin-fang Lin, where she was researching the effects of radiation on bacterial samples. Fascinated by the way radiation affected the clear glass, turning it gray, he suddenly wondered what it would do to silicon-based semiconductors. His research on the effects of radiation on silicon chips and semiconductors led to historic findings that aided US security and allowed longer lifespans for satellites.

In addition to his excellence in research and mentoring, Ma recognized the value of international research collaboration and encouraged students and faculty alike to develop a global vision and an innovative mindset. He established the Yale–Peking University Joint Center for Microelectronics and Nanotechnology and promoted academic exchanges and partnerships between the two institutions. He was an honorary guest professor of Tienjin, Tsinghua, and Shandong Universities and a consultant to the NTU–Taiwan Semiconductor Manufacturing Company Research Center.

For research and contributions to the field of gate dielectrics and to the development of the microchip, he received the 2005 Andrew S. Grove Award, one of his many honors. In 2006 the Semiconductor Industry Association bestowed its annual University Researcher Award on him for his pioneering work in semiconductor technology. He received as well Yale's Harding Bliss Prize in 1975, the Connecticut Yankee Ingenuity Award in 1991, two B.F. Goodrich National Collegiate Inventor's Advisor Awards (1993, 1998), the Paul Rappaport Award of the IEEE Electron Devices Society in 1998, the Pan Wen-Yuan Outstanding Research Award (2005) for researchers of Chinese descent who have made theoretical innovations, and the 2008 Connecticut Medal of Technology.

He was a member of the National Academy of Engineering and the Connecticut Academy of Science and Engineering, a foreign member of the Chinese Academy of Sciences, and an academician of Taiwan's Academia Sinica. He was a life fellow of IEEE, member of Sigma Xi, the Electrochemical Society, and Materials Research Society, and a life member of the American Physical Society. In 2016 he received an honorary doctorate from the National Chiao Tung University in Taiwan.

TP was appreciated by students, postdocs, and colleagues for his warmth, kindness, generosity, humor, welcoming smile, and mentorship. "To me," said C.C. Wei, CEO of the Taiwan Semiconductor Manufacturing Company, "TP was more than an advisor. His guidance and wisdom had enormous influence on my career…. It is now up to each one of us to…help the next generation in ways worthy of his investment in us." Other students characterized Ma as "life advisor, close friend, role model," and "full of wisdom, solid on his rationales, frank in his technical judgments, and yet fully open minded to all points of view." One said simply, "People love him."

He was such a distinguished researcher that few might have imagined his avocation: he was an accomplished ice skater. Anyone coming to Yale's Ingalls Rink during a lunch skate or on a weekend when the Yale Figure Skating Club was practicing might have seen him making as many intricate configurations on the ice as he did in parallel over the years in his laboratory—configurations for which Yale University is deeply grateful.

TP was a loving husband to Pin-fang Lin during their 49 years of marriage, a devoted father to Mahau Ma and Jasmine Ma, and a playful grandfather to his four grandchildren.

JOHN C. MARTIN

1951–2021

Elected in 2008

"For the invention, development, and commercialization of anti-viral medicines, especially treatments for HIV/AIDS."

BY RICHARD J. WHITLEY
SUBMITTED BY THE NAE HOME SECRETARY

JOHN CHARLES MARTIN, a chemist, long-time chief executive officer of the biopharmaceutical company Gilead Sciences Inc., and more recently a philanthropist dedicated to addressing health disparities in communities around the world, died March 30, 2021, at the age of 69.

John was born in Easton, Pennsylvania, on May 7, 1951. His parents, Dr. Tellis Alexander Martin and Janet Sacks Martin, both chemists by training, raised John and his three siblings in Evansville, Indiana. John's first job, picking strawberries, was seemingly unrelated to the career path he would take following in his parents' footsteps, but his work ethic, humility, and perseverance were present even at a very young age.

College took John to Purdue University, where he graduated with honors, earning a degree in chemical engineering (1973). He continued his studies at the University of Chicago, joining the laboratory of Professor Josef (Gus) Fried (NAS 1971) working on synthesis of prostaglandins. John received his PhD in organic chemistry in 1977 and, per Gus' recommendation, joined Syntex in Palo Alto, where he quickly advanced to a section leadership role in drug discovery.

At the same time, John attended evening classes and earned his MBA from San Francisco's Golden Gate University (1984), an experience that years later led him to design and implement an onsite, subsidized MBA program for employees of Gilead Sciences, many of whom would otherwise not have had the time or resources to complete their advanced education. The creation of this program was one of many examples of John's commitment to supporting the development of the people he employed and worked with, in all roles and at all levels.

A creative and prolific synthetic chemist, John had an extraordinary ability to mentally visualize the orientation and symmetry of atoms and molecules in three dimensions. At Syntex he synthesized ganciclovir, thus coinventing the first acyclic nucleoside antiviral drug to treat and prevent infections caused by cytomegalovirus. This drug and its prodrug remain cornerstones in the management of cytomegalovirus infections.

John joined Bristol Myers in 1984 to lead its antiviral and antiinfective research programs in Syracuse, New York, where he directed the development and eventual licensure of two dideoxynucleoside antivirals to treat HIV/AIDS—didanosine and stavudine. While at Bristol Myers, John initiated collaborations with Professors Antonín (Tony) Holý in Prague and Erik De Clercq in Leuven, and together they forged the new field of nucleotide antivirals.

In 1990 John joined the then early-stage biotechnology company Gilead Sciences in Foster City, California, to build and evolve its emerging research programs. His first accomplishment was negotiating rights from Tony and Erik to a library of nucleotide analogues. After sustained research and development of these compounds, Gilead was transformed to become a powerhouse of antiviral drug manufacturing and commercialization. The company's continuous success drove the productivity level of an entire industry and, most importantly, reduced life-threatening viral infections to manageable chronic diseases.

In 1996 John was appointed Gilead's chief executive officer, a role he would hold for the next 20 years. During that time he launched 20 innovative medicines, made Gilead medicines accessible to millions of patients in developing countries, and increased the company value 140-fold to $120 billion. He was appointed chair of the board of directors in 2008 and remained in that role until 2019.

His leadership at Gilead was nothing short of legendary. Under his direction, the company developed multiple breakthrough medicines, perhaps most notably for people with HIV, hepatitis B, and hepatitis C. These inventions changed the treatment landscape and John's leadership reshaped the foundation of global access to life-saving therapies.

To simplify HIV treatment, John directed Gilead in forming an unprecedented partnership among three companies that led to the creation of the first regimen of three best-in-class anti-HIV medicines formulated into one pill dosed once daily. This single-tablet regimen was approved by the FDA in 2006 and transformed the care of people living with HIV by avoiding regimens of multiple pills—sometimes more than 30 a day—that made compliance challenging and led to the potential for drug-resisting treatment failures.

A few years later, following John's vision, the company gained regulatory approval for the first HIV medication indicated to prevent transmission of the infection, an approach known as preexposure prophylaxis, or PrEP, for people at risk for HIV infection. To continually advance patient care, John's directive was that "we must continue to innovate to make obsolete our own products," where each innovation improved on the prior advance.

Meanwhile, John turned his focus to curing hepatitis C and put Gilead in the lead to bring to patients several groundbreaking, safe, and curative regimens, essentially eliminating the need for liver transplantation caused by hepatitis C.

His pursuit of innovative science expanded into pioneering solutions for global health. In 2003, when he traveled to Africa with Tommy Thompson (then US Secretary of Health and Human Services), John was struck by the devastation HIV/AIDS was having across the continent. He recognized that the effects extended beyond human lives to economies and societies as a whole.

There was no precedent or blueprint for how a company could enable equitable access, but Gilead forged the path under John's leadership. He directed the design of a revolutionary access program that would deliver the company's HIV treatments to more than 130 resource-limited countries. The program provided licenses and technology transfers to generic manufacturers in India and other countries so that these companies could rapidly scale up production yet maintain low prices. The program later extended beyond HIV to include Gilead's medicines for viral hepatitis B and C. Today, more than 18 million people in low-income countries around the world receive these life-saving medicines each day, owing to John's business ingenuity, engineering excellence, and moral compass.

John's commitment to addressing health disparities was fueled by a deep understanding based on first-hand observations. He traveled to regions of the world most impacted—sub-Saharan Africa, Southeast Asia, and Latin America—and met with healthcare providers, public policy experts, and people doing the work in these regions to develop a better understanding of the barriers individuals faced daily. He then prompted the formation of the Gilead Foundation in 1995 for improving health and well-being in underserved communities around the world.

In 2014 John established his private foundation, the John C. Martin Foundation, with the goal of facilitating the establishment of sustainable improvement of health care for populations in socially and economically disadvantaged settings.

John was widely recognized for his scientific and global health contributions to humanity. His honors include the Horace S. Isbell Award from the Carbohydrate Division of the American Chemical Society (1990), Gertrude Elion Memorial Lecture Award from the International Society for Antiviral Research (2003), Lifetime Achievement Award for Public Service from the Institute of Human Virology at the University of Maryland School of Medicine (2014), Biotechnology Heritage Award from the Biotechnology Industry Organization (2017), Stanford Medicine Lifetime Achievement Award for contributions to science benefitting humanity (2019), and National Academy of Sciences Award for Chemistry in Service to Society (2019). He was elected to the National Academy of Engineering in 2008.

In addition, John was honored by Belgium's Order of the Crown (2017), Senegal's Order of the Lion (2017), and the Republic of Georgia's Golden Fleece (2017). He accepted honorary doctoral degrees from Katholieke University Leuven (2017) and the Scripps Research Institute (2019).

John's expertise was widely sought through private and public sector appointments. He was president of the International Society for Antiviral Research (1998–2000) and chaired two leading industry organizations, the California Healthcare Institute (2005–06, 2009) and BayBio (1999–2001). He served on the boards of Golden Gate University, University of Southern California, University of Chicago, University of California School of Global Health, Scripps Research Institute, Sarepta Therapeutics, Leyden Labs, and Kronos Bio.

He was a member of the NAE COVID-19 Call to Action Committee (2020–21) and the National Academies of Sciences, Engineering, and Medicine's Board on Global Health (2020–21) and Committee on Advancing Pandemic and Seasonal Influenza Vaccine Preparedness and Response: Recommendations for Vaccine Research and Development (2021). He also served on the NAE's Finance Committee (2019–21). His public service included the National Institute of Allergy and Infectious Diseases Council and AIDS Research Advisory Committee (2000–03), the US Centers for Disease Control and Prevention Health Resources and Services Administration's Advisory Committee on HIV and STD Prevention and Treatment (2004–07), and the Presidential Advisory Council on HIV/AIDS (2006–09).

A quiet, unassuming force, John was a visionary leader, an admired mentor, a trusted friend, an endearing partner, and a proud and loving father. His overwhelming generosity and humility were notable characteristics. Never one to seek the spotlight, he took great joy in celebrating others' accomplishments, even when they were achieved through his steady guidance and support. His brilliance changed forever what a diagnosis of HIV or viral hepatitis mean, and his commitment to helping people around the world never faltered.

He is deeply missed by all who knew and loved him. John is survived by his three siblings, son John D. Martin, daughter Margaret R. Martin, and life partner Lillian L. Lou.

JYOTIRMOY MAZUMDER

1951–2021

Elected in 2012

"For quantitative transport modeling for laser interaction and design and commercialization of direct metal deposition machines."

BY YORAM KOREN

JYOTIRMOY MAZUMDER, foremost scholar and educator, entrepreneur, pioneering scientist and guiding force in the field of laser materials processing, inventor of metal deposition machines, and the Robert H. Lurie Professor of Engineering and director of the Center for Laser-Aided Intelligent Manufacturing at the University of Michigan, passed away April 10, 2021, at the age of 69.

Jyoti, as he was generally called, was born in Kolkata, India, to Gouri and Jitendra Mohon Mazumder on July 9, 1951. He received his bachelor's degree in metallurgical engineering from the the University of Calcutta (now the Indian Institute of Engineering Science and Technology) in 1972 and his diploma and PhD in process metallurgy from Imperial College London in 1978. He was a professor for 16 years at the University of Illinois, Urbana-Champaign, and then spent 25 years at the University of Michigan, Ann Arbor.

He became internationally renowned for his innovations, commercialization, and publications in the field of laser-materials interaction, development of quantitative modeling and commercialization in the field of laser materials processing, and leadership in the international laser processing community.

He also pioneered metallic additive manufacturing processes such as closed-loop direct metal deposition (DMD) systems and was recognized as the world's leading authority in metallic additive manufacturing.

In addition, he broke new ground in quality-assured manufacturing through diagnostics and process control. His research in this area continues to provide the fundamental and technological breakthroughs required to establish a new manufacturing paradigm for "certify-as-you-build," a robust and viable approach to reduce manufacturing waste due to problems with quality.

Professor Mazumder was an innovator of the closed-loop DMD process, a method for 3-dimensional printing with metals that was dubbed "the third industrial revolution" by *Economist* magazine in April 2012. Jyoti and his colleagues invented an in situ diagnostic to identify solid-state microstructure from the characteristics of the plasma emission during laser processing. This method has revolutionized the practice of materials synthesis.

He sought to bring scientific understanding to the interactions of laser emission and materials and the application of laser manufacturing to satisfy various needs. He dedicated his professional career to establishing the science and engineering base for laser-materials interactions to meet these needs, and he shared his deep knowledge through his publications, patents, students, and technology transfer.

As an example, the three-dimensional heat transfer model that he developed as part of his PhD thesis for laser processing of titanium alloys with a CO_2 laser was adapted by McDonnell Douglas (subsequently acquired by Boeing) for commercial application. And in 1992 Jyoti developed the mathematical model for Nd-YAG laser drilling used by the General Electric Aircraft Engine Group; at the time the company made 18 billion laser-drilled holes annually for its turbines and controlled the majority of the aircraft turbine market worldwide. The new technique was an industry game changer.

From his earliest days in research, Jyoti built the science base for laser-materials interaction and related applications. In 1994 he published in *Physical Review* models for nanoparticle generation by laser ablation. In 2015 he and his colleagues published in *Nature: Scientific Reports* a prediction of dendrite orientation during additive manufacturing with nickel super alloy. He created the first self-consistent comprehensive mathematical model for laser material processing and subsequently applied that theory to additive manufacturing. He constructed the theory by incorporating relevant new phenomena, and also invented measurement techniques to validate the models using physics-based diagnostics for in situ measurement and monitoring. For example, he invented and patented methods to measure the fluid velocity and resultant surface deformation during laser processing.

Jyoti's breakthrough impacts are summarized below:

- He developed the first 3D self-consistent energy transfer model for laser processing.
- He was the first to identify the mechanism of diffusion in laser surface alloying.
- He authored the first scientific paper on the role of surface tension flow for laser melting.
- He developed and patented the first closed-loop DMD technology.
- He was first to develop and publish on microchannels for implantable artificial lungs.

Besides McDonnell Douglas (Boeing) and General Electric, he transferred his technology to other major industries such as Nissan and Ford. He also created three startup companies:

1. He was the founding director of Quantum Lasers, applying laser cladding technology for repair of engineering components such as aircraft turbines. Quantum Lasers became a major maintenance partner for Delta Airlines and Honeywell Corporation.
2. He patented the first closed-loop DMD technology, where components can be made directly from CAD, and commercialized the technology through a startup called POM Group Inc., which was launched with $25 million venture capital.

3. He launched his third company, SenSigma LLC, in 2012 with the encouragement of the University of Michigan to commercialize his patents on detection of defects and phase transformation during laser manufacturing.

Prof. Mazumder was the inventor on 25 patents in closed-loop metal deposition machines. A prolific author, he published some 400 papers, and coauthored books on laser chemical vapor deposition and on laser materials processing.

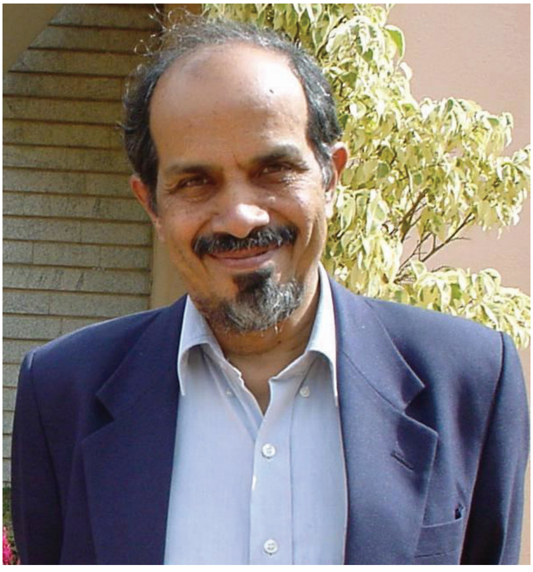
In addition to his NAE membership, he was a fellow of the American Society of Mechanical Engineers (ASME), American Society of Metals, and International Academy of Photonics and Laser Engineering, and he was named president of the Laser Institute of America in 2000.

For the National Academies he served on the Committee on Connector Reliability for Offshore Oil and Natural Gas Operations (2016–18), and for the NAE he served on the Mechanical Engineering Search Committee (2015–19; chair, 2017–18).

In recognition of his accomplishments, Jyoti received several notable honors: the Distinguished University Innovator Award (2012) from the University of Michigan, Adams Memorial Membership Award (2007) from the American Welding Society, Schawlow Award (2003) for seminal contributions to laser application research from the Laser Institute of America, and, from ASME, the Thomas A. Edison Patent Award (2010) for inventing the first closed-loop direct metal deposition system and the William T. Ennor Manufacturing Technology Award (2006).

Apart from all his professional accomplishments, he was a wonderful human being who was loved by so many during his life. He leaves a legacy of bright engineers throughout the world carrying on his teachings and research spanning decades. He is deeply missed by his family and by colleagues, students, and friends all over the world.

His two sons, Debashis and Debayan, had a father who always lived by example and instilled the value of giving your best effort to everything you do. He was a loving husband to Aparajita and they lived an exciting life building their careers, raising their children, traveling the world, and enjoying wonderful moments with family and friends. Jyoti will be forever loved.



RODDAM NARASIMHA

1933–2020

Elected in 1989

"For leadership in the development of aeronautics in India and for many significant contributions to the understanding of fluid flow."

BY KATEPALLI R. SREENIVASAN

RODDAM NARASIMHA, a star researcher and a thoughtful leader, passed away December 14, 2020, at age 87. He was professionally active almost until the end. His career covered teaching, research, technology development, leadership of learned societies and national institutions, scientific advice to the government at the highest levels, and philosophy and history of science. He will be remembered for the quality of his work, the dignity of his personal interactions, and the inspiration he provided to a number of younger colleagues.

He was elected to the NAE as a foreign member in 1989, in the aeronautical engineering section. His primary areas of research interest were the dynamics of turbulent flows, some of them with a geophysical flavor. Other areas of interest were the structure of shock waves, nonlinear dynamics, and a stochastic theory for airworthiness of aircraft. He was closely associated with several major aerospace projects in India, such as the light combat aircraft and light transport aircraft.

Roddam was born July 20, 1933, and brought up in Bengaluru, where his father taught physics in the Central

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Readers may also enjoy recollections of Roddam's life and contributions written by many of his colleagues and his daughter, available online by searching ICTS Newsletter VII-II SPL RODDAM NARASIMHA.PDF.

College. Influenced thus, he considered studying physics, but the sociopolitical circumstances of the recently independent India led him instead to pursue a mechanical engineering degree (1953) from the University of Mysore.

As an undergraduate, he happened to visit the Indian Institute of Science (IISc) on an Open Day and saw Spitfire aircraft of World War II vintage (loaned for the occasion by the Indian Air Force) in the quadrangle of IISc's Department of Aeronautical Engineering. It was love at first sight: he was so fascinated by the design of the aircraft and the complex technology that made it fly that he decided to study aeronautics after his undergraduate degree.

He joined the Department of Aeronautical Engineering at IISc for a diploma and followed it with an associate's degree (equivalent to a master's degree), which he completed in 1957. The association with IISc was to last almost all his life. The chair of the department at the time was O.G. Tietjens, a student of Ludwig Prandtl. Satish Dhawan (NAE 1978) had joined the Department of Aeronautical Engineering in 1951, after obtaining his PhD from the California Institute of Technology under Hans Liepmann (NAE 1965). Roddam's two papers on laminar-turbulent transition, one of which was coauthored with his mentor Dhawan, are still among the most influential fluid dynamics papers to have come from Bengaluru.[1]

Inspired by Dhawan, Roddam went to Caltech to pursue his PhD degree in aeronautics with Liepmann. He set up a facility for measuring jet noise in an anechoic chamber, and the findings were published with Erik L. Mollo-Christensen of MIT. Roddam's theory for free molecular flows using the Boltzmann equation and the Bhatnagar-Gross-Krook (BGK) approximation developed a few years earlier drew immediate attention: Russia had just launched Sputnik and launching a satellite became a national objective in the United States.

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[1] Narasimha R. 1957. On the distribution of intermittency in the transition region of a boundary layer. *Journal of the Aeronautical Sciences* 24:711–12; and Dhawan S, Narasimha R. 1958. Some properties of boundary layer flow during the transition from laminar to turbulent motion. *Journal of Fluid Mechanics* 3(4):418–36.

Rarefied gas dynamics being an essential approximation of flow around space vehicles, Roddam's expertise assumed sufficient importance for him to be hired as a consultant while still a student by one of several companies set up to support NASA's space program. He completed his PhD in 1961 (thesis title: "Some flow problems in rarefied gas dynamics").

He returned to India in 1962 and joined the IISc Department of Aeronautical Engineering as assistant professor. He quickly became a senior professor, and helped to shape outstanding students and assistants who became experts in their subjects and went on to hold important positions. He also later served as dean of engineering (1980–82) and chair of the Department of Aerospace Engineering (1983–84).

India's space program was just starting when Roddam returned to IISc from Caltech and his expertise in rarefied gas dynamics was immediately in demand. He also began a program of Monte Carlo simulations of the Boltzmann equation for space applications.

Much of the research those days concerned shock structure and the Boltzmann equation, turbulent bursting, supersonic flows, flow control, wake structure and turbulence modeling, relaminarization (where a turbulent flow goes back to an orderly laminar state), and drag reduction. An ingenious example of how the boundary layer theory could be applied outside of fluid mechanics is his work on the vibration of elastic strings.

In the mid-1970s, an interdisciplinary group interested in the monsoons started nucleating at IISc and eventually led to the creation of the Centre for Atmospheric and Oceanic Sciences in 1982 with Roddam as its leader. He became convinced that the monsoons were an important fluid-dynamical problem to tackle, and central to this effort were convective clouds.

While there was a plethora of studies on cloud microphysics (how cloud droplets form and grow), cloud dynamics remained poorly understood, particularly the consequences of the release of latent heat on entrainment and mixing processes. So laboratory simulation of clouds was attempted and Roddam's group finally found a novel way to set up cloud-like plumes in the laboratory. He conceived the idea of a monsoon field program to measure the atmospheric boundary layer properties and develop flux relations relevant to monsoon conditions, and the Monsoon Trough Boundary Layer Experiment (MONTBLEX) was carried out in the Indo-Gangetic Plains in 1990. The data analysis led to a new formulation for surface flux at low winds.

In the meantime, Roddam's involvement in India's aeronautical programs was growing. As an example, Indian Airlines had procured Avro aircraft but, at some point, the pilots refused to fly them claiming that the climb rate was too low and the aircraft unsafe to fly. A one-man "Dhawan Committee" aided by a team of advisors from IISc, the National Aeronautical Laboratory (NAL), and Hindustan Aeronautics Limited was formed by the government to examine Avro's airworthiness. Roddam spent considerable effort in this assessment.

It was thus natural that Roddam would be appointed director of NAL (1984–93). His tenure saw many new initiatives, including the development of light combat aircraft, advanced composites, parallel computers, civilian aircraft, and numerical modeling of the monsoon. His focus was on developing advanced technologies and building products. He steered NAL toward contributing to aerospace projects of the Defence Research and Development Organization and Indian Space Research Organization. He was instrumental in changing the culture in NAL from being satisfied with good publishable results to becoming part of projects with defined deliverables.

When he retired from NAL, Roddam was called on to take charge of the National Institute of Advanced Studies (NIAS) as its second director (1997–2004). NIAS was created for interdisciplinary studies and to enrich leadership in industry, government, and public affairs. He excelled in this new role as well, which gave him the opportunity to hone his dormant interests in history of science and philosophy. He authored and edited several books on metaphysics, consciousness, and history and traditions of Indic science. An interesting theme was that the notion of proof, sacrosanct in Western mathematics, was supplanted in the Indic tradition by the focus on successful algorithms and computability, often obliterating the proof by which the algorithms were established.

After his term at NIAS, Roddam made the Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR) his professional home. As chair of its Engineering Mechanics Unit, he oversaw the initial years of its evolution. With less pressure to lead national projects, he returned to his earlier love of research on stability, transition, turbulence, clouds, and the like, and guided students while continuing his interests in philosophy and science policy.

He was an outstanding teacher, both in the classroom and in individual interactions, and a world-class researcher. He cared enormously for quality rather than quantity: For him, writing was an integral part of research because it allowed him to marshal his thoughts rigorously and express them attractively. Over some 65 years he published steadily—about 200 papers, often in the best journals of his field.

His role in various national projects was important as he dispensed advice and wisdom to the highest circles in the country (he was on the advisory council for two prime ministers). Less well known is his dialogue with the US National Academies about India's nuclear program and security. Altogether, his intellectual impact was remarkable and extensive.

Roddam never shrank from responsibilities to which he was called. In addition to those mentioned above, he served as convenor of the Centre for Atmospheric Sciences (1982–89), president of the Indian Academy of Sciences (1992–94), and founder-president of the Indian Society for Mathematical Modeling and Computer Simulation (1998). He was responsible for getting off the ground the Asian Congress of Fluid Mechanics (1980), and most people are unaware that the institutewide fluid mechanics seminar at IISc was created by him.

In addition, the journal *Sadhana*, published by the Indian Academy of Sciences, is his creation, and his interest in higher education was behind the inception of the academy's journal *Resonance*. He was instrumental in establishing the Ministry of Earth Sciences in New Delhi. He expressed on more than one occasion the view that academies should not merely recommend action to the government but also constructively do things themselves.

He was recognized nationally and internationally. Among the prestigious visiting positions he held were the Clark B. Millikan Professor and Sherman Fairchild Distinguished Scholar at Caltech and the Jawaharlal Nehru Professor of Engineering at Cambridge University. Besides being elected to the NAE (1989), he was a foreign member of the US National Academy of Sciences (2000) and a fellow of the Royal Society of London, American Academy of Arts and Sciences, Third World Academy of Sciences (TWAS), and all the academies in India. He had the rare distinction of being elected honorary fellow of the Indian Institute of Science. He received the 1974 Shanti Swarup Bhatnagar Prize for Engineering Sciences as well as India's third and second highest civilian awards, Padma Bhushan (1987) and Padma Vibhushan (2013), and the Gujarmal Modi Award (1990) and Srinivasa Ramanujan Medal (1998) from the Indian Science Congress, among others. Internationally, he received the Fluid Dynamics Award (2000) of the American Institute of Aeronautics and Astronautics, the TWAS Trieste Science Prize (2008), and the 2019 Lifetime Achievement Award for Mentoring in Science established by *Nature* magazine.

The many honors and recognitions that came his way made no difference to Roddam's personal qualities that endeared him to so many: easy accessibility to all; the openness with which he interacted with people of all walks of life; abiding interest in intellectual pursuits and love for truth, scientific culture, and scholarship; unprejudiced and disciplined advice provided when sought; clarity of thought in spoken and written words; the personal example he naturally and effortlessly set; genuineness of curiosity; and the inspiration he provided to numerous colleagues. His is a legacy that will endure far into the future.

He is survived by his wife, Dr. Neelima Narasimha, and their daughter, Professor Maitreyi Narasimha.


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B/F

ROBERTA J. NICHOLS

1931–2005

Elected in 1997

"For the development of alternative fuels and flexible-fuel vehicles."

BY WALLACE R. WADE, CHARLES K. WESTBROOK,
RICHARD J. WINELAND, JOHN J. KOSZEWNIK,
AND KATHLEEN A. McDONALD

ROBERTA JEAN NICHOLS, a pioneering aerospace and automotive engineer who led the development of alternative fuel vehicles for Ford Motor Company, died April 3, 2005, of leukemia at her home in Plymouth, Michigan, at the age of 73. Born November 29, 1931, to Robert and Winifred Hilts in Venice, California, Roberta grew up following her father to junkyards to salvage parts, learning to weld, and helping to work on his vintage cars. Her professional career was inspired by her father, who was a Douglas Aircraft Company engineer.

She graduated from Santa Monica High School in 1949. She earned a bachelor's degree in physics from the University of California, Los Angeles in 1968, and then her master's (1975) and doctoral (1979) degrees in environmental engineering from the University of Southern California. She attained all three of her degrees while working full time and raising a family.

Roberta's first job in 1957 was as a mathematician at Douglas Aircraft Company. In 1958 she joined Space Technology Laboratory in Redondo Beach, CA, one of the prime contractors for the Air Force Space Program, and worked on computer technology.

When Congress formed the Aerospace Corporation in El Segundo, CA, in 1960, she was transferred there to work as a data analyst and researcher. The corporation was established as a nonprofit organization to aid the Air Force in "applying the full resources of modern science and technology to the problem of achieving continuing advances in ballistic missiles and military space systems." Over the next 19 years she worked on weapons systems and air quality controls.

Roberta often said, "My first love is the internal combustion engine." She was initially interested in what she called "funny fuels," not to reduce air pollution but to enhance the performance of internal combustion engines in the boats and cars that she raced. She raced blown-fuel hydroplanes at the quarter-mile boat drag races and held the women's world record, 131 mph, from 1966 to 1969. From 1964 to 1972 she headed the board of directors of the National Drag Boat Association.

By 1972 Roberta decided to concentrate on racing vintage cars, especially a 1954 Mercedes-Benz 300-SL Gullwing—once owned by actress Jeanne Crain—that she bought in 1968. She restored the vintage Gullwing and raced it at Laguna Seca and other venues. She even raced a methanol-powered 1929 Model A Ford and reached her fastest speed of 190 mph at the Bonneville Salt Flats in Utah.

In 1978 Roberta formed California's synthetic fuel office and personally converted a Ford Pinto station wagon to run on methanol. A year later, a Ford Motor Company official learned of her work and hired her to be the driving force for alternative fuels at Ford. Through her initiative, the company delivered its first fleet of methanol vehicles to California in 1981. She worked tirelessly on methanol, ethanol, natural gas, and electric vehicles, including experiments with hybrid gasoline-electric vehicles. She made frequent trips to Washington, DC, to show alternative fuel cars to members of Congress.

She worked at Ford from 1979 until her retirement in 1995, first as a principal research engineer, then as manager of alternative fuels, and later as manager of electric vehicle external affairs, strategy, and planning. Reflecting on her Ford career, she simply said, "Sustainable, clean energy became my passion."

Roberta worked tirelessly to solve the so-called "chicken and egg" dilemma as it related to alternative fuel vehicles and the infrastructure needed for alternative fuels: Vehicle manufacturers could not justify producing vehicles capable of operating on alternative fuels if they could not be refueled, and energy companies could not justify developing the infrastructure for alternative fuels without a sufficient number of vehicles to use the fuel. As a breakthrough solution, Ford began development of a dual- or flexible-fuel vehicle (FFV) in 1982 and, between 1985 and 1992, built and delivered over 700 experimental FFVs to California and Canada. They could operate on either methanol or gasoline or any mixture of the two fuels, with only one fuel system.

The key incentive that initiated widespread adoption of FFVs was the Alternative Motor Fuels Act of 1988, which Roberta was instrumental in promoting. The act provided significant Corporate Average Fuel Economy (CAFE) credits for the manufacture of FFVs that could operate on either an alternative fuel or gasoline. These FFVs would be assigned a higher fuel economy value for CAFE purposes in recognition of the fact that they could displace gasoline use and thus reduce dependence on foreign oil. The special CAFE calculation encouraged the production of FFVs by helping automobile manufacturers meet the CAFE standards, and led to widespread adoption of FFV technology and greater demand for ethanol made from corn and other biomass (renewable organic material from plants and animals). This in turn provided an expanded market for US farmers. Thus began the movement toward ethanol as the primary source of alternative fuel, the growth of a vehicle fleet capable of operating on alternative fuel, and the development of an infrastructure to support the fleet.

In model year 1991 Ford introduced its methanol FFV Taurus, which was produced until model year 1998. In model year 1994 the company added the ethanol FFV Taurus. Since these beginnings, FFV technology has been used in millions of production Ford vehicles. Other US manufacturers followed and by 2015 more than 80 different vehicle models with FFV capability were offered in the United States. Within 5 years 22 million FFVs were on the road.

The Department of Energy reports that there are now 3300 stations in 42 states dispensing ethanol (E85) fuel, up from only 126 stations in 2002. Since ethanol is a domestic energy source in the United States, it helped to reduce reliance on imported oil. The E85 used in FFVs consists of 85 percent ethanol and 15 percent gasoline. Roberta's research showed that the 15 percent gasoline provided adequate fuel vaporization for cold weather starting. Additionally, an E85 flame is easily visible in daylight for safety purposes.

Because of the corrosive nature of ethanol, which contains oxygen, Roberta oversaw the development of ethanol-compatible materials for FFV fuel system components (e.g., lines, hoses, gaskets, valves, fuel pumps, fuel injectors, and fuel tanks). As a result, these materials are now commonly used across the industry as the ethanol content in most gasolines has increased to 10 percent.

Roberta authored or coauthored over 60 publications and held three patents for the FFV, with an engine capable of using 100 percent gasoline, alcohol, or any mixture of both without any special action by the driver. The patents describe methods for (i) determining the desired air-to-fuel ratio for a mixture of two different fuels, such as gasoline and ethanol, with different stoichiometric, or chemically correct, air-to-fuel ratios; and (ii) a method for controlling the amount of spark advance for a mixture of two different fuels with different volatility and volumetric energy content. These methods were programmed in Ford's EEC IV on-board engine computer so that the process was entirely automatic. Roberta was also instrumental in introducing the "FlexFuel E85 Ethanol" badge that was used on Ford as well as General Motors vehicles.

She also supported Ford's worldwide alternate fuel vehicle programs. She served as an alternative fuel consultant to India at the request of the National Science Foundation and the United Nations in 1984.

Most notable is her work that supported Ford's transition to ethanol fuels in Brazil. Because Brazil did not have any domestic petroleum production, all of the fuel needed to accommodate the country's growing transportation demand was imported. By using excess sugar cane production to make ethanol, Brazil could "home grow" most of the fuel needed to replace imported gasoline. Roberta's ethanol engine research was instrumental in greatly improving the drivability, performance, and emissions of Ford's Brazilian vehicles operating on ethanol. These improvements resulted in high customer satisfaction with ethanol-fueled vehicles.

As an accomplished veteran of boat and vintage car racing, in 1994 Roberta drove Ford's small electric Ecostar delivery van in the 600-mile American Tour de Sol, the world's largest electric and solar vehicle road rally; she finished second, behind another Ecostar. With a sodium-sulfur battery storing energy for a 75 horsepower (56 kW) electric motor, the Ecostar introduced the road-and-leaf logo now used on a number of Ford products to represent the company's environmental commitment and alternative fuel leadership.

One of the authors (CKW, NAE 2017) was an enthusiastic and appreciative beneficiary of Roberta's research. As he studied the hydrocarbon fuel molecules with the simplest possible structures, methane and methanol, to understand variations in engine performance using different fuels (among other things), he found that everywhere he looked, all the best work on methanol was done by R.J. Nichols. After several years, he was pleased to discover that this pioneering researcher was Dr. Roberta J. Nichols at Ford Motor Company.

She became well known and honored for her work. She was elected a member of the National Academy of Engineering in 1997—at the time one of only 37 women elected since its formation in 1964. She was the first woman to be elected a fellow of the Society of Automotive Engineers and one of only 270 fellows among the organization's 80,000 members worldwide. She was also a fellow of the Society of Women Engineers (SWE) and a member of the American Society of Mechanical Engineers. Her awards include the SWE National Achievement Award (1988) and the Gene Ecklund Award from the Department of Energy (1996). In 1989 the California South Coast Air Quality

Management District selected Roberta to receive one of its first Clean Air Awards for her work with alternative fuels.

Roberta was a founding member of the advisory board for the College of Engineering – Center for Environmental Research and Technology (CE-CERT) at the University of California Riverside (UCR). Her devotion to CE-CERT and the UCR students continues through her generous creation of an endowed scholarship at UCR to encourage women in mechanical engineering. "I just grew up not knowing that girls weren't supposed to like to do those kinds of things," she told *Woman Engineer* magazine in 1992, after she had become a role model inspiring young women to go into her male-dominated profession. "As soon as I start talking to people about engines, they know I really do know what I'm talking about. It doesn't matter anymore that I'm a woman."

Her expertise was also recognized in appointments to National Academies committees to Review the Research Program of the Partnership for a New Generation of Vehicles (1999–2002), to Review the R&D Strategy for Biomass-Derived Ethanol and Biodiesel Transportation Fuels (1998–99), on the Advanced Automotive Technologies Plan (1997–98), and for a Review of the National Automated Highway System Consortium Research Program (1997–98). In addition, she served on the Charles Stark Draper Prize Committee (2000–02).

In a speech to SWE in March 2005, Roberta said, "Not all of us get to realize our dreams, but it is important to have them and never give up trying to attain them. It is amazing what can happen when you want something bad enough." That was truly reflective of how she lived her life. No challenge was too small, no goal too large. She hoped that every young person, male or female, who heard her story would be inspired to pursue a career in engineering.

Roberta's husband of 30 years (they married in 1974), Lynn Yakel, died July 27, 2008. She is survived by her daughter Kathleen McDonald, stepsons David Yakel and Dennis Yakel, and four grandchildren. She was preceded in death by her first husband (1948–59), William McDonald, and their son Robert McDonald. She was married to J.E. Nichols from 1960 to 1973.

JAMES J. O'BRIEN

1929–2020

Elected in 2012

"For development of standards of practice for computerized scheduling of construction projects and capital programs."

BY LILLIAN C. BORRONE

JAMES JEROME O'BRIEN, an early adopter and proponent of the critical path method of construction management scheduling and former chair and CEO of O'Brien-Kreitzberg & Associates, died of natural causes December 31, 2020, in Yardley, Pennsylvania, at the age of 91.

Jim was born to Sylvester Jerome and Emma Belle Filer O'Brien in Philadelphia on October 20, 1929. He was proud of his Irish heritage and a go-getter. When he enrolled at Cornell University in a 5-year engineering course in 1948, he realized that, while he was fortunate to be there, he needed a job. He waited tables at one of the fraternity houses and decades later noted that it gave him the opportunity to follow "Big Red" football passionately as the fraternity president was close friends with key team members. He also joined NROTC to assist with his financial situation.

Jim graduated from Cornell with a bachelor's degree in civil engineering in 1952. It was a momentous year for him as he also married Carmen Heister that June. Shortly after marrying he began his service in the United States Navy, serving during the Korean War. He and Carmen also began their family with their first child, Jessica, born in December of 1953. They subsequently added two more children, Michael and David.

Jim's first engineering job was with Rohm & Haas as a project engineer (1955–59). While there he began to focus on project management and also did some postgraduate study at the University of Houston.

In 1959 he accepted a project engineer position with the Radio Corporation of America, where he served on project installations in New Jersey, Greenland, and Alaska through 1962. That year he returned to the Philadelphia area and went to work for John Mauchly (NAE 1967), one of the pioneers of the computer field who, with J. Presper Eckert (NAE 1967), created the ENIAC (Electronic Numerical Integrator and Computer).

With his project management experience and an interest in the critical path method (CPM) of contract scheduling, Jim now worked with a mentor who both supported his interests and had developed a computing device that offered the capacity to introduce CPM more broadly to the engineering community. Jim worked with Mauchly & Associates until 1965, when he founded and became senior vice president of Meridian Engineering Company of Philadelphia with Fred Kreitzberg.

Licensed in Pennsylvania, New York, and New Jersey, Jim then served as president of Molecular Delivery Corporation (1968–72) in Cherry Hill, NJ, before establishing the consulting firm of James J. O'Brien, PE (1972–77). Both served as platforms for him to promote the CPM concept.

CPM was used as the basis of a management information system to support the US Army Corps of Engineers in the construction of the vertical assembly building (VAB) for the Saturn rocket program at Cape Canaveral, Florida, in the mid-1960s.[1] Its success led to NASA's choosing Meridian Engineering and their team to develop a similar system for all aspects of the Apollo space travel program.

In 1968 O'Brien led a team to apply "the Cape Canaveral approach" to New York City's capital program, which had

[1] As reported in a profile published in *Engineering News Record* (May 26, 2003), "Off the Critical Path? Experts Debate the State of CPM Scheduling."

a $4 billion public works backlog and needed to expedite projects to the bid stage.

During the 1970s O'Brien-Kreitzberg & Associates, founded in 1972, evolved into a well-known consulting firm with a team monitoring 2500 projects. Jim served as president of the firm (1977–80), CEO (1980–89), and then chair, from 1993 until the firm was acquired by URS in 1997.

In 1988 the Port Authority of New York and New Jersey brought in the O'Brien-Kreitzberg team to help expedite, organize, and manage its $2 billion John F. Kennedy International Airport 2000 renewal program. Among other responsibilities, the contract called for O'Brien-Kreitzberg to introduce and educate the Port Authority Engineering Department staff about the use of CPM, which it did with great effect. The PA staff became proponents of the scheduling approach and later adopted other strategies promoted by Jim O'Brien, including formalized project management and value engineering.

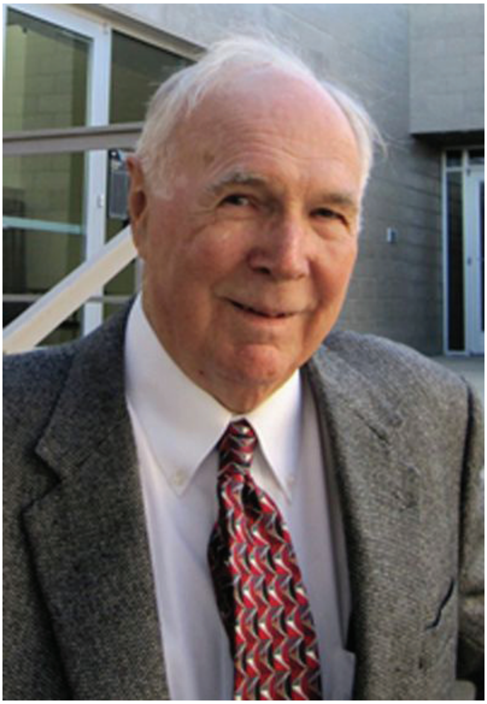
Eager to put out the word about the critical path method, he published the first textbook on the subject, *CPM in Construction Management: Scheduling by the Critical Path Method* (McGraw-Hill, 1965). It became a bestseller and a staple of academic study, and is now in its eighth edition. He also wrote or coauthored eleven other books.

In addition to his professional career, Jim was very engaged in engineering organizations. He was a cofounder of the Project Management Institute (elected a fellow in 1989) and Society for the Advancement of Value Engineering; and he was very active with the Lawrence D. Miles Value Foundation, for which he served 6 years as director of the board and 19 years as a trustee; Construction Management Association of America (elected a fellow in 1993); American Society of Civil Engineers (elected a fellow in 1996); and Project Management Association of America.

In addition to his election to the NAE, he was recognized with the Professional Manager Award from the NY Chapter of the Society for the Advancement of Management in 1969.

However one defines success, it is clear that Jim O'Brien was one. He leveraged his knowledge and experience in unique fashion using his management experience to contribute to the growth of a new industry and new applications to educate practitioners and enhance the practice of engineering.

He and Carmen divorced in 1984 and later that year he married Rita F. Gibson, who eventually became executive vice president of O'Brien-Kreitzberg. She had two children, Susan Mathers (William) and Stephen Gibson (deceased). Rita died in November 2010. Jim is survived by his children Jessica Snyder (Marc), Michael O'Brien (Victoria), and David O'Brien (Pamela); four grandchildren and four great-grandchildren; and Rita's daughter and grandchildren.



HAROLD W. PAXTON

1927–2021

Elected in 1978

"Contributions to metal science and application of this understanding to the improvement of metals and their processing."

BY ALAN W. CRAMB

HAROLD WILLIAM PAXTON, US Steel Professor Emeritus in the Department of Materials Science and Engineering at Carnegie Mellon University, was a noted physical metallurgist who shaped the future of metal science, steel production and its application, and engineering education. He died March 8, 2021, at the age of 94.

Known to everyone as Harry, he was not only a well-respected, world-leading metallurgist but also an outstanding organizational leader in industry, universities, government agencies, and nonprofits. He was well known for his wry sense of humor, his ability to solve difficult problems in novel ways, and his love of golf.

Hilda and Jack Paxton announced the birth of Harry on February 6, 1927, in Goldsboro, Yorkshire, England. Twenty years later he earned his bachelor's (1947) and master's (1948) degrees in metallurgy from the University of Manchester and, after spending a year on scholarship at Carnegie Tech in Pittsburgh, got his PhD (1952) from the University of Birmingham, where he met and married Ann Dorothy Davies. In 1953 they moved to the United States when he accepted a position at Carnegie Tech (now Carnegie Mellon University) as an assistant professor in the Metallurgy Department, teaching a course on alloy steels.

He became department head and director of the Metals Research Laboratory in 1966.

With the exception of a few stints away from the campus, Carnegie Mellon was Harry's professional home. He was a visiting professor at Imperial College London in 1962 and at the Massachusetts Institute of Technology in 1970. He left CMU briefly (1971–73) to become the first director of the Materials Division of the National Science Foundation (NSF), and again in 1975 when US Steel hired him as vice president of research. After retiring from US Steel as vice president of corporate research and technology assessment in 1986, he returned to CMU as the US Steel Professor in the Department of Materials Science and Engineering until his retirement in 1996.

In addition to his work in the development of alloy steels—his most significant contribution to metals science—he coauthored the book *Alloying Elements in Steel* (American Society for Metals, 1966) with Edgar C. Bain (NAS) of US Steel.

He was also active on committees of the National Academies of Sciences, Engineering, and Medicine. He was appointed to the Committee on the Competitiveness of the Minerals and Metals Industries (1988–90), Committee to Review the Ohio Thomas Edison Technology Centers (chair; 1989–91), Committee on Research Programs of the US Bureau of Mines (1994–96), and Committee on Materials Technologies for Process Industries (1999–2001). In his capacity as an NAE member, he served on the Materials Engineering Peer Committee (1987–89), Awards Committee (1986–87; chair, 1987–88; and 1988–89), and Committee on Membership (1991–94).

His technical and educational contributions were well recognized. He received the ASM Bradley Stoughton Award for Young Teachers of Metallurgy in 1960. In 1978, besides his NAE election, he was selected as the ASM Edward DeMille Campbell Memorial Lecturer. In 1983 he gave the ASM Zay Jeffries Lecture and received the ASM Gold Medal for the Advancement of Research. In 1985 he was designated an honorary member of the Iron and Steel Institute of Japan and delivered its Yukawa Memorial Lecture, and in 1987 he gave the Harold Moore Lecture to the Institute of Metals (London). He also lectured in Argentina, Brazil, China, France, Holland, Mexico, Poland, the United Kingdom, and the former USSR.

He was president of the American Society for Metals and Minerals (ASM) in 1976 and president (1982) and honorary member (1991) of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME). He was a fellow of the American Association for the Advancement of Science, ASM, and TMS (the Minerals, Metals & Materials Society, which became a separate entity from ASM in 1986).

As previously noted, Harry loved golf, and he was very involved in the Oakmont Country Club, where his putting prowess was often challenged. It was on the golf course that his humor and competitiveness were at their best. He always had an amusing story about the club members or about a time when he played with a famous industry or government leader. However, on serious topics it became clear that Harry thought deeply about the future for materials, for education, and, in particular, for Carnegie Mellon University, which was his professional passion.

His personal passion was, of course, his family, of whom he was very proud. His wife Ann was an accomplished artist, and during their 67 years of marriage she was also his companion, muse, and golf partner. In 1996 they moved to Green Valley, Arizona, where Harry got involved with the Community Performance and Art Center and became its chair in 2009.

Ann survives him, as do their four children—Jane Wasilov (Alex), Sally Paxton, Anthony Paxton (Lisa), and Nigel Paxton (Sue)—and six grandchildren.

Harry's was a life well lived. He recorded an oral history for AIME[1]; for anyone who wishes to better understand the man, in his own words, there can be no better way to spend an hour.

[1] Available at https://aimehq.org/what-we-do/oral-histories/harold-w-paxton.

DENNIS J. PICARD

1932–2019

Elected in 1990

"For leadership in development of radar computer systems essential for national security."

BY MARK E. RUSSELL

DENNIS J. PICARD, a defense industry legend and leader, who as Raytheon Company's chair and CEO led the company through a historic era of industry consolidation and helped it emerge as a global leader in defense technology, passed away October 21, 2019, in Concord, Massachusetts, at the age of 87.

He was a dedicated and widely respected engineer and business leader, and one not shy in dealing with comment and controversy. He was very highly regarded in engineering circles for his knowledge and expertise in the design of large strategic radars, missile guidance systems, and ballistic missile defense. In the defense industry he was well known as a demanding manager, a persistent and implacable competitor, and for his ability to assemble and lead outstanding teams of engineering and technical professionals and business managers.

Dennis Picard was born to Joseph and Louise Picard in North Providence, Rhode Island, on August 25, 1932, and was a graduate of LaSalle Academy. After service with the Air Force in the United States and overseas during the Korean War, he attended RCA Institute in New York and graduated as a licensed broadcast engineer. He opened a TV repair business in the basement of his parents' RI home.

He began his career as an engineering assistant at Raytheon's Waltham operation in 1955, after famously getting lost en route to a scheduled interview at GTE's Waltham plant; as he slowed traffic while struggling to read a map, a policeman directed him to a Raytheon hiring center instead. During his early days with the company, he concurrently completed bachelor's degrees in electrical engineering and management at Northeastern University, graduating cum laude in 1962.

He rose rapidly through Raytheon's engineering ranks and into program and general management, becoming CEO in 1991; he retired as CEO in 1998, as chair in 1999, and remained on the company's board of directors until 2000. His career with the company spanned 44 years, from the early days of the growth of electronics, radar, and guided missile technologies through the first Gulf War and the subsequent wrenching consolidations of the defense industry.

An engineer by training as well as a registered professional engineer, he was tapped in 1983 to lead Raytheon's Missile Systems Division, specifically to help complete the Patriot defense system. He helped turn around the program, which was then designed to defend against aircraft, and championed its development as an antimissile system.

He succeeded long-time Raytheon CEO Tom Phillips (NAE 1971) in March 1991, shortly after the Patriot rose to fame during the Gulf War. He engineered the company's mid-1990s acquisition of E-Systems and the defense units of Chrysler, Texas Instruments, and Hughes Electronics. As he said about the negotiations, "They were our archrivals. It was like the Red Sox and Yankees suddenly having to work together." The acquisitions, which took place during a period of unprecedented industry consolidation triggered by post–Cold War budget cuts, doubled the size of Raytheon and enabled it to become one of the world's largest defense contractors.

Picard took a broad view of his responsibilities to the community, beyond those of his corporate position. In the mid-1990s he grew concerned about the departure of manufacturing companies—and jobs—from Massachusetts, largely because of burdensome taxes that directly affected the manufacturing sector. He spearheaded an alliance of corporate, labor, academic, and political leaders that eventually succeeded in passing legislation establishing a new basis for the state's taxation of manufacturing industries.

He was a member of the Business Council and the National Business Roundtable, and a former member of the Defense Policy Advisory Committee on Trade, the President's National Security Telecommunications Advisory Committee, and the President's Export Council. He had also served as a trustee of Northeastern University and Bentley University, director of State Street Boston Corporation and the Discovery Museum of Acton, MA, and member of the advisory committee of the American Red Cross.

For the National Academy of Engineering, he served on the Council's Industry Advisory Board (1997–2000) and the Fritz J. and Dolores H. Russ Prize Committee (2006–09).

Picard was broadly recognized and rewarded for his contributions, beginning with his NAE election in 1990. He was an honorary fellow and past president of the American Institute of Aeronautics and Astronautics, and a life fellow of the Institute of Electrical and Electronics Engineers, having been cited by IEEE for his "leadership in the development and implementation of large phased array radars." In addition, the IEEE Dennis J. Picard Medal for Radar Technologies and Applications was established in 1999, sponsored by Raytheon, to honor outstanding accomplishments in advancing the fields of radar technologies and their applications.

In 1991 he was inducted into the US Army's Order of Santa Barbara, and in 1996 he received the National Security Industrial Association's Environmental Achievement Award. In March 1997 he was honored by the Navy League of the United States with the Fleet Admiral Chester W. Nimitz Award "for outstanding contributions to the United States' Maritime Strength"; in May he was selected for the Intrepid Museum Foundation's Intrepid Salute Award for his "support of the men and women of America's armed forces"; in September he received the John R. Alison Award from the US Air Force Association; and in October the Association of the US Army presented him with its John W. Dixon Award. Also that year he was named "New Englander of the Year" by the New England Council and received the Ralph Lowell Distinguished Citizen Award from the Boston Minuteman Council of the Boy Scouts of America. In 1998 he received the Industrial Leadership Award from the National Defense Industrial Association, the Semper Fidelis Award of the Marine Corps Scholarship Foundation, and, from the Navy League–New York Council, the Rear Admiral John J. Bergen Leadership Medal for Industry. He received honorary doctorates from Northeastern University, Merrimack College, and Bentley University.

He felt strongly about the value of education and, among other substantial gifts to his alma mater, established the Dennis Picard Engineering Legacy Scholarship. In his honor Raytheon endowed the Dennis Picard Trustee Professorship in electrical and computer engineering at Northeastern.

Picard was an avid fisherman and boater, sailing out of Harwich Port on Cape Cod, where he was an active member and past board member of the Allen Harbor Yacht Club. He also loved skiing, hockey, the Boston Bruins, the New England Patriots, and spending time with his children and grandchildren, for whom, and for his many friends, he was always a much-appreciated problem solver.

He was the beloved husband of Dolores M. (née Petit) Picard, whom he married in 1953, and the loving father of their five children: Dennis J. Picard Jr. (wife Joan), Mary Doherty (husband Dennis), Ken Picard (partner Colleen), Sharon Ayoob (husband Mitchell), and Linda Jones (husband Keith). He is also survived by eight grandchildren and four great-grandchildren.

DELLA M. ROY

1926–2021

Elected in 1987

"For internationally recognized contributions to the applied science and engineering of cement and concrete."

BY SUSAN E. TROLIER-McKINSTRY

DELLA MARIE MARTIN ROY, professor emerita of materials science at the Pennsylvania State University, died March 27, 2021, at age 94. Throughout her career she combined a keen intellect with unruffled grace while managing a large research program and working on important problems in cement strength, hydroxyapatite formation, nuclear waste disposal, and reuse of industrial byproducts such as fly ash.

She was born to Harry L. and Anna Martin on November 3, 1926, in Merrill, Oregon. After graduating from high school at age 16, she enrolled at the University of Oregon, where she graduated Phi Beta Kappa with a bachelor's degree in chemistry in 1947. She then crossed the country to Pennsylvania State University for her graduate studies, receiving her MS degree in mineralogy in 1949, under Elburt F. Osborn (NAE 1968), future director of the US Bureau of Mines.

During her graduate work, she shared an office and lab with another graduate student, Rustum Roy (NAE 1973), who later became a significant figure in materials research as a founding member of the university's Materials Research Laboratory. Their relationship grew and they married in June 1948, a marriage that spanned 62 years until Rustum's death in 2010.

The following year the couple moved briefly to India, where he had grown up, but returned to Penn State in 1950; Rustum joined the faculty and Della pursued a PhD in mineralogy, which she received in 1952. She then joined her husband on the Penn State faculty, where she rose to the rank of full professor in 1975. In her 50-year research and teaching career at the university she mentored dozens of graduate students, as MS or PhD advisor, as well as postdoctoral fellows. After "retirement" from Penn State, she remained active in research there and at Arizona State University, where she was a research professor.

She became renowned as a leader in the world of cement and concrete, known especially for her work in advanced concrete materials for pavements, chemically bonded cements, ancient cement-based building materials, and high-temperature cements for geothermal wells. Her other areas of research included chemically bonded ceramics, crystal growth and crystal chemistry, and phase equilibria. Her patents range from porous biomaterials for bone repair to methods for radioactive storage.

In 1971 she founded the journal *Cement and Concrete Research*, the first in the field, and served as its editor until 2005. She was also the author or coauthor of more than 400 publications; among the most important of these papers are:

- "Hydroxyapatite Formed from Coral Skeletal Carbonate by Hydrothermal Exchange"[1]
- "Ettringite and C-S-H Portland Cement Phases for Waste Ion Immobilization: A Review"[2]
- "Effect of Silica Fume, Metakaolin, and Low-Calcium Fly Ash on Chemical Resistance of Concrete"[3]
- "New Strong Cement Materials: Chemically Bonded Ceramics"[4]
- "Tissue Ingrowth of Replamineform Implants"[5]

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[1] Roy DM, Linnehan SK. 1974. *Nature* 247(5438):220–22.

[2] Gougar MLD, Scheetz BE, Roy DM. 1996. *Waste Management* 16(4):295–303.

[3] Roy DM, Arjunan P, Silsbee MR. 2001. *Cement and Concrete Research* 31(12):1809–13.

[4] Roy DM. 1987. *Science* 235(4789):651–58.

[5] Chiroff RT, White EW, Weber JM, Roy DM. 1975. *Journal of Biomedical Materials Research* 9(4):29–45.

Della was active in the broader community and well recognized by her peers for her contributions. She was a distinguished life member, fellow, and trustee (1992–95) of the American Ceramic Society (ACerS) and received its John Jeppson Award (1982), Copeland Award (1987), and Bleininger Award (2004). The ACerS Della Roy Lecturer Award was established in her honor in 2000.

In 1987 she became the first female materials scientist and the first Penn State woman elected to the National Academy of Engineering, and she and Rustum were the first couple to be thus honored. Also that year she was named an honorary member of the Institute for Concrete Technology. In 1991 she was elected to the World Academy of Ceramics as its first female member, and in 2012 she was one of the recipients of the first annual Golden Goose Award, which is given by Congress to honor federally funded research leading to major breakthroughs in scientific, technological, medial, public health, and other fields of benefit to the public.

In addition, in 1965 the mineral dellaite was named after her—one of only 112 women to have one of the nearly 5500 minerals named after them (as of May 2019).

Della valued her privilege to serve the Academies. She was appointed to many committees, including the NIST Assessment Board's Panel for Building Technology (1985–91), Committee for the Review of the New York State Low-Level Radioactive Waste Facility Siting Process and Methodology Selection (1993–96), Committee on Unconventional Concrete Technology for Renewal of the Highway Infrastructure (1995–97), Committee on the Waste Isolation Pilot Plant (1994–97), and Committee for Research on Improved Concrete Pavement for Federal-Aid Highways (1999–2004).

For the NAE she served on the Academic Advisory Board (1989–92), Materials Engineering Peer Committee (1990–93), and Membership Policy Committee (1993–96 and 2001–04).

The Roys made their home in State College a central meeting location where they hosted a variety of luminaries, including governors of California, the president of India, and Nobel Laureate Linus Pauling.

Della is survived by sons Ronnen Andrew Roy (wife Sinaly) and Jeremy Roy (wife Lydia), and two grandchildren. Son Neill Rathan Roy predeceased her in 2018.

ROBERT E. SCHAFRIK SR.

1946–2018

Elected in 2013

"For innovation in materials for gas turbine engines."

BY MARY L. SCHAFRIK AND JIM WILLIAMS

ROBERT EDWARD SCHAFRIK SR., 72, passed away July 10, 2018. He was born in Cleveland, Ohio, to Edward E. and Sylvia Farina Schafrik on February 6, 1946, and lived most recently in Williamsburg, Virginia.

Bob graduated from St. Ignatius High School in 1963 with a scholarship to Case Institute (now Case Western Reserve), where he was a member of the honors fraternity Phi Kappa Phi and served as the chapter treasurer. In 1967 he received his bachelor of science degree in metallurgy.

He worked briefly as a filtration engineer at American Air Filter in Louisville, Kentucky, where he met Mary Louise Schuhmann. They married in October 1968, the same year he was commissioned as a 2nd lieutenant in the US Air Force. While in the service he earned a master of science degree in aerospace engineering from the Air Force Institute of Technology (1974), and a doctorate in metallurgical engineering from the Ohio State University (1979). He later earned an MS degree in information systems from George Mason University (1996).

In the Air Force Bob advanced to the rank of lieutenant colonel in 1984 and was assigned increasingly responsible positions, including division chief of Air Superiority Headquarters, AF Systems Command, Andrews AFB (1984–87) and division chief, Strategic Defense Initiative Office, Washington, DC (1987–88).

When he retired from the Air Force in 1988 he accepted a position as vice president of R&D at Technology Assessment and Transfer in Annapolis, Maryland, until he was hired in 1991 at the National Research Council (NRC), where he became director of the National Materials Advisory Board (1993–97) and Board on Manufacturing and Engineering Design (1995–97).

In 1997 he joined GE Aviation in Cincinnati, where he rose to general manager of the Materials and Process Engineering Department, heading the unit responsible for developing leading-edge materials, characterizing material properties, selecting materials for specific applications, preparing specifications, and ensuring an adequate global materials industrial base to support the company's NPI and legacy turbine engines. He and his team reduced the development time for new materials such as low rhenium turbine blade alloy, high-temperature cast-and-wrought disk alloy, and titanium aluminide turbine blade alloy, and expanded the use of composite applications in engines. He retired in 2014.

He held 21 US patents and was certified as a professional engineer in Ohio. He authored or coauthored over 20 papers in refereed journals, and coedited the chapter on "Modern Manufacturing" in the 1998 CRC *Mechanical Engineering Handbook*.

Bob was a nationally and internationally renowned expert in materials and manufacturing. After he left the NRC staff and joined GE, he was sought for service on a number of its boards and committees. Between 2005 and 2018, he served on some 15 studies and panels, including the Committee on Technologies to Deter Currency Counterfeiting (chair, 2005–07), Committee on Research Opportunities in Corrosion Science and Engineering (ROCSE) (cochair, 2008–10), National Materials and Manufacturing Board (2006–13; chair, 2013–15), Committee on Defense Materials, Manufacturing, and Infrastructure (vice chair, 2010–16), and Committee on Connector Reliability for Offshore Oil and Natural Gas Operations (chair, 2016–18).

He was quite active in other professional activities, such as ASM International, for which he chaired the Federal Affairs Committee (1997–2000) and Awards Policy Committee

(2011–18). His involvement with other professional activities included the Gordon Research Conferences, Theoretical Foundations of Product Design and Manufacturing, American Institute of Aeronautics and Astronautics, IEEE, TMS, and Air Force Scientific Advisory Board. In addition, he served on the Materials Department external advisory committees for the Ohio State University and University of Cincinnati.

In recognition of his contributions, he was elected to the NAE and designated an ASM fellow in 2013. He also received the GE Edison Award (2010) and ASM Eisenman Award for Lifetime Achievement in Materials (2014), and was inducted into the GE Aviation Propulsion Hall of Fame (2016). A research laboratory in the new OSU Biomedical Research Building is named in his honor, and in 2018 he was designated the first Presidential Distinguished Professor of Industrial, Systems, and Manufacturing Engineering, a new position at the University of Texas at Arlington.

Bob was an avid outdoorsman and became a member of an elite group of people who had climbed to the summit of all 58 of the Rocky Mountain 14,000-foot peaks. He ran the Marine Corps Marathon in Washington, DC, and the Cincinnati Flying Pig Marathon several times, and completed the RAGBRAI weeklong 468-mile bike ride across Iowa five times. He also was civic minded and chaired the Huber Heights, OH, Bicentennial Commission (1975–77).

In addition to Mary, Bob is survived by their four children, Catherine Spage, Franki, Robert Jr., and Steven, and two grandchildren.

FRANK J. SCHUH

1935–2020

Elected in 1989

"For innovation and leadership in the advancement of drilling procedures and design methods, particularly the technology for high-angle drilling."

BY KEITH K. MILLHEIM

FRANK JOSEPH SCHUH was all about the profession of drilling. A pioneering innovator and industry leader in drilling technology, especially horizontal drilling, he worked for ARCO Oil and Gas Company as head of drilling and production mechanics research and later was the founder and president of Drilling Technology Inc. He passed away in Plano, Texas, December 24, 2020, at age 85.

He was born February 3, 1935, in Columbus, Ohio, to Sebastian and Elizabeth Schuh. When the time came, he attended the Ohio State University, where he earned concurrent BS and MS degrees in petroleum engineering in 1956.

In 1956 as a drilling engineer at ARCO he developed the tools and techniques for medium curvature horizontal drilling, and the company was one of the first to drill such wells as a research effort.

As soon as Frank retired from ARCO in 1984, he founded his own company, mainly to promote the use of horizontal drilling. He developed novel geological targeting techniques and methods for calculating the stresses in horizontal drilling.

In many conversations about how the drilling engineering profession was not acknowledged in comparison to reservoir, production, and facility engineering, he was adamant that one of his goals was to change that. And he did. With his technological innovations and outspoken commitment, Frank's lasting impact on the oil industry was profound.

He was one of the very first champions of drilling engineering, and it can be said that he significantly helped the United States develop oil and gas reserves using horizontal drilling technology, which was previously thought to be uneconomical. He not only helped develop the technology but also was a key player in selling it to industry. His leadership and gregarious nature made people listen. Today's reliance on horizontal drilling is a tribute to his vision and persistence.

As a champion for drilling engineering, Frank pushed the discipline through his active engagement in organizations like the Society of Petroleum Engineers (SPE). He was chair of the Dallas SPE Section (1979), a Distinguished SPE Lecturer (1982), served on the SPE Board of Directors (1982–84), and chaired SPE forums on Well Control, Well Design Methods, and Horizontal Drilling. For his indefatigable efforts, he received the SPE Drilling Engineering Award in 1986 and was designated a distinguished member.

Even with his extensive involvement in the SPE he was frustrated with its lack of attention to the drilling engineering profession. So in 1981 he founded (and chaired) the Drilling Engineering Association, which built a significant membership. In addition, he was active with the International Association Drilling Corporation (IADC; in 1987 he chaired the SPE/IADC Program Committee) and American Petroleum Institute, for which he chaired the Standardization Committee for Valves and Wellhead Equipment (1985–88).

Parallel to his activities with professional societies and associations, Frank taught workshops on horizontal drilling, was active with the University of Tulsa, authored numerous technical articles, and had 29 patents in a broad range of drilling areas.

For the National Academies, he volunteered his expertise as a member of the Committee to Examine the Research Needs of the Advanced Extraction and Process Technology Program (1992–93). And after his election to the National Academy of Engineering in 1989, he made the most of his membership by serving on the Earth Resources Engineering Peer Committee (1995–97; vice chair, 1997–98; chair, 1998–99), Section 11 (Earth Resources Engineering) Executive Committee (1998–99), Committee on Membership (Peer Committee chair, 1998–99; vice chair, 1999–2000; chair, 2000–01), 2000 Nominating Committee (1999–2000), and Membership Policy Committee (2005–08).

In addition to his NAE election, his contributions were recognized with his selection to receive the AIME's 1994 Robert Earll McConnell Award and the Ohio State University's 1995 Benjamin G. Lamme Meritorious Achievement Medal.

There is no doubt that he also influenced many people on his journey through life. I was one of them. In 1989 Frank was the first drilling-oriented engineer inducted into the NAE. The next year I was elected and later learned it was Frank who had sponsored my nomination.

When Frank and I got together, after exhausting oil-related topics, we would discuss areas of mutual interest—football and in particular the Dallas Cowboys. He was an adamant fan of the Cowboys and would discuss the details and strategies of the team, acquired from his attendance at special Cowboys events with the coaches. But we did have one area of debate: who was better, his Ohio State Buckeyes or the University of Oklahoma Sooners.

Frank was a family man who loved his summer vacations sailing and coaching baseball with his children. He was also a diehard golfer—given a chance he'd be on a golf course. He was a member of St. Rita Catholic Community in Dallas since 1965 and taught CCD (the Confraternity of Christian Doctrine, or catechism).

Frank is survived by Alice Kasler, his wife of 64 years, their sons Dwain J. Schuh (Kimberly) and Michael J. Schuh (Wyn), six grandchildren, and two great-grandchildren. He was preceded in death by daughter Barbara Ann Van Zile (Thomas).

I will always remember Frank with his constant smile, his humor, his readiness to discuss and debate, and his passion for drilling technology and drilling engineering.

GEORGE W. SUTTON

1927–2021

Elected in 1994

"For contributions to ballistic missile re-entry, lasers, medical devices, imaging systems, and aero-optics."

BY EARL H. DOWELL

GEORGE WALTER SUTTON—an eminent aerospace engineer and scientist and the longest-serving editor in chief of the *AIAA Journal*—passed away February 13, 2021, at the age of 93. His impact on the journal and indeed on all publications of the American Institute of Aeronautics and Astronautics remains an unmatched legacy. In addition to his substantial technical contributions, he is remembered for the high standards and rigorous editorial process that he established and that have been maintained and built on by his successors. A man of firm views leavened by a dry sense of humor, his wisdom and candor continually moved AIAA publications in a more productive direction.

George Sutton was born to Jack and Pauline Sutton in Brooklyn, New York, on August 3, 1927. After attending Brooklyn Technical High School he served in the United States Merchant Marine during World War II and the Army Air Force in Okinawa through 1947. After his military service, he earned his bachelor's degree in mechanical engineering with honors from Cornell University's School of Engineering

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This memorial was prepared with the willing and respectful help of his successors as editor in chief of the *AIAA Journal*: Tom I-P. Shih, since 2021; Alexander J. Smits (NAE 2011), 2015–20; Peretz P. Friedmann, 2009–14; and Elaine S. Oran (NAE 2003), 2003–08.

in 1952 and received both his master of science degree (1953), also in mechanical engineering, and doctor of philosophy in engineering and physics magna cum laude (1955) from the California Institute of Technology.

His career spanned government, the private sector, and academia. He began at General Electric in Philadelphia (1956–63), where he invented the heat protection material for hypersonic flight through the Earth's atmosphere—enabling the first US reconnaissance satellites, as high-resolution film could be returned to Earth in a recovery vehicle. He then worked for the US Air Force Headquarters in the Pentagon (1963–65) before moving to a series of opportunities in industry, culminating with his job at Cobham Analytic Solutions as principal senior scientist for new projects and the Space Laser Project (1999–2011) and then as a consultant at Analysis and Applications, Inc. in Huntsville, Alabama. He also taught at Stanford University, the University of Pennsylvania, and the Massachusetts Institute of Technology, and authored or coauthored 130 papers, coauthored or edited 3 books,[1] and held eight patents.

A pioneer and expert in heat protection material for hypersonic flight, magnetohydrodynamics, and high-power lasers, Dr. Sutton made many significant contributions in aerospace. In addition to being the first to measure the heat transfer in the throat of a rocket nozzle, he invented the ablation heat shield material allowing safe reentry from space used by US ICBMs and early crewed spaceflight; produced the first resolved photograph of a foreign spacecraft from Air Force Maui Optical Station (AMOS) telescope in Hawaii; developed the concept design for the first high-power CO_2 laser that generated 130 kW; demonstrated the small high-frequency transcutaneous energy supply for artificial hearts used by Abiomed; and developed the concept design of the SOFIA aircraft for infrared astronomy and aero-optic analysis of the airflow.

[1] His books include *Engineering Magnetohydrodynamics*, coauthored with Arthur Sherman (McGraw-Hill, 1965), and *Direct Energy Conversion* (McGraw-Hill, 1966), which was translated into Japanese and Russian.

As editor in chief of the *AIAA Journal*, he made it clear that he did not want the journal to "be all things to all people; instead, each paper has to have some relevance to aerospace, either directly or by demonstrating a technique that could be useful in aerospace. The emphasis is on the practical for our industry, without which the journal would not exist…." Under his leadership (1968–96), the *AIAA Journal* disseminated an enormous amount of knowledge that nurtured and advanced aerospace engineering in its golden era, during which so many remarkable accomplishments were made.

Dr. Sutton's accomplishments were recognized by his peers through numerous honors, beginning in 1965 when he received the Arthur S. Flemming Award for "unique contributions to the fields of heat protection of hypersonic reentry vehicles, and magnetohydrodynamic power generation." He received the AIAA's 1980 Thermophysics Award, 1988 Distinguished Service Award, and 2007 Plasmadynamics and Lasers Award for his pioneering work in aero-optics and in the development of high-power gas lasers, both pulsed and continuous wave, and in laser effects, and was designated an honorary fellow. In addition to his membership in the National Academy of Engineering, he was a fellow of the American Association for the Advancement of Science. The American Society of Mechanical Engineers awarded him the Nancy DeLoye Fitzroy and Roland V. Fitzroy Medal in 2015 "for distinguished contributions to the art and science of mechanical engineering including cavitation, hypersonic heat transfer, direct energy conversion, high-energy lasers and aero-optics; and for the invention of the first successful reentry ablation material and the development of the transcutaneous energy supply for artificial hearts."

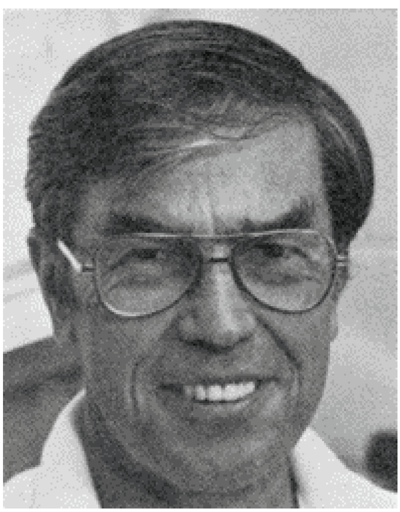
He was involved in a number of activities of the National Academies and NAE. He was appointed to the committees on Aging Avionics in Military Aircraft (2000–01), Thermionic Research and Technology (2000–01), Implications of Emerging Micro- and Nanotechnologies (2001–03), and Directed Energy Technology for Countering Indirect Weapons (2007–08), among others. And for the NAE he served on the Audit Committee

(1995–96) and Section 01 (Aerospace) Executive Committee (1998–2000) and Peer Committee (1998–2001).

George enjoyed playing classical piano, sailing, swimming, tennis, and the theater. He was also a devoted family man, treasuring opportunities to travel abroad with his wife, go sailing with his sons, and spend time with his much-loved grandchildren.

He was preceded in death—just a month earlier—by his beloved wife and best friend of 68 years, Evelyn Doris (née Kunnes) Sutton. They are survived by sons James, Charles, Richard, and Stewart, and six grandchildren.


DECITRIG
MADE IN U.S.A.



JOHANNES WEERTMAN

1924–2018

Elected in 1976

"Contributions and research on deformation of materials at high temperatures and strain rates and on fatigue of metals."

BY LYLE H. SCHWARTZ

JOHANNES WEERTMAN passed away October 13, 2018, at age 93. His wide-ranging and groundbreaking research spanned creep of crystalline solids; internal friction, fatigue, and fracture of metals; dislocation theory; geothermal energy; mechanics of glaciers; and stability of ice sheets, among others.

Hans was born May 11, 1925, to Roelof "Rudy" and Christina van Vlaardingen Weertman in Fairfield, Alabama. During his school years he got excited about science and math thanks to good teachers. In World War II he enlisted in the US Marines (1943–46) and served in occupied Japan as a corporal. He had intended to pursue chemical engineering but changed his mind when he enrolled in the Carnegie Institute of Technology (now Carnegie Mellon University), where he majored in physics and received his BS in 1948 and his DSc in 1951. His thesis, "Internal Friction and Young's Modulus of Cold-Worked Copper Single Crystals," was published joint with James S. Koehler.[1]

At Carnegie, Hans met Julia Ann Randall. The two were married February 10, 1950, and honeymooned in New York City for a week. After they finished their theses, they moved to Paris where both were postdocs (1951–52). Hans, a Fulbright

[1] *Journal of Applied Physics* 24:624 (1953); https://doi.org/10.1063/1.1721339.

Postdoctoral Fellow at the École Normale Supérieure, called it a "golden postdoc grand honeymoon." During a side trip to London and a visit to the nearby US Office of Naval Research, Hans was recruited to the Naval Research Laboratory (NRL) in Washington. Julia was a successful "walk-in" applicant to NRL when they arrived.

Hans worked in solid state physics at NRL from 1952 to 1958, continuing his work on dislocation theory and broadening his interest in materials to include problems of a geologic nature, including glaciology and the migration of subglacial lakes under ice sheets. He wrote several career-defining papers during this period.[2]

In 1958–59 he served as a scientific liaison officer for ONR in London. He expected to return to NRL stateside, but while in London he was recruited to join the Materials Science Department at Northwestern University (NU). He was hired as an associate professor and chaired the department from 1964 to 1968, when he was designated the Walter P. Murphy Professor. His early publications and continuing interest in applying deformation concepts to geophysics had also led to his joint appointment in 1963 in the Department of Geological Sciences.

With NU colleague Morris Fine (NAE 1973), the Weertmans contributed to and edited volumes in the early 1960s *Macmillan Series in Materials Science* based on graduate courses offered at NU. For years these were among the primary materials science textbooks for courses at NU and elsewhere, and the Weertmans' coauthored book *Elementary Dislocation Theory* (Collier-Macmillan Ltd., 1964) was still used in NU's materials science and engineering classes into the 21st century. It was translated into three other languages and republished in 1992 by Oxford University Press.

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[2] On creep: Theory of steady-state creep based on dislocation climb. *Journal of Applied Physics* 26(10):1213 (1955); and, with G.S. Ansell, Creep of a dispersion-hardened alloy. *NRL Technical Report 5176* (1959). On glaciers: On the sliding of glaciers. *Journal of Glaciology* 3(21):33–38 (1957); and Traveling waves on glaciers, Union Géodésique et Géophysique Internationale, Association Internationale d'Hydrologie Scientifique, Symposium de Chamonix, September 16–24, pp. 162–68 (1958).

In the 1970s, as part of a multidisciplinary group studying fatigue, Hans extended the theory of dislocation-induced crack tip formation. He also expanded his work to "hot rocks" and geothermal energy. Spending his summers at Los Alamos he did technical work that led to DOE-funded geothermal research at NU with colleagues in the Chemical and Mechanical Engineering departments. In 1975 he wrote "Water pumped into the deep earth to make steam causes fracturing of rock"[3]—words familiar in today's world of oil and gas extraction by "fracking." His early work in this field remains "groundbreaking"! Two decades later he published *Dislocation Based Fracture Mechanics* (World Scientific Publishing Company, 1996).

He was active in service to the profession. He chaired the 1969 Gordon Conference on Physical Metallurgy and served on the governing council of the International Glaciological Society (1968–71 and 1982–83). For the National Academies he was appointed to the 1972–73 steering group of the NAS Ross Ice Shelf Project and chaired the Ad Hoc Panel on Polar Ice Coring (1985–87). As an NAE member he served on the Peer Group Committee for Mining-Metallurgy/Ceramics/Materials Engineering (1977–81; chair 1980–81), Academic Advisory Board (1988–91), and Materials Engineering Peer Committee (2000–01).

He was the associate editor of the *Journal of Geophysical Research* (1972–75), editorial advisor to the *Journal of Glaciology* (1972–91), and coeditor of *Mechanics of Materials: An International Journal* (1980–99).

His groundbreaking work was recognized with numerous honors. In 1960 his seminal contributions in geophysics, initiated at NRL, were honored by the British Antarctic Place Names Committee and recognized by the US Board on Geographical Names with the naming of Weertman Island, situated at 66°58′S, 67°44′W in Antarctica, approximately

[3] Weertman J. 1975. Theory of velocity of earthquake dislocations. *GSA Memoirs* 142:175–83. Also see Weertman J, Weertman JR. 1975. High temperature creep of rock and mantle viscosity. *Annual Review of Earth and Planetary Sciences* 3:293–315.

3½ miles long, peak elevation approximately 600 meters (~1,968.5 feet). He went on to receive the Robert E. Horton Award of the American Geophysical Union (1962), Champion H. Mathewson Gold Medal of the Metallurgical Society of AIME for work on creep and fatigue fracture (1977), Acta Metallurgica Gold Medal (1980), and Seligman Crystal of the International Glaciological Society (1983). He was elected to the National Academy of Engineering in 1976 and was a fellow of the Geological Society of America, ASM International, American Physical Society, American Geophysical Union, TMS-AIME, American Academy of Mechanics, and American Academy of Arts and Sciences.

In 2017 TMS renamed its TMS Educator Award the Julia and Johannes Weertman Educator Award, which "recognizes a higher caliber individual who has made outstanding contributions to education in metallurgical engineering and/or materials science and engineering."

Julia died July 31, 2018. They are survived by their daughter Julia Ann Zerebny and husband Nicholas, son Bruce and wife Leslie Miller, and a grandson.


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JULIA R. WEERTMAN

1926–2018

Elected in 1988

"For exceptional research on failure mechanisms in high-temperature alloys."

BY LYLE H. SCHWARTZ

JULIA ANN RANDALL WEERTMAN was born February 10, 1926, in Mount Lebanon, Pennsylvania, the daughter of Winslow and Louise Neumeister Randall. When she died July 31, 2018, at age 92 in Evanston, Illinois, she was the Walter P. Murphy Professor Emerita of Materials Science and Engineering at Northwestern University. Her life and career were marked by numerous firsts.

As a youngster, Julia was interested in airplanes. In her words: "When I was in junior high school I was enthralled with airplanes. Airplanes were more exotic back then than the buses of the sky that they are now. I chose to study science and math to become an aeronautical engineer."[1] Instead, she enrolled at Carnegie Institute of Technology (now Carnegie Mellon University) and majored in physics at the encouragement of Frederick Seitz (NAS 1951). She was the first woman undergraduate in the College of Engineering and Science at CIT and received her BS (1945), MS (1947), and DSc (1951) from that institution. Her thesis publication, joint with Immanuel Estermann, was titled "Specific Heat of Germanium Between 20°K and 200°K."[2]

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[1] From her profile on the NAE's EngineerGirl website (https://www.engineergirl.org/2919/Julia-Weertman).

[2] *Journal of Chemical Physics* 20(6):972 (1952); https://aip.scitation.org/doi/10.1063/1.1700659.

Julia met Johannes Weertman (NAE 1976) during her first year of graduate school; she was a teaching assistant for a physics class in which he was a student. They married on Julia's 24th birthday and, after a week's honeymoon in New York, finished their theses and spent 1951–52 in Paris, where Julia was a Rotary International Fellow at the École Normale Supérieure.

After the fellowship, she began work as a solid state physicist at the Naval Research Laboratory (NRL) in Washington, DC, where Hans was already employed. Julia was a successful "walk-in" applicant to NRL when they arrived. In the late 1950s her NRL career ended when she gave birth to the first of their two children; thus began the period of her life later noted on her resume as "raising family." Hans accepted a position at Northwestern in 1959 and the family moved to Evanston.

Even when she was not formally employed, Julia's interest in the field did not wane. She collaborated with Hans on some of his work, and in the early 1960s, with him and Morris Fine (NAE 1973), coedited the *Macmillan Series on Materials Science* based on graduate courses offered at Northwestern University (NU). The Weertmans' book *Elementary Dislocation Theory* (Collier-Macmillan Ltd., 1964) was included in the series, subsequently translated into three other languages, and republished in 1992 by Oxford University Press. It remained in use in NU's MSE classes into the 21st century.

By the early 1970s the Weertman children had reached their teenage years and it was time for Julia to end her "raising family" period. In 1972 she was appointed "visiting" assistant professor in the NU Materials Science and Engineering (MSE) Department and the next year invited to join the faculty formally, the start of her 45-year career there. She was NU's first female materials science professor. (It is believed that she was the third female MSE faculty member in the United States, following Della Roy [NAE 1987] of Penn State and Doris Kuhlman-Wilsdorf [NAE 1994] of UVA.)

She established a research program on deformation and creep of metals and alloys and the effects of very high temperatures on the fatigue and failure of pure metals and alloys.

She investigated the structural effects of such deformation at high heat using small-angle neutron scattering (SANS). Her pioneering use of SANS techniques to study cavitation and damage during the deformation of metals yielded a new view of cavitation, providing information about the size and shape of micrometer-sized cavities in a nondestructive manner.

She contributed substantially to understanding of boundary interactions, mechanical properties, basic deformation processes, and failure mechanisms in a variety of materials, from nanocrystalline metals to high-temperature structural alloys—she studied the former long before "nano" became a popular area in materials science. She also examined the mechanical behavior of materials where grain boundaries determine their strength and deformation characteristics.

Julia's interests in materials broadened to include high-cycle fatigue and, with Hans and several faculty from various departments, she participated in the NSF-funded Fatigue Thrust Group at Northwestern. This group was responsible for much of the fundamental understanding that led to lifetime prediction used in aircraft today.

In 1987 she was promoted to chair of the department, a position she held until 1992. According to Northwestern, Julia was the first woman in the country to chair a university materials science department. During her tenure the number of materials science undergraduate students more than doubled, and she recruited two new female faculty members.

Julia was a mentor and role model to female graduate students and faculty not just at Northwestern but throughout the materials community.[3] She believed that scientists have a responsibility to improve society, and actively worked on women's issues and advocated for women in all walks of life. Further exercising her responsibility as a global scientist, she wrote letters on behalf of persecuted scientists overseas. She spoke at other universities and national meetings and

[3] Julia's influence on generations of students is described in a 2019 tribute published in *MRS Bulletin* 44:221–22, available at https://link.springer.com/article/10.1557/mrs.2019.55.

published extensively about issues of diversity. Her leadership was recognized by the Society of Women Engineers, which bestowed on her its Distinguished Engineering Educator Award (1989) and Achievement Award (1991). She also received two Special Creativity Awards for Research from the National Science Foundation.

Other honors include induction into the National Academy of Engineering in 1988; the TMS Leadership Award (1996); Von Hippel Award (2003)—she was the first woman to win this highest honor of the Materials Research Society; and Gold Medal (2005) of ASM International. She was selected for the TMS Institute of Metals/Robert Mehl Lecture in 2006 and was the ASM/TMS Distinguished Lecturer in 2012. The American Association of Engineering Societies awarded her the 2014 John Fritz Medal for her role in the understanding of materials and for inspiring women to pursue careers in science. She was a fellow of ASM International, the Neutron Society of America, the American Academy of Arts and Sciences, and the first woman named a fellow by TMS-AIME.

In 2014 the MSE Department at Northwestern established the Johannes and Julia Randall Weertman Graduate Fellowship in honor of the couple's contributions to materials science and to the university. In 2017 TMS renamed its TMS Educator Award the TMS Julia and Johannes Weertman Educator Award for an individual who has made outstanding contributions to education in metallurgical engineering and/or materials science and engineering. The award website notes that "Drs. Julia and Johannes Weertman have accomplished, both individually and jointly, a very rare feat: (a) they rose to prominence in materials science and engineering through their pioneering research accomplishments which have profound effects on technology; (b) they were instrumental in the emergence of materials science and engineering as a new discipline; [and] (c) as a couple, they developed a rare synergy, a unique phenomenon in our field and an example for the younger generations."

Julia's professional activities included serving on the Neutron Scattering Facilities Review Committee of the Department of

Energy's Council on Materials Science (1985–87), National Steering Committee for an Advanced Steady-State Neutron Source (1986–92), TMS Board of Directors (1990–93), Materials Research Society Board of Directors (2001–07), and TME Long-Range Planning Committee (1988–93, chair 1990–93).

She also served on quite a few National Academies committees, including—in keeping with her personal dedication—the Committee on Human Rights of the NAS, NAE, and NAM (1994–2000); Committee on Women in Science, Engineering, and Medicine (1995–2005); Celebration of Women in Engineering Organizing Committee (1997–99); and Committee on a Guide for Recruiting and Advancing Women in Science and Engineering Careers in Academia (2002–06). In addition, she was appointed to the Condensed Matter and Materials Research Committee (1990–97; vice chair, 1992–93; chair, 1993–95); Solid State Sciences Committee (1990–97; chair, 1993–95); Committee on Microgravity Research (1991–94); National Materials and Manufacturing Board (1999–2004); and Committee on Assessing the Feasibility, Accuracy, and Technical Capability of a National Ballistics Database (2004–08). For the NAE she served on the Council (1996–2002) and Materials Engineering Section Peer Committee (1993–96; vice chair, 1994–95; chair, 1995–96).

In her 2012 profile on the NAE's EngineerGirl website, she wrote, "I can't imagine wanting any career other than engineering. My advice to young women who are considering engineering as a major involves the usual clichés, but they are nonetheless valid: Work hard and try to be the very best, keep your sense of humor active, and don't take yourself too seriously. Stick with top-notch people. And most of all, enjoy what you do."

Julia enjoyed gardening, traveling, jazz, border collies, and collecting southwestern Pueblo and Hopi pottery. She is remembered as a dedicated teacher, pioneering researcher, valued colleague, and friend, a woman of warmth and inspiration who made seminal contributions to her field.

Hans died October 13, 2018. They are survived by daughter Julia (Nicholas Zerebny), son Bruce (Leslie Miller), and a grandson.

ROBERT J. WEIMER

1926–2021

Elected in 1992

"For application of stratigraphic principles to exploration, and for promoting continuing professional education."

BY PAUL WEIMER, LAURA LAMAR, AND HOSSEIN KAZEMI

ROBERT JAY WEIMER passed away August 25, 2021, in Boulder, Colorado. He was 94 years old. An internationally known geologist, he distinguished himself in a 7-decade career as an outstanding teacher, influential researcher, and innovative explorationist.

Bob was born September 4, 1926, in Glendo, Wyoming, to John and Helen Weimer. In 1944 he graduated from high school (in a class of 14 students) and joined the US Navy's officer training program and studied engineering at the University of Southern California until the end of the war. After being discharged in 1946, he enrolled at the University of Wyoming, where he received a BA in 1948 and MA in 1949, both in geology.

While in college, Bob met his life partner, Ruth Adams, a journalism student and campus leader. They married in September 1948 and she became the secret ingredient in Bob's success.

His first job (1949–51) was with Union Oil, at several locations in the Four Corners area. He took a leave of absence to continue his geology studies at Stanford University, where he completed his PhD in the 2½ years covered by the amount of funding remaining from his GI Bill. In 1954, PhD in hand, he returned to work with Union Oil for 1½ years in Wyoming and

Montana, and then began working as a consulting geologist in late 1954.

As an explorationist, Bob broke new ground at age 32 with his innovative discovery of the Patrick Draw Field in southwest Wyoming in 1959. Previously, major Rocky Mountain oil fields had been associated only with structural traps. Bob, however, recognized the presence of a productive stratigraphic trap; namely, the combination of the updip pinchout of the Almond Sandstone and where it overlies the Wamsutter arch. This Patrick Draw discovery launched a decade of exploration in the Rockies and nationwide, searching for similar kinds of previously unrecognized or ignored stratigraphic traps. Later, in 1973, Bob applied the same stratigraphic concepts to help discover the Spearhead Ranch Field in the southwestern portion of the Powder River Basin in northern Wyoming.

While he was identifying new techniques to locate petroleum fields, Bob also pursued his lifelong dream of becoming a teacher. In 1957 he was hired as a professor at the Colorado School of Mines (CSM) and soon became well known in the Rocky Mountain geologic community as he chose to research areas that were not only economically productive but also near CSM and Denver. This made it easy for local geologists to visit the outcrops he studied and apply his concepts to their companies.

Bob published several papers that quickly became standard references and the starting point for understanding the regional framework of the Upper Cretaceous strata.[1] Local companies applied this framework extensively, leading to major productive petroleum discoveries.

In the classroom, Bob used his experience in industry to bring an applied perspective, so his students learned both

[1] For example, [1] Upper Cretaceous Stratigraphy, Rocky Mountain Region. *Bulletin of the American Association of Petroleum Geologists* 44(1) (1960); and [2] Relation of Unconformities, Tectonics, and Sea-Level Changes, Cretaceous of Western Interior, USA, in *AAPG Memoir 36: Interregional Unconformities and Hydrocarbon Accumulation*, ed. Schlee JS (1984).

geologic theory and pragmatic operational concerns. Many of them credit him for their successful careers.

Bob was influential not only for the quality of his teaching but also for the number of students he taught. In his 60-year tenure at CSM, he personally taught more than 1000 students; many of them took his “Principles of Stratigraphy” class, which was required for all geology, geophysics, and petroleum engineering majors. A significant number of those students found employment in the Rocky Mountain geocommunity and built lifelong ties with their former professor.

His commitment to education extended beyond his CSM students—he was motivated to educate the public and public officials. In evenings and during the summers of 1971–88, Bob designed and taught special courses for congressmembers and staff, industry and business leaders, and other key people to give them a sense of how science and the energy industry work.

His industry short courses used cores from the laboratory he established at CSM in 1972 and outcrops in the Golden and Morrison areas. His summer field courses started with Precambrian rocks at Red Rock Park and progressed to the Pennsylvanian Fountain Formation and, in Morrison, the Permian Lyons Sandstone and Lykins Formation. At the I-70 roadcut he pointed out the Jurassic Morrison Formation and Lower Cretaceous Muddy (J) Sandstone. He would also go to the Muddy (J) outcrops at Dinosaur Ridge and Turkey Creek—the latter is a surface oil seep, and he would tell participants that they were walking through an oil field. He also took groups to the Upper Cretaceous Niobrara Formation north of Boulder and the Cretaceous Hygiene Sandstones near Hygiene, CO.

The CSM campus is unique because of the near vertical, uppermost Cretaceous outcrops that bound the west end of campus. Large portions of the strata were quarried for clay in the early 20th century for building materials in Denver. The excavations left spectacular exposures, which Bob meticulously described; his work was eventually turned into an educational “walking geology trail” known as the Bob Weimer

Mines Geology Trail.[2] The strata display a record of Colorado Front Range uplift—the rocks exposed on the CSM campus and the Table Mountains and Green Mountain 3 miles south of the campus—showing the outcrops of the Pierre, Fox Hills, Laramie, and Arapahoe formations, rich with fossils and dinosaur tracks.

In all his courses and tours, he was eager to share his knowledge and help people understand the terrain around them. As he said, "It is important for us to take an active role in the management of our resources…. [And] we must also get involved with the education of our young people about natural resources by leading field trips and spreading our knowledge into the primary and secondary schools."

Bob served as CSM Geology Department chair (1964–69) and held the inaugural Getty Chair from 1978 until his retirement in 1983. For the next 30 years he remained active both as an emeritus professor at CSM and as a geoconsultant in the Denver area.

In addition to local pursuits, he traveled and taught internationally. For example, he taught as part of a Fulbright program at the University of Adelaide in 1967, and returned to Australia several times to teach short courses. He also taught at the University of Calgary (1970) and at the Institute of Technology of Bandung in Indonesia (1975). These trips were life-changing experiences for both Bob and his family and led to many lasting friendships in numerous countries.

Bob's strong professionalism led to extensive service for many geologic and engineering professional associations. He was active with the local Rocky Mountain Association of Geologists, which recognized him as an honorary member (1973) and Outstanding Scientist (1982). He was president of the Society for Sedimentary Geology (SEPM; 1972–73) and American Association of Petroleum Geologists (AAPG; 1991–92) and a distinguished lecturer for both the AAPG and Society of Exploration Geophysicists. For the National

[2] It is described and illustrated in Colorado School of Mines Geology Museum Special Publication No. 1, 2004.

Academies, he volunteered as a member of Committee on Integrated Resource Planning in Romania (1992–93), Panel on Review of the Oil Recovery Demonstration Program of the Department of Energy (1994–96), and Ford Foundation Diversity Fellowships Predoctoral Review Panel on Physical Sciences and Mathematics (1999, 2000, 2003). After his election to the NAE in 1992, he served on both the Peer Committee (1994–97) and Executive Committee (vice chair, 1997–99; chair, 1999–2000) for Earth Resources Engineering (Section 11).

Bob received many awards during his distinguished career, including the AAPG Sydney Powers Medal (1984); American Institute of Professional Geologists' Ben H. Parker Medal (1986); University of Wyoming Distinguished Alumnus (1994); SEPM Twenhofel Medal (1995); American Geoscience Institute's Legendary Geoscientist Medal (2006); and honorary memberships with several groups. The Colorado School of Mines honored Bob with the Mines Medal (1982), Brown Medal (1990), an honorary degree (2008), and in 2012 establishment of the Weimer Distinguished Chair in the Department of Geology and Geological Engineering.

While Bob was building his career, he and Ruth raised their family on Lookout Mountain near Golden. In his 55 years there, Bob served many volunteer roles, including president of his community and chair of the local water committee. With his geologic expertise, he found the best locations to drill water wells in Mount Vernon Country Club. To this day, that water fills the taps for Mount Vernon's 100 households, swimming pool, and restaurant. He also served as president of the North Woodside Conservancy Foundation and a board member at the Foothills Art Center. As part of a family of homesteaders, he cherished the landscapes of the Rockies and spent substantial time with family and friends outdoors—hunting, fishing, backpacking, camping, skiing, rafting, and coaching baseball.

Bob is survived by sons Tom, Paul (Laurie), and Carl (Kathy); four grandchildren; and two great-grandchildren. He was preceded in death by Ruth (2017) and son Loren (1971).

To summarize a life well-lived, Bob represented the very best of his profession. He understood that in exploration geology the line between success and failure is infinitesimally thin, and he maintained the humility that is born of that understanding. His professional service was driven by his deep gratitude for the opportunities that came his way. Sometimes, at odd moments, one could hear Bob quietly crooning his favorite Louis Armstrong song, "I'm Just a Lucky So-and-So."

Bob was more than an outstanding geologist: he was a greatly valued friend and colleague to many. He mentored hundreds of geologists in an informal yet effective and lasting way. He was extremely generous in sharing his time, resources, and enthusiasm with members of his profession and his community. He relished guiding young people to discover the wonders of the geologic world and helping every person he encountered to feel truly special.

He is sorely missed.

PETER WHITTLE

1927–2021

Elected in 2016

"For contributions to the mathematics of operations research and statistics."

BY FRANK P. KELLY

PETER WHITTLE, who died August 10, 2021, at 94 years of age, will be remembered as an outstanding pioneer across the fields of probability, statistics, and optimization. He wrote a number of important papers, but it is in his books that one can best appreciate the broad sweep of his achievements and the simplicity, unity, and generality of his approach. His 12 major volumes covered times series, prediction, constrained optimization, dynamic programming, optimal control, stochastic systems, the foundations of probability theory, and neural nets. Several of these works were ahead of their time: indeed some of his early works appear to have been written for the audience of today, such is the extent to which they anticipated developments.

Peter was born in Wellington, New Zealand, on February 27, 1927. His parents, Percy Whittle and Elsie Tregurtha, were New Zealanders of 19th century British and Irish extraction. His father, an orphan, began working at the post office in 1914 and rose to become assistant postmaster for Wellington; his mother was a schoolteacher. Peter spent his first 22 years in the spectacularly beautiful Island Bay, a suburb south of Wellington, facing onto Cook Strait.

He graduated from the University of New Zealand with a BSc in mathematics and physics in 1947, ranked first in the country in the exams for these subjects, and an MSc in mathematics in 1948. He intended a career in mathematical physics, but vacation work in the NZ Department of Scientific and Industrial Research (DSIR) offered statistical problems from agriculture and biometrics that attracted his scientific interest. His first paper was on the design of experiments.

A traveling scholarship in 1949 took him to Uppsala, Sweden, for his doctoral work under Hermann Wold. Profoundly influenced by Maurice Bartlett (NAS 1993), then working in Manchester, Peter began his work on time series analysis. In his doctoral thesis and four papers following from it he essentially solved the large-sample inference problem for a stationary time series generated by a linear Gaussian model. The terms "multivariate Whittle likelihood" and "Whittle estimation" are now common, but at the time this early groundbreaking work was not widely appreciated. Whittle remarked that, perhaps in unconscious emulation of the admired Bartlett, he wrote too gnomically.

In marked contrast, his corresponding analysis for spatial processes, published in 1954, had an immediate and sustained impact.[1] His asymptotic inference theory for Gaussian processes and related spatial processes was ahead of its time in considering power law covariance functions, now central in image analysis.

Peter returned in 1953 to his home country and the DSIR. Work on New Zealand rabbits (imported pests of the first order) produced the Whittle threshold theorem for stochastic process models of an epidemic. Oscillations in oceanographic data (from the Island Bay rock channels) uncovered nonlinear effects. During this period he also became interested in polymerization and in reversibility, both topics he would later return to.

Peter believed that his subsequent interests and career were largely shaped by his time in the NZ DSIR, working on problems from geophysics, agriculture, and industry. His superior

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[1] Whittle P. 1954. On stationary processes in the plane. *Biometrika* 41(3/4):434–49.

there wrote "His genuine interest in people and their work, his boyish sense of humour and lack of pretension, made it possible for him to carry his own intellectual preeminence without exciting jealousy or antagonism."

Peter came back to Britain in 1959 as a lecturer in the Statistical Laboratory, Cambridge. In 1961 he succeeded Bartlett as chair of mathematical statistics at Manchester, where his interest in optimization developed; he kept his interest in spatial processes, with his student David Brook producing an early result on Markov random fields; and he obtained his first results on networks of queues and partial balance.

In 1967 Peter returned to Cambridge as the first Churchill Professor of Mathematics for Operational Research, a newly established chair endowed by Esso. The position gave him the perfect platform for his vision that what needed developing was not just narrow-sense operational research but the whole area of what in Cambridge is now termed "applicable mathematics." This includes, for example, probability, statistics, optimization, game theory, and aspects of disciplines such as control theory, communications theory, and mathematical economics that might be pursued by someone technically based in probability and optimization. Developments in the United States had convinced Peter of not only the practical importance of these topics but also the depth and coherence of the theory they generate.

He felt that the subject of statistics itself is thoroughly penetrated by optimization concepts and is viewed aright only when embedded in this larger context (a view now taken for granted in statistics generally and in areas such as machine learning). He set about creating the new courses to deliver this vision, and this began an evolution of the Mathematical Tripos at Cambridge that has continued to this day. He served as director of the Cambridge Statistical Laboratory from 1973 to 1986.

By the time of Peter's second major work on time series (*Prediction and Regulation: Linear Least-Square Methods*, English Universities Press, 1963, rev. 2nd ed., 1983) his interest had moved from inference to prediction and control. His four volumes on optimization marked his continuing interest in stochastic control, and in temporal optimization generally, using dynamic programming ideas. *Optimization under Constraints: Theory and Applications of Nonlinear Programming* (John Wiley & Sons, 1971) is shot through with insight in a prose style combining power and economy.

Notable in *Optimization over Time, Dynamic Programming and Stochastic Control, Volume 2* (Wiley, 1983; volume 1 was published in 1982) is Peter's treatment of the multiarmed bandit problem. Despite its whimsical name this problem—the sequential allocation of effort in the presence of uncertainty—arises in areas as varied as the design of clinical trials or the choice of exploration avenues in artificial intelligence. The problem was first formulated during World War II and, as Peter famously remarked, efforts to solve it so sapped the energies of Allied analysts that someone suggested the problem be dropped over Germany as the ultimate instrument of intellectual sabotage.

Later, in *Risk-Sensitive Optimal Control* (Wiley, 1990) the complete theory for the linear/quadratic/Gaussian case is transferred to a significantly more general case.

His vision for the whole area of applicable mathematics was by now well established, providing the mathematical foundations for central areas of engineering and economics. Mathematicians often do not see the impact of their work on other fields. It is noteworthy that in the foreword to the second edition of *Prediction and Regulation* (University of Minnesota Press, 1983), Thomas Sargent (NAS 1983), later awarded the Nobel Prize in Economics for empirical research on cause and effect in the macroeconomy, wrote about the importance of Peter's work for understanding dynamic economic phenomena.

Peter's book *Probability via Expectation* (1970, expanded in 2000, 4th ed., Springer) is an exposition of probability theory that formulates its axioms in terms of expectation rather than measure, developing Peter's view that this approach has advantages at many levels. One advantage is that probability theory and probability of quantum theory are seen to differ in only a modification of the axioms—a modification rich in consequences, but (as in so much of Peter's work) succinctly expressible.

Peter had a lifelong interest in statistical/physical models, and his book *Systems in Stochastic Equilibrium* (John Wiley & Sons, 1986) collects his work on polymerization and random graphs and on partial balance in networks. His work on networks continued with *Neural Nets and Chaotic Carriers* (John Wiley & Sons, 1998) and *Networks: Optimization and Evolution* (Cambridge University Press, 2007).

In his final years he maintained his interest in neural nets, finding the notions of self-optimizing and self-organizing systems both fascinating and of enormous potential. But even he might have been surprised to see the pace of the ongoing realignment of mathematics, with statistics, optimization, and machine learning permeating applied mathematics and leading to remarkable advances across swaths of physical, biological, and social science.

His distinctions are too numerous to list, but it would be remiss not to note the Sylvester Medal of the Royal Society, the Guy Medal in Silver (1966) and Gold (1996) of the Royal Statistical Society, and the Lanchester Prize (1986) and John von Neumann Theory Prize (1997) of the US Institute for Operations Research and Management Science. He was a fellow of the Royal Society and in 2016 was elected a foreign member of the US National Academy of Engineering.

Peter married Käthe Blomquist in 1951 and they had six children. Käthe was Finnish and they had met in Uppsala; they did their courting in Swedish, a second language to each and their only common language.

He sometimes described himself as a "loner" and as far as his academic work was concerned he was certainly refreshingly away from the crowd. But it is hard to think of anyone who took such pleasure from his large family as really alone. The keenness of Peter's observation of personalities was another factor—to be read so clearly can be disconcerting.

As a schoolboy in New Zealand Peter played the flute in the school orchestra, and throughout his life he got pleasure from making and playing instruments. He was particularly attracted to woodwind instruments, especially the oboe. In his middle years he learned the flamenco guitar, mastering the *rasgueado*—the continuous drum-roll achieved with the backs of the fingernails. He also played the chanter—the part of the bagpipes that creates the melody without the bag and drones. Languages were another interest: French, Swedish, and Russian early in his life, and after retirement Scottish Gaelic, whose evocative charms fascinated him. He was a talented runner and kept up distance running into his later years. He also enjoyed carpentry, general DIY, and toymaking, finding them a useful counterweight to his academic work. Throughout his life he greatly missed New Zealand, and asked that his ashes be cast into the waters of Island Bay, which he had grown up overlooking.

Käthe died in 2020. She and Peter are survived by their children Martin (Christine), Lorna, Gregory (partner Lynda Jenkins), Jennifer Southam (Jeremy), and Elsie (partner Paul Tansley); seven grandchildren; and one great-granddaughter. Son Miles died in October 2021.

SHELDON M. WIEDERHORN

1933–2021

Elected in 1991

"For outstanding advancements in the development and application of test methods and basic understanding of the mechanical properties of ceramics."

BY BRIAN R. LAWN

SHELDON MARTIN WIEDERHORN passed away June 4, 2021. He was 88 years old, spanning an illustrious career in science.

Shelley was an extraordinary human being, larger than life. Beloved by his colleagues and friends, he had the kind of outgoing personality that was simply impossible to dislike. His huge smile said it all. What set him apart was his rosy attitude toward his fellow man—he saw good in just about everyone, even those who sometimes behaved questionably, and always gave people the benefit of the doubt. He was the consummate gentleman and humanitarian.

He was born May 4, 1933, and proudly raised in the Bronx by his immigrant parents Joseph and Estelle. In the later periods of our friendship he confided some mischievous episodes of his youth, related with a self-satisfied grin. I particularly liked the one where he ran away from a summer camp, refused to climb down from a tree, then wandered onto a farm and helped milk the cows. Like all of us, he must have driven his parents mad at times. But through all that was pure goodness of spirit, the likes of which we find in a select few.

He graduated from the Bronx High School of Science and earned his BS at Columbia University in 1956, and then his MS (1958) and PhD (1960) at the University of Illinois

Urbana-Champaign, all in chemical engineering. His PhD work was conducted under Harry Drickamer (NAE 1979), Nobel Laureate in 1946 for his work on the development of high-pressure apparatus to study phase transformations in solids.

After a brief spell as a research engineer at E.I. du Pont de Nemours and Company in the early 1960s, Shelley took a permanent appointment in 1963 at the National Bureau of Standards (NBS; in 1988 it became the National Institute of Standards and Technology, NIST) under the direction of Jack Wachtman (NAE 1976). This was a bold move, as NBS in those days was stationed in downtown Washington in somewhat antiquated labs. Shelley's wife Nancy famously asked him, "You gave up DuPont for this?" But NBS soon moved to a new and expansive campus in Gaithersburg, Maryland, where Shelley's work flourished.

I first met Shelley in the early 1970s, when we were both trying to understand how the presence of water accounted for the fatigue and failure of brittle materials. His pioneering work illustrated the complexity of subcritical crack growth in glass due to chemical reactions between water and stressed bonds (stress corrosion cracking). The work was published in a 1970 paper that is considered one of the most important in the field.[1] It earned more than 1000 citations during his lifetime and arguably kick-started a revolution in ceramic research.

Science began to enter the world of brittle materials in explosive fashion, highlighted by a series of exciting Gordon Conferences in the 1970s and 80s. Shelley, along with Arthur Heuer (NAE 1990) and Anthony Evans (NAE 1997), was at the forefront of the new age. At NIST he established a laboratory dealing with fracture and deformation, starting with electron microscopists Bernard Hockey and Nancy Tighe and expanding into a world-class group. His work helped put NIST on the map in materials science. He was duly awarded the institute's Silver (1969) and Gold Medals (1982) for his scientific

[1] Wiederhorn SM, Bolz LH. 1970. Stress corrosion and static fatigue of glass. *Jounal of the American Ceramics Society* 52(10):543–48.

achievements. He was also designated a NIST fellow in 1988. He spent brief periods in managerial roles, but disliked those, freely acknowledging that he had no administrative bones in his body. Instead he focused on his research, which now forms his proud legacy.

Beyond NIST, he was active in the community. He was a fellow and then a distinguished life member of the American Ceramic Society (ACerS) and editor of its journal for 15 years. He served on a number of committees of the National Academies, beginning in 1977 with his appointment to the Committee on Army Basic Scientific Research (1977–83). Over the next decades, he was also a member of, among others, the Condensed Matter and Materials Research Committee (1992–95), Panels for Review of Air Force Office of Scientific Research (AFOSR) Materials Research Proposals (1994–96, 1996–97, 1998), Committee on Materials Technologies for Process Industries (1999–2001), and Committee on Testing of Body Armor Materials for Use by the US Army (2009–12). After his election to the NAE in 1991, he volunteered his service for the Materials Engineering Section and its peer and executive committees (1999–2003) as well as the Committee on Membership (2001–02, 2004–06).

Shelley was the recipient of many honors. In 1977 he won the NBS Samuel Wesley Stratton Award. He received just about all the awards that ACerS has to offer, including the Ross Coffin Purdy Award (1971) and the John Jeppson Award (1994) for outstanding research on ceramic materials. He spent sabbatical periods at the Max Planck Institute in Germany. In 2016 Columbia University presented him with the Thomas Egleston Medal, its highest honor for alumni, citing him as "an authority on the mechanics of stress and fracture whose work has contributed to shatterproof glass used on so many products, from the windows of spacecraft to smartphone screens, and ceramics used in a variety of electronics."

Testament as to how high Shelley was held in esteem is the outpouring of tributes from a vast number of national and international colleagues. My email box was inundated with expressions of loss and sadness. He was truly a man of the world.

When Shelley married Nancy Wanderman, many saw a perfect match. They united while at Columbia and shared interests in travel, museums, theatre, and literature. Nancy was his muse. Shelley also enjoyed swimming, ice cream, and being a handyman for family and friends, fixing dishwashers, cribs, and other items on demand. He was a devoted family man and talked proudly about his children and grandchildren.

Shelley was preceded in death by his beloved Nancy (2016). He is survived by son Jonathan (Elizabeth) and daughter Miriam Rust (Harry), and two grandchildren.

Shelley Wiederhorn. A pioneering scientist and a beautiful man.

J. ERNEST WILKINS JR.

1923–2011

Elected in 1976

"Peaceful application of atomic energy through contributions to the design and development of nuclear reactors."

BY PERCY A. PIERRE

JESSE ERNEST WILKINS JR. was a legend in the Black community and beyond. He was a child prodigy and became an outstanding mathematician and engineer. He passed away at age 87 on May 1, 2011, in Fountain Hills, Arizona.

J. Ernest, as he was called, was born in Chicago on November 27, 1923, to J. Ernest and Lucile Beatrice Robinson Wilkins. His father was a prominent attorney and assistant secretary of the Department of Labor during the Eisenhower administration; his mother held a master's degree and taught in the Chicago Public School system.

The younger J. Ernest entered the University of Chicago at 13 years of age—the institution's youngest student ever—and, after earning his BS (1940) and MS (1941), received his PhD (1942), all in mathematics, at age 19. In 1942 he won a Rosenwald Scholarship and studied at the Institute for Advanced Study in Princeton. He wrote his first papers that year, both on geometry.[1]

Although he was recognized as a "genius," in the 1940s and 1950s Black scientists and engineers had limited job choices.

[1] Wilkins JE Jr. 1943. The first canonical pencil. *Duke Mathematical Journal* 10(2):173–78; Wilkins JE Jr. 1945. A special class of surfaces in projective differential geometry. *Duke Mathematical Journal* 12:397–408.

Some major universities accepted Blacks as students but not as faculty. J. Ernest's first job after he got his PhD was teaching mathematics at the Tuskegee Institute (now Tuskegee University), one of this country's historically Black colleges and universities (HBCUs).

In 1944 he joined the University of Chicago Metallurgical (Met) Lab, working on the Manhattan Project. His team was scheduled to be transferred to Oak Ridge, Tennessee, in the fall of 1944, but Jim Crow laws prevented him from taking a scientific post there. Instead, Edward Teller (NAS 1948) recommended him for a position with Eugene Wigner (NAS 1945), who at the time was researching the design and development of nuclear reactors that would convert uranium into weapons-grade plutonium.

From 1944 to 1946 Wilkins collaborated with Wigner at the Met Lab on research in neutron absorption, leading to their discovery of the Wigner-Wilkins approach for estimating the distribution of neutron energies in nuclear reactors. Their paper, "Effect of the Temperature of the Moderator on the Velocity Distribution of Neutrons with Numerical Calculations for H as Moderator," written in 1944 and declassified in 1948, was eventually published in Wigner's *Collected Works* (Springer-Verlag Berlin Heidelberg, 1993).

Working with Arthur Compton (NAS 1927) and Enrico Fermi (NAS 1945) in the early 1940s, Wilkins researched methods for producing fissionable nuclear materials, focusing on plutonium-239. He made major contributions to the Manhattan Project[2] and nuclear engineering, including the formulation of mathematical models to explain gamma radiation, which was critical to the development of shielding against gamma radiation emitted by nuclear sources and the sun and thus key to the design of safe nuclear reactors and space probes.

After World War II Wilkins worked as a mathematician for the American Optical Company (1946–50) in Buffalo, New York, designing and testing optical techniques for microscopes,

[2] He was not told of the ultimate goal of the work until after the atomic bomb was dropped on Hiroshima on August 6, 1945.

telescopes, and other ophthalmologic uses. He then went to work at the United Nuclear Corporation, which later became General Dynamics (1950–60), in White Plains, NY; while there, he continued his academic pursuits and earned both BA (1957) and MA (1960) degrees in mechanical engineering from New York University. He then took a job as assistant chair of theoretical physics at General Atomic Company in San Diego; during his decade there he was promoted to assistant director of defense science and engineering and then director of computational research.

In 1970 he was hired as Distinguished Professor of Applied Mathematical Physics at Howard University, where he established the university's PhD program in mathematics. He had his choice of going to other universities but chose Howard, acting on his lifelong commitment to the Black community.

He left academia to work in nuclear engineering at EG&G, Inc., a scientific technology firm in Idaho Falls (1977–84), where he rose from vice president and associate general manager for science and engineering to vice president and deputy general manager for science and engineering, before accepting a term as a fellow at the Department of Energy's Argonne National Laboratory (1984–85). After retiring from Argonne, he returned to academia in 1990, as Distinguished Professor of Applied Mathematics and Mathematical Physics at Clark Atlanta University, a position he held until his retirement in 2003. During his academic career he was thesis or dissertation advisor for 22 minority graduate students.

I met J. Ernest in 1972 when I was dean of engineering at Howard. In 1977, when I became assistant secretary of the Army for Research, Development, and Acquisition, I asked J. Ernest to chair the Army Science Board (1978–81). The ASB "provides the Army with independent advice and recommendations on matters relating to the Army's scientific, technological, manufacturing, logistics, and business management functions, as well as other matters the Secretary of the Army deems important to the Department of the Army." During his tenure as chair, the ASB provided advice on matters ranging from basic science to the development of advanced weapons systems.

He also served in other ways. He was an active member of the American Mathematical Society (council member, 1975–77), American Association for the Advancement of Science (elected a fellow in 1956), Mathematical Association of America, Institute of Mathematical Statistics, Optical Society of America, Society for Industrial and Applied Mathematics, American Nuclear Society (board of directors, 1967–77; president, 1974–75), American Society of Mechanical Engineers, Association for Computing Machinery, and National Association of Mathematicians. He also served on board of directors of Oak Ridge National Laboratory.

For the National Research Council, he was appointed to the Ford Foundation Diversity Fellowships Predoctoral Review Panel on Engineering (1999, 2000, 2001), Committee for a Decadal Study of the Mathematical Sciences (1999–2000), and US National Commission on Mathematics Instruction (1995–98).

J. Ernest was recognized by his colleagues and peers for his outstanding work. He was elected to the NAE in 1976—the second African American to join its esteemed ranks. He received the US Army's Outstanding Civilian Service Medal (1980); was an honorary life member of the National Association of Mathematicians and recipient of its Lifetime Achievement Award (1994); and he received the QEM Network's Giant in Science Award (1994), DOE Special Recognition Award (1996), and Professional Achievement Citation (1997) from the University of Chicago Alumni Association. He was elected to Phi Beta Kappa (1940), Sigma Xi (1942), Pi Tau Sigma (1956), and Tau Beta Pi (1956).

During his term as ASB chair, J. Ernest and the board members traveled around the world to visit Army sites. Once when they were in the Las Vegas area they went to a casino. It turns out that J. Ernest liked to play blackjack. He had a photographic memory and won a lot—but not too much; had he won too much, they would have kicked him out. His colleagues were impressed.

He was predeceased by his wives Gloria Louise Stewart, whom he married in 1947, and Maxine G. Malone. He is survived by a daughter and son from his first marriage, Sharon Wilkins Hill and J. Ernest Wilkins III.

EUGENE P. WILKINSON

1918–2013

Elected in 1990

"For outstanding leadership in naval nuclear propulsion programs and improvement in the operation of commercial nuclear power plants."

SUBMITTED BY THE NAE HOME SECRETARY

EUGENE PARKS WILKINSON, one of the US Navy's pioneers, died July 11, 2013, at home in Del Mar, California. He was 94. Vice Admiral Wilkinson was the first officer to command a nuclear-powered submarine and nuclear-powered surface ship.

Dennis, as he was known, was born August 10, 1918, in Long Beach, California, the son of Dennis William and Daisy Parks Wilkinson. His parents died when he was a boy, and he was raised by his grandparents. He attended Holtville High School and San Diego State College, where, having skipped two grades in school, he graduated in 1938 at the age of 19 with a bachelor of arts degree in chemistry. He taught chemistry and math courses for a year at his alma mater and attended the University of Southern California. The following year he had a teaching fellowship in chemistry at USC. During those two years he completed the coursework for a PhD but never did a thesis.

In December 1940 he was commissioned as a Naval Reserve officer through the V-7 program. He graduated from the Naval Submarine School in Groton, Connecticut, in March 1942 and

\Readers may also be interested in a biography of Vice Admiral Wilkinson: Winters AD. 2016. *Underway on Nuclear Power! The Man Behind the Words: Eugene P. "Dennis" Wilkinson, Vice Admiral USN*. La Grange Park IL: American Nuclear Society.

was sent to the Pacific, where he engaged in eight patrols aboard submarines. One of these was on the USS *Darter* at the Battle of Leyte Gulf in October 1944, the largest naval battle of World War II. For his leading role in a critical attack, he was awarded the Silver Star. He transferred to the regular US Navy on August 28, 1946.

Admiral Hyman G. Rickover selected Dennis for the nuclear submarine project because he had not attended the US Naval Academy and had a scientific approach to shipbuilding. Dennis received advanced training in nuclear physics at the Oak Ridge National Laboratory in Tennessee, worked as an associate engineer at Argonne National Laboratory in Chicago, and was Chief of the Operations Branch and Bureau of Ships Representative at the US Atomic Energy Commission facility near Pittsburgh.

Dennis drafted a schedule to develop the first nuclear submarine and presented it to Admiral Rickover in 1949, anticipating a launch date of January 1955. As first commanding officer of USS *Nautilus* (1955–57), his inaugural cable, sent January 17, 1955, read "Underway on nuclear power." These words are engraved on the US Navy War Memorial in Washington, DC.

He attended the US Naval War College in Newport, Rhode Island (1958), and was then appointed the first commanding officer (1959–63) of USS *Long Beach*, America's first nuclear-powered surface ship. As a rear admiral he went on to serve as director (1963–66) of the Submarine Warfare Division (OP-31), chief of staff of the US Forces Japan (1966–69), and commander (1969–70) of Submarine Flotilla Two. He was promoted to vice admiral shortly before being named commander of the Atlantic Submarine Force in February 1970.

In addition to the Silver Star, Vice Admiral Wilkinson received many honors and awards during his career: Navy Unit Commendation (1944); Golden Fleece Award (1955); Legion of Merit (1957); Defense Commendation Medal (1964); Second Order of Sacred Treasure, Japan (1969); Distinguished Service Medal and 2nd and 3rd Awards (1969, 1972, 1974); Navy Meritorious Public Service Citation (1978); George Westinghouse Gold Medal, ASME (1983); Oliver Townsend

Award, Atomic Industrial Forum (1984); Gold Medal Award, Uranium Institute (1989); and election to the NAE (1990).

After his retirement as deputy chief of naval operations for submarine operations in 1974, he worked in private industry and consulted with federal agencies and laboratories. He was executive vice president of Data Design Laboratories (1976–80), and then, in the wake of the Three Mile Island accident, was tapped to serve as president of the newly established Institute of Nuclear Power Operations (1980–84). During his tenure he oversaw the creation of inspection and regulation criteria and protocols for the safe and reliable operation of commercial nuclear power plants.

Salomon Levy (NAE 1974) wrote:

> I had the opportunity to work with E.P. Wilkinson during several safety reviews of boiling water reactors…. He had a special ability to detect plant problems such as seeing water drops leaking and predicting their growth to dangerous levels. Many of the nuclear plants' workers were hired after they left the nuclear Navy and they were proud to mention their previous experience and Wilkinson would ask a few questions about their naval experience, primarily to validate…their claims.
>
> He turned down most opportunities for entertainment and preferred to retire and to get up early to complete his investigations. His favorite food was hamburgers and he preferred to find the nearest hamburger store next to our hotel. He was a thorough investigator and he presented his findings well with the primary purpose to improve the plants. He insisted in discussing and summarizing our findings before their oral presentations to the plant managements in order to avoid surprises. He relied on my participation to handle the more difficult boiling water reactor issues. He was a very fast learner…. It was an honor to have the chance to work with him.

There's no question that Dennis was deeply committed to his work, but he also played tennis and bridge, and he and his wife enjoyed quite a bit of travel, including a three-month vacation in Australia to celebrate their 50th anniversary. They also visited Bali, Borneo, Japan, Peru, Singapore, and the United Kingdom.

He had married Janice Edith Thuli in 1942; she died in 2000. They are survived by their children Dennis Eugene of Nagasaki, Japan; Stephen Jones of Austin; Marian Lynn Cassazza of Del Mar; and Rodney David of Bremerton, Washington; four grandsons; and seven great-grandchildren.

JOHN J. WISE

1932–2021

Elected in 1986

"For inspiring technical contributions and leadership in the development and commercialization of important petroleum, petrochemical, and synthetic fuels processes."

BY MICHAEL P. RAMAGE AND THOMAS F. DEGNAN JR.

JOHN J. WISE, a former vice president of research at Mobil Research and Development Corporation, died June 13, 2021, in Princeton, New Jersey, at the age of 89.

Jack was born in Cambridge, Massachusetts, on February 28, 1932, to Alice (née Donlon) and Daniel Wise. His father was prominent in the university textbook publishing business in Boston. While in his early teens, Jack read many of the textbooks that his father brought home, including those used in classes for Harvard Law School and MIT. His "textual" sampling of a broad number of university disciplines led him to decide at the ripe age of 14 to become a chemical engineer. He would later say that his decision was "based on no rational reason, except that chemical engineering sounded interesting and was a fashionable career choice at the time." In September 1949 he entered Tufts University, from which he graduated in 1953 with a BS in chemical engineering.

Upon graduating Jack joined Mobil Research and Engineering in Paulsboro, NJ, as a senior research engineer. His timing was fortuitous as Mobil had very recently begun to research a class of catalysts known as zeolites. Zeolite catalysts would eventually revolutionize refining and petrochemical manufacture by increasing the amounts of gasoline and high-value petrochemicals to be produced from each barrel of petroleum. Jack's research focused on identifying and improving zeolite catalysts for producing aromatics, hydrocarbons that formed the building blocks for polymers, including polyester and polycarbonate.

One of Jack's patents (US 4,101,596, Low-Pressure Xylene Isomerization) was the basis for a new Mobil process for producing p-xylene, a key intermediate for producing polyethylene terephthalate (PET). PET is a large-volume (56 M tonnes/year) precursor in the manufacture of plastic bottles and tires. He went on to be the named inventor or coinventor on 15 US patents.

Jack's other research led to new catalysts and catalytic processes that increased gasoline octane and improved the quality of Mobil's lubricants. In the late 1950s Jack led a large joint chemical-refining project that was successful in commercializing several new aromatics technologies.

Excited by the advances in mainframe computing, in the early 1960s Jack developed an interest in computer-based optimization of refineries. As a result, he was offered a position in Mobil's Engineering Department, which was headquartered in New York City. He turned down this offer and began to consider opportunities in the business side of the petroleum industry.

Jack applied to Harvard Business School, was accepted, and decided to sit in on a few classes before making his decision to pursue a full-time MBA. The classes did not excite him, but the prospect of returning to school did. Instead of business school, he set his sights on obtaining his PhD. At the time, Mobil had an Incentive Fellow Program that selected very promising early-career BS degree scientists and engineers to take time to pursue a PhD at company expense. Jack applied for and was chosen as a Mobil Incentive Fellow.

With the fellowship in hand he applied to MIT and was accepted into its PhD chemistry program. He had developed an interest in inorganic chemistry and selected as his thesis advisor a young, ambitious chemistry professor by the name of F. Albert Cotton (NAS 1967). Cotton would go on to be one of the most prominent inorganic chemists of the 20th century and, at the age of 31, was the youngest professor ever offered full tenure at MIT. Jack completed his PhD in three years, graduating in 1965.

That same year he returned to Mobil Research and Development as a senior engineer and group leader in the Applied Research and Development Division. Over the next 25 years he progressed steadily up the Mobil research managerial ladder. In 1968 he was appointed assistant manager of the Process Research Section; in 1972, manager of the Reforming, and Special Processes Development Section; in 1976, manager of the Process Research and Development Division; the next year, vice president of planning for Mobil Research and Development Corporation; in 1981, manager of Mobil's 500-person Field Research Laboratory in Dallas, Texas, responsible for developing and implementing new technology for Mobil's Exploration and Producing Division; in 1984, manager of Mobil's 800-person Paulsboro Laboratory; and in 1987 he was promoted to vice president of research, responsible for Mobil's worldwide research and development—a position he held until his retirement in 1997.

Under Jack's leadership, Mobil Research grew into one of the most highly regarded and impactful research organizations in any industry, creating billions of dollars in value for Mobil and ExxonMobil. Jack led by walking around and by setting examples. He was a motivator, exciting to work for and highly respected not only by those who worked for him but throughout the company. The philosophy in Mobil Research, set by Jack, was that research managers were required to have both strong leadership and technical skills. This led to a challenging, exciting culture, enabling Mobil to hire the very best. Eleven members of the NAE were mentored by Jack!

Technologies developed under Jack's leadership impacted every aspect of Mobil's businesses. Examples include catalysts and new processes for refining and chemicals, new lubricant products, advanced modeling tools for refining and oil production, new seismic technology for subsalt imaging, new aromatics technologies to produce polymers such as polyester, and technology for synthetic gasoline production. Jack led the successful commercialization of Mobil's methanol-to-gasoline

(MTG) process in New Zealand in 1986. He was personally involved in negotiations to construct the first MTG plant (14,000 BBL/day of gasoline) in Motunui Taranaki, New Zealand.

As vice president of research, he cochaired the interindustry Auto/Oil Air Quality Improvement Research Program. He was a joint director of the Mobil Solar Energy Corporation and director of the Mobil Foundation. He also served on the board of directors of the Industrial Research Institute and in 1995, in recognition of his excellence in research management, was awarded its Gold Medal. He was also recognized for his work as a member of the Intergovernmental Panel on Climate Change (IPCC).

Jack was very active in the National Research Council, including service on the Board on Energy and Environmental Systems (1998–2004), Committee on Impact and Effectiveness of Corporate Average Fuel Economy Standards (CAFE) (2001–02), Committee on Review of DOE's Office of Heavy Vehicle Technologies (1999–2002), Committee on Developing a Federal Materials Facilities Strategy (chair, 1998–2000), Committee on Aviation Fuels with Improved Fire Safety (chair, 1996–97), Board on Chemical Sciences and Technology (1994–95; cochair, 1995–98), and Study on Transportation and a Sustainable Environment (1995–97). He was also an ex officio member of the US National Committees for Crystallography (1995–98), the International Union of Biochemistry and Molecular Biology (1995–98), and International Union of Pure and Applied Chemistry (1995–98). For the NAE he served on the Chemical Engineering Peer Committee (1991–93; chair, 1993–94) and Committee on Membership (1993–94).

He married Rosemary Seary Bishop in 1967. They met in Philadelphia, where, as a pioneer in early childhood education, Rosemary supervised a teacher training program for Head Start. The couple lived in Pennsylvania, Connecticut, and Texas before retiring in Princeton. Rosemary predeceased Jack in 2013. He renewed an old friendship with Mary Masland Adams, who became a loving companion in his last eight years.

Jack had a passion for fishing and especially loved to fish on Cape Cod, a favorite summertime location for many years. He frequently fished off Nauset Beach in Orleans or from a chartered boat out of Rock Harbor. His ashes are laid to rest along the bluffs overlooking Priscilla Bay in East Orleans.

Jack is survived by daughters Susannah Scovil Wise and Jean Porter Wise, and grandson Alexander Wise Philbrick, for whom he wrote a book, *A Letter to Alexander*, about his lessons learned in the petroleum industry. He considered it his memoir and published it as a remembrance for his grandson and others who might be interested in his life and career.

APPENDIX

Members	Elected	Born	Died
Jan D. Achenbach	1982	8/20/1935	8/22/2020
Isamu Akasaki	2008	1/30/1929	4/1/2021
Clarence R. Allen	1976	2/15/1925	1/21/2021
Arthur G. Anderson	1975	11/22/1926	8/31/2021
Stephen D. Bechtel Jr.	1975	5/10/1925	3/15/2021
David T. Blackstock	1992	2/13/1930	4/30/2021
Ned H. Burns	2000	11/25/1932	11/5/2016
Max W. Carbon	2012	1/19/1922	6/23/2021
Chun-Yen Chang	2000	10/12/1937	10/12/2018
Hsien K. Cheng	1988	6/13/1923	7/11/2007
Malcolm Currie	1971	3/13/1927	4/18/2021
C. Chapin Cutler	1970	12/16/1914	12/1/2002
John E. Dolan	1980	5/9/1923	3/17/2018
David A. Duke	1992	11/26/1935	10/9/2017
Peter S. Eagleson	1982	2/27/1928	1/6/2021
Dean E. Eastman	1988	1/21/1940	3/4/2018
Robert W. Farquhar	2012	9/12/1932	10/18/2015
Hans K. Fauske	2016	12/7/1935	9/27/2021
John E. Ffowcs Williams	1995	5/25/1935	12/12/2020
Francis B. Francois	1999	1/21/1934	2/17/2021
William L. Friend	1993	6/17/1935	1/27/2021
Shun Chong Fung	2007	1/28/1943	7/21/2021
Richard J. Gambino	2004	5/17/1935	8/3/2014
Charles M. Geschke	1995	9/11/1939	4/16/2021
Earnest F. Gloyna	1970	6/30/1921	1/9/2019
William E. Gordon	1975	1/8/1918	2/16/2010
Karl A. Gschneidner Jr.	2007	11/16/1930	4/27/2016
William J. Hall	1968	4/13/1926	6/9/2020
Delon Hampton	1992	8/23/1933	1/14/2021
William R. Hewlett	1965	5/20/1913	1/12/2001
Gerald D. Hines	2001	8/15/1925	8/23/2020
Tatsuo Itoh	2003	5/5/1940	3/4/2021
Stephen C. Jacobsen	1990	7/15/1940	4/3/2016
David Jenkins	2001	10/4/1935	3/6/2021
Steven P. Jobs	1997	2/24/1955	10/5/2011

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Angel G. Jordan	1986	9/19/1930	8/4/2017
Jack L. Kerrebrock	1978	2/6/1928	7/19/2019
Justin E. Kerwin	2000	3/24/1931	5/23/2021
Makoto Kikuchi	1987	12/6/1925	11/6/2012
Robert M. Koerner	1998	12/2/1933	12/1/2019
Prabha S. Kundur	2011	3/18/1939	10/9/2018
Sau-Hai Lam	2006	12/18/1930	10/29/2018
T. William Lambe	1972	11/28/1920	3/6/2017
Louis Landweber	1980	1/8/1912	1/20/1998
Gerald J. Lieberman	1987	12/31/1925	5/18/1999
Kuo-Nan Liou	1999	11/16/1944	3/20/2021
Raymond C. Loehr	1983	5/17/1931	4/15/2021
Tso-Ping Ma	2003	11/13/1945	4/6/2021
John C. Martin	2008	5/7/1951	3/31/2021
Jyotirmoy Mazumder	2012	7/9/1951	4/10/2021
Roddam Narasimha	1989	7/20/1933	12/14/2020
Roberta J. Nichols	1997	11/29/1931	4/3/2005
James J. O'Brien	2012	10/20/1929	12/31/2020
Harold W. Paxton	1978	2/6/1927	3/8/2021
Dennis J. Picard	1990	8/25/1932	10/21/2019
Della M. Roy	1987	11/3/1926	3/27/2021
Robert E. Schafrik Sr.	2013	2/6/1946	7/10/2018
Frank J. Schuh	1989	2/3/1935	12/24/2020
George W. Sutton	1994	8/3/1927	2/13/2021
Johannes Weertman	1976	5/11/1925	10/13/2018
Julia R. Weertman	1988	2/10/1926	7/31/2018
Robert J. Weimer	1992	9/4/1926	8/25/2021
Peter Whittle	2016	2/27/1927	8/10/2021
Sheldon M. Wiederhorn	1991	5/4/1933	6/4/2021
J. Ernest Wilkins Jr.	1976	11/27/1923	5/1/2011
Eugene P. Wilkinson	1990	8/10/1918	7/11/2013
John J. Wise	1986	2/28/1932	6/13/2021