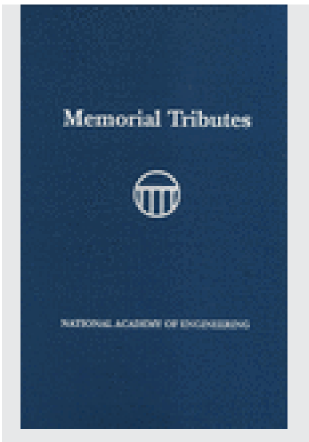

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FOREWORD

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

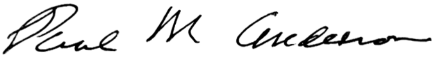
Through its members and foreign associates, the Academy carries out the responsibilities for which it was established in 1964. Under the charter of the National Academy of Sciences, the National Academy of Engineering was formed as a parallel organization of outstanding engineers. Members are elected on the basis of significant contributions to engineering theory and practice and to the literature of engineering or on the basis of demonstrated unusual accomplishments in the pioneering of new and developing fields of technology.

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

Thomas F. Budinger
Home Secretary

Memorial Tributes

NATIONAL ACADEMY OF ENGINEERING



PAUL M. ANDERSON

1926–2011

Elected in 2009

"For contributions that have advanced the analysis and control of electric power systems worldwide."

BY ANJAN BOSE

One night in 1958 on the second floor of Coover Hall, a young electrical engineering instructor was setting up another load flow study for one of the Iowa utilities. Many of the Midwestern power companies used the network analyzer on the Iowa State College campus in Ames to study their power networks. As he set up this roomful of analog devices that modeled the Iowa power grid, Paul Anderson knew that the days of such devices were numbered. The digital Cyclone Computer, with a design similar to the Illiac at the University of Illinois, was being built in the same building and Paul was already thinking about how to model the power network on this computer. His 1961 doctoral dissertation showed how this new contraption of vacuum tubes that required five tons of air conditioning and coils of paper tape could be used to solve the power network equations.

Paul Maurice Anderson was born January 22, 1926, in Des Moines, Iowa, the younger brother of Frances, son of Neil and Buena. In 1932 the family moved to the small town of Winterset, Iowa, where Paul finished his schooling during World War II. He enlisted in the Army Air Corps and was still stateside when the war ended in 1945. He then attended Iowa State College (later University), graduating with a BS in electrical engineering in 1949, whereupon he accepted his first job as an engineer with Iowa Public Service Company in Sioux City.

It was at Iowa State University (ISU) that he met his bride to be, Virginia Worswick, and they married in 1950. They set up home in Sioux City, where their first son was born in 1953. As an engineer in a small power company, Paul was immersed in all aspects of hands-on electric power engineering, but what he enjoyed most was going back to Ames to run the network analyzer to conduct the seasonal analysis of the grid. This led, in 1955, to an opportunity for him to go back to ISU as an instructor while working on his graduate degrees. His responsibilities included the running of the network analyzer, which led to his lifelong fascination with the modeling and analysis of the power grid. He found that he loved teaching and, after obtaining his MS and PhD, stayed on at ISU as a faculty member in electrical engineering.

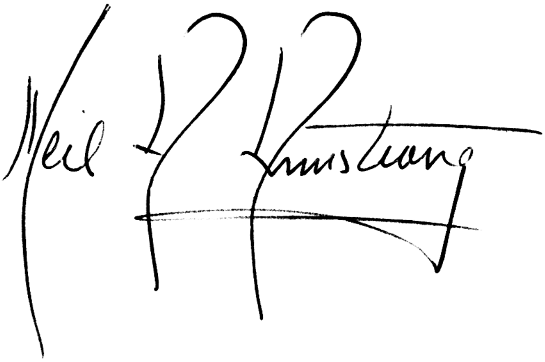
Paul was one of the intellectual leaders in the 1960s who led the application of digital computation to electric power engineering. This application was accelerated by the 1965 blackout in the Northeastern United States, which was the first one that cascaded over a large area of a continent. It became obvious that the design, analysis, and operation of larger and larger interconnected grids all over the globe would require the computational power of the digital computer to accomplish the mathematical modeling and simulation.

In addition to the many papers that record his pioneering work in this area, his first two books established the language and format for power systems analysis in the digital computer era. *Analysis of Faulted Power Systems* (1973) translated the method of symmetrical components into the matrix transformations needed for digital computation. The book is still used as the bible for such studies. *Power System Control and Stability* (1977), coauthored with A.A. Fouad, was the first book to formulate the mathematical modeling of the power grid components needed for digital simulation. He wrote three other books, all of which are popular references.

Paul was recruited by the Electric Power Research Institute to be the founding manager for its Grid Operations and Planning Program (1975–1978), where he sponsored the development of new simulation packages that (or their successive variations) are still in production use today. In 1978 he formed his consulting company, Power Math Associates, Inc., and ran it till 1998. He also served as chair in Electric Power Systems at Arizona State University (1980–1984) and was Schweitzer Visiting Professor at Washington State University in Pullman (1996–1997). He was a fellow of the IEEE, where he played a leadership role in establishing the first technical committee on power system dynamics and editing a series of books on electric power engineering.

Paul always loved music, from the time in 5th grade when he used to practice his new baritone horn on the front porch of his home ("probably to the consternation of the entire neighborhood," he once said) through high school and college. He was a member of several glee clubs, choruses, and big bands. Paul loved playing his beloved Steinway piano and entertaining friends and family with his singing of old Air Corps songs and commercial jingles.

Paul died peacefully at home on April 26, 2011, in San Ramon, California, while listening to Beethoven after complications following congestive heart failure and a long battle with Alzheimer's disease. He will be remembered for his remarkable contributions to the field of electric power engineering as a researcher, professor, and author, as well as being a loving father and family man. He is survived by his wife of 60 years, Virginia; their four sons and spouses/partners: Bill and Anne, Mark and Holly, Jim andYuriko, Tom and Tracy; and granddaughter Tomel.



NEIL A. ARMSTRONG

1930–2012

Elected in 1978

"For contributions to aerospace engineering, scientific knowledge, and exploration of the universe as an experimental test pilot and astronaut."

BY RICHARD H. TRULY

As long as there are history books, Neil Armstrong will be in them.

In May 1961, President John F. Kennedy had committed the nation "to achieving the goal, before the decade is out, of landing a man on the Moon and returning him safely to Earth." On July 20, 1969, Neil Armstrong commanded the Apollo 11 mission that simultaneously ended the Soviet-American space race and met America's goal with more than five months to spare.

Neil, with Colonel Edwin E. "Buzz" Aldrin Jr. at his side, steered their lunar landing craft Eagle to a lunar plain close to the southwestern shore of the Sea of Tranquillity. With the world watching, onboard computer alarms sounding, and the fuel extremely low and getting lower, Neil was in his test pilot element. He skimmed over large boulders covering the planned landing site, and softly touched down. His words to Houston were as historic as his deed: "Houston, Tranquillity Base here, the *Eagle* has landed."

"Roger, Tranquillity," CapCom Charlie Duke in mission control replied. "We copy you on the ground. You've got a bunch of guys about to turn blue. We're breathing again. Thanks a lot." The same could have been said for hundreds of millions of people around the world watching on black-and-white television.

About six and a half hours after landing, with a television camera watching every step, Neil climbed down *Eagle's* ladder, set his feet in the lunar dust, and said: "That's one small step for [a] man, one giant leap for mankind."

The moonwalk lasted 2 hours and 19 minutes, long enough to let Neil and Buzz test their footing and set up an American flag, a television camera, and scientific instruments and collect rock samples.

Apollo 11 left a plaque on the Moon, attached to *Eagle's* ladder leg, which Neil read aloud: "Here men from the planet Earth first set foot upon the moon. July 1969 AD. We came in peace for all mankind."

Aboard the spacecraft *Columbia* about 60 miles overhead, Michael Collins circled in lunar orbit awaiting Neil and Buzz's return. Mike played a crucial role throughout the mission, especially in ensuring a safe docking in lunar orbit prior to returning to Earth.

Apollo 11 capped a tumultuous and consequential decade that saw three assassinations, rioting in American streets, and the buildup of the Vietnam War. But Neil's flying skill had allowed human beings to finally reach that longtime symbol of the unreachable.

~

Neil Alden Armstrong was born on August 5, 1930, on his grandfather's farm five miles west of the small town of Wapakoneta, Ohio, to Stephen Armstrong and the former Viola Louise Engel. His father was a state auditor, which caused the Armstrong family to move every few years to a new Ohio town while Neil was growing up. The Armstrong family was back in Wapakoneta, however, when Neil finished the local Blume High School at age 16. Like so many future astronauts, Neil earned his Eagle Scout badge.

One day at about the age of six, Neil and his father skipped Sunday school and his Dad took him on a ride in a Ford Trimotor airplane, known as the *Tin Goose*. In an oral history later, Neil said that he didn't remember the flight, but it must have impressed him, for he soon became an avid model airplane builder. Building model airplanes was an interest that followed him from home to the Scouts and later at Purdue and while he was in the Navy. He built a rudimentary wind tunnel by age 14 and by age 15, before he got his driver's license, he had learned to fly.

Neil won a Navy scholarship and entered Purdue University as an engineering student in 1947. In *First Man: The Life of Neil Armstrong,* James R. Hansen wrote that in Neil's first year at Purdue, Chuck Yeager broke the sound barrier in the rocket-powered Bell X-1. It was exciting but bittersweet for young Neil. He thought aviation history had already passed him by.

"All in all, for someone who was immersed in, fascinated by, and dedicated to flight," Neil told his biographer, "I was disappointed by the wrinkle in history that had brought me along one generation late. I had missed all the great times and adventures in flight."

The Navy had other ideas, and interrupted his college years. In 1949 Neil was ordered to Pensacola for flight training. He won his Navy wings 18 months later as a "flying midshipman."

Neil was an ensign by the time he was flying Grumman F9F-2 Panthers as the youngest pilot in the VF-51 *Screaming Eagles,* deployed off the Korean coast aboard USS Essex (CV-9). Another pilot in the squadron was Lieutenant Tom Hayward, a future Chief of Naval Operations. Neil flew 78 combat missions, and on September 3, 1951, on a high-speed, very low run he flew into a cable that severed several feet of his Panther's starboard wing. He fought the damaged aircraft's controls until he was over friendly territory before ejecting. Two days later, he was back in combat. It was a hellish cruise for the *Essex,* which suffered 27 Navy fatalities and saw a major flight deck fire.

Neil recalled that the author James A. Michener, fresh off a Pulitzer Prize for *Tales of the South Pacific,* was an *Essex* guest in late 1951, and would sit in the VF-51 ready room listening to stories of the guys coming off combat missions. The result was Michener's novel *The Bridges at Toko-Ri.*

Back at Purdue after the Navy, Neil plunged more earnestly into aeronautical engineering studies, his grades rising and a career in sight. In his first year back, he also met Janet Shearon, a freshman student in home economics from Evanston, Illinois.

Neil had set his sights on becoming an experimental test pilot, and soon after his graduation landed an engineering and flying job at the National Advisory Committee on Aeronautics' Lewis Center in Cleveland. But within five months he moved to the NACA High Speed Flight Station (later the NASA Dryden Flight Research Center) in the Mojave Desert at Edwards, California, legendary home to the X-planes. A few months later, in January 1956, Neil and Jan were married. They had two sons, Eric and Mark, and a daughter, Karen.

His first flight in a rocket plane was in the Bell X-1B, a successor to the plane Yeager had first flown faster than the speed of sound. Neil impressed his peers. Another NACA test pilot, Bill Dana, said he "had a mind that absorbed things like a sponge and a memory that remembered them like a photograph." Neil eventually flew seven X-15 flights, reaching the edge of space, and piloted many more of the most innovative and dangerous research aircraft ever developed.

One evening during their early years in California, Neil and Jan attended a lecture by Wernher von Braun in Lancaster. They were surrounded by many interested NACA leaders and test pilots, and heard von Braun say that based on his experience, he believed that a rocket could be built to carry the required load for man to explore space. Jan remembered, "It was the first time I had ever dreamed of a possibility of space travel…. This was an eye opener for me."

It was also during the mid-50s that the Society of Experimental Test Pilots was born; Neil was a charter member. During the first SETP banquet in October 1957, the Soviet Union shocked the world by launching Sputnik.

Even before NASA selected the first *Mercury* astronauts, Neil was involved in not one but two space programs. In June of 1958, at the age of 27, he was one of nine test pilots selected for the USAF Man in Space Soonest program, designed to put a man into outer space before the Soviet Union did. The program was short-lived. That same year, Neil was chosen as a NACA (later NASA) consultant for a military space plane project, the X-20 Dyna-Soar, and in 1960 was secretly named one of the astronauts. The Dyna-Soar was being designed and developed for the USAF by Boeing in Seattle, Washington.

Jan and the children joined Neil on several trips to Seattle, and it was here in the summer of 1961 that tragedy struck the family. On an outing to a local park, two-year-old Karen, whom Jan and Neil called Muffie, took a childhood spill. But the knot on her head led to a series of tests back in California, resulting in a diagnosis of an inoperable brain tumor. After six agonizing months, Karen died in January 1962.

~

Soon after Neil returned to his X-15 engineering and flying, he was attracted by another opportunity. NASA was receiving applications for the second group of astronauts, following the Mercury Seven. Neil quietly decided to go for it. His flying reputation after seven years at Edwards had preceded him; in September he was tapped for the NASA astronaut corps in Houston.

In Houston, he began training for flights in the two-person *Gemini* spacecraft, forerunner to the three-person *Apollo*. His first crew assignment was as backup commander to Gordon Cooper on *Gemini V.* In March 1966, Neil became the first American civilian astronaut to fly in space as commander of *Gemini VIII.*

The purpose of the planned *Gemini VIII* 55-orbit mission was severalfold, but directly focused on capabilities needed for the coming *Apollo* lunar missions. A critical aspect of the mission included demonstrating a rendezvous and docking with an *Agena* target vehicle and a planned long spacewalk, which his copilot David R. Scott would accomplish. Both Neil and Dave were orbital rookies. On March 16, 1966, they were strapped into their *Titan II/Gemini* on pad 19 at the Kennedy Space Center as the target *Atlas/Agena* lifted off pad 14. Neil and Dave lifted off shortly thereafter, with the *Agena* in orbit above them.

With the flight just a few hours old, Neil performed the rendezvous and then the first successful docking of two vehicles in space. They passed into the night and out of contact with Houston at the Tananarive tracking station.

Once docked, however, the joined spacecraft began to unexpectedly roll, and attempts to steady the vehicles were unsuccessful. Thinking that the problem was aboard the Agena, Neil undocked the *Gemini*, but the rolling only increased, to the point that the crew was in danger of passing out. The problem was a stuck-on roll thruster aboard the *Gemini*. The astronauts turned the control thrusters off, switching to the reentry control system. Stability was slowly restored, but once the reentry propulsion was activated, the crew was told by mission control to prepare to deorbit before the end of their only day in orbit.

They deorbited to an emergency target about 500 miles east of Okinawa and were picked up by the destroyer USS *Leonard Mason* (DD-852) after floating alone for two hours in the Western Pacific. Neil commented later that *Gemini* made a fine spacecraft, but a lousy boat.

Both Neil and Dave were bitterly disappointed that all the objectives of the mission were not accomplished, but they were home and safe. Two days after returning to Houston, Neil was assigned as backup commander to Pete Conrad on *Gemini XI*, his final assignment before the *Apollo* missions began.

In January 1967 NASA suffered a crippling setback when a cockpit fire during *Apollo* launch pad tests killed astronauts Gus Grissom, Ed White, and Roger Chaffee. As a result of the investigation, the *Apollo* command module was redesigned over the next year.

In April, on the Monday after NASA's formal release of the pad accident report, Deke Slayton called together 18 of the astronauts, including Neil, and told them that they would be the ones to fly the first lunar missions. He laid out the strategy for the series of early missions, and at the end of the meeting he named the first three crews. Neil was named commander of the backup crew for *Apollo 9*. In a later shake-up of the schedule, Neil was moved up as the backup commander to Frank Borman on *Apollo 8*, the first flight to circumnavigate the Moon, doing so at Christmastime in 1968. And this put Neil in position to command *Apollo 11.*

NASA's mid-1962 decision to use Lunar Orbit Rendezvous as the design roadmap for *Apollo* had mandated the need for a Lunar Module (LM), a contract eventually awarded to Grumman. The Lunar Landing Research Vehicle (LLRV) was intended to provide design input to the LM and the Lunar Landing Training Vehicle (LLTV) to prepare *Apollo* commanders for the actual landing. At various points in the project, Neil had design input into both vehicles. To familiarize themselves with the lunar landing profiles, the astronauts used helicopters, but their control characteristics were so different from the LM that this approach was discarded as the primary trainer.

The basic LLRV/TV design included a jet engine, pointing down, which operated at 5/6 of the vehicle weight, simulating the 1/6 Earth gravity of the Moon. Large downward-firing thrusters, plus multiple but smaller attitude thrusters, all controlled by the crewman as he was strapped into a Weber ejection seat, simulated the LM descent engine and reaction control system. Eventually, two modified LLRVs and three LLTVs were used as trainers at Ellington Air Force Base in Houston.

These were some of the strangest flying machines in the history of aviation. They looked like flying bedsteads—and they proved to be dangerous. On March 6, 1968, Neil flew a training flight at Ellington Field in one of the converted LLRVs. As he was making a low approach to landing, the vehicle control began to seriously degrade and then failed completely. The LLRV was below 100 feet, rolling into a 30-degree bank when Neil ejected in the last split second. His parachute opened just before he impacted a grassy area adjacent to the runway, and the LLRV was destroyed. Neil suffered a bit tongue. An hour later, he was back at his desk in the astronaut office, quietly shuffling papers.

Before the *Apollo* program was done, three of the five LLTVs were lost in out-of-control ejections. Neil flew a total of 27 training missions in them.

With training complete, *Apollo 11* lifted off for the Moon from Kennedy Space Center Launch Complex 39 on July 16, 1969, and splashed down 210 nautical miles south of Johnston Atoll in the Pacific on July 24, where the crew was picked up by USS *Hornet* (CVS-12).

Neil, Buzz, and Mike spent a full month in quarantine, before and after the historic mission. When they emerged, it was into a different world.

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The *Apollo 11* astronauts were swamped with relentless media and public attention. In a single day, in mid-August 1969, the astronauts and their families departed Houston on Air Force 2 and attended huge ticker-tape parades in New York City and Chicago. They then flew to Los Angeles, where President Nixon hosted them at the elegant Century Plaza Hotel that evening at a dinner attended by more than 1,000 people. They were presented with the Medal of Freedom by Vice President Agnew at the dinner. The crew later addressed a joint session of the US Congress, and departed in September on a nonstop 45-day international tour of 23 nations, on every continent except Antarctica.

At the 1969 SETP annual meeting later that year, Neil described the lunar landing to the gathered experimental test pilots. Later at the banquet, he sat next to Charles Lindbergh, who was inducted that year into the Society as an Honorary Fellow.

For about a year, Neil served as NASA deputy associate administrator for aeronautics at NASA Headquarters. He initiated a research program on digital "fly-by-wire" control systems that, now matured, have revolutionized much of modern aviation. But he tired of the Washington desk job. Ignoring many high-level offers in business and academia, he returned to Ohio as a professor of aeronautical engineering at the University of Cincinnati, and he and Jan bought a 300-acre farm near Lebanon, Ohio. For the next eight years, he taught in the small aeronautics department at Cincinnati.

In subsequent years, Neil turned his attention to corporate life, where he briefly tried his hand as national spokesperson for Chrysler. But his principal interest turned to corporate boardrooms where, over the years, he served as a director for many companies, both in the local area such as Cincinnati Gas and Electric Company, and on the national scene, including United Airlines, Morton Thiokol, and the Eaton Corporation.

Neil served on several national studies and commissions, most prominently as vice chairman to former Secretary of State William P. Rogers on the commission to investigate the loss of the Space Shuttle *Challenger* in 1986. Rogers was "Mr. Outside," based on his extensive Washington political experience, and Neil ran the commission as "Mr. Inside," principally devoting himself to the technical accident investigation itself.

Throughout his life, Neil remained active in flying organizations like the SETP and the Golden Eagles, a small group of former Navy and Marine carrier pilots whose members are legend in the history of naval aviation. He took pride in his membership in the National Academy of Engineering, and was active in several NAE efforts. One was the selection of the Top 20 Engineering Achievements of the Twentieth Century. Neil presented the results at the National Press Club, where he said, "Science is about what is; engineering is about what can be."

In February 1991 Neil suffered a slight heart attack while skiing in Aspen, Colorado, but incurred little heart damage. He was released from the hospital the next day, and within six months had passed his private pilot's license physical with no restrictions.

After a period of separation, Neil and Jan's marriage of 38 years ended with a divorce in 1994. Neil later married Carol Knight, a widow whose husband had been killed in a light airplane accident in 1989. Carol was the mother of two children, Molly and Andrew, and she and Neil lived in Indian Hill, a suburb of Cincinnati.

After the postflight parades and the world tour for the Apollo 11 astronauts, Neil gradually withdrew from the public eye. He was not reclusive, but as much as possible he sought to lead a private life. He was careful to preserve the positive image and immense accomplishment that he, Mike, Buzz, and the NASA *Apollo* team had achieved, but he always deflected credit from himself. Though he traveled and often gave speeches, he rarely gave media interviews and avoided the spotlight. He was a quiet, private man, and, at heart, a first-rate aeronautical engineer and test pilot.

Over the years, Neil was decorated by 17 nations. In addition to the Presidential Medal of Freedom, he was the recipient of the Congressional Gold Medal, Congressional Space Medal of Honor, Explorers Club Medal, Robert F. Goddard Memorial Trophy, NASA Distinguished Service Medal, Harmon

International Aviation Trophy, Royal Geographic Society Gold Medal, Fédération Aéronautique Internationale Gold Space Medal, American Aeronautical Society Flight Achievement Award, Robert J. Collier Trophy, AIAA Astronautics Award, Octave Chanute Award, and John J. Montgomery Award.

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On August 25, 2012, Neil Armstrong died of "complications following a cardiac procedure" according to a family statement. He was 82 years old. The statement continued, "He remained an advocate of aviation and exploration throughout his life and never lost his boyhood wonder of these pursuits…. [A]s much as Neil cherished his privacy, he always appreciated the expressions of good will from people around the world and from all walks of life."

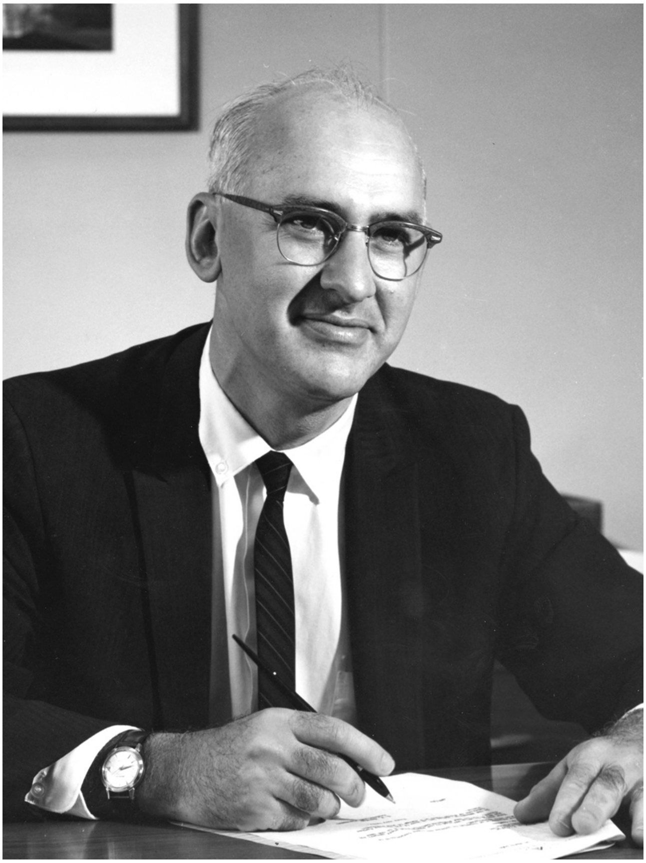
Remembrances flowed in from across America and the world. Michael Griffin, president of AIAA, summed it up for all of us when he said, "Neil Armstrong showed us how to be famous with dignity, how to be celebrated without becoming a celebrity, and how to do it with a gracious modesty and the unyielding courage to do the right thing as he saw it. We will miss him dearly, not so much for what he did, but for who he was."

A private service for family and friends was held in Cincinnati. A few days later, the nation said goodbye at a national memorial service at the National Cathedral in Washington, DC, on September 13. Music filled the cathedral, which was overflowing with family, friends, dignitaries, fellow astronauts and Golden Eagles, sailors, naval officers, and members of the public.

The following morning with his family on the deck, Neil Armstrong was buried at sea from the USS *Philippine Sea* (CG-58) in the waters of the Atlantic Ocean. Over the horizon and to the west lay the Kennedy Space Center's Launch Complex 39, where it all began.

Author's Acknowledgment

In writing this tribute I relied on many sources, particularly John Noble Wilford's *New York Times* article about Neil of August 25, 2012, and Neil's authorized biography by James F. Hansen, *First Man: The Life of Neil A. Armstrong.* Several close friends of Neil assisted me with edits. A special thanks to Carol Armstrong, to Jan, Rick, and Mark Armstrong, and to Neil's sister June Armstrong Hoffman for their gracious help. Most of all, I depended on memories of a man who was my friend for almost five decades. America is fortunate that such a talented, humble, and gracious man was the person who represented her in the most celebrated achievement of the 20th century.



E. J. Barlow

EDWARD J. BARLOW

1920–2010

Elected in 1968

"For leadership in weapons systems and space systems studies."

SUBMITTED BY THE NAE HOME SECRETARY

EDWARD J. BARLOW, a renowned engineer in space systems studies, died February 3, 2010, at the age of 89.

Edward was born in East Orange, New Jersey, on September 5, 1920, to English parents Capt. John and Amy Bell Barlow of the Cunard steamship company. He won a competitive scholarship to Cooper Union School of Engineering in New York City and graduated summa cum laude in April of 1941 with a degree in electrical engineering. He went to work at Sperry Gyroscope Company in New York where he pioneered modifications to make shipboard compasses more accurate for the Navy when operating near the magnetic pole in the Aleutians.

At the conclusion of that project, Edward moved to the Sperry radar group on Long Island where he helped develop various types of radar, including Doppler radar for the war effort. In 1945, he carried out a technical mission on microwave radar and tube development in England and France. He was awarded the Sperry Graduate Scholarship for 1945–1946 and attended Columbia University.

As a hobby, Edward mastered the mathematics of quantum mechanics and relativity; he envisioned an experiment that could be used to test a specific aspect of the theory of relativity. He was invited to present his experimental design to the monthly Princeton Physics Department graduate seminar. Just as he was being introduced, Prof. Einstein came into the room and sat in the first row. It was only then that Edward remembered that Einstein was on the Princeton faculty. Edward said that he "survived the presentation and a direct question from Einstein and got out with my life."

In 1948 Edward was recruited to join the fledgling RAND Corporation in Santa Monica, California, where he rose to be vice president of the Engineering Division specializing in air defense studies for the US Air Force. He distinguished himself for his ability to successfully manage large and complex studies that would affect the design of US defense forces for the ensuing decade. He managed a second defense study in 1954 that developed new philosophies and doctrines for air defense in response to the development of thermonuclear weapons. This study included work on anti-intercontinental ballistic missile (ICBM) early warning radar systems, wherein Edward specified the design of the specialized radar that was used in the Defense Early Warning network that was constructed across northern Canada. During his last two years at RAND, from 1958 to 1960, he was the director of interdisciplinary projects.

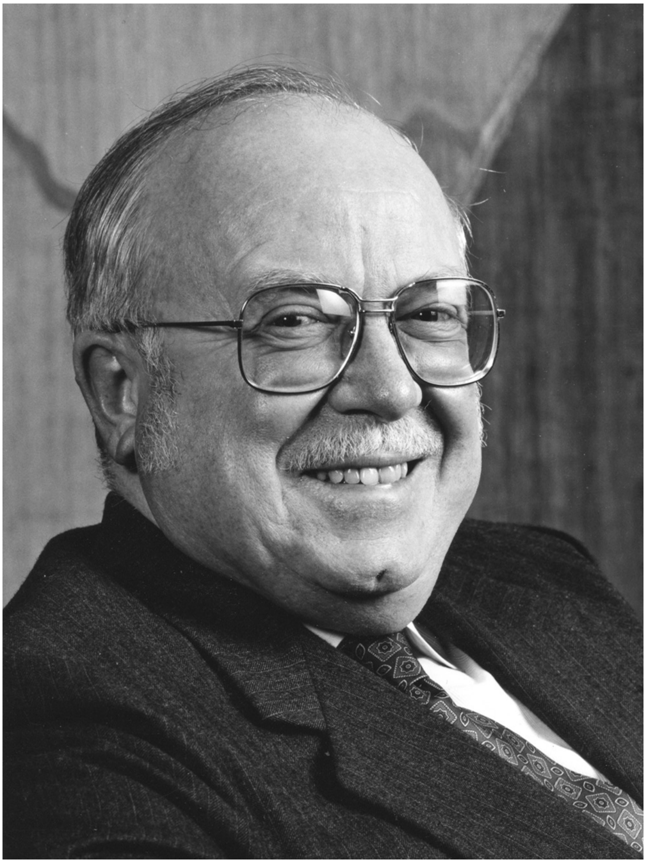
In 1960 Edward was recruited to join the newly formed Aerospace Corporation in El Segundo, California, where he was vice president and general manager of the engineering division, leading engineering studies on missile and satellite systems for the US Air Force and NASA. The corporation was organized and funded as a nonprofit company in the public interest to provide independent engineering reviews and objective leadership in the advancement of space science and technology for the government of the United States. In this work, Edward held high-level security clearances and, among other projects, helped develop the booster systems for the first orbital spy satellites in conjunction with Skunk Works at Lockheed in Sunnyvale, California. Another major project was the development of the Titan 3C heavy lift rocket system, which was "his baby." He also led the certification of the Titan missile for use in the Gemini program. He was in the blockhouse at Cape Canaveral for every launch and, on behalf of Aerospace Corporation as contractor, signed a document at T minus 30 seconds and counting that "the rocket will work."

In 1968, Edward was recruited by Varian Associates in Palo Alto to serve as vice president of the instrument division, which manufactured analytical instruments such as gas chromatographs and mass spectrometers in competition with Hewlett-Packard and PerkinElmer. He was successful in this private-sector job and retired in 1984.

During his career, Edward was a member of the President's Advisory Committee, Technical Capabilities Panel, the Advisory Panel on Aeronautics of the Office of the Secretary of Defense, and a special consultant to the Deputy Chief of Staff, Development, United States Air Force. He was chairman of the Aero-Space Vehicles Panel of the Air Force Scientific Advisory Board in 1960. He also served on the Space Technology Panel and the Ballistic Missile Defense Committee. He was a member of the Joint DOD/NASA Large Launch Vehicle Panel Group in 1961. He was elected to the National Academy of Engineering in 1968, and served for many years on the Report Review Committee of the National Research Council.

In the 1960s Edward was recognized by the city of Los Angeles for his work in civil rights and also by NASA for his service on the Rogers Commission that worked to help return the space shuttle to flight after the *Challenger* disaster. He was passionate about helping to return the space shuttle to flight because he was extremely interested in astronomy and cosmology, and the Hubble Space Telescope had not yet been launched. He knew that the Hubble would yield answers to major questions about the origins and age of the universe. He lived to be among the first humans to know the age of the universe at 13.7 billion years, plus or minus 200,000,000 years, and that Einstein was right, after all, about the cosmological constant, and that the universe is expanding under the influence of dark energy. He got the answers for which he worked most of his life to develop the rocket systems that would launch the great telescopes.

Edward was married for 50 years to the late Barbara Thompson Barlow. He is survived by his children, Jim, Anne, and John. He was a cold warrior who abhorred war and was a great American with a brilliant intellect and gift for both mathematics and management—a rare combination.



ROBERT R. BEEBE

1928–2011

Elected in 1990

"For notable contributions to the mining industry in the area of mineral processing and materials handling."

BY COURTNEY A. YOUNG
SUBMITTED BY THE NAE HOME SECRETARY

ROBERT "RAY" BEEBE, a highly respected scientist, engineer, mining executive, and consultant, died peacefully in his home in Tucson, Arizona, June 11, 2011, at the age of 83. He applied his expertise in mineral processing, crushing, grinding, flotation, leaching, solvent extraction, and electrochemical separations to both ferrous and nonferrous metals processing, particularly copper and gold.

Ray was born on April 21, 1928, to George W. and Emilda M. Beebe in Butte, Montana. He grew up watching the Anaconda Copper Company mine and process ore in Butte and ship the resulting concentrate to Anaconda about 20 miles to the west where it was smelted and refined into metallic copper. He worked in the mines and concentrators for most of his youth, helping with the war effort and thereby ensuring that the copper supply for making ammunition was endless.

His fascination with the mining industry planted the seeds for his career, but his pride in country took precedence. Upon graduating from Butte High School in 1946, Ray joined the US Army and served for three years, honorably discharged as a Supply Sergeant on July 12, 1949. He affectionately stated that he was the original Sgt. Bilko and could get anything when no one else could! Within the month, he went back to work in the mines but also enrolled in the Montana School of Mines, now known as Montana Tech. He earned a BS degree in 1953 and an MS in 1954, both in metallurgical engineering. His thesis was entitled "The Dissolution of Calcium Tungstate in Sodium Carbonate Solutions."

Mr. Beebe's career began with his first professional job as an assistant research engineer with the Montana School of Mines Research Foundation. A year later, in 1955, he took a position as principal metallurgical engineer with the Mineral Beneficiation Division of Battelle Memorial Institute, only to return to the Montana School of Mines for a one-year appointment as an assistant professor in metallurgical engineering.

On December 22, 1956, he married Aliss Marie Hansen and the following year they moved to Missouri where he worked as a metallurgist for St. Joseph Lead Company. Their only child, a son, Robert Russell Beebe, was born on August 25, 1958. Soon thereafter, the family relocated to Rapid City where Ray taught as an assistant professor of metallurgical engineering at South Dakota School of Mines and Technology. While there, he took a short course on basic nuclear engineering from North Carolina State College and Oak Ridge National Laboratory and earned a certificate from the US Atomic Energy Commission and American Society for Engineering Education. Two years later, he accepted a similar position at Michigan College of Mining and Technology, now known as Michigan Technological University or Michigan Tech for short. In 1962, Ray relocated his family to Minneapolis where he spent the next four years at the University of Minnesota, the first two as NSF Science Faculty Fellow in the School of Mineral and Metallurgical Engineering and the latter two as research associate and project engineer with the Mines Experiment Station. In 1966, he became senior engineer with Carpco Research and Engineering in Jacksonville, Florida. A year later, the family moved to San Francisco when Ray accepted a position as manager of Mineral Resource Development for Marcona Corporation.

His career in senior management began five years later. In 1972, Mr. Beebe moved his family back to Jacksonville to become president, CEO, and director of Carpco Research and Engineering. He took this position because his close friend, J. Hall Carpenter who founded the company, passed away. The

Carpenter family asked for Ray's help to sell it. That happened within two years when Frank Knoll, who was the senior engineer at the time, purchased the company and retained Ray on the board of directors for as long as Ray wanted. As soon as the transition to Frank was completed, Ray rejoined Marcona Corporation, initially as general manager of special projects but soon thereafter as vice president of project development.

Following their son's graduation from high school in 1976, Ray and Aliss moved to Norwalk, Connecticut, where he enjoyed 10 years working in New York City with Newmont Mining Corporation as senior metallurgical engineer and vice president of project development. In 1986, he accepted a similar position with Homestake Mining Company in San Francisco and eventually became senior vice president.

For his support and volunteerism to Montana Tech and in recognition of all of his accomplishments with both Newmont and Homestake, Mr. Beebe was presented the Distinguished Alumni Award in 1985 and Gold Medallion Award in 1990.

Ray retired in 1992 to become a consultant for the mining industry and, toward the end of the year, relocated to Tucson, where he continued on Carpco's board of directors through 1993, chaired the University of California–Berkeley's Mineral Engineering Department's Industrial Advisory Board (1990–1993), served as director of Santa Elina Gold Corporation (1994–1996), and was a member of Montana Tech's Metallurgical and Materials Engineering Department's Industrial Advisory Board (1994–2006). The department's name was changed from Metallurgical Engineering largely because of Ray's collaborative suggestions and efforts with other board members, including Milton Wadsworth with whom he loved to interact.

Ray's passion for the mining industry turned to frustration as he worked to save it from the hard times it had fallen into due to mounting social, political, and environmental issues: the US trade deficit was increasing; the US Bureau of Mines (USBM) was dismantled; companies were being driven abroad; US foreign dependence on minerals and metals, not just oil, was increasing…. Ray felt like his patriotism was under attack and likened it to "a civil war without ammunition."

Throughout his retirement until 2010, Ray devoted his time to the National Academy of Engineering, to which he was elected in 1990. He became involved with the National Academies when he was elected to serve as vice chair of the National Research Council (NRC) study on the Competitiveness of the Minerals and Metals Industries (5/1/88–12/31/90) and as a member of the National Materials Advisory Board (7/1/89–12/31/95). He became a member of the NAE Earth Resources Engineering Peer Committee (2/1/92–1/31/95) and the Nominating Committee (3/1/93–6/30/94), both of which overlapped with his time as chair of the NRC Committee on Research Programs of the USBM (1/20/94–2/7/95). Ray then became a member of the NAE Committee on Membership (1/2/95–1/12/98) and the Audit Committee (7/1/95–6/30/96). At the same time, he chaired the NRC Committee on Industrial Technology Assessments (11/15/95–6/30/99). He was appointed to the Section 11 Executive Committee, for which he served as vice chair and section liaison (7/1/97–6/30/00), chair (7/1/00–6/30/01), and councillor (7/1/01–6/30/04). He served simultaneously with the Petroleum, Mining, and Geological Engineering Section as vice chair and section liaison (7/1/97–6/30/00) and then chair and section liaison (7/1/00–6/30/01).

During these busy times, Ray also cochaired the NRC Committee on the Impact of Selling the Federal Helium Reserve (2/9/98–6/30/00) and was a member of six other National Academies committees: the NRC Panel on Separation Technology for Industrial Recycling and Reuse (8/15/97–12/31/98), Work Group #1: Academy Structure (1/1/98–1/31/99), NAE Membership Task Group (1/1/98–1/31/99), NRC Committee to Evaluate Proposals to the New York State Science and Technology Foundation for Designation as Centers for Advanced Technology (1/1/98–5/5/98), NAE Membership Policy Committee (7/1/99–6/30/02), and NRC Panel on Technologies for the Mining Industries (2/23/00–3/31/01). In recognition of his tireless efforts, Ray was elected to a six-year term as NAE Councillor (7/1/01–6/30/07). He concluded his service to the National Academies by returning to the Committee on Understanding the Impact of Selling the Helium Reserve to serve as a member (4/15/08–12/31/09).

Mr. Beebe was also a member of the Society for Mining, Metallurgy, and Exploration (SME) since 1952, Mining and Metallurgical Society of America (MMSA) since 1968, Society for Minerals, Metals and Materials (TMS) since 1995, and American Association for the Advancement of Science (AAAS) since 1996. He often represented the societies, both internally and externally. For MMSA, he was treasurer (1981–1985), vice president (1985–1987), and president (1987–1989). For SME, he was a representative and chaired the Subcommittee on Technology Requirements and Mining Research for the American Mining Congress (1989–1992); and he was a member of the board of directors for the National Advanced Drilling and Excavation Technologies Research Institute (1994–2011). For both SME and TMS, he served in 1995 on the Mining Technology Vision Panel for US DOE and USBM. That same year, he became chairman of the USBM Advisory Board for two years.

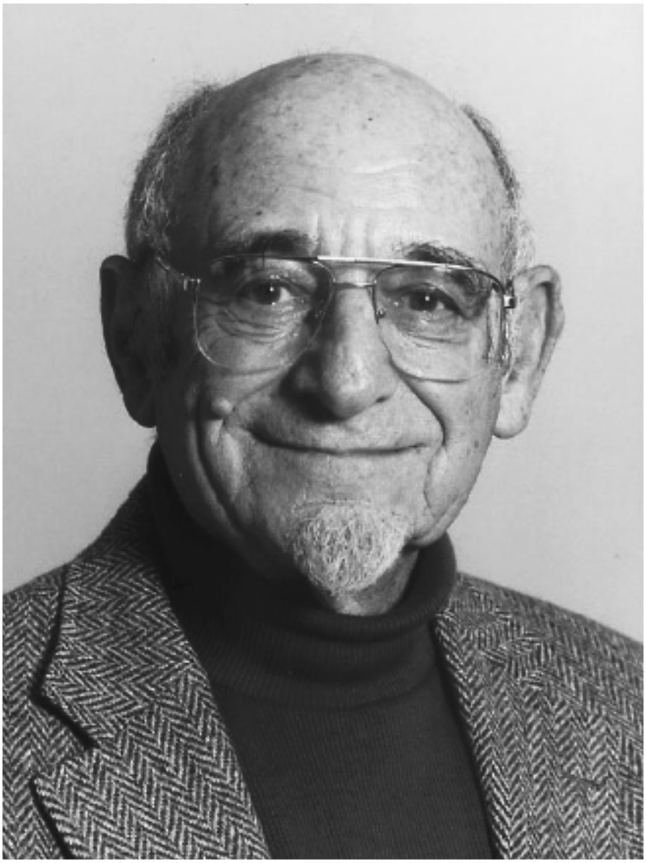
Mr. Beebe presented and published numerous papers for these societies throughout his career and well into retirement. His proudest paper was "Micro- and Macro-Engineering: Industrial Perspectives," because it resulted in his being named an SME Henry Krumb Lecturer in 1990.

His friends and colleagues were many and, although too many to name here, included Larry Watters, George Grandy, Sandy Stash, Milton Wadsworth, Ann St. Clair, Louis Connelly, Mike Frazer, and Frank Knoll. They all shared memories of a human being who was a wonderful and generous friend, mentor, and sponsor. He was there when you needed him most or even a little. He took immediate interest in both you and your career. You never had to ask; he offered. His advice was always exactly what was needed personally or professionally. He helped many navigate their trials and tribulations of the industrial and corporate world at all levels. It did not matter if you were student or CEO, scientist or engineer, male or female. He got along with everyone and everyone benefited from his wise counsel and support. He was candid, feisty, and stubborn. He was humble and one of a kind. People like him are few and far between. He knew how to apply the lessons of history to the present world. If only our current world leaders had this gift.

Throughout his life, Ray was always the consummate professional. He worked hard and played hard, mixing business with pleasure only when he had to. Even when he was on the golf course, it was business with clients and employees or pleasure with family and friends. He was not a great golfer but he made up for it with great conversation and always made it fun. Ray simply loved to offer his perspective on what was going on throughout the world. As one of the most intellectually curious people in the world, he had a great passion for books. In fact, Sandy Stash noted that she cherishes the books they discussed and shared and how proud she is of the collection she retains in his memory. He was a Friend of the Montana Tech Library.

Ray was so well read and versed in all aspects of politics and culture that he could discuss any number of subjects at length, including popular music. Just before relocating from Florida to California, his son Bob fondly recalls that his Dad was so intrigued about the music scene in San Francisco that he looked forward to moving there in part to listen to the new rock groups of the day. Bob wondered in amazement that his Dad mentioned names like the Grateful Dead and Jefferson Airplane before he had ever heard of them. Ray was clearly in tune with the times in more ways than one!

At work, Ray rarely spoke of family but in private there was no questioning his love for his family. Aliss, his bride of 35 years, passed away on July 24, 1992. He is survived by his son and daughter-in-law, Bob and Joya Beebe, and their two sons, Sean and Griffen. He was extremely proud of his son for the man and father he is. Ray adored his grandsons tremendously; they were his world. They all reside in California. Ray is also survived by his sister, his only sibling, Darlene Grinolds, of Butte, and her family, Judy Fisher (Marty Petritz), Sandy James, Patty Skakles (Kiki), John Grinolds (Derinda), Dan Grinolds (Shelly Coward), and Dale Grinolds (Mary Carroll), along with their families. He spoke highly of his numerous great-nieces and -nephews. Most reside in Butte and Anaconda. No doubt, Ray smiles down from heaven at them all but reserves an extra twinkle for the few who have ventured into the mining industry like he did. Such is the circle of life. Such is the heritage of Robert "Ray" Beebe. May he rest in peace!



SEYMOUR M. BOGDONOFF

1921–2005

Elected in 1977

"For contributions to gas dynamics and mechanics of viscous fluids, especially in hypersonic flow and shock boundary layer interaction."

BY RICHARD B. MILES, ALEXANDER SMITS, AND SAU-HAI LAM

SEYMOUR MOSES BOGDONOFF, Robert Porter Patterson Professor of Aeronautical Engineering Emeritus, died on January 10, 2005, his 84th birthday, at Helene Fuld Hospital, in Trenton, New Jersey, of injuries sustained in a fall in his home in Princeton.

Professor Bogdonoff, known to many simply as "Boggy," was born in New York City in 1921. He studied at Rensselaer Polytechnic Institute and received his bachelor of aeronautical engineering (BAE) degree in 1942. He chaired Princeton University's Department of Mechanical and Aerospace Engineering from 1974 to 1983.

Boggy started his career as an aeronautical engineer at the National Advisory Committee on Aeronautics (NACA, the predecessor to NASA) at Langley Field, where he met and married Harriet, a mathematician. Both worked for Arthur Kantrowitz. When Lester Lees joined the faculty of Princeton University's very young aeronautics department in 1946, he brought Boggy with him as his assistant. Boggy enrolled in the Princeton graduate program, earned his master's degree in 1948, and was immediately appointed an assistant professor. The department was only six years old in 1948 and growing very rapidly—first under the leadership of Dan Sayre and later Court Perkins. In addition to Boggy, Sayre and Perkins recruited many creative and talented faculty members, all with strong credentials in high-speed flight and rocketry.

The Princeton department was fully involved with the exciting aerospace problems of those days. Boggy's interests were in supersonic and hypersonic aerodynamics—high-speed flights that involve enormous mechanical and heat transfer loads on the vehicles and complex interactions with strong shock waves. Boggy pioneered this world and spent a lifetime exploring its challenges. His work was instrumental in developing the nation's space program and was crucial to solving the problems of safe reentry. Examples of his work include his investigations of shock-wave boundary-layer interactions at compression corners, his study of the reattaching shear layer problem, and his innovation of the air spike for drag reduction. His development of testing facilities and wind tunnels for these flow conditions was highly influential. He was nationally and internationally renowned for his work, and he was especially well known in Europe and the Soviet Union, where he was widely recognized for his contributions as an experimentalist.

At Princeton, Boggy was promoted to associate professor in 1952 and full professor in 1957. He was a skilled and demanding teacher, and his students went on to dominate all aspects of the field of gas dynamics. He was named the Robert Porter Patterson Professor of Aeronautical Engineering in 1964 and was elected to the National Academy of Engineering in 1977. He became department chairman in 1974 and served nine years. He recognized the importance of numerical computations very early and was instrumental in the establishment of Princeton's Program in Applied and Computational Mathematics in the early 1980s.

Boggy's skills as a consultant were widely sought by industry and government, and he had enormous influence on shaping research activities and research policies in aerospace engineering. He was an advisor to the National Science Foundation, the Office of Science and Technology Policy, the Defense Science Board, and the National Aeronautics and Space Administration. From 1963 to 1986 he served on the

Air Force Scientific Advisory Board, which helps guide the US Air Force's research and development plans. He was a key advisor to NATO through his activities in the Advisory Group for Aerodynamics Research and Development, and he helped found and nurture European efforts in high-speed aerodynamics and space. For this work he was recognized with numerous honors, including membership in the French Academy of Air and Space. At the same time he maintained close contacts with Soviet scientists, helping to maintain vital scientific links at a time when governments were engaging in Cold War brinkmanship.

But Boggy was much more than a very good scientist and engineer. Above all else, he was committed to his family, enjoying his children and grandchildren. He had many interests, including traveling the world, playing his Senegalese drum, and building furniture. He was an active member of the community, a mentor to the Boy Scouts, and one of the founders of the Jewish Center of Princeton, serving as one of its early presidents. He skied, played squash, and found time to tinker in his garage.

From his early days, Boggy loved cars, and they were a passion throughout his life. He was a superb mechanic and an expert driver, honing his skills with his Porsche at Watkins Glen. He challenged the New Jersey Motor Vehicle Commission by bringing down from the back woods of Maine a vintage orange Citroën Deux Chevaux, a car that failed to meet almost all US safety standards, and he overcame all bureaucratic nightmares to drive it triumphantly to work. In his later years he worked to establish a driver education program for senior citizens.

Boggy was a born leader. After Lester Lees left Princeton for Caltech in 1953, Boggy took over the Princeton Gas Dynamics Lab, and under his direction it became a national powerhouse in aeronautical research. He surrounded himself with a team of outstanding faculty colleagues, including Wallace D. Hayes and Sin I. Cheng. At its peak the laboratory had seven faculty members, about 10 postdoctoral and upper-level research associates and technicians, and dozens of graduate students.

Their work was supported by a wide range of helium, nitrogen, and air wind tunnels designed and built by Boggy, often aided by his close associate Irwin Vas. From that research flowed a torrent of papers and reports that helped shape our understanding of high-speed flight. But more than that, an entire generation of students and researchers went out from the lab to support the national programs in supersonic flight and the race to the moon. These students and researchers went on to dominate virtually all aspects of gas dynamics research and engineering. That legacy continues today, with the earlier researchers and students in turn training second, third, and fourth generations of aeronautical engineers. One can still go to such places as the Air Force Research Lab in Dayton, Ohio, or the von Karman Institute in Brussels, or DLR in Göttingen, and find wind tunnels that are copies of those designed by Boggy, run by people who were trained by him.

In 1954, Boggy and Antonio Ferri coauthored the first general description of the design and operation of intermittent supersonic wind tunnels, an enormously influential guide to experimental work for the burgeoning interest in high-speed flows. It was published as *AGARDograph* No. 1, literally and figuratively at the start of a new age.

Boggy was a man who held strong opinions, and he defended them passionately. He was renowned as a severe critic and as a man of action. He got the job done. If you disagreed with him, you had better come prepared and be as tough as Boggy himself. As a number of people have said, he was a force of nature. Natalie Crawford of the RAND Corporation, who served with him on the Air Force Scientific Advisory Board, called him the grain of sand that makes the pearl in the oyster. He challenged those around him to be better and stronger, and although it may not always have been pleasant at the time, it was an excellent education. Many students remember his help and guidance, often warmly. At heart he was a generous, charming, and kind man. He did many things for many people, even for those with whom he disagreed, and those who knew him well remember him fondly.

He is survived by his wife, Harriet; three children—Sondra Bogdonoff (of Portland, Maine), Zelda Bogdonoff (of Bethlehem, Pennsylvania), and Alan Bogdonoff (of New London, Connecticut); and five grandchildren.

SETH BONDER

1932–2011

Elected in 2000

"For technical and organizational leadership in military and civilian operations research."

BY STEPHEN POLLOCK AND DAVID MADDOX

SETH BONDER, a respected, admired, and valuable member of the operations research community, died in Ann Arbor, Michigan, on October 29, 2011, at the age of 79. He served many roles—exemplary analyst, innovative applied researcher, entrepreneur, educator, philanthropist, mentor, and critical advocate for his profession.

Seth Bonder was born in the Bronx, New York, in 1932. His parents had immigrated from Russia and worked in the garment district. By his own admission, Seth took little interest in education during his youth and did not do well academically. Instead, he became an accomplished pool, billiards, and basketball player in the South Bronx streets. He enrolled in the City College of New York to play basketball, but left soon after as an innocent victim of its 1951 point-shaving scandal. After driving a truck in New York for a while, he enlisted in the Air Force and took advantage of a program that allowed enlisted men to apply to flying school. He received his commission and served as a pilot in the Air Force from 1952 through 1956. During his service it became clear that a college degree would be necessary if he were to have a meaningful career, so he left the Air Force and entered the University of Maryland in 1957. After a rocky start, he excelled academically and showed his entrepreneurial leanings by starting a freshman tutoring service, creating and participating in a flying club, and driving a taxicab at night in the District of Columbia and Prince Georges County, Maryland.

Upon obtaining a degree in mechanical engineering from Maryland in 1960, and after a short stint at the Westinghouse Air Arm Division in Baltimore, Seth Bonder enrolled at the Ohio State University as its first systems fellow. He was introduced to military operations research via a project meant to determine requirements for new armored systems. He identified two unresolved problems that he referred to as "interesting": determining the feasibility of the requirements (could the system actually be built?) and the operational effectiveness of the system (would the resulting system be of any value?). He wrote a proposal to study these questions and—*as a graduate student*—landed a contract to run a multiyear research program in which he was responsible for the work product of both faculty and graduate students. He received his PhD in industrial engineering (operations research) from Ohio State in 1965.

From 1965 through 1972, as a faculty member in the Department of Industrial Engineering at the University of Michigan, Seth Bonder developed the capabilities and processes required of an operations analyst and created unique ways to teach and mentor these analysts. Throughout the rest of his professional career he was an adjunct professor at Michigan—something of which he was exceedingly proud (except for exactly one day during each football season).

In 1972, at the urging of the Army's assistant vice chief of staff, Seth Bonder founded, and then headed for the next 32 years, Vector Research, Inc. (VRI), an operations research consulting firm. VRI grew over the next three decades to eventually employ over 400 professionals in Ann Arbor, Texas, and Washington, DC. Seth and his colleagues at VRI developed a variety of novel mathematical models to represent military operations and—most important to him—used the insights from these models to inform decision making about national security issues at the highest levels. In 1990, he received the Award for Patriotic Civilian Service from the Secretary of the Army.

From 1995 through 2001 Seth Bonder led VRI in a successful effort to convince private firms, as well as federal and state agencies, to invest in operational and systems engineering approaches to address increasingly critical problems inherent in the delivery of health care. In 2001 VRI was acquired by ERIM (the former Willow Run Laboratory) and the merged entity was renamed the Altarum Institute. While serving on Altarum's board of directors, Seth Bonder maintained his commitments to the profession and community. He founded the Bonder Group and contributed to, led, and participated in studies sponsored by the National Academies, serving on the NRC Board on Army Science and Technology as well as the Army Science Board and a variety of academic and healthcare boards, and provided consultant services to the Department of Defense up until his untimely death.

One critical hallmark of Seth Bonder's unique and far-reaching contributions to operations engineering was his insistence on addressing real problems using application-driven theoretical developments. In the national security domain, his friendships with decision makers reinforced this concern, and these provider-client interactions evolved into close professional and personal relationships based on mutual appreciation and respect for excellence and intellectual depth.

Seth Bonder's role as a mentor was an equally valuable and appreciated influence. His students at Michigan and associates at VRI formed a cadre of high-level analysts, populating the leadership and awardee lists of his profession and forming what can be reasonably called a virtual "Bonder School" of operational systems engineering.

Seth Bonder's professional leadership and consequent recognition were extensive: he served as president of the Operations Research Society of America and vice president of the International Federation of Operations Research Societies. He received the Institute for Operations Research and the Management Sciences (INFORMS) President's Award for service to society (2001), its Kimball Award for distinguished service to the society and to the profession of OR (1993), its Military Applications Society's Jacinto Steinhardt Memorial Prize (1999), and the Omega Rho Distinguished Lectureship (2004). He was a member of the Military Operations Research

Society (MORS) board of directors, its vice president, and president. He received its Rist Prize for the best-implemented study presented at a MORS Symposium and was awarded its 1986 Vance R. Wanner Memorial Award for distinguished service to the profession.

Seth Bonder was elected a member of the National Academy of Engineering (NAE) in 2000 and chaired the Industrial, Manufacturing, and Operational Systems Engineering Section. In that forum and other venues he campaigned for the recognition of operational systems engineering as the implementation component of operations research. He was active in studies and programs of both the NAE and the Institute of Medicine, bringing to bear his experience and perspectives to problems in both defense and health care.

He generously endowed fellowships at the Ohio State University and the University of Michigan and established and funded two INFORMS scholarship programs, for applied operations research in military applications and in health services.

In the last decade of his life, after leaving behind the pressures of running a multimillion-dollar enterprise, Seth Bonder found many ways to relax and enjoy life. He made time to appreciate foreign travel (not necessarily associated with visiting a military base or installation). He developed an appreciation for fine food and wines and devoted his legendary focus and undiluted passion for excellence to a well-designed program for physical fitness for himself and those around him. He was an excellent tennis player (his son Eric played tennis for Ohio State University and his daughter Lisa was a highly ranked professional).

More recently he took up golf and used his second home in Longboat Key, Florida, as a base from which he continued his consulting and enjoyed life with the same intensity and attention he had dedicated to his professional work.

Seth Bonder is survived by his wife Merrill, two children, Lisa and Eric, four grandchildren, two step-grandchildren, and hundreds of deeply saddened and appreciative friends and colleagues.

Y. AUSTIN CHANG

1932–2011

Elected in 1996

"For applications of thermodynamics, phase diagrams, and kinetics to the understanding of modern materials of technological significance."

BY HIS COLLEAGUES IN THE DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING AT THE UNIVERSITY OF WISCONSIN–MADISON
SUBMITTED BY THE NAE HOME SECRETARY

PROFESSOR YONG-SHAN AUSTIN CHANG, Wisconsin Distinguished Professor Emeritus of Materials Science and Engineering at the University of Wisconsin–Madison and a guiding force in alloy thermodynamics, died on August 2, 2011, at the age of 78.

Chang was born in Goon village, Henan province, China, where he grew up during the Second Sino-Japanese War. For a time he lived in a cave with his illiterate mother, a simple stove, and no electricity. Her hiding him in a local school house may well have protected him from kidnapping for forced military service. His education was interrupted frequently by the difficulties of the time. From these humble beginnings and with resolute determination and creativity, he grew into an international leader in the field of alloy thermodynamics.

Chang traveled to the United States in 1950 to pursue postsecondary education, initially as a foreign student at Baylor University and subsequently as an engineering student at the University of California at Berkeley. He earned undergraduate and master's degrees in chemical engineering from UC–Berkeley and the University of Washington at Seattle, respectively, and a PhD in metallurgy from UC–Berkeley in 1963. He was employed as a senior engineer at Aerojet General Corporation in Sacramento, California, before beginning his academic career at the University of Wisconsin–Milwaukee in 1967. He served as department chair from 1971 to 1977 and as associate dean for research from 1978 to 1980, all the while building an outstanding reputation in research and in education. He joined the Department of Metallurgical and Mineral Engineering at UW–Madison in 1980. As department chair from 1982 to 1991, he guided research and education programs toward the current comprehensive offerings across the broad spectrum of the materials field and through the department's renaming to Materials Science and Engineering. Although he officially retired in 2006, he pursued his professional passions—research, research education, mentoring of junior faculty, and department leadership—until his death.

Chang's scholarship is known globally for its exceptionally high rigor and reliability and its focus on technologically important alloy systems. His peers characterize his approach as an astute integration of fundamental science with a keen sense of technological relevance. He is credited with advancing key innovations on important problems that few others attempted to tackle with comparable depth and originality. His contributions in metallurgical thermodynamics and phase equilibria have had immense impact in materials science, materials engineering, physical metallurgy, and chemical engineering. With his fundamental science approach he advanced the understanding and applications of a variety of materials including structural materials (Al-alloys, Mg-alloys, and Ni-based superalloys), compound semiconductors, magnetic materials, and materials for applications in energy technologies. His international stature in the profession was recognized by his induction into the National Academy of Engineering, the Chinese Academy of Sciences, and Academia Sinica (Taiwan), and by numerous research, education, leadership, and career awards from the University of Wisconsin and the professional societies of his field.

In addition to his stellar scholarship, Chang was an outstanding teacher and educator. His accomplishments as a teacher and mentor have been recognized by his peers and colleagues both at the University of Wisconsin and nationally through many awards, most recently though the TMS Educator Award and the Albert Easton White Distinguished Teacher Award of ASM International. However, the true, deep, and lasting impacts of his teaching and mentorship of students are much more vividly articulated in the respect, gratitude, and love expressed in the memories shared by his students in his memorial guest book. Many of these students hold high positions in industry or are recognized leaders in academia at institutions around the world. Their comments were truly inspiring to those Austin left behind.

Chang served the University of Wisconsin and the materials profession with distinction throughout his career as a member of many university and professional committees. He was an active member of the Minerals, Metals, and Materials Society (TMS) and ASM International (formerly the American Society for Metals), from which he received a number of prestigious awards in recognition of his research, teaching, and professional service. Most recently he was recognized by the TMS Leadership Award in 2011.

Based on computer programming codes that gained him international recognition, he founded CompuTherm LLC, a Madison-based company that develops powerful, user-friendly computer software and an alloy database for thermodynamic calculations. Upon his retirement, he and his wife P. Jean Chang generously endowed a chair in the UW Department of Materials Science and Engineering.

Chang's family—Pi-Ying Jean Chang, his wife; his sons Vincent D., Lawrence D., and Theodore D.; his daughters-in-law Suzanne and Diana; his grandchildren Kristina, Jing Chang, Brian, Alyssa, Steven, and Michael; his brothers Douglas and Raymond; his sisters Wan-Ru and Ai-Ling; and his many nieces and nephews—were always first and foremost in his thoughts and his actions. Austin and Jean enjoyed their life together for almost 55 years. They enjoyed many walks, sunsets, scenic places, and musical programs together. They travelled extensively to many countries on several continents. Since 1980 Austin brought Jean back to visit his birthplace, Goon village, and paid homage to his ancestors twice. In 2010 he published his last text book, *Materials Thermodynamics* (Wiley Series on Processing of Engineering Materials; John Wiley & Sons). He dedicated this book to his honorable mother, Shu-Ying, and his beloved wife, Jean.

Austin Chang will be remembered and admired as the best in the academic tradition. He was a brilliant, creative, productive, and entrepreneurial scholar who took upon himself a significant and continuous presence in the classroom and a magnanimous role in service to the University of Wisconsin, the State of Wisconsin, and the materials profession. One of his highly respected competitors once described him as "without question, the most gracious, generous, and unselfish superstar I know." His wisdom, leadership, and grace will be sorely missed by his colleagues in Wisconsin and around the world.

BEI T. CHAO

1918–2011

Elected to NAE in 1981

"For pioneering contributions to heat transfer research and leadership in engineering education."

BY JAMES W. PHILLIPS AND KIMBERLY GREEN
SUBMITTED BY THE NAE HOME SECRETARY

BEI-TSE ("BATES") CHAO, professor emeritus and former head of Mechanical and Industrial Engineering (M&IE) at the University of Illinois at Urbana-Champaign (UIUC), passed away March 2, 2011, at age 92.

Born December 18, 1918, in Su Zhou, China, Bates spent most of his early life in Shanghai. He received a BS degree in electric engineering summa cum laude from Shanghai Jiao Tong University in 1939 and, after working five years at a machine tool company in Kunming, China, entered the University of Manchester, England, where in 1947 he completed his doctorate degree. His doctoral dissertation was entitled "The Effect of Speed and Feed on the Mechanics of Metal Cutting."

Dr. Chao joined UIUC as a visiting research assistant in 1948. He became an assistant professor in M&IE in 1951 and rose quickly through the ranks, becoming an associate professor (1953–1955) and full professor in 1955. He served as department head from 1975 until his retirement as professor emeritus in 1987. As department head, he built M&IE into a first-class research department. He provided critical input and helped to shape the future direction of the department, in part by participating in interviews and the evaluation process of the appointments of subsequent department heads.

Dr. Chao was elected to the National Academy of Engineering in 1981 for his pioneering contributions to heat transfer research and leadership in engineering education. A recognized expert on heat transfer and energy systems, he was the author of more than 100 articles, four US patents, and a well-received book, *Advanced Heat Transfer* (1969). In addition to his NAE membership, he received an impressive number of honors and awards: membership in the Academia Sinica, Taiwan; fellow of the American Society of Mechanical Engineers (ASME), American Association for the Advancement of Science, and American Society for Engineering Education (ASEE); Boxer Indemnity Scholar, Sino-British Cultural and Educational Foundation (1945–1948); Blackall Machine Tool and Gage Award, ASME (1957); Distinguished Lecturer, University of Washington, Seattle (1964); Distinguished Lecturer, Ohio State University (1970); Heat Transfer Memorial Award, ASME (1971); Russell S. Springer Visiting Professor of Mechanical Engineering, University of California, Berkeley (1973); Western Electric Fund Award, ASEE (1973); Ralph Coats Roe Award (1st), ASEE (1975); Service Award, National Science Council, Republic of China (1976, 1979); Five-Year Effective Teacher Award, M&IE Alumni Association, UIUC (1978); Southwest Mechanics Lecturer, Southwest Universities Association (1982); Board of Governors' Certificate of Appreciation for Service as Technical Editor (1975–1981), *Journal of Heat Transfer,* ASME (1982); Max Jakob Memorial Award, ASME and American Institute of Chemical Engineers (1983); Prince Distinguished Lecturer, Arizona State University (1984); Outstanding Achievement Award, American Academy of Higher Education (1984); Benjamin Garver Lamme Medal, ASEE (1984); Tau Beta Pi Daniel C. Drucker Eminent Faculty Award (1st), College of Engineering, UIUC (1985); University Scholar, UIUC (1985–1988); William T. Ennor Manufacturing Technology Award, ASME (1992); Centennial Medallion, ASEE (1993); and NASA Certificate of Recognition for Creative Development (1993).

In addition to teaching, Dr. Chao served as design engineer at Scully Jones Co., Chicago (summer 1951–1952); resident research associate, Argonne National Laboratory (summer 1961); member of the technical staff, Jet Propulsion Laboratory (summer 1964); Russell S. Springer visiting professor of mechanical engineering, University of California, Berkeley (spring 1973); visiting scientist, Argonne National Laboratory (1975); and consultant to Scully Jones, the US Atomic Energy Commission, University of Washington in Seattle, Clemson University, State University of New York–Buffalo, and Argonne National Laboratory.

Dr. Chao was very active in his profession. He was member of a number of professional societies, a founding member of the Society of Engineering Science, and an honorary member of Phi Tau Sigma. He was also listed in the *Dictionary of International Biography, Who's Who in the World, Who's Who in America,* and *Who's Who in Engineering.*

Bates is survived by his wife May Kiang, whom he married in 1947 in Manchester, England. They met in Chongqing, the wartime capital of China, in 1945. They had no children of their own, but for eight years they raised Bates' nephew and niece, Fred and Clara Chao, who had survived a tragic automobile accident in their home country of Brazil that claimed the lives of their father (Bates' brother), mother, and three siblings. Fred and Clara later returned to Brazil and now have families there.

Everyone who met Bates was impressed by his kindness, by how easy it was to speak with him, and by the range of his intellect, including his knowledge of science and of the stock exchange. He was a true visionary, and his death is a profound loss for his family and friends, the University of Illinois, and the science and engineering communities.

FLOYD L. CULLER JR.

1923–2004

Elected in 1974

"For contributions to the development of successful nuclear power."

BY JEFF BREHM
SUBMITTED BY THE NAE HOME SECRETARY

FLOYD L. CULLER JR., president of the Electric Power Research Institute (EPRI) from 1978 to 1988, and deputy director at Oak Ridge National Laboratory (ORNL) from 1970 to 1977, died September 29, 2004, in San Juan Capistrano, California, at the age of 81.

Born in Washington, DC, on January 5, 1923, Floyd graduated from Frederick (Maryland) High School in 1940. After earning a bachelor's degree in chemical engineering from Johns Hopkins University in 1943, he came to Oak Ridge, where he worked at the huge Y-12 Electromagnetic Separation Plant. "We learned fast," Floyd told the *EPRI Journal* in an interview in 1978. "And I had a chance to do things while young that most people will never get to do."

Floyd also met his wife of 52 years, Della Hopper, in Oak Ridge. She died in 1995.

In 1947, Floyd moved to ORNL as a design engineer for nuclear fuel recycling plants. He was one of the few people given the opportunity to move for a year throughout the labs, working where he wished and attending lectures by many of the outstanding scientists then at Oak Ridge. He became section chief and later director of the Chemical Technology Division.

Floyd managed the lab's development of solvent extraction and other processes for recovery of uranium, plutonium, and fission products from spent nuclear fuels. His team established nuclear fuel reprocessing techniques used worldwide. He served as lab associate director for nuclear technology in 1964 before being named laboratory deputy director. He also was acting laboratory director in 1973–74 after the retirement of Alvin Weinberg.

"Floyd is above all a man of excellent character, so wonderfully open, so enthusiastic, and basically so totally honest. There's no sham about him whatsoever," Weinberg said. "As you come to know him, you realize he's a man of extraordinary intellect and capable of keeping in mind a fantastic wealth of detail. Finally, he is a person of extraordinary practical sensibilities and sensitivities."

Often described as a "muddy boots type," Floyd enjoyed working directly with craftsmen and with the people of Oak Ridge. Active in the community, he chaired the Oak Ridge Regional Planning Commission, which was responsible for the alphabetical naming of the city's streets and helped govern the community before it was incorporated as "a civilian town," after its special wartime role in the development of the atom bomb.

Friends and colleagues enjoyed teasing Floyd about his talkative nature. "He talks a lot," one said. "He can talk your ears off." "Outsiders might get irritated because he seemed to be dominating a meeting, but it's just that he gets so enthusiastic and involved," Weinberg said. "And unlike a lot of other people, you realize he knows what he's talking about…he never talks nonsense."

Floyd succeeded EPRI founder Chauncey Starr as president of the institute on May 4, 1975. Some in the electric industry expressed concerns that his long affiliation with the nuclear field might make his role in overseeing the wide-ranging R&D at EPRI, then only in its fifth year, "a little tough going." But their fears were allayed by those who knew Floyd, especially Starr. "I had one general criterion [for my successor]," Starr said, laughing. "He could do everything I could do, only better!"

Floyd was asked why he chose to leave Oak Ridge after 33 years. "I love Oak Ridge, and I love the people there," he said. "But I decided that it would be fun to try something different…and [EPRI] is too marvelous an opportunity to work essentially with the same kind of people, the same spread of thought, with the same scope of R&D, and to do something very important in the energy business."

"All those who have known him and have worked with him testify to his warmth, his availability and human concern, his honesty, and his deep integrity as a person," the *EPRI Journal* wrote in the 1978 article introducing Floyd as the institute's new president. "What one hears is that he is not only deeply respected but also loved by his colleagues."

Floyd described his management style as "a very personal one…based on a mutual bond of personal respect, in which we know one another's strengths and weaknesses and can relate without being critical of one another, only of the things with which we are dealing. This way, hopefully, it is possible to work objectively on technical issues—even to disagree violently—without wounding one another or losing a lot of mutual respect."

Former EPRI colleague Ric Rudman said Floyd "was a unique blend of humanity, intellectual curiosity, integrity and vision." He "genuinely cared about every person he came into contact with. Who you were, where you came from and where you wanted to go, what excited you and what you had to share with him were all of interest to Floyd," Rudman said. "The breadth and depth of Floyd's intellectual curiosity was staggering, as was his mastery of a wide range of scientific and engineering disciplines.

"My favorite memory of Floyd is of a tour that EPRI's senior staff took of Battelle Memorial Institute's laboratories in the early 1980s. We walked through a handful of different labs including materials, genetic engineering, computer science, and bioengineering," Rudman recalled. "At each station, the same pattern would repeat itself. Floyd would listen intently to what the presenter had to say. Then he would ask a question that went well beyond what the presenter covered.

The presenter would inevitably say something to the effect of, 'That's a great question that I need to think about.'

"Floyd was more than just an accomplished scientist; at his core, he was a visionary engineer," Rudman added. "When he became EPRI's CEO, Floyd was immediately struck by the need to encourage electric utilities to apply many of the technologies that had been developed during EPRI's first five years. His goal was to demonstrate these technologies at a large enough scale on utility systems to show they were economically and technically viable. This decision helped to accelerate the commercialization of many technologies. It also served to broaden the utility industry's perspective on EPRI from simply an R&D think tank that produced useful scientific insights to a partner that produced valuable technological results.

"When Floyd retired, EPRI was larger, stronger, and better positioned to provide value to society, its member utilities, and the ratepayers they serve."

Floyd received the Department of Energy's Ernest O. Lawrence Memorial Award in 1965. He was elected to the National Academy of Engineering in 1974 and also was a fellow of the American Institute of Chemists (1968), the American Institute of Chemical Engineers (AIChE; 1981), and the American Association for the Advancement of Science (1981). He received the 1969 Atoms for Peace Award of the Ford Motor Company Fund, and in 1972 AIChE's Robert E. Wilson Award. In 1977 the American Nuclear Society gave him a special award for his outstanding work in chemical technology to recycle fuel and in 1980 honored him with its 25th Anniversary Exceptional Service Award.

Floyd was survived by his son Floyd Culler III and daughter-in-law Kirsten Culler, Irvine, California; granddaughters Amanda, Meredith, and Grace Culler, also of Irvine; sister Doris Summers, Frederick, Maryland; and brother Carl Culler, Fort Myers, Florida.

LEONARD S. CUTLER

1928–2006

Elected in 1987

"For scientific and engineering contributions to the fields of atomic frequency standards and electronic instrumentation and measurement."

BY JAMES N. HOLLENHORST
SUBMITTED BY THE NAE HOME SECRETARY

LEONARD S. CUTLER, cofounder of Hewlett-Packard Laboratories and internationally recognized inventor and scientist, died of heart failure on September 4, 2006, at the age of 78.

During his career of almost 50 years with Hewlett-Packard and Agilent Technologies, Len established a reputation as the company's most respected scientist and innovator. His numerous innovations in time and frequency control and contributions to the world's most accurate commercial clocks earned him the nickname "Father Time." He was the first and still the only person to hold Agilent's highest technical honor, Distinguished Fellow, in recognition of his long-standing and far-reaching contributions, particularly in the areas of precise measurement of time and position.

Len was born on January 10, 1928, in Los Angeles, where his parents ran small businesses such as grocery stores and a restaurant. Years later, he liked to tell the story of having to eat the spoiled food left over at his parents' restaurant during the Great Depression, explaining that this is how he developed a lifelong hatred of fish.

He had an early interest in science and music and discovered that he had perfect pitch. He appeared briefly in the 1945 film "Anchors Aweigh" playing the piano in the Hollywood Bowl. He was 17 years old at the time.

Ultimately, he had to choose between music and science and decided he wasn't a good enough musician to make a decent living at it. In 1945, after high school, he joined the Navy, where he trained as an electronics technician and ended up teaching some of the courses himself.

Next, Len went to work as an electronics technician for the Hoffman Radio Company in Los Angeles. Soon after, in 1947, he began his college career at Stanford University. He ran out of money after two years and headed back to Los Angeles in 1949 to work for a small company, Gertsch Products, where his starting pay was $1.50 per hour. He worked at Gertsch for eight years designing things like frequency meters, power supplies, and filters, eventually rising to the position of vice president of engineering. During this time, he married Dorothy and they had their first child, Jeffrey.

In 1957, he decided to go back to Stanford to finish his college degree. To support his growing family, he began his career at Hewlett-Packard in the same year. His employment application form reveals the true Len. When asked what work he liked, he said: "design and development." When asked what he disliked, he said "management work." Many years later, when I took over one of Len's management roles, he couldn't hide his thrill in handing over budgets and personnel matters to me, while he relished the chance to spend more time designing better atomic clocks. At management meetings that we both attended, Len could frequently be spotted solving complex but timeless equations while the rest of us debated an urgent but fleeting administrative issue.

Hewlett-Packard supported his tuition at Stanford, where he pursued a bachelor's degree (1958) and graduate degrees (1960, 1966) in physics. He delighted in quantum mechanics, general relativity, and mathematical physics. In 1966 he earned a PhD in theoretical physics under the direction of Dirk Walecka, with whom he investigated electron scattering off nuclei and noise in lasers and masers. Concurrently at HP, he worked on precision oscillators and got very interested in atomic frequency standards, which combined his love of physics and quantum theory with HP's practical needs for instrumentation. He developed the first cesium beam clock with all solid-state electronics (no vacuum tubes), which became a commercial product in 1964, and he took on management responsibilities in the process. The performance and reliability of HP's atomic clocks were much better than anything previously available, so they rapidly captured the market and became widely used throughout the world.

He also invented a new approach to distance measurement using a Zeeman-split two-frequency laser interferometer. This became an important business that today enables nanometer-scale positioning in photolithography for the semiconductor industry. It was also around this time that Barney Oliver and Len founded HP Labs. In 1967 HP decided to buy the division of Varian that was working on atomic frequency standards and Len went to Beverly, Massachusetts, to run that operation for several years. During this time, he met and worked with Norman Ramsey, Robert Vessot, and Joe Holloway. Len became a second-level manager and Director of Quantum Electronics for HP.

After the Varian operation was moved to California, Len came back to HP Labs as director of the physics research lab. He continued to work on atomic clocks but directed other activities as well. For example, he led the program on magnetic bubble memories, developing a one-megabit device, which was a very impressive accomplishment at the time. Later he became director of the instruments and photonics lab, developing photonics instrumentation and frequency standards. In 1987, shortly after the discovery of high-temperature superconductors, Len and John Moll founded the Superconductivity Lab and became its codirectors.

In 1990, Len became the first Distinguished Contributor in HP and was happy to be relieved of his lab director duties and work full time on his greatest passion, time and frequency standards. He led a small team whose innovations enabled the introduction in 1992 of HP's 5071A cesium clock, with an accuracy of one second every 1.6 million years. It soon became the most successful commercial time standard in the world.

In the 1990s, at David Packard's request, Len helped to create the first true basic research effort in HP, at a time when most companies were stopping basic research. He hired Stan Williams to lead the effort, which subsequently became one of the preeminent nanotechnology groups in the world.

In 1999 the original measurement businesses of Hewlett-Packard spun off as a new company, Agilent Technologies. Len continued to lead his small team in the new Agilent Labs, always working on matters of importance to the business. He was soon named Agilent's first Distinguished Fellow, the highest technical honor bestowed by the company.

Len was responsible for innovations in many areas of technology. At the time of his death, he had submitted two patent applications, which were subsequently granted, bringing his career total to 27 patents. Among his technical achievements, two stand out above all others: atomic clocks and laser interferometers. Clocks designed by Len form the cornerstone of the time standards maintained by laboratories throughout the world. They were the first to be flown in airplanes to perform the synchronization of world clocks and later to test the variations in the flow of time predicted by Albert Einstein. Like the clocks built by John Harrison in the 18th century to solve the longitude problem, the impact of Len's work is crucial to modern commerce. Accurate timekeeping is essential to GPS navigation, computer networks, financial transactions, transportation systems, and many other things that we take for granted. His invention of the two-frequency laser interferometer is a key element in maintaining the fraction-of-a-nanometer positional accuracy in photolithography systems. This has enabled remarkable advances in integrated circuit technology, ushering in the age of nanotechnology.

Len was the recipient of many awards and honors. In addition to being named IEEE Fellow for "contributions to the design of atomic frequency standards and to the theory and measurement of frequency stability" and Fellow of the American Physical Society for work on atomic frequency standards and laser interferometers, he received the IEEE

Centennial Award, Morris E. Leeds Award, Rabi Award, the Third Millennium Medal, IRI Achievement Award, AIP Industrial Applications of Physics Award, and Precise Time and Time Interval Distinguished Service Award. In 1987 he was elected to the National Academy of Engineering for "scientific and engineering contributions to the fields of atomic frequency standards and electronic instrumentation and measurement." He served on numerous government, professional society, industrial, and academic committees and advisory boards.

All who knew him agree that Len was among the most brilliant people they ever met. Beyond his technical accomplishments and leadership, Len had an enormous impact on HP and Agilent by setting a standard of the highest scientific and engineering excellence and by striving to hire the very best employees. Unlike most hiring managers, his vision went far beyond the project at hand. He recognized that the people he hired would contribute to the company for many years, so he was willing to make a bet on people with great drive and ability, even though their expertise might not be aligned with the immediate needs of his projects. A significant part of his legacy is the continuing impact of several generations of employees that he hired and mentored.

His son Jeff wrote:

> Len Cutler was a deeply introverted man, and highly analytical. He was happy when he was designing circuitry or solving mathematical equations. He was a caring, principled father who tried to instill good values in his children. As a boy, the time I spent with him was an education in itself. He loved photography and optics. When I was around ten years old he taught me how to use a light meter to measure luminosity and then calculate a photographic exposure based on film speed. He also constructed a small refracting telescope.
>
> He loved cats. From the time I was a little boy we always had one or two cats in the house. And on his desk at Hewlett Packard and Agilent he kept framed pictures of his cats along with his family. As an engineer he appreciated fine machinery. He admired fine automobiles, and especially liked Porsches and Ferraris. In the mid-

1970s he took all four of us sons to see the Can Am races at Laguna Seca Raceway in Monterey, California. It was a fun day for us and for him.

In spite of serious heart trouble, Len continued to work almost without interruption until his death. He passed away peacefully while doing something that gave him great joy—camping in the beautiful Santa Cruz Mountains with his extended family. At the time of his death Leonard S. Cutler was survived by his wife Dorothy; his sons Jeffrey, Gregory, Steven, and Scott; grandchildren Kim, Michelle, James, and Lindsay; and his sister Anita Roth.

GEORGE C. (CLEMENT) DACEY

1921–2010

Elected in 1973

"For pioneering experimental and theoretical field-effect transistor studies and directing important laser research."

BY C. PAUL ROBINSON

GEORGE CLEMENT DACEY was a pioneer who began his career at the start of the early nuclear and electronics efforts of the 1940s, as new discoveries in these fields began to transform the American science scene. After earning a bachelor of science degree from the University of Illinois in 1942, he worked at the Westinghouse Research Laboratories in support of the US military research and development efforts during World War II. After achieving some notable success in helping to develop a system for jamming German gun-laying radars, he was assigned by Westinghouse to join the work at the University of California Radiation Laboratory—within the Manhattan Project—that was to successfully produce the world's first atomic bombs/nuclear weapons, whose use in Japan brought an end to the war. Late in the project George moved on assignment to work at another highly classified site of the Manhattan Project at Oak Ridge, Tennessee. When the war ended, he pursued and earned a PhD in physics from the California Institute of Technology, in 1951.

Dacey stayed at Caltech for a year under an A.O. Smith postdoctoral fellowship. But after hearing a seminar at Caltech by William Shockley, the inventor of the transistor, he got sufficiently excited that he applied to and soon joined the efforts on solid-state transistors at the Bell Telephone Laboratories in

New Jersey. A highlight of his early work there was when he and a colleague, Ian Ross, invented and developed the first working field effect transistor device, which became the most popular solid state electronics device for many years thereafter.

George accumulated nine patents in related technologies and led a group at Bell Labs in developing new silicon transistor devices, becoming assistant director (1958) and then director of solid-state electronics research (1960–1961). He was then chosen by the Bell Labs leadership to go to Sandia National Laboratories in Albuquerque, New Mexico, as their vice president of research. At that time Sandia, operated by Bell Labs for the US Atomic Energy Commission, was responsible for the development, design, and engineering of all of the electronics and many other weapons systems—including arming, fusing, and firing components—as well as security protection and state-of-health systems for all US nuclear weapons. George proved himself to be a very capable and inspiring leader at Sandia to take on these sensitive and difficult responsibilities, and he built up the advanced research capabilities there, ensuring that the highly classified weapons systems utilized leading-edge technologies, including some of the most advanced mechanical and electrical devices anywhere.

George's success at Sandia led to his recall by the Bell leadership to Bell Labs, where he was promoted to executive director of the Telephones and Power Divisions (1963–1968) in Holmdel, New Jersey—the group responsible for the design of the actual telephone instruments used nationwide at that time. He next became a vice president of the Bell Telephone Laboratories, where he was responsible for the Telephones and Power Division for the next 13 years (1968–1981). From that post he took charge of the planning and systems analysis of the major expansion of the US telephone infrastructure (1981).

George's classified knowledge from his unique Sandia experiences served him exceptionally well, as he led several national studies on how best to deploy the systems, while ensuring the survival and continuing operations of the US communications infrastructure and systems under radiation effects from nuclear attacks, including electromagnetic pulse threats. These highly classified studies were among the most important studies of these phenomena and stood for many, many years as the pinnacle of design practice for ensuring continuity of US strategic communications systems.

In 1973 George Dacey received the singular honor of election to the National Academy of Engineering, where he joined both the Electronics, Communication, and Information Systems Engineering and the Industrial, Manufacturing, and Operational Systems Engineering sections. He subsequently served as a member of the Committee on the International Exchange and Movement of Engineers. He was also named a fellow of the Institute of Electrical and Electronics Engineers and of the American Physical Society, and inducted into several scholastic honorary societies: Eta Kappa Nu, Phi Kappa Phi, Sigma Xi, and Tau Beta Pi.

In August of 1981, Bell Labs selected George Dacey to become president of Sandia Corporation and director of the Sandia National Laboratories, where he served for six years. He immediately focused a major effort on developing advanced systems to protect the electronics of communications and military satellites against radiation effects from their continued passages through the Van Allen belts and to increase their survivability against other intense radiation attacks. He cross-pollinated the radiation effects research and development teams by exchanging personnel between Bell Labs and Sandia, which provided synergy, later thought to have been crucial, for raising both the capabilities and resiliency of both organizations for developing US electronics systems for many diverse applications. In those years, and since, it was clear that the US lead in research on radiation effects on advanced electronics technology systems was unsurpassed.

George brought a number of unique strengths to the management of Sandia, including his penchant for "big picture" thinking. He pushed Sandia to become a leader in planning future work efforts, promoting the greatest possible synergy among all the technologies and ensuring that future technical challenges got identified well before their solution became urgent. This emphasis on what we today call "strategic planning" grew to become a core competency at Sandia during George Dacey's tenure, and it remains a valuable asset for Sandia and the country. He also recognized the importance of raising the technology levels in every one of the mission elements of the labs, and he expanded the advanced scientific research, supporting technologies, and exploratory development efforts accordingly. During that period Sandia ramped up its "full solution" approach for engineering critical systems for the nation's defense needs and for civilian infrastructures.

George helped increase the emphasis on conventional weapons for the Department of Defense and military services, as well as advancing new energy technologies, as the Atomic Energy Commission evolved to become the US Department of Energy during George's tenure as Sandia's president. It was frequently recognized internally and externally that George had been truly placed "in the right place at the right time," and he knew how to advance a strategic advantage for maximum accomplishments and contributions.

In the latter years of his tenure at Sandia, George took note of the teaming with industrial suppliers that often accompanied the labs' request for new systems, such as advanced supercomputers or high-speed, radiation-resistant circuitry, and he began to try to build that approach as a normal part of the laboratory's role on behalf of the nation. He thus foresaw the possibilities for the multiprogram national laboratories for "bridging the gap" between knowledge-driven research at universities and commercial product development by industries. He began to stress the role of "demonstrating the feasibility of new products and developments" at the labs, which could then be shared with industrial entities, greatly lowering the risk, and lowering the costs for fielding working hardware systems. That germ of an idea has now grown to make Sandia the nation's top laboratory for industrial partnerships, advanced developments, and cooperative projects and programs.

After George retired in 1986 from his grand career(s), he was called on to serve on numerous corporate boards of directors, including Perkin-Elmer, W.R. Grace, and Milliken Industries, as well as on the United Way board and those of other charities.

From his birth in Chicago in 1921 to his retirement to Naples, Florida, in 1986 George Dacey lived an incredibly full and productive life. Throughout his life he did indeed exemplify the strategic intent that has long been the inspiration for all members of the Sandia National Laboratories: "to render exceptional service in the national interest." He died on November 27, 2010, survived by his wife, Anne Z. Dacey, and their two daughters, Donnie Hutcheson and Sarah Dacey Charles; their son, John C. Dacey, preceded his father in death.

George Dacey set an enviable record of advanced science and hard work, enormous patriotism, and senior leadership. He was a truly exceptional leader and manager of US advanced science and engineering.

His daughter Sarah wrote

> What you may not know about my father is that he had a love for the performing arts. He was an amateur actor for a short time while in graduate school at Caltech starring in "The Play's the Thing" at the Pasadena Playhouse. But it was his glorious tenor voice that I remember most growing up with him. He'd sit down at the baby grand piano in the living room and plunk through Nessun Dorma. Then he'd grab his Broadway songbook and call me over. "Come on, Sarah, let's sing through the duet in Porgy and Bess." I was 9 or 10 years old at the time. You could say my Dad was my first music teacher and I loved every minute of it. We would sing through everything from torchy love ballads to classical selections from Handel's Messiah. A young aspiring actress couldn't ask for a better education. Also, Dad used his voice to help pass the time on long car trips. During the 2-day journey to Hilton Head, Dad serenaded the whole family with story-song arias like "The Glory Road" or our favorite, "The Green-Eyed Dragon with the Thirteen Tails." But memories of Dad's singing were not always sublime. For instance, he would often jump up from the piano bench and storm into the

kitchen just as mother was making dinner, and blast out a high C. "Listen to this!" he'd chirp with delight. Whereupon we'd whine and cover our ears, "DAD! It's too loud!"

According to family lore, my grandfather, Clem Dacey, who was a famed professional singer in his day on the radio and in Vaudeville, urged my Dad to pursue singing professionally. My father, however, could not be persuaded from following his true passion, science. Father and son came to a compromise. My Dad could major in engineering as long as he also promised to take classes in opera at the university. He kept his promise and remained an ardent lover of the arts throughout his life. Ironically, it was his artistic gifts that were passed on to each of his children. His oldest daughter became an accomplished painter, his son a rock musician, and his youngest, myself, a professional actress in musical theater.

We will always remember my father for his brilliant scientific mind, passion for the arts, and resonant voice, which still rings in our hearts. I'll close with lyrics to a song that he learned from his father and then passed on to us. From "Wagon Wheels," we sing in remembrance:

Wagon wheels, wagon wheels,
Keep on a-turnin', wagon wheels.
Roll along, sing your song.
Carry me over the hill….
There's a pasture at the end of the road.
Wagon wheels, carry me home.

Ruth M Davis

RUTH M. DAVIS

1928–2012

Elected in 1976

"For contributions to computer science, particularly information science technology."

BY C.D. (DAN) MOTE JR.

RUTH M. DAVIS, a pioneer in satellites and computers and the founder of the Pymatuning Group, Inc., which specialized in industrial modernization strategies and corporate technology development, died on March 28, 2012, at the age of 83. She was born in Sharpsville, Pennsylvania, to W. George and Mary Anna Ackerman Davis. In 1961 she married George Lohr, who passed away in 1994.

Ruth Davis set her life's course as a determined and innovative technical person when she was in high school by displaying no interest in the clerical or teaching jobs that awaited most girls growing up in the 1940s. She earned her BA in mathematics at American University in 1950, and her MA in 1952 and PhD in 1955 in mathematics at the University of Maryland College Park, where she was the first woman to earn a doctorate in mathematics. During the summers she worked at the National Bureau of Standards (NBS, now the National Institute for Standards and Technology) in College Park as a computer and software pioneer. Some of her earliest work on computers and software is preserved in the Smithsonian Institution. When she completed her doctoral program, she, not surprisingly, approached IBM for a job in the computer business but the company had only secretarial positions open for women at the time.

The IBM rejection led her to a position with Navy Admiral Hyman Rickover, who was in search of computer people to help him create the nuclear navy. She ended up writing the first computer codes for nuclear reactor design. In 2004 Ruth noted: "I would like to say that it was hard, as a woman, to get hired, but he was eccentric enough that it wasn't." She also noted, "He gathered six of us [women] from around the country. He didn't care if you were yellow, purple, green, or had five arms." After writing the nuclear reactor design code, her next task was to establish the Navy's first Command and Control Technology Organization. So at age 27, Ruth Davis became technical director of the new program to design a system for managing naval operations worldwide.

Her position with Admiral Rickover accelerated her professional career in public service, where she was already a pacesetter. She held management positions at the National Bureau of Standards, the Department of Health, Education, and Welfare (HEW), and the National Library of Medicine. She was an assistant in Intelligence and Reconnaissance in the Department of the Navy. She directed the NBS Institute for Computer Sciences and Technology and was the first director of the HEW National Center for Biomedical Communication. She rose to become deputy undersecretary of defense for research and advance technology, managing $4 billion of R&D programs (1977–1979), and assistant secretary of energy for resource applications (1979–1981).

As deputy undersecretary of defense for research and advanced technology under Admiral Arleigh Burke, then chief of naval operations, she created some of the earliest computer software for defense and space applications. She reminisced with friends about her 1-cubic-foot desktop computer that preceded the PC by 15 years.

Over her public service career Ruth managed $4 billion production enterprises: the US Uranium Enrichment Services, the Strategic Petroleum Reserves, the Federal Power Marketing Administrations, and the Naval Petroleum Reserves.

Ruth Davis initiated major projects that had significant impact on the industrial, governmental, and academic sectors of our country. They included the Very-High-Speed Integrated Circuit (VHSIC) Program sponsored by industry and the Department of Defense (DOD; 1979–1980); the DOD Directed Energy Program (high-energy lasers and particle beams) (1977–1979); the world's first data encryption standard (DES) for nondefense computer systems (1972–1979); the first satellite communications system for remote healthcare applications in Alaska (1967–1970); the online computer network for medical literature retrieval, MEDLINE (1967–1970); and the first computer-based automation or robot-systems support by the federal government (1964–1967).

At one point during the HEW remote healthcare applications project in Alaska, Ruth and her staff were found on a rooftop with an antenna planted in a bucket of cement, looking for the right spot to capture the satellite signal connecting Aleut villagers with much-needed medical expertise at Midwestern universities.

Her telemedicine work led Ruth to concerns about personal privacy issues associated with the possible interception of a person's medical information. This motivated her to engage in data encryption. Not finding software for nonmilitary encryption at the National Security Agency, Ruth, as first director of the NBS National Institute for Computer Science and Technology, led a team to develop the public data encryption standard that remains in use today.

In 1980, at age 52, Ruth retired from the federal government and founded the Pymatuning Group, which she named after an Indian tribe in western Pennsylvania that, not surprisingly, was headed by a woman chief. This management company specialized in industrial modernization strategies and technology development, with concentrations in microelectronics, computers, information, automation, and robotics. She also taught as a part-time lecturer at the University of Maryland, American University, Harvard University, University of Pennsylvania, and University of Pittsburgh, and on one occasion was a Regents Professor at the University of California, Berkeley.

Ruth Davis chaired the board of trustees of the Aerospace Corporation from 1992 to 2000 and served on many corporate and university boards: Sprint; Air Products & Chemicals; BTG, Inc.; Ceridian Corp.; Consolidated Edison Co. of New York; Florida Rock Industries; Premark International Inc.; Principal Financial Group; Tupperware; Varian Associates; the Institute for Defense Analyses; University of Pennsylvania board of overseers for the School of Engineering and Applied Science; USC School of Business Administration; and the University of Maryland College of Computer, Mathematical, and Physical Sciences.

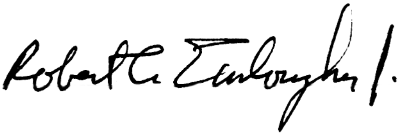
She was lauded by government, industry, and universities alike. In addition to the National Academy of Engineering, the National Academy of Public Administration and American Academy of Arts and Sciences elected Ruth to membership. She served on the NAE Council for six years and on many academy committees. She was named Computer Science Man of the Year in 1979 (the next year the award name was changed). She was selected for the Director's Choice Award of the National Women's Economic Alliance (1989), Distinguished Service Medals from the Department of Energy (1981) and Department of Defense (1979), the Department of Commerce Gold Medal (1972), the National Civil Service League Award (1976), the Federal Woman of the Year Award (1972), the Ada Augusta Lovelace Award for Computer Science (1984), and the Rockefeller Public Service Award for Professional Accomplishment and Leadership (1973). She was inducted into the Government Computer News Hall of Fame in 1988 and the University of Maryland Alumni Hall of Fame in 2000. *Washingtonian* magazine named her among the most powerful women in the nation's capital. She received honorary doctoral degrees from Carnegie Mellon University in 1979 and the University of Maryland in 1993.

Ruth's home in Silver Spring, Maryland, revealed her fun side. Sharing room space with floor-to-ceiling shelves of engineering and technology awards was her "critter collection," an extensive assortment of stuffed animals and dolls including two from her childhood. Her garage was home to two Porsche Carreras, a carryover from her practice of buying two new Porsches every three years—one for herself and one for her late husband George.

Ruth Davis never talked about being a woman working in a man's world. She always emphasized what you do and not who you are. In one interview she said, with a bit of marvel creeping into her voice, "You go to work in the morning, come home in the evening after you worked on something that had never been done before."

Ruth always strived for the best and would not be stopped. She never allowed anything to stand in the way of her talent and creativity. And she drove her Porsches, drove a US M-1 battle tank, and drank her bourbon with the same spirit: flat out.

Ruth Davis was generous, appreciative, and respectful of everyone who worked with her and for her. She infected all who knew her with her sense of purpose and fun. She was the "real deal" even after driving her Porsche into my garden after her 75th birthday party at the University of Maryland. Ruth leaves us with fond memories of an outstanding engineer and a great lady.



ROBERT C. EARLOUGHER JR.

1941–2011

Elected in 1996

"For contributions to pressure transient analysis of petroleum reservoirs and for technological management."

BY R. LYNDON ARSCOTT

ROBERT CHARLES ("BOB") EARLOUGHER JR. passed away on August 19, 2011, after a long struggle with Lewy body dementia. He wished to be remembered "as an engineer and scientist," and in 2009 he wrote "wherever you place my remains, my heart remains in the Colorado mountains."

After graduating from Central High School in Tulsa in 1959, he earned BS, MS, and PhD degrees in petroleum engineering from Stanford University. One of his former professors remembers Bob as "the top student by far in his petroleum engineering class. He intimidated the other students with his work ethic and intelligence."

In 1966, Bob joined Marathon Oil Company as a research engineer and went on to hold a series of research positions at Marathon's Petroleum Technology Center in Littleton, Colorado. In 1977 he was appointed manager of the Engineering Department. During his time in the Research Center, he established technical teams to transfer research products and technology to field application. In particular, he formed teams of engineers and technologists to conduct pressure and flow rate measurement tests, including multiwell tests, called interference tests, on a regular basis to improve field performance.

Bob was a recognized expert in well test analysis and authored many important papers on that subject and on reservoir simulation and enhanced oil recovery. In 1977 he authored an SPE monograph, *Advances in Well Test Analysis,* that has sold 40,000 copies and is still used as a textbook in several universities.

After his years at the Marathon Research Center, Bob held operating management positions in Casper, Wyoming, and Bridgeport, Illinois. In 1988 he became coordinating manager for production for Marathon Oil UK, and then manager of its Brae Projects (South Brae, North Brae, Central Brae, East Brae, and West Brae), and was based in London for nearly seven years. The Brae fields offered excellent opportunities for Bob's engineering talent. The East Brae field was the first offshore gas condensate field in the North Sea to be developed by gas cycling for pressure maintenance and improved recovery. The Central Brae project was Marathon's first subsea development.

After returning to Houston he was named vice president, international production, until his retirement in January 2000. During his time with Marathon he also completed a four-month MBA course at Harvard Business School.

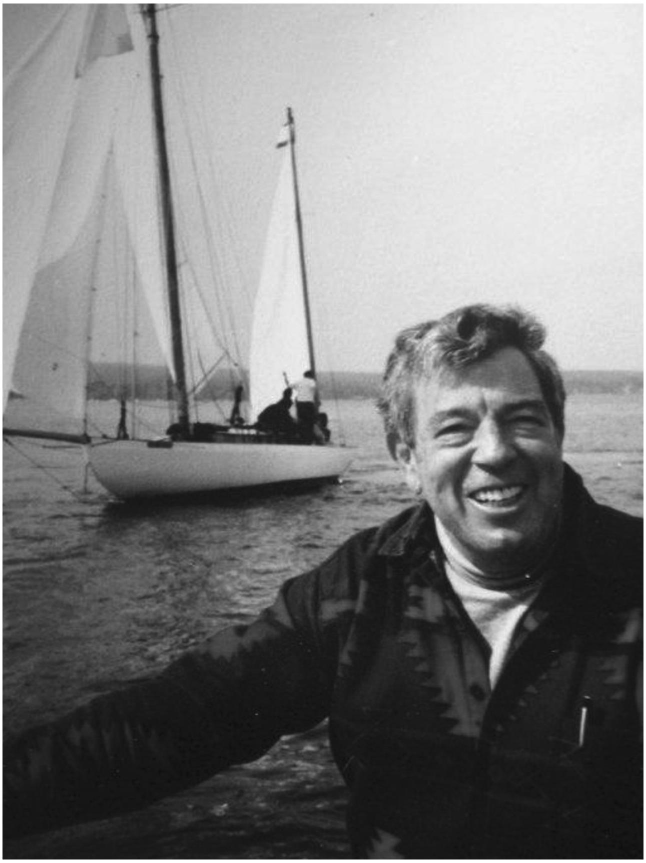
Bob was very active in the Society of Petroleum Engineers for more than 35 years. He served on or chaired many SPE national-level committees, and was a national director (1980–1983), distinguished lecturer (1985–1986), and an officer in the Denver and London SPE sections. He was a Registered Professional Engineer in Colorado, Texas, Oklahoma, and California. He authored 28 peer-reviewed publications and has three issued patents. He was the author of more than 30 technical talks and papers.

Bob was awarded the Lester C. Uren Award in 1979 for distinguished achievement in the technology of petroleum engineering and the John Franklin Carll Award in 1990 for distinguished contributions in the application of engineering principles for petroleum development and recovery. In 1996, he was elected to the National Academy of Engineering. In 1997, he was named an honorary member of the SPE, the highest honor SPE presents to an individual. He was a member of Sigma Xi, the Scientific Research Society of America, Tau Beta Pi, and Phi Beta Kappa. At the SPE Annual Technical Conference in New Orleans in 2009, he was recognized as a "Legend of Production and Operations."

Bob is survived by his wife of 41 years, Evelyn; daughter Katie Konold, her husband Eddie, and cherished granddaughter Charley Rose, of Boulder, Colorado; two sisters, Jan Hawkins and her husband Jim, of San Diego, California, and Anne O'Connell Malinowski and her husband Gene, of Morristown, New Jersey; several nieces and nephews; and five cousins.

Bob's main interest was anything associated with the Colorado mountains: downhill and cross-country skiing in winter and hiking and mountain climbing in the summer. By the mid-1970s he had scaled all of Colorado's 14,000-foot peaks, most of them more than once. Later on, he scaled many of these peaks with Katie. He continued to ski every year in Colorado until 2010.

He will be remembered by his colleagues and friends for his amazing intellect, his dedication to his profession, and his concern for others.



KENNETH McK. ELDRED

1929–2012

Elected in 1975

"For contributions in noise and vibration control of air, space, and transportation vehicles and in delineating acceptable noise environment for people."

BY ERIC W. WOOD AND GEORGE C. MALING JR.

KENNETH McKECHNIE ELDRED devoted his professional career to practical applications of a wide range of engineering noise and vibration control principles, helping to make both communities and industrialized portions of the world quieter. He received worldwide recognition for his contributions and was considered by many of his colleagues to be among the best practitioners in the nation. He was born on November 25, 1929, in Springfield, Massachusetts, to parents Robert Moseley and Jean Ashton Eldred. He married Barbara Fischer in 1957 and passed away on January 30, 2012, in his 83rd year.

Ken earned his SB (general engineering) degree with a combination of courses in naval architecture, marine transportation, and business administration from the Massachusetts Institute of Technology in 1950, where he also took graduate courses in acoustics. He supplemented his education with graduate courses in mathematics at University of California, Los Angeles.

Early in his professional career (1950–1954), he served as director of shipboard vibration, noise control for submarine machinery and propellers, and underwater sound activities at the Boston Naval Shipyard Sound and Vibration Laboratory. He also served as chief of the Physical Acoustics Section, Bioacoustics Branch, at the USAF Wright Air Development Center in Dayton, Ohio, where he worked closely with

Dr. Henning von Gierke from 1954 to 1957. At the Wright Air Development Center, he directed research in the evaluation and abatement of Air Force noise sources, including both rockets and jet aircraft. His technical projects addressed the design of fatigue-resistant structures for high-speed aircraft and aerospace vehicles considering realistic acoustic, fluctuating aerodynamic, engine vibration environments and their characteristics, including proof tests required to qualify structure and equipment. He studied how noise from aircraft propagates through the atmosphere and criteria for exposure of personnel to high-intensity jet aircraft noise. Here, with von Gierke, he developed the equal-energy hypothesis for assessing the effects of noise on people and the use of cumulative noise contours around airports. It was also here that he met his future wife Barbara, Henning von Gierke's wife's younger sister.

Ken served as vice president and consultant in acoustics and vibration while at the Western Electro-Acoustics Laboratory in Los Angeles from 1957 to 1963. The broad scope of his consulting activities included the vibration of complex vehicle structures, sonic fatigue, noise and vibration of aircraft and missiles, model-scale simulation studies, evaluation of noise and vibration in manufacturing facilities, environmental noise studies, and architectural acoustics.

In 1963 Ken was appointed director of research at Wyle Laboratories, El Segundo, California, in the newly formed research department with the directive to expand Wyle's testing facilities for the Air Force in view of the increasing technical requirements of the space program. First, at Huntsville, Alabama, he set up a staff to directly support NASA on the Apollo manned moon program, and later, at El Segundo, California, and in Washington, DC, he was responsible for drawing together a staff of talented engineers from the United States and other countries. The initial work involved predicting, and then testing in simulation at specially built test facilities, the noise and aerodynamic loading of space vehicles and the resultant vibration and stress. This work quickly expanded into other areas of acoustics, vibration, unsteady aerodynamics, fluid dynamics, and experimental stress analysis. During his time at Wyle, Ken was a mentor to many young engineers and scientists who went on to successful careers in noise, vibration, and environmental engineering.

In 1973 Ken joined the Cambridge, Massachusetts, office of Bolt Beranek and Newman (BBN), where he served as group vice president, principal consultant, and director of many outstanding professionals. They provided consulting services in environmental, transportation, and industrial acoustics; building vibrations; architectural acoustics; surface ship and submarine noise and vibration control; underwater sound; and signal processing, as well as a wide range of special national security projects for various federal government agencies. While at BBN, Ken also provided consulting services for clients that included airport operators and the EPA's Office of Noise Abatement and Control (ONAC). One of the highlights of EPA's noise program was the 1974 publication of *Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety*. The report, usually known as the *Levels Document* is probably the most widely distributed and used EPA report on the subject of noise. Ken Eldred was a principal author.

After leaving BBN in 1982, he formed Ken Eldred Engineering, located first in Concord, Massachusetts, and later in East Boothbay, Maine. For many years he continued providing important consulting services to airport and industrial clients. His papers at this time included "Airport Noise: Solving a World Class Problem" and "Sound Exposure without Decibels." In addition to directing staff at major consulting firms, he found time to conduct his own original work in the areas of aircraft noise, including sonic booms and acoustic testing in simulation of aeroacoustic and unsteady aerodynamic loading.

One particular interest was community response studies resulting from airport noise. Ken's understanding of the nature of "community response" to environmental noise was deeper and better developed than that of most other engineers in the field. In 1974, based on his decades of consulting and research in community noise response, he included the concept of "normalized" day-night level (DNL) in Appendix D of the EPA *Levels Document*. He believed that DNL should be tailored to individual communities, so he added adjustments to Table D7 of the *Levels Document* to account for factors such as "prior experience with the intruding noise," the presence of pure tones, and impulsive sounds. The "normalized" DNL was a single number that accounted for acoustic factors not represented by simple A-weighted measurements and for non-acoustic factors unique to a community, such as a shared belief that good faith efforts were being made to control the noise.

Normalized DNL saw little use for many years. In 2002 an updated version of it was included in International Standard ISO 1996 Part 1 and in American National Standard ANSI S12.9 Part 4 but remained little used. Recent research on community tolerance for transportation noise exposure has confirmed that Ken's understanding was correct. A single-valued variable—a "Community Tolerance Level" or CTL value, in modern terms—represents the sum of the nonacoustic influences on community annoyance. DNL and CTL together account for appreciably more variance in annoyance prevalence rates in communities than a simple, A-weighted measure of cumulative exposure. A CTL value, in units of DNL decibels, describes the amount by which a specific community departs from a hypothetical "average" community.

These latest research developments leave little doubt that the normalized DNL is a useful and important concept. Although it took decades to systematically confirm Ken's understanding of community noise, it is now clear that a form of normalized DNL is essential for assessing community response to noise. Without it, the term "community response" has little meaning and it is not possible to assess response to noise in an actual community, but only in some hypothetical average community. Ken was always ahead of the rest of his colleagues.

Ken was a founding member of the Institute of Noise Control Engineering of the USA, which he served as director, chair of the finance committee, and president. As chair of the finance committee he was responsible for turning around the INCE/USA financial situation of 1976 to make INCE/USA vigilant on cost control and income generation. For the first time the Institute was operating in the black, and his insight into investment strategies in the early 1980s helped it continue to serve the noise control engineering community for many years. He maintained his membership and affiliation with INCE/USA for 40 years.

At the INCE/USA-sponsored INTER-NOISE 72 Congress, Ken made a seminal contribution to the passage of the Noise Control Act of 1972, an act that guided American noise policy for nearly a decade. Leo Beranek has told the story in more detail; but, in summary, Ken served on the Supersonic Aircraft Neighborhood Noise Committee for the US Department of Transportation (DOT), which reported to William M. Magruder, director of DOT's Supersonic Aircraft Division. Magruder later became a special assistant to President Richard Nixon and was invited to be the keynote speaker at the INTER-NOISE 72 opening luncheon on October 4, 1972. He accepted, and his announced topic was "Technology, National Goals, and the Administration's Noise Program." Ken and others met with Magruder just before the luncheon and, after a telephone call by Magruder to the White House, were assured that President Nixon would sign a bill if passed by the Congress. The announcement was made at the luncheon and, after negotiations too numerous to mention, the Noise Control Act was passed by both houses of Congress on the last day of the 92nd Congress.

Ken made significant contributions to the world of standards as related to the noise control engineering profession. Standards development in the Acoustical Society of America (ASA) began in 1930, and Ken was involved in standards for more than half of the years since, taking his first leadership position in 1968 as chair of S1/WG 45 Sound Level Meters and Their Calibration. Few persons did as much as Ken for standards and ASA's role therein. He quickly got to the heart of a problem and was a great strategic and tactical thinker. For example, in 1977 he organized and chaired a special standards meeting, in cooperation with the EPA, in Deerfield Beach, Florida, with the purpose of establishing what is now the S-12 Committee on Noise. The meeting also produced an ASA report on environmental acoustics. The purpose of the new committee was to deal with noise measurements, including environmental, occupational, and other special purpose noise measurements. Ken had many roles in the program and its international component, which remain important in the ASA standards to this day.

He served as ASA standards director from 1987 to 1993, chair of S12 from 1984 to 1987, and chair of ISO/TC 108 from 1994 to 1998. In addition, he chaired S1/WG 74 Guidelines for Standard Procedures for Measurement of Sound Source Emission (Joint with S3) through the mid-1970s; S1/WG 45 Sound Level Meters and their Calibration (1968–1984); S2/WG 83 Acoustic Vibration Testing (1983–1986); the ANSI Acoustical Standards Management Board and Standards Planning Panel, both in the mid-1970s; and the ANSI Panel on Noise Abatement and Control (1976), which was set up to meet the EPA's needs. He was also an individual member of S1 and S2.

Ken was a member of the DOT SST Advisory Panel for Noise, a consultant for the President's Aviation Advisory Commission, and principal consultant to the State of California Department of Aeronautics for the development of the first comprehensive regulations for airport noise. He was a registered professional engineer in the states of California and Alabama; a member of the National Academy of Engineering, to which he was elected in 1975; a fellow of the Institute of Noise Control Engineering; a director of the INCE Foundation; and a fellow of the Acoustical Society of America. In 1994 he received the Silver Medal in Noise from the ASA "for contributions to noise control and environmental acoustics, and for leadership in the development of standards."

Sailing was a passion for Ken since age 4, when he built his first boat from cereal boxes. At age 12, he built and sailed on the Niagara River a 12-foot gaff-rigged sloop. While at MIT he was co-skipper of a sailing team. He taught classes in sailing, raced Thistles on the East and West Coasts, and built his own

International 14 and raced it in California, winning many trophies including West Coast Champion (Thistle Class) in 1959. He bought his beloved 44-foot sailing sloop, Ammersee, in 1985 and, when he moved to Maine in 1992, had only one stipulation—that his home be on the coast where he could always see his boat. He loved cruising the Maine coast and faraway places such as the Windward and Leeward Islands in the Caribbean, Cuba, and the western Caribbean. He also enjoyed racing out of the Boothbay Harbor Yacht Club.

Ken is survived by his wife, Barbara, his daughter, Heidi McKechnie, and his granddaughters, Ceysa and Tess McKechnie. His family and friends wish him smooth sailing, fair winds, and love. Shared below is a poem offered by his family.

I am standing upon the seashore.
A ship at my side spreads his white sails
To the morning breeze and starts for the blue ocean.

He is an object of beauty and strength
I stand and watch him until at length
He hangs like a speck of white cloud
Just where the sea and sky come to mingle
With each other.

Then someone at my side says, "There, he is gone!"

"Gone where?"
Gone from my sight. That is all.
He is just as large in mast and hull and spar
As he was when he left my side
And he is just as able to bear his load of living freight
To his destined port. His diminished size is in me, not in him.

And just at the moment when someone at my side says,

"There, he is gone!"
There are other eyes watching him coming
And other voices ready to take up the glad shout,
"Here he comes!"

– adapted from Henry Van Dyke, a 19th century clergyman

The authors thank Paul Schomer and Richard Potter for their assistance with this tribute.

RICHARD G. FARMER

1928–2012

Elected in 2006

"For the solution of problems in the dynamic operation of electric power systems, including subsynchronous resonance and system stabilization."

BY VIJAY VITTAL AND GERALD T. HEYDT

RICHARD G. (DICK) FARMER died peacefully at his home in Phoenix, Arizona, on March 26, 2012, after a courageous battle with cancer.

He was born November 5, 1928, in Laramie, Wyoming. He graduated from Eaton (CO) High School in 1946 and immediately joined the United States Navy. His math aptitude was fostered in Fire Control School after boot camp. It was this naval training that headed Richard toward electrical engineering. After discharge he attended Colorado State University, Fort Collins, earning his degree in electrical engineering in 1952 and later his master's degree from Arizona State University (ASU) in 1964.

Richard's work experience spanned the globe. His first job was in the Digital Computer Laboratory at the Massachusetts Institute of Technology. Then in 1957, while employed by Miner and Miner of Greeley, Colorado, he moved his family to Beirut, Lebanon, where he worked on rural electrification in that country.

In 1965 he began work at Arizona Public Service Company (APS) in Phoenix, where he became the principal engineer until his retirement in 1994. While working at APS, he was asked by ASU to teach an evening class in electric power engineering. After retirement from APS, he increased his class load at ASU, where he attained full professorship and worked until his final day.

Dick brought real engineering cases to his ASU teaching. He loved to tell students the story of the Mohave Generating Station, which had a catastrophic generator shaft failure, due to subsynchronous resonance—twice. It was not unusual for students to be in Dick's office at all hours to seek practical advice on a homework assignment, a thesis, or a job offer. Perhaps the most touching note attesting to his devotion to his students accompanied a bouquet of flowers that appeared anonymously at his office upon his death: "Thank you, Professor Farmer, for showing me what kind of man I really want to be."

The two incidents of shaft failure at the Mohave Generating Station in the early 1970s alerted the electric utility industry to a technical problem with far-reaching economic consequences. The total cost of the two outages was estimated at about $66 million. Through his individual technical expertise and his leadership in the IEEE Power Engineering Society Working Group on Subsynchronous Oscillations, Richard Farmer developed and implemented innovative, state-of-the-art techniques that provided (a) a means of understanding the origin of the problem, (b) measurement approaches and monitoring equipment, and (c) guidelines for subsynchronous resonance (SSR) countermeasures. As a testimony to the effectiveness of the solutions developed, it is important to note that an event of such magnitude has not occurred since.

This seminal work on SSR mitigation provided a new lease on life for series-compensated transmission lines. Due to the geographical expanse of the Western United States and the long distances between generating units and load centers, it is imperative to use series compensation on these lines for enhanced performance and efficiency. However, the threat of SSR-related equipment failure would have been a serious limiting factor to the level to which these lines could be compensated. The techniques developed by Mr. Farmer and the group under his leadership provided efficient approaches to increase series compensation and mitigate the possibility of SSR. This has significantly enhanced the transmission capability of the lines and their efficiency in transporting bulk power to energy-hungry urban areas.

The Western system, with its long lines and heavy power transfers, is also susceptible to low-frequency interarea oscillations. The work done by Mr. Farmer in the area of power system stabilizer tuning has had a significant impact on the mitigation of the low-frequency oscillations problem in the Western United States. As a planning engineer for APS, he developed innovative techniques for the tuning of power system stabilizers that have become industry standards. He was also the principal architect of the first automatic islanding scheme in the Western Interconnection.

Richard was elected to the National Academy of Engineering (NAE) in 2006. In 2007 he was awarded the IEEE Power and Energy Society's Charles Concordia Award and in 2010 IEEE named him Outstanding Power Engineering Educator. He was also the author or coauthor of multiple power system engineering books and publications and a speaker at power system conferences. Through his work, he inspired and educated many students and colleagues with his rich knowledge and willingness to share his expertise.

Perhaps Dick's most important accomplishment was his family. He married Jo-Anne Overman in 1949 and together they raised four children. He was the tutor, the Little League and Pop Warner coach, the biggest fan, and the rock of the family. Jo-Anne passed away in 1995. Dick was blessed with additional love in his life. He married Gloria Sue Roberts on June 9, 2009. Dick and Sue could be seen dancing two or three nights a week at the Scottsdale American Legion up until the final month of his life. Dick lived a full, rich, and happy life to the end.

Richard was preceded in death by his first wife, Jo-Anne, his parents, William Farmer and Mary Roy, and his stepfather, Jack Roy. He is survived by his wife Gloria Sue Farmer; his children Kristine Farmer (partner Carole Dietzel) of Phoenix, Gregg Farmer (Valerie) of Estes Park, Colorado, and John and Lee Farmer, both of Phoenix; and his grandchildren Taylor Farmer, Mikayla Farmer, Marcella Farmer, Meredith Donner, Ann Lambiase-Mitchell, and Virginia Lambiase-Mitchell.

JOHN DOUGLASS FERRY

1912–2002

Elected in 1992

"For developing experimental and a conceptual framework for modern viscoelasticity of polymers."

BY R. BYRON BIRD AND A. JEFFREY GIACOMIN

JOHN DOUGLASS FERRY, professor in the Department of Chemistry at the University of Wisconsin-Madison from 1946 until his retirement in 1982, was both a world–renowned rheologist and a highly respected chemist who made important contributions to physical chemistry, biological chemistry, and bioengineering. He was born May 4, 1912, in Dawson, Yukon, Canada, to US citizens. His father, Douglass Ferry, worked at the time as a civil engineer for the Yukon Gold Company. His mother, Eudora Bundy Ferry, a former schoolteacher, wrote a book describing their life in the mining community, *Yukon Gold: Pioneering Days in the Canadian North.*

John Ferry's childhood was spent in small mining towns in Idaho, Washington, and Oregon. In 1932, at age 19, he graduated with an AB from Stanford University, his parents' alma mater, with a straight A record, the first in the history of the institution. After two years of graduate study and research on ultrafiltration of proteins in London at the National Institute for Medical Research, he returned to Stanford to complete his PhD in 1935 in chemistry.

John then worked with D. Spence, a rubber chemist, on vulcanization accelerators. For the next ten years he held a series of positions at Harvard University and nearby: instructor in biochemical sciences; member of the Society of

Fellows; research associate in the Harvard Medical School; researcher at the Woods Hole Oceanographic Institution (developing antifouling paints for the US Navy during World War II); and member of the E.J. Cohn group, working on large-scale fractionation of human blood plasma to obtain serum albumin and other plasma proteins for clinical use by the US Armed Forces. This latter work began a career-long interest in fibrinogen and fibrin as well as the general problem of blood coagulation. With colleague Peter Morrison he developed several new products, including a fibrin film that was the first safe and effective surgical replacement for the dural membrane, thereby facilitating brain surgery.

After this decade of involvement in diverse research topics in several fields, John accepted a position in the Department of Chemistry at the University of Wisconsin–Madison in 1946, where he decided to focus on the rheology of polymeric fluids and the relation of these properties to molecular structure and molecular motion. Together with his graduate students T.L. Smith, R.S. Marvin, J.N. Ashworth, W.M. Sawyer Jr., E.R. Fitzgerald, D.J. Plazek, M.H. Birnboim, and others, John was the first to develop sophisticated equipment to measure the real and imaginary components of complex viscosity, $\eta^* = \eta' - i\eta''$, from oscillatory experiments. He and his PhD student Thor Smith may well have been the first to measure both components.

John's well-defined experimental program produced data on a wide variety of polymeric materials, illuminating many aspects of the physics of these materials. His results were written up in his groundbreaking monograph *Viscoelastic Properties of Polymers*, 1st edition (1961), 2nd edition (1970), 3rd edition (1980), published by John Wiley & Sons. In each succeeding edition, he added material reflecting the accomplishments of the rheological community during the preceding decade.

John Ferry's work on the temperature dependence of viscoelastic properties, and specifically his discovery of the shift factor $a_{T,}$ had an enormous impact on polymer engineering. The famous Williams-Landel-Ferry (WLF) equation, $\log_{10} a_T = -17.44\left(T - T_g\right)/\left(51.6^{\circ}K + T - T_g\right)$, where T_g is the glass transition temperature, allowed engineers to extrapolate rheological properties over a wide range of temperatures [M.L. Williams, R.F. Landel, and J.D. Ferry, *J. Amer. Chem. Soc.* 77:3701-3707 (1955)]. This eliminated the need for tedious rheological measurements at many temperatures.

Ferry's team perfected the measurement of complex viscosity, and this work spawned an industry of commercial rheometers for doing the same. But the eventual impact of Ferry's rheometry on polymer engineering awaited the fortuitous development of the Cox-Merz rule (1958). This rule, that the magnitude of the complex viscosity versus angular frequency matches the steady shear viscosity versus shear rate, $|\eta^*(\omega)| = \eta(\dot{\gamma})|_{\dot{\gamma}=\omega}$, suddenly made complex viscosity indispensable for the design of polymer processing operations, which depend on $\eta(\dot{\gamma})$. Whereas $\eta^*(\omega)$ was easily measured, $\eta(\dot{\gamma})$ required (and still does) an undue amount of experimentation.

By publishing accurate and precise measurements of complex viscosity, Ferry's team enabled and motivated others to relate rheological properties to the molecular structure of polymers. Ferry's measurements, for example, inspired Prince E. Rouse in 1953 to use a freely jointed chain of beads and Hookean springs to model polymers in dilute solution. Rouse's work was the springboard for further structure-property developments that continue to this day, enabling polymer engineers to adjust their polymer manufacturing operations by changing the polymer's molecular structure.

Because of his organizational skills and his straightforward manner, John was elected by his colleagues to chair the University of Wisconsin Department of Chemistry from 1959 to 1967. In 1968, he was a founding member of the University's Rheology Research Center, in which he played an active role well beyond his retirement. In addition, he was president of the Society of Rheology (1961–1963), and in 1961 hosted the Society for its annual meeting. He also chaired the National Research Council Committee on Macromolecular Chemistry from 1958 to 1962, served on the Visiting Commitee for the Department of Chemistry at Harvard University from 1975 to

1981, and was joint editor of *Advances in Polymer Science* from 1958 to 1986.

In addition, John held visiting appointments at institutions in Brussels, London, Grenoble, Strasbourg, and Kyoto. His sojourns in France, Belgium, and Japan were opportunities for him to further his hobby of foreign language study, a pastime that engaged him since his youth. As a boy, he had taught himself enough Latin and German to go directly into advanced classes.

His scientific contributions were recognized by many awards, including five from the American Chemical Society: the Eli Lilly Award in Biological Chemistry, the Kendall Award in Colloid Chemistry, the Witco Award in Polymer Chemistry, the Charles Goodyear Medal, and the Division of Polymer Chemistry Award. He also received the Bingham Medal of the Society of Rheology (for his contributions to knowledge of the rheology of polymeric systems, particularly in the field of periodic stresses), the Colwyn Medal of the Institution of the Rubber Industry (UK), and the Technical Award of the International Institute of Synthetic Rubber Producers. In addition, he was named an honorary member of the Groupe Français de Rhéologie and the Japanese Society of Rheology. His research accomplishments were recognized by his election to the National Academy of Sciences, the American Academy of Arts and Sciences, and the National Academy of Engineering (the latter in 1992).

John passed away on October 18, 2002, in Madison after an extremely productive career and a life of professional leadership and teaching. In addition to his treatise on viscoelasticity, he was author or coauthor of more than 350 research publications, about 30 percent of them on fibrinogen and fibrin. He supervised more than 60 PhD and MS students and about 30 postdoctoral fellows, many from foreign countries. It is fitting that we close with a quote from the memorial resolution prepared by his colleagues at the University of Wisconsin, who knew him well and appreciated his personal qualities:

John Ferry was equally well known and appreciated for attributes other than his scientific abilities and contributions. He was a true gentleman, a dedicated teacher, and mentor who always had a genuine and abiding interest in and concern for all of his former students and collaborators. His gentle, patient, and quiet personality had an effect on all who were privileged to know and work with him. His reputation for absolute integrity and his uncanny ability to emphasize and encourage the best in others are attributes to which we all should aspire. Former students and colleagues have many fond memories of times spent at the Ferry home with John and his charming and vivacious wife, Barbara [Norton Mott], a former chemist [Radcliffe 1942] turned artist.

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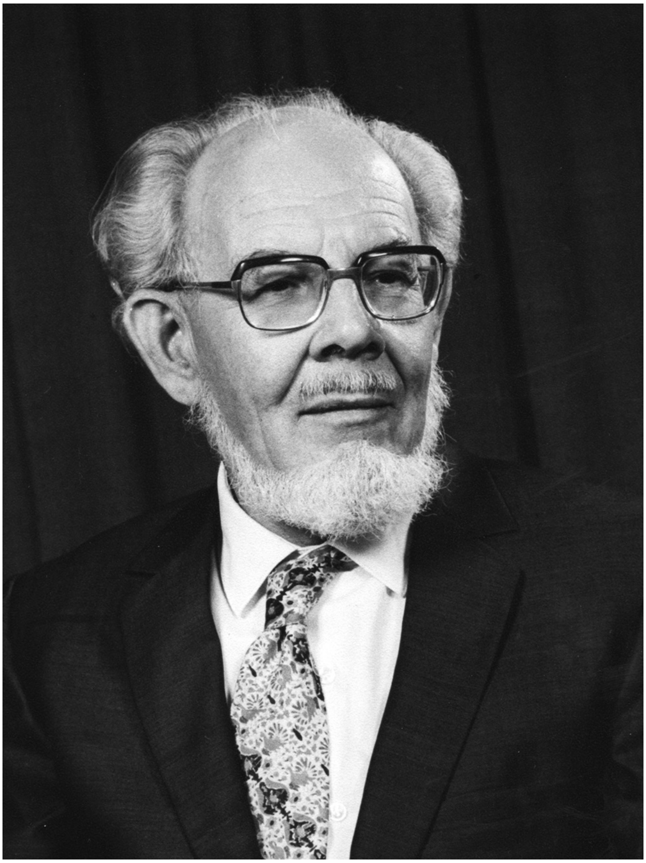

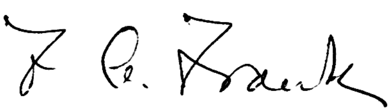

SIR CHARLES FRANK

1911–1998

Elected in 1980

"For providing fundamental understanding of the behaviour of dislocations in solids."

BY R.G. CHAMBERS
SUBMITTED BY THE NAE HOME SECRETARY

FREDERICK CHARLES FRANK, scientist, was born on March 6, 1911, in Durban, South Africa, the eldest of three sons of Frederick Frank (1877–1970), farmer, and his wife Medora Celia Emma (1876–1966), daughter of Charles Read of Brundish Hall, Suffolk, and his wife Emma. Frederick Frank's father, Charles Henry Frank of Poslingford, was a Suffolk farmer, like Medora's father, but an impoverished one, and a number of his 17 children emigrated to Canada or South Africa in search of a better life. Frederick himself became a merchant seaman and sailed more than once around the Horn before enlisting in the Third South African Light Horse (Kitchener's Horse) during the Boer War. After the war, he joined two of his older brothers in a business in Durban, and in 1910 he married Medora, who had nursed him in hospital 10 years earlier. In 1911, when their son Frederick Charles was only ten weeks old, the family moved back to England, eventually settling at Abbot's Farm, Denham Abbots, Suffolk, where Charles Frank (he never used the forename Frederick) spent his childhood.

His early schooling, till the age of 9, was at a tiny village school near Denham Abbots, run by a Mrs. Petley. He then went as a boarder first to Thetford Grammar School from 1920 to 1926, and then, after the family had moved from Denham Abbots to Cavendish, to Ipswich School from 1927 to

1929. There he took part in school plays—in the part of Mrs. Hardcastle he is said to have fondled, scolded, and complained in turn with equal skill and energy—and school debates, in one of which he eloquently opposed a motion, proposed by his younger brother John, that scientists should be kept in their place. There, too, he learnt chemistry and gained an open scholarship to Lincoln College, Oxford, and a state scholarship.

At Oxford, he coxed, rowed, punted, and pursued the study of chemistry, gaining a First in 1933. He then became nominally an engineer, earning a D. Phil. in 1937 for work on dielectrics carried out in the Oxford Engineering Laboratory. Part of his later strength as a theoretical physicist lay in the breadth of his background: from 1936 to 1940, he worked successively as a physicist with Debye in Berlin, as a colloid chemist with Rideal in Cambridge, and (in the early days of the war) as a chemist at Porton, before finding his wartime métier with R.V. Jones in Air Ministry Intelligence. He had met Jones at Oxford, and they became lifelong friends. The story of their wartime collaboration is well told in Jones's book *Most Secret War*, which includes several stories of the inspired common sense with which Charles Frank managed to interpret the confused scraps of information coming from occupied Europe, and the extraordinary observational powers that enabled him to detect enemy radar stations from the tiny blurred images on aerial reconnaissance photographs and led to the successful Bruneval raid in 1942. For this work he was appointed OBE in 1946.

In the same year he came to the Physics Department in the University of Bristol, where he worked until (and long past) his retirement in 1976, becoming a professor in 1954 and head of department in 1969. With publications spanning 60 years, he was remarkable for the sheer breadth of his contributions to science. His main work was in dislocation theory, but he also made major contributions to our understanding of cold fusion, liquid crystals, alloy structures, polymers, earthquakes, and continental drift.

Soon after Frank's arrival in Bristol, Cecil Powell and his group there discovered the pi-meson, and this led Frank to look for other possible explanations of what Powell had found, and to his brilliant realization that a mu-meson might catalyze nuclear fusion by enabling two nuclei to approach very close to each other. (A year or so later, Sakharov made the same suggestion independently.) Fifty years later, muon-induced fusion remained an active field of study, and Frank's original paper continued to be widely quoted.

But this was by way of a digression for Frank: his main field of work for many years was the study of dislocations, imperfections in crystal structure that profoundly influence the mechanical strength of metals and other materials, and that are therefore of great technological importance. His contributions were manifold and of fundamental significance: they included the laws governing dislocation branching, the existence and properties of dislocation networks, and the Frank-Read mechanism for the generation of dislocations. The idea for this mechanism came simultaneously and independently in 1950 to Frank and to Thornton Read, working at Bell Laboratories in the United States, and they published it jointly.

A year earlier, Frank had shown that accepted theories failed by an enormous factor to account for the observed growth rates of crystals, but that these could readily be explained if the growth face contained a screw dislocation and that this mechanism would produce "growth spirals" on the growth face. This theory was dramatically confirmed when he presented it at a conference: a member of the audience rose to say that he had recently observed just such spiral features and produced photographs of them illustrating exactly what Frank had predicted.

One can illustrate the diversity of other fields in which Charles Frank made significant contributions by choosing (almost at random) three characteristically short and incisive papers: one on asymmetry in nature (1953), which anticipated population dynamics studies; one on liquid crystals (1958), which stimulated a vast amount of subsequent work on these materials; and one on island arcs (1968), the curved chains of islands that occur particularly in the Pacific. The latter drew a delightful analogy between the earth's crust and a ping-pong ball: if one pushes one point on a ping-pong ball inward, it will form a saucer-shaped dimple with a sharp rim, and Frank showed that island arcs are probably formed by a similar deformation of the earth's crust.

In his retirement, he continued to publish until well into his eighties. In particular, he undertook the substantial task of editing the Farm Hall transcripts: the secretly made recordings of the conversations of a group of eminent German physicists who were detained at Farm Hall in Cambridgeshire between June and December 1945, including their reactions to the dropping of the first atomic bombs. He had himself visited and talked with them in November 1945; now, almost 50 years later, he was able to correct errors in the transcripts and to elucidate their contents, which make a fascinating story.

In his later years he became increasingly infirm physically, though his clarity of mind and his phenomenal memory remained practically unimpaired, and he bore his infirmities with stoic patience. A few hours before he died, on April 5, 1998 (at Southmead Hospital, Bristol, of internal bleeding), he was busy reading and vigorously discussing with his friends a new book on geophysics.

Charles Frank was one of the outstanding physicists of his generation. In all his work, he showed deep physical insight, an easy mastery of the relevant mathematics, great originality, and an incisive clarity of presentation. For his many scientific achievements, he was elected a fellow of the Royal Society (FRS) in 1954, and was awarded the Copley Medal, the Royal Society's highest honor, in 1994. He served as a vice president of the Society from 1967 to 1969, and was knighted in 1977. His many other academic honors included seven honorary degrees. For more than 60 years, he contributed profoundly to our understanding of nature, not only through his own 200 publications but also through endless conversations with all the colleagues who came to seek his help and advice in understanding their work.

But his interests were not confined to science: they included languages and etymology, the history of science, and the theater, music, and art. He also served for many years as a governor of two of Bristol's schools, Queen Elizabeth's Hospital and Badminton School.

Of middle height, with an impressive head, he was gruff but even-tempered, warmhearted but unsentimental, and habitually rigorous in his thinking, and he could be counted on to express lively, stimulating, and well-argued views not only on scientific matters but on almost any issue worthy of debate. So too, on nonscientific matters, could his wife. In December 1939, he had met Maita Asché (1918–2009), the lively and delightful daughter of a professor of engineering in St. Petersburg. Her family was Finnish and she was born in Finland, but through the accidents of revolution and civil war she had been brought up in Czechoslovakia. She was staying in Cambridge with Walter Adams, the secretary and later director of LSE, when Charles Frank met her. They married in April 1940. They were a splendidly matched couple and together contributed greatly to the social life of both the university and the city of Bristol.

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Maurice C. Fuerstenau

MAURICE CLARK FUERSTENAU

1933–2012

Elected in 1991

"For outstanding contributions to mineral processing, hydrometallurgy, and engineering education."

BY KENNETH N. HAN, ROE-HOAN YOON, AND FRANK F. APLAN

DR. MAURICE C. FUERSTENAU died on October 7, 2012. At the time of his death he was emeritus professor of metallurgy in the Department of Mining and Metallurgical Engineering at the University of Nevada, Reno. Right up to the onset of his final illness, he remained active in both teaching and research.

Maurice Fuerstenau was born on June 6, 1933, in Watertown, South Dakota, to Erwin and Hazel Karterud Fuerstenau. At the time of his birth, Maurie's parents were farming, but they left a year later, victims of the Dust Bowl, moving to the Lemmon area and then to Mobridge where Maurie started grade school. In 1943, his parents moved to Rapid City, South Dakota, where he completed grade school and high school. After graduating from Rapid City High School in 1951, he entered the South Dakota School of Mines and Technology and graduated with a bachelor of science degree in geological engineering in 1955. He then enrolled as a graduate student at the Massachusetts Institute of Technology where he was awarded the degrees of master of science (1957) and doctor of science in metallurgy (1961). His thesis supervisor at MIT was Professor A.M. Gaudin (NAE, Founding Member). In 1953, he married Joyce Helen Snyder.

Having participated in the ROTC program as an undergraduate, late in his graduate studies he was called to active duty where he spent six months as an engineering officer at the Aberdeen Proving Ground. After graduating from MIT, Dr. Fuerstenau worked as a research engineer for the Beryllium Corporation in Reading, Pennsylvania, and later for the New Mexico Bureau of Mines in Socorro where he conducted detailed research on the flotation of beryl, the main source for beryllium. This sparked his long-time interest in the role of metal ion hydrolysis in flotation. In 1963, he decided to pursue an academic career and went on to teach on the faculties of the Colorado School of Mines, the University of Utah, the South Dakota School of Mines and Technology, and the University of Nevada, Reno. He was the consummate educator, championing excellence in teaching, counseling students, guiding research, and in professional and public service. He inspired countless students to achieve excellence in themselves and their careers. Former students, protégés, and business associates describe Dr. Fuerstenau as an exceptional teacher, a sensitive counselor, and an internationally renowned scholar. His contributions in the field of mineral processing and extractive metallurgy over his long and productive career have been recognized worldwide.

His first academic position was as assistant professor of metallurgical engineering at the Colorado School of Mines. He taught undergraduate and graduate courses in mineral processing and extractive metallurgy and initiated a very active graduate program. During his tenure at the Colorado School of Mines, he turned out more PhDs in mineral processing than had been produced in this area at the school prior to his arrival.

When he joined the University of Utah in 1968, the Department of Metallurgy and Metallurgical Engineering had great strength in hydrometallurgy but essentially none in mineral processing. Dr. Fuerstenau was able to bring one of his recent PhD graduates from the Colorado School of Mines to Utah as an assistant professor, and they organized and developed a very strong program that is still one of the premier programs in mineral processing/extractive metallurgy in the country. He came to Utah as associate professor but after one year was promoted to professor of metallurgical engineering.

Upon being invited to be the head of the Department of Metallurgical Engineering at the South Dakota School of Mines and Technology, Dr. Fuerstenau returned to South Dakota in 1970 and served there with distinction for 18 years, as professor and head of the Department of Metallurgical Engineering for 17 years and, in the last year, as Interim Vice President for Academic Affairs. Under his leadership, several new faculty were brought in and the Department of Metallurgical Engineering was transformed into a world-class undergraduate program. He also made very important contributions to the school's infrastructure. His dedication to teaching and research was recognized with his selection as the first recipient of the Presidential Award (Outstanding Professor) of the School of Mines in 1979 and Distinguished Professor of Metallurgical Engineering in 1985. He was also honored by the school with the prestigious Guy March Silver Medal (1998) and the Distinguished Alumni Award (2004).

Maurie concluded that his year as interim vice president was too stressful and when an opportunity arose at the University of Nevada, Reno in 1988, he accepted it and joined the faculty there as Echo Bay Mines Distinguished Professor. He taught undergraduate and graduate courses in mineral processing and extractive metallurgy and continued an active research program right up to the time of his death. In the very week before he entered the hospital, he had recorded the first two lectures of his fall course that was to be available online. He served the university in many administrative and advisory capacities. His excellence as an administrator was known, and he was asked to serve as acting chair of departments (Mining Engineering and also Mechanical Engineering) in two different colleges. He was named a University of Nevada Foundation Professor in 1996 and recipient of a Senior Scholar Mentor Award in 2002.

Dr. Fuerstenau was an excellent teacher and he loved to teach, particularly classes for undergraduate students. He was enthusiastic about the opportunities in a metallurgical engineering career, and was an avid recruiter of freshmen metallurgical engineering students. He was known for his dedication to the welfare of his students. He was very proud of the large number of undergraduates and graduate students who studied under his direction—more than 80 master's degrees and doctorates during his 50 years in academia. A major fraction of his former students have had outstanding and exceptionally productive careers. A number of them selected academic careers and have themselves produced more than 100 MS and PhD graduates. Some of his former students became presidents of companies, and one the president of a major university in Nigeria. Maurie was a truly dedicated teacher in the broadest sense, one who inspired countless young extractive metallurgists and mineral processing engineers in their earliest careers, mentoring not only his own former students but other young engineers in industry. His impact in teaching was recognized nationally by the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) in 1989 when he was named the recipient of the AIME Mineral Industry Education Award.

On several occasions Dr. Fuerstenau was invited to present short courses or to participate in special conferences around the world. On five or six occasions he was invited as the principal instructor or lecturer at various places in Mexico. The first was quite momentous in that after his presenting a series of lectures in Mexico City, two outstanding students chose to come to South Dakota where they earned their MS degrees and then continued their graduate education in Berkeley for their PhD degrees. Both returned to Mexico where they have had distinguished careers as university professors in metallurgical engineering. In 1978, he and his brother, Professor Douglas W. Fuerstenau (NAE 1976) of the University of California, were invited to give a special one-week winter course at the South African Institute of Mining and Metallurgy on the principles of flotation. This course resulted in a monograph *Principles of Flotation*, edited by Professor R.P. King (NAE 2003), then of the University of Witwatersrand. Of the thirteen chapters in the book, nine were written by the Fuerstenau brothers.

In 1981, Maurie was invited to China where he presented a series of seminars on his flotation research at six universities and institutes in various regions of the country, this still being quite early in the opening of China to foreign visitors.

He was known internationally for his research accomplishments in the areas of froth flotation, hydrometallurgical processing, and environmental remediation. Many classic papers resulted from these investigations. Of particular note are the large numbers of seminal papers that helped unravel the complex surface chemistry and solution chemistry involved in the selective flotation of a wide range of mineral systems—research that enhanced the recovery of minerals in the processing of ores. His half-century of research extended over a range of areas important to mineral processing. His initial research was concerned with solid/liquid separation, namely thickening. He pioneered the use of X-rays to determine the concentration of solids in a slurry during the thickening process. When he moved into the investigation of flotation principles, he and his graduate students showed in an unambiguous way how metal ion hydrolysis and the formation of insoluble surface compounds control the flotation of various metal oxides and silicates. In particular, they showed that optimal flotation with chemisorbing collectors occurs at the pH where surface metal ions hydrolyze. He sparked the synthesis and development of a chemical reagent that is now used worldwide as a flotation collector and flocculant in the mining industry: potassium octyl hydroxamate, which he patented in 1965. This reagent is especially effective for minerals containing copper, iron, and rare earth elements. He was the first person to study carefully the electrochemistry of pyrite flotation, clearly showing that the xanthate collector is oxidized to dixanthogen at the surface. This has major importance in optimizing pyrite flotation, particularly for gold-bearing pyrite.

There has always been great interest by the mineral industry in understanding the effect of residual reagents in tailings and effluents on the environment. Being an avid fisherman, Dr. Fuerstenau pioneered the study of the effect of the toxicity of selected sulfhydryl collectors on the population of fish. For this purpose he obtained fingerling trout from the local fish hatchery. He also developed various means and models to remove fine particles and various toxic metal elements from water using packed beds and other media. Some of his effort was also directed at the dissolution kinetics of oxide/sulfide mineral systems and laid down factors that control dissolution rates. Another example of how far his contributions to mining could reach was his detailed investigation that showed considerable cost savings could be had by optimizing energy costs in mining and ore preparation. Specifically, he showed that increased ore grindability and plant throughput could be achieved with controlled blasting in mining the ore. During his half-century of research, he published more than 100 technical papers. He also authored one book and edited six in mineral processing/extractive metallurgy, including the textbook *Principles of Mineral Processing*, one of the top selling books published by the Society for Mining, Metallurgy, and Exploration (SME). He played a leading role in planning the commemoration of the 100th anniversary of the establishment of the froth flotation process: a symposium was held in Australia in 2005 and a commemorative volume was published by SME in 2007. This volume, entitled *Froth Flotation: A Century of Innovation* and edited by Maurice C. Fuerstenau, Graeme Jameson, and Roe-Hoan Yoon, includes the historical aspects of flotation, flotation fundamentals, flotation chemistry, flotation cells, modeling and simulation, and plant practice. Dr. Fuerstenau took it upon himself to obtain pertinent papers and personally edited each one. This comprehensive volume should have a long and useful life as a reference for scientists and engineers in mineral engineering.

The significance and quality of his wide-ranging research were recognized with a number of awards and honors. He was recipient of the Arthur F. Taggart Award and the Antoine M. Gaudin Award of SME, the Robert H. Richards Award of AIME, and the Frank F. Aplan Award of the United Engineering Foundation.

Dr. Fuerstenau had an excellent rapport with the mineral industry, particularly after moving to Nevada where gold mining is extensive. As a consultant, he advised numerous companies in their efforts to improve gold extraction techniques and the flotation of gold-bearing pyrite in complex ores. He was particularly effective in utilizing his fundamental knowledge to solve the kinds of complex problems encountered in his consulting, and as a result was widely respected by other engineers and executives for his successes.

His professional society activities were mainly with SME and AIME. He served as SME president in 1982 and on the board of directors of both of these organizations. Under his leadership as president of SME, the Society launched a major effort to expand its scope in the international area. The first long-range planning study undertaken by SME was initiated under his leadership and resulted in a number of new directions and innovations. An example of his interest in fostering SME programs was his conception and implementation in 1976 of the Antoine M. Gaudin Award (NAE Founding Member) for scientific or engineering contributions that further the understanding of the technology of mineral processing. We would like to point out that Dr. Fuerstenau spent considerable effort in shepherding nominations of deserving engineers for recognition with various awards, such as the Gaudin Award and others.

Dr. Fuerstenau was chair or member of over two dozen committees in AIME and SME and their divisions, and also served on numerous advisory panels/committees and workshops for the National Academy of Sciences, the National Academy of Engineering, the National Research Council, and the National Science Foundation. Fellow committee members found it a pleasure to work with Maurie because of his pleasant personality, his respect for other viewpoints, and the many new ideas that he often put forward. His overall impact on the mineral engineering profession was recognized by his election to the National Academy of Engineering and by his being named an honorary member of AIME. In 2006 he was inducted into the South Dakota Hall of Fame in the "professional" class.

Dr. Fuerstenau always felt the need to give back to the institution that provided the foundation for his outstanding career. He endowed the Maurice C. Fuerstenau Scholarship for students majoring in metallurgical engineering at the South Dakota School of Mines and Technology. He and his brother Douglas endowed the Erwin, Hazel, and Richard Fuerstenau Scholarship for students majoring in the minerals industry fields. Many students from South Dakota have benefited from these scholarships.

Dr. Fuerstenau was also active in his community. He gave generously to service in the community in Rapid City, and was especially active in youth basketball and softball, serving as organizer, coach, and umpire. He was also actively involved in the governance of St. Martin's Academy in Rapid City, serving on the school's board of governors for three years and as board president for two years. With the need for a gymnasium at the school, he chaired the organizing committee to select a building design and establish financing.

Maurie's main avocation related to the outdoors. He was a fairly active golfer. Through most of his life he fished for trout, but in two of his last summers, he went to Alaska to a salmon fishing camp, about which he was really enthusiastic. However, his overriding enthusiasm was for hunting. He liked to go deer hunting, but especially enjoyed hunting pheasants on the farms of his South Dakota cousins. He virtually never missed the opening weekend for pheasant hunting; and after moving to Nevada, he went back to South Dakota every year for the opening of the pheasant season. He had even made plans for October 2012.

Dr. Maurice C. Fuerstenau will be remembered as a consummate educator, world-renowned researcher, and dedicated professional and public servant. To those who knew and interacted with him, Maurie is remembered as a caring person who was considerate, patient, very kind, genuinely enthusiastic, and who had a delightful personality. He is greatly missed by his family, friends and many professional colleagues. He is survived by his brother Douglas (Peggy) Fuerstenau; sister Jean Hadeen; children Gregg (Shelley Graves) Fuerstenau, Jeff (Therese) Fuerstenau, Beth (James) Schuster, and Anne (Mark) Maxwell; 13 grandchildren; and numerous nieces and nephews.

ELMER L. GADEN JR.

1923–2012

Elected in 1974

"For contributions to fermentation technology and leadership in the field of bioengineering."

BY ARTHUR HUMPHREY

ELMER L. GADEN JR., Wills Johnson Professor Emeritus of the University of Virginia, widely regarded as the "father of biochemical engineering," died on March 10, 2012, in Charlottesville, Virginia. He is survived by Jennifer, his wife of 48 years, a daughter, two sons, and their families.

Elmer was born and raised in Brooklyn, New York. He attended Columbia University where he earned his BS, MS, and PhD in chemical engineering. As an undergraduate at Columbia, he was enrolled in the V-12 program and, as a result, served from 1944 to 1946 in the US Navy as a radar officer with the Pacific Fleet during World War II. After the war he returned to Columbia University for graduate studies. His PhD work was a seminal piece of research that enabled the initial large-scale manufacture of antibiotics. For this and other bioengineering-related contributions, Professor Gaden was awarded in 2009 the Fritz J. and Delores H. Russ Prize and Gold Medal, considered the Nobel Prize of Bioengineering.

After graduating, Elmer engaged in research and development on microbial processes for the manufacture of antibiotics and fine chemicals at Pfizer Inc. In the fall of 1949 he returned to the Columbia University faculty to establish in the Chemical Engineering Department the first North American academic program in biochemical engineering. During his association with Columbia, he served as department chair of chemical engineering for the periods of 1960–1970 and 1971–1974.

In the fall of 1974 Elmer went to the University of Vermont, where he served as dean of the College of Engineering, Mathematics, and Business Administration. Then, in 1979, he was appointed the Wills Johnson Professor in the Chemical Engineering Department at the University of Virginia, from which he retired in 1994.

While at Columbia University and the University of Vermont, Elmer held joint appointments in their history departments and taught courses in military and Civil War history, a lifelong interest. He also wrote short publications for historical journals on the "Iron Boats of the Civil War" and conducted Civil War battlefield tours for students and friends. Virginia was an inspiring environment for these tours.

Dr. Gaden's primary technical focus was biotechnology, especially bioprocesses. He was the founding editor of the international research journal *Biotechnology and Bioprocesses* and served as its editor for more than 25 years. After his election in 1974 to the National Academy of Engineering, he served as a member or chair of a number of NAE and National Research Council committees.

In 1986 he received Columbia University's Egleston Medal for distinguished engineering achievements and in 1987 was awarded an honorary doctor of engineering degree by the Rensselaer Polytechnic Institute. In 1988 he received the AIChE Founders Award, and in 1970 was the first recipient of AIChE's Food, Pharmaceutical, and Bioengineering Award. Among his many other honors are the Chemical Engineering (Union Carbide) Lectureship Award (ASEE), the Harold C. Urey Phi Lambda Upsilon Award (Columbia University), and the ACS David Perlman Memorial Lectureship and Marvin J. Johnson Award in Microbial and Biochemical Technology, Division of Biochemical Technology. He was also proud to receive the Great Teachers Award from Columbia University (given by the Society of Columbia Graduates) and the Mac Wade Award from the University of Virginia (from the students of the School of Engineering and Applied Science).

Both awards recognized his exceptional capacity as a teacher and were based on nominations from the student body.

Elmer shared a deep concern for the environment with his wife. In particular, they loved birding. He spent countless hours observing the birds and other wildlife from the deck of their home, which is surrounded by woods, in the Charlottesville countryside. In his later years this interest in the environment spilled over into his research as he focused on the creation of alcohol-based fuels and foods by biotechnology (fermentation) processes.

Alan J. Goldman

ALAN J. GOLDMAN

1932–2010

Elected in 1989

"For significant contributions to and outstanding leadership of public sector operations research and transportation science."

BY DANIEL Q. NAIMAN AND CHRISTOFF WITZGALL
SUBMITTED BY THE NAE HOME SECRETARY

ALAN J. GOLDMAN, emeritus professor at Johns Hopkins University's Department of Applied Mathematics and Statistics, died on February 13, 2010, at the age of 77.

Alan grew up in Brooklyn, New York, a short walk from Coney Island, as the only child of Leonard and Sylvia Goldman, both of whom worked for the New York City Public Schools. As a student at the local Abraham Lincoln High School he showed an interest in a wide variety of activities, including competing for the school's Chess Club and Math Team and playing basketball and handball. In 1947 he won first prize in the American Accordionist Association's Junior Soloist contest. He graduated first in his class, and his talents led to scholarships and his being one of the winners in the 1949 Westinghouse Science Talent Search.

At Brooklyn College Alan majored in mathematics and physics and graduated *summa cum laude* (second in his class) in 1952. During this time he met Cynthia Timberg. They married on June 25, 1955, and on August 20, 1958, they had a son, Peter H. Goldman.

Alan enrolled as a graduate student in mathematics at Princeton, a department with great strengths in topology, algebra, and logic. Contrasting with these pure mathematical areas were active research groups in applied mathematics, including work on nonlinear differential equations led by Solomon Lefschetz and the Logistics Project directed by Albert Tucker. Tucker ran a weekly seminar in game theory, linear programming, and combinatorial optimization, and Goldman's active participation profoundly shaped his career. While writing his PhD thesis on a subject in algebraic topology under the direction of Ralph Fox, Goldman contributed three seminal papers to *Annals of Mathematics Study 38*, which was edited by Harold Kuhn and Albert Tucker.

Goldman's appreciation of the contributions of the Princeton group to the areas of game theory, mathematical programming, and combinatorial optimization is eloquently expressed in a citation he authored for the award of the von Neumann Theory Prize to David Gale, Harold Kuhn, and Albert Tucker in 1980. In it he points out their profound influence on himself and others, and expresses his gratitude to Albert Tucker for his leadership: "[N]ot only did he involve the mathematical community from the very beginning, but he organized the research efforts and set standards for rigor and clarity of exposition that have been a source of inspiration to all."

Acting on his deep commitment to mathematical application, Alan joined the National Bureau of Standards (NBS, now the National Institute of Standards and Technology, NIST) in Washington, DC, an agency dedicated to the pursuit of the "hard" sciences and their metrology. He became part of the Mathematics Division, which in the wake of electronic computing had become a major player in the development of numerical analysis.

Alan brought with him to NBS a different vision: to address and distill the mathematical problems that surface when planning and strategizing the activity of administration and corporate management. In 1956, he was tapped to establish and lead an Operations Research Section in the Mathematics Division. Always forward-looking, he steered his new team toward geometric and combinatorial optimization.

While promoting basic research, Alan reached out to a host of government agencies and actively participated in resulting collaborations. The US Postal Service was one of the first agencies with which he collaborated in work to determine suitable locations for post offices; this work sparked Alan's longtime fascination with problems of optimal facility location. The many aspects of transportation were another considerable source of collaborations. He played a key role in planning and demand-forecasting for intercity and urban transportation systems. The list of applications Alan and his NBS team investigated and wrote about is vast and includes antimissile defense, mail sorting and distribution systems, runway capacity, impact and viability of new aircraft, network viability, lead paint poisoning, pesticide propagation, arms control modeling, and fire department operations.

Alan earned high accolades from those who worked under his tutelage. He was always fully invested in their efforts without resorting to micromanaging. Throughout his career he was well known for his voracious appetite for new ideas, his keen ability to recognize promising directions, and his ability to nurture talented people. Several individuals that he hired or mentored at NBS went on to distinguished academic careers: Jack Edmonds, who won a von Neumann Theory Prize in 1985; Karla Hoffman, winner of the 2005 Kimball Medal; and George Nemhauser, who was elected to the National Academy of Engineering in 1986.

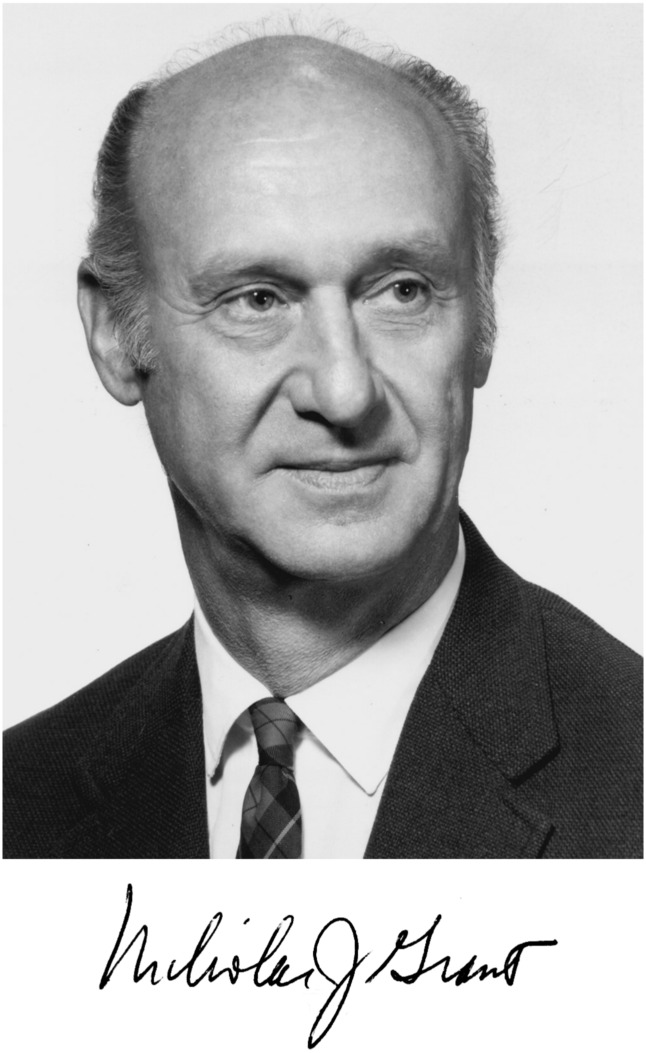
For his leadership and his far-reaching research, Alan was awarded the Gold Medal for Excellence in Service by the US Department of Commerce in 1976. Alan Hoffman, who hired Goldman at NBS, wrote, "To say that Alan was an outstanding leader would be insufficient. I have told many people that hiring Alan was probably my biggest contribution to the organization."

In 1979, Alan joined the faculty of Johns Hopkins University (JHU) in the Department of Mathematical Sciences (later renamed the Department of Applied Mathematics and Statistics), successor to the Department of Operations Research. He played a critical role in rebuilding operations research at JHU and led the department's operations research group until his retirement in 1999, when he became professor emeritus.

At Johns Hopkins Alan continued to exhibit an unparalleled passion for mathematical theory and application, inspiring a new generation of faculty and students in the process. His ability to quickly grasp the main ideas in the work of others—whether in manuscripts, PhD dissertations, or seminar presentations—was viewed by faculty and graduate students as nothing short of uncanny.

Alan's dedication was unmatched. Throughout his time at Johns Hopkins he could be found working in his office late into the evening and on weekends. He supervised 13 PhD dissertations, served as a referee for countless submitted papers, and provided feedback to many of his colleagues on their work. Writers of manuscripts subjected to his scrutiny could expect copious pages of detailed comments across a whole spectrum of points of view, from deep issues related to content to matters of style. Yet his approach was always positive and encouraging. Alan's own publication list would surely be orders of magnitude longer had he not been so generous. As an emeritus professor he continued to supervise the research projects of graduate students and to develop and teach new courses in operations research, such as "Math in Sports" and "Supply Chain Management." Students with serious academic aspirations benefited enormously from the unfailing care he put into his efforts as teacher and mentor.

Alan's death resulted in a huge outpouring of comments from the many colleagues and students whose lives had been deeply touched by him, and from these comments familiar themes emerge. Alan was passionate and caring and eager to be exposed to new ideas; his intellectual generosity was unmatched. Alan was a true *optimizer*, striving to do things as close to perfectly as possible; and in so doing, he brought out the best in everyone around him. He is deeply missed by his colleagues.



NICHOLAS J. GRANT

1915–2004

Elected in 1980

"For contributions to the science and technology of high temperature alloys."

BY MERTON C. FLEMINGS

NICHOLAS J. GRANT, a leader in high-temperature metallurgy and former professor in the Department of Materials Science and Engineering at Massachusetts Institute of Technology (MIT), died May 1, 2004, at the age of 88.

Professor Grant, known to all as Nick, was born Nicholas John Dwaresky in South River, New Jersey, on October 21, 1915, the bilingual son of Russian immigrants. He was the youngest of four brothers, nicknamed "The Little Professor" even as a boy. When his brothers changed the family name to Grant (they liked the American sound of Ulysses S. Grant) he complained that they might at least have translated it to "Steward," but by then it was too late. Through the determined mentoring of his high school science teacher, who was also his football coach, Nick went to Carnegie Tech in 1935 on a football scholarship. He received his bachelor of science degree there in 1938 and then went on to MIT, where he earned his ScD in metallurgy in 1944. He remained at MIT for the remainder of his career, becoming an instructor immediately upon graduation and then rising through the academic ranks to full professor in 1956.

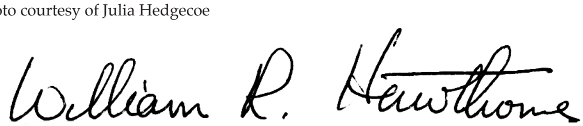
Professor Grant's research career began during World War II, with research on the casing for the atomic bomb. Thereafter he focused mainly on high-temperature metallurgy, following a path from steelmaking to alloy and process development for high-temperature alloys to rapid solidification processing. He published more than 500 papers and was granted more than 30 US patents. He was a member of the National Academy of Engineering and the American Academy of Arts and Sciences, and a fellow of the American Institute of Mining and Metallurgy and of the American Society of Metals. Other honors included the J. Wallenberg Award of the Royal Swedish Academy of Engineering Sciences in 1978.

His government service was wide ranging. He served on NASA's Advisory Committee on Materials and Structures (1958–1966), including a period as chairman, and Research Advisory Committee (1968–1974). He also served on numerous other government and institutional advisory committees, in the Office of Naval Research (ONR), Atomic Energy Commission (AEC), Ordnance Division of the US Army, Department of Commerce, NATO, and National Research Council (NRC). He was a busy consultant and visited the USSR frequently, starting in the late 1940s. MIT's first Russian graduate student was in Nick Grant's lab.

Nick was above all a teacher who was simultaneously demanding, generous, and endlessly supportive. And each graduate student could count on being beaten by Nick at handball. He loved sports with a passionate self-discipline, and he held the Carnegie Tech javelin record for decades. He skated, skied, swam, and jogged until he was past 80. An avid outdoorsman, he loved fishing, camping, and gardening.

Professor Grant was married twice. His first wife, Anne Phillips, died in 1957, and in 1963 he married the writer Susan Cooper. He had five children, four of whom survived him, as did eight grandchildren and six great-grandchildren.

Photo courtesy of Julia Hedgecoe



SIR WILLIAM REDE HAWTHORNE

1913–2011

Elected in 1976

"For pioneering contributions in the understanding of fluid dynamics and thermodynamics and their applications in mechanical engineering, particularly jet engines."

BY EDWARD M. GREITZER AND JOHN H. HORLOCK

SIR WILLIAM HAWTHORNE, a pioneer in the aerodynamics and thermodynamics of gas turbine engines, and a sought-after technology advisor and consultant to industry and government, died in Cambridge, England, on September 16, 2011.

Will was born in Benton, England, near Newcastle-on-Tyne, May 22, 1913. His father was a consulting civil engineer, his mother one of the first women graduates in biology of the University of Glasgow. His family moved to London soon thereafter, and he was educated at Dragon School in Oxford and at Westminster School, where he rowed and also acted.

He won an exhibition to Trinity College, Cambridge, in 1931, where he read mathematics before moving to mechanical sciences, receiving double firsts at graduation. He took a particular interest in thermodynamics, winning the Ricardo Prize in that subject and sharing the Rex Moir Prize awarded to the best student in the Mechanical Sciences Tripos. He also rowed for Trinity and joined the Pentacle Club (conjurers), appearing in their London revue with his sleight-of-hand show; he maintained a lifelong love of conjuring. After leaving Cambridge, he worked as a graduate apprentice at Babcock & Wilcox in Renfrew.

In 1935 Hawthorne received a Commonwealth Fellowship to attend MIT, where he joined the chemical engineering department, working with Professor H.C. Hottel. His doctoral research was in combustion, in particular the influence of turbulence on flame length, showing that the rate at which oxygen mixes with fuel controls the length of the flame. It was this work for his ScD that would enable him to help Sir Frank Whittle later in the development of the first jet engines.

Hawthorne left MIT to take a position as a development engineer at Babcock & Wilcox, studying boiler and furnace design issues, but he returned to Cambridge, Massachusetts, in April 1939 to receive his degree and to marry Barbara Runkle, granddaughter of the second president of MIT. After the outbreak of war, Barbara came back to the US, where their son was born.

Hawthorne was posted as a scientific officer at the Royal Aircraft Establishment in 1940 when, as he said, he was "loaned" to Frank Whittle to help with the development of the jet engine. Hawthorne's insight was critical to solving the severe combustion problems that plagued the Whittle jet engine in 1940–41. The prototype engines, constructed in great secrecy with the personal support of Winston Churchill, could not be made to run smoothly because of instability in the combustion processes. Hawthorne realized that the answer lay in his thesis work on the mixture of fuel and air in flames and found a way to spray the fuel into fast-moving compressed air so that combustion took place reliably. By January 1941, the engine could run for long periods and the first successful flight took place on May 15, 1941. Hawthorne then became head of the newly formed Gas Turbine Division at the Royal Aircraft Establishment until 1944, when he was sent to the British Air Commission, Washington, with responsibility for technology transfer. He subsequently became deputy director of engine research in Britain's Ministry of Supply. For his wartime work he was awarded the US Medal of Freedom in 1947.

In 1946, Hawthorne became associate professor of mechanical engineering at MIT, where he was promoted soon after to George Westinghouse Professor of Mechanical

Engineering. At the MIT Gas Turbine Laboratory, in addition to his interest in, and exposition of, gas turbine thermodynamics, he began research on the fluid mechanics of turbomachinery, which was to remain a primary interest. This latter included his path-breaking research on secondary flow (a type of fluid motion often manifested as a flow swirling about the mainstream primary flow) in turbomachinery and many other fluid machinery applications. His work laid the conceptual foundation for current thinking about this important topic. His two daughters were born during the period he spent on the MIT faculty.

In 1951 Hawthorne returned to England when he was elected the first holder of the Hopkinson and ICI Chair of Applied Thermodynamics at Cambridge University, a post he held until 1980. He also became a fellow of Trinity College. But even while a full-time member of the Cambridge faculty, his relationship with MIT continued, as he became the first Jerome C. Hunsaker Visiting Professor of Aeronautical Engineering in 1955–56, a Visiting Institute Professor (MIT's highest professorial rank) in 1962, and a member of the MIT Corporation from 1969 to 1974. Further, these were not the only connections, because he was able to maintain ongoing and active collaborations with faculty and students at both universities. It is a pleasure to report that the technical and intellectual transatlantic linkages he created and fostered are still in place and the collaboration still vigorous.

Another of Hawthorne's interests developed as the Suez crisis unfolded in the 1950s. The oil tanker shortage that followed closure of the Suez Canal in 1956 encouraged Hawthorne to conceive and develop an alternative transport system. The "Dracone" project, as it was called, proposed flexible barges—long, sausage-shaped tubes that could be filled with fuel and towed, then collapsed after each delivery and returned for refill, even by air. The first Dracones snaked uncontrollably from side to side, but with intensive research and testing the problem was addressed and the motion made stable. The problem of finding sufficiently strong and flexible fabrics was also resolved. For Hawthorne, and many of his students, the Dracone was a major development project. The Suez crisis ended before development was completed but Dracones were subsequently used for short-distance transport of fresh water and fuels to areas without port facilities, for military purposes, and in the cleanup of oil and effluent spills.

Hawthorne had great ability to see immediately where the root of an engineering problem lay and to visualize its solution, often in elegantly simple mathematical terms. He applied these skills with much success to understand the intricacies of the three-dimensional kinematics that are inherent in secondary flow. In this he was undoubtedly aided by his extraordinary ability to write original vector analysis of a particularly complex fluid flow as if he were writing a letter.

In 1968 Hawthorne was named Master of Churchill College, a new college at Cambridge University focusing on scientific and engineering studies, created, with substantial support from Commonwealth countries and from the United States, as a memorial to Sir Winston Churchill.

In addition to his many professional activities, Hawthorne was active and popular, known for his support for the rowing club and musical activities, and as a gracious host for the many visiting scholars. The Churchill Archives Centre, which he was instrumental in creating, now houses the papers of Winston Churchill, Margaret Thatcher, and many other distinguished political and military personalities. Hawthorne remained Master until 1983.

In parallel with his mastership, Hawthorne was head of the Engineering Department at Cambridge from 1968 to 1973. During this time he kept his research work going, and he and one of us (JHH) established the new Turbomachinery Laboratory, now known as the Whittle Laboratory.

During his career Hawthorne was sought after as an advisor to the British and American governments on a broad range of defense, energy, and security questions. Of these, we will mention only his chairmanship of the Home Office Scientific Advisory Council, in which he was active for almost a decade. He was made Commander of the Order of the British Empire in 1959 and knighted in 1970 for "services to thermodynamics," a citation that greatly pleased him. In this regard, he has been described as "the first knight of the Second Law of Thermodynamics."

Hawthorne received a number of further honors and awards for his work. He was elected Fellow of the Royal Society in 1955, of which he was vice president in 1969–70 and 1979–81 and from which he received a Royal Medal in 1986. As vice president he led the first Royal Society visit to postwar China, during which he entertained the staff and passengers of the train he was travelling on with a magic show. He was elected foreign associate of both the National Academy of Sciences (1965) and the National Academy of Engineering (1976), honorary fellow of several professional societies including the American Institute of Aeronautics and Astronautics and the Royal Aeronautical Society, honorary member of ASME, and fellow of the Royal Academy of Engineering. He was the recipient of six honorary degrees.

In the context of US industry, Will had a long relationship with the Cummins Engine Company in Indiana. He was a director from 1974 to 1986 and carried out research on turbochargers, with Cummins and its British subsidiary, Holset, until the age of 85. He is credited with giving technology and research a more significant role in the company. He was also a long-time consultant to Pratt and Whitney, the jet engine manufacturer, helping to shape the direction of its early work on three-dimensional compressor flows.

Hawthorne was a genius of originality in a variety of fields in mechanical engineering, producing many major papers, each beautifully written. In a way one of us (JHH) became his scribe, writing a textbook on actuator disc theory in 1978 and, in 2003, another book on gas turbine cycles, based partly on the brilliant course first given by Hawthorne at MIT and dedicated to him.

Hawthorne's hobbies included cookery, theater, and conjuring. In connection with the last of these he was a member of the Cambridge University conjuring club as an undergraduate and its president for 20 years, and he celebrated his 70th and 80th birthdays with conjuring shows on both sides of the Atlantic. A high point of the latter was his demonstration of sawing a young woman in half and then joining her together again, a feat reported as the most ambitious and spectacularly successful postprandial talk ever held in Churchill College's Senior Combination Room. Another hobby lay in his appreciation of science fiction, starting as a young admirer of the works of H.G. Wells. For many years he was a subscriber to *Astounding Science Fiction* magazine, and he would reflect with colleagues on the feasibility of some of the ideas advanced therein.

Sir William's colleagues particularly remember him as a generous and enthusiastic teacher who encouraged others to excel, and as an engineer committed to his profession, imbued with a strong sense of duty and the belief that engineering could contribute to solving important problems facing humankind. They also recall his continuing interest, even in old age, in the institutions he served, and in new developments, ideas, and issues.

His wife, Barbara, was a graduate of Radcliffe College. She died in 1992. They are survived by their children Alexander, Joanna Amick, and Elizabeth O'Beirne-Ranelagh, and grandchildren Alexandra Amick Vrazo and Charles Amick.

CLAUDE R. HOCOTT

1909–2001

Elected in 1974

"For contributions to increased oil recovery through petroleum reservoir engineering, including fluid dynamics, phase behavior, and geochemistry."

This memorial resolution is reproduced with the permission of the Office of General Faculty and Faculty Council at the University of Texas at Austin and was originally prepared in February of 2002 by a special university committee consisting of Professors Larry W. Lake (chair), Gary A. Pope, and Robert S. Schechter.

CLAUDE R. HOCOTT, a pioneer in research to improve the discovery and production of oil and gas whose career spanned the modern oil industry, died in Austin, Texas, September 9, 2001. He was born in Excelsior, Arkansas, in 1909. After his family moved to the Rio Grande Valley, he lived the remainder of his life in Texas. He attended Edinburgh Junior College and later transferred to the University of Texas at Austin, where he studied chemical engineering, at the time a relatively new discipline in the College of Engineering.

Hocott's studies were interrupted when he had to leave college for a semester to earn money. He lived with his brother and sister, both of whom attended the university, and he needed to pay his share of the expenses, so during the semester he grew an onion crop. But when he harvested the onions, he discovered that the large produce buyers had no need for them. A very resourceful individual, he loaded the onions into a truck and went from town to town and house to house selling onions until he had sold the entire crop. The proceeds financed his remaining undergraduate studies. In subsequent years, whenever the Great Depression and the hard times it engendered were mentioned, Hocott enjoyed telling the story of this enterprise. Based on his experiences, he always disagreed with the proposition that the many Americans who joined the Communist Party during the Depression were hungry intellectuals. He was one of the rugged individualists so prominent in Texas in the Depression years.

It was because of his South Texas background that Hocott retained a lifelong interest in Latin America, traveling there frequently and learning to speak Spanish.

When Hocott graduated with his bachelor's degree in 1933, E.P. Schoch, a chemistry professor of great vision who founded the Department of Chemical Engineering, persuaded him to enroll in graduate school. Hocott taught classes in chemical engineering and helped with Schoch's pet research project—the production of acetylene by passing an electric arc through natural gas. Schoch was greatly disturbed by the sight of the massive flares lighting the Texas Gulf Coast that burned unwanted methane coproduced with the crude oil; he considered this a great waste of an important Texas resource and resolved to do something about it. Hocott stayed to research the Schoch process and earned his PhD in chemical engineering in 1937.

At about the same time, Humble Oil Company, on the recommendation of W.K. Lewis, a professor at the Massachusetts Institute of Technology, had formed a research laboratory entirely devoted to researching methods for finding and producing oil and gas. Hocott was hired as a research engineer to work in this new laboratory. Since the laboratory was the first of its kind in the world, there was no shortage of interesting and important problems to be researched. Researchers did pioneering work that was to become the basis for modern exploration and production technology; Hocott's early publications related to issues of crucial importance for reservoir engineering. The success of the production research laboratory is perhaps best measured by noting that, by 1948, every major oil company in America, and many outside the United States, instituted laboratories similar to Humble's.

Hocott was appointed director of the Humble Laboratory when Stuart Buckley, codiscoverer of the Buckley-Leverett theory, retired. When Humble was merged with Esso to form Exxon Production Research Co., Hocott was named executive vice president of the newly created company. He served in that capacity until he retired in 1974. During his years at Humble, he became an important spokesman for the oil industry, serving as an oil and gas advisor to the Carter administration and appearing on the McNeil-Lehrer Report.

Hocott held many offices in the Society of Petroleum Engineers, including president in 1952, director in 1954, and distinguished lecturer in 1963 and 1987. He was an American Institute of Mining and Metallurgical Engineering director and served on many national committees.

Hocott helped to found the Gulf Universities Research Consortium, a group of universities in states bordering the Gulf of Mexico with faculties in marine science and geology. He served as vice president of this consortium from 1979 to 1983.

When Hocott retired from Exxon, he elected to devote his time to higher education, which he valued as the most important activity to ensure the future welfare of Texas. He initially commuted between Houston and Austin, where, in addition to teaching classes in chemistry and chemical engineering, he helped to found the Institute for Christian Studies, now the Austin Graduate School of Theology. Hocott supported the institute through advice and financial support for more than 30 years, and was chancellor at the time of his death. He was very interested in theological studies that encompassed a profound respect for both Biblical studies and scientific truths. His primary goal at the institute was to promote high-quality research through research and travel grants.

His dedication to higher education was severely tested when the then dean of the College of Engineering, Earnest Gloyna, asked him to come out of his partial retirement to chair the Department of Petroleum Engineering. Hocott reluctantly agreed to take on this challenge, saying his first and most important task was to identify his successor. He was appointed professor of petroleum engineering and chaired the department in 1974–1975.

Once a successor was found, however, Hocott did not return to full retirement. He became director of the Texas Petroleum Research Committee (TPRC), a group under the auspices of the Texas Railroad Commission that funded petroleum engineering research at both UT Austin and Texas A&M University. He was the director of TPRC from 1975 to 1979.

Hocott's commitment to higher education, and to good applied research and the benefits it provides, was profound. It was a passion, truly worthy of his time, energy, and financial support. Claude and his wife, Billy, who died in 1979, endowed the Billy and Claude R. Hocott Distinguished Centennial Engineering Research Award as well as the Hocott Lectureship in petroleum engineering.

Hocott received considerable recognition for his efforts on behalf of the oil industry, his profession, and higher education. He was named a distinguished graduate of the University of Texas College of Engineering in 1971, elected to the National Academy of Engineering in 1974, and named an honorary member of the American Institute of Mining, Metallurgical, and Petroleum Engineers in 1975. He received the DeGolyer Distinguished Service Medal (1980) and the Anthony F. Lucas Gold Medal (1981), both awarded by the Society of Petroleum Engineers.

Claude R. Hocott was dedicated to his country, his state, his profession, his religion, his two universities, and, above all, his family. He is survived by his second wife, the former Judy Mathews, whom he married in 1983; two daughters, Elaine Gainey and Gail Hancock; five grandchildren; and five great-grandchildren. A brother, Dr. Floyd Hocott, and a sister, Mable Ogle, survived him, but are now deceased.

His stepson wrote that

> Dr. Hocott had a fine library on the history of Texas and the Southwest. He had particularly fine memories of the historians and naturalists around the University of Texas. He was also very fond of the artists of the Southwest. Dr. and Mrs. Hocott developed a love of the Texas coast around Corpus Christi and spent much time there during his retirement.

JOHN A. HRONES

1912–2000

Elected in 1975

"For contributions as a teacher and administrator; pioneer in the field of automatic control and leader in engineering education."

BY THOMAS P. KICHER AND JOHN C. ANGUS

JOHN ANTHONY HRONES was born on September 28, 1912, and raised in the Boston area. He received his primary and secondary education at the Longfellow School, Washington Irving Junior High School, and Mechanics Arts High School, and attended the Massachusetts Institute of Technology (MIT), where he received three degrees in mechanical engineering: BS (1934), MS (1936), and DSc (1942).

After a short stint in industry as the factory manager at Coldwell Lawnmower Company, he returned to MIT to begin a long and successful career as an educator and administrator in higher education. His career is best described in two separate stages, first as a faculty member and administrator at MIT, and second as the vice president of academic affairs at Case Institute of Technology and provost of science and technology at Case Western Reserve University.

At MIT, John taught in the Department of Mechanical Engineering for more than 19 years, promoted from instructor (1936) to professor (1948). He also served as the head of the Machine Design Division and director of the Dynamic Analysis and Control Laboratory. His most notable publication was an encyclopedic collection of solutions to the "four bar mechanism," the simplest of all kinematic mechanisms, often used as the foundation for design synthesis studies.

He generated solutions for various selections of linkage dimensions and plotted the complete trace of their possible positions for a full rotation of the input link. The effort was completed before the advent of the digital computer and was published in an oversized text that required special handling by most scientific libraries. The work is still cited as the definitive authority in mechanism design synthesis and is used as a benchmark to test modern computer method results. John also made major contributions to machine control theory, which was a popular topic of the day.

John came to Cleveland in the fall of 1957 to be the educational leader of Case Institute of Technology under President T. Keith Glennan. John was the ideal candidate to follow in the footsteps of William E. Wickenden, the fourth president of Case and a nationally recognized engineering educator. Dr. Wickenden had conducted an exhaustive study of engineering education in America and Europe in 1929 and had defined the guidelines for educating the next generation of engineering students. John had been a member of the "Grinter Committee," which had prepared recommendations for the education of engineers based on "the lessons learned from World War II." Case had used the findings of the Grinter Committee to initiate a pilot experimental program in engineering science.

Shortly after John's arrival, Dr. Glennan was appointed by President Eisenhower to reorganize the National Advisory Committee for Aeronautics into the National Aeronautics and Space Administration. Undeterred, John launched a complete reorganization of the Case engineering curriculum and administration to support the new educational initiative. The pilot Engineering Science Program became the basis for a core collection of mathematics, science, and engineering courses common to all curricular programs in engineering. The Carnegie Foundation supported an effort to reorganize separate departments of engineering into a single Division of Engineering. New degree programs were defined and graduate programs in research developed. As a direct result of these efforts, Case was one of the earliest, if not the first, to offer ABET-accredited undergraduate programs in computer engineering, biomedical engineering, polymer engineering, systems engineering, and fluid and thermal engineering science. In addition, proposals were prepared and funds secured from the Ford Foundation for the establishment of two unique graduate research centers, the Engineering Design Center and the Systems Research Center.

In parallel with the remaking of the engineering program, the humanities and social science courses were expanded and strengthened and new faculty hired. The engineering curriculum featured an extensive component of arts, humanities, and social and behavioral sciences that accounted for approximately 25 percent of the academic requirements. This part of the program was supported with a new building, including a library and music lounge with a lending library of thousands of LP recordings. John also fostered an effort to develop a unique program in the history of technology that had been initiated by the faculty.

Early in the 1960s, it became obvious that industries could use a direct infusion of basic research to bolster their competitiveness. John led an effort to directly connect local industries with Case via a "research park," adjacent to the campus, where students could participate in applied research for industry. Case was one of several universities attempting to connect with their local industries, an effort that required new educational and business norms. One of these activities led to the Chi Corporation, a state-of-the-art computing facility, available to both the campus community and local industries as a "utility." This concept is still popular today, with many universities around the country serving as the central hub of local computer activities.

John worked with a variety of industries as an engineering consultant, notably Chrysler, DuPont, and Corning. He also advised several foundations and educational institutions and was a founder and life trustee of the Asian Institute of Technology in Bangkok, Thailand, where the John A. Hrones Prize is awarded annually to a graduating student for outstanding academic performance in the graduate program in the management of technology. John was a member of the

American Society of Engineering Education, the American Society of Mechanical Engineers, Tau Beta Pi, Sigma Xi, and Pi Tau Sigma. He was elected to membership in the American Academy of Arts and Sciences (1952) and the National Academy of Engineering (1975). In 1992 he received the Bronze Beaver Award from the MIT Alumni Association for his distinguished service to the institution.

His son Steve remembers that his father was a sports enthusiast. He played hockey in high school and as an undergraduate at MIT he was captain of the hockey team, but later he took up free-style skating. He also enjoyed tennis and after retirement he swam almost every day.

His daughter Janet wrote that

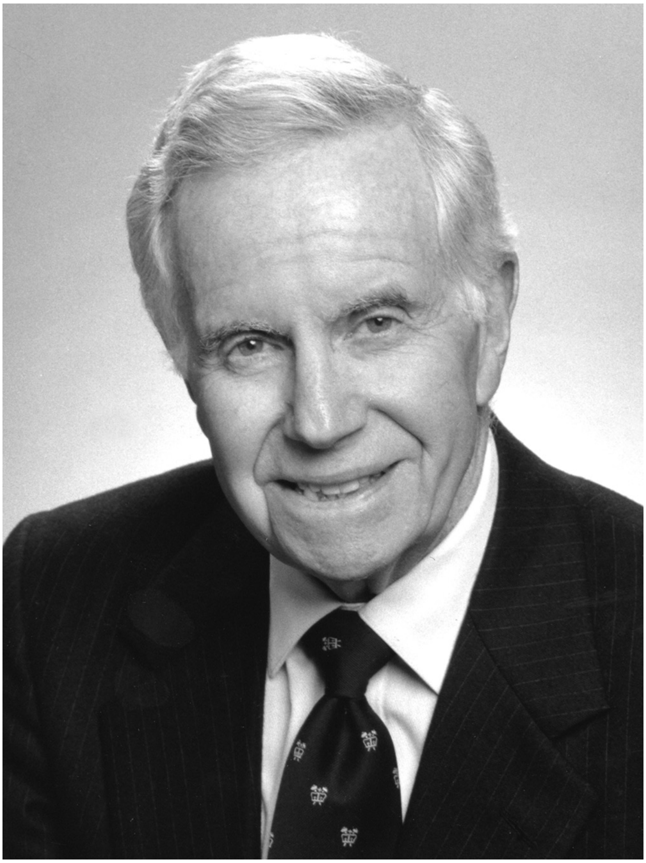
> His family was very important to him. He was a wonderful father and had outstanding relationships with his seven grandchildren. He took his wife and four children to Europe for six months in 1956 while on sabbatical. During his busy life as a professor at MIT, he found time to be president of the School Board in Wellesley, Massachusetts, for many years.

She added that he loved MIT and that, in his retirement years, he was president of the MIT Club in southwest Florida.

John was married to Margaret Baylis for 53 years before her death in 1991. They raised two daughters, Janet Roach of Waldron Island, Washington, and Mary Parsons of Ann Arbor, Michigan, and two sons, Stephen of Concord, Massachusetts, and John A. Jr. of Needham, Massachusetts. John maintained his fondness for the New England area, dividing his time in retirement between Jaffrey, New Hampshire, and Sarasota, Florida. When John died in 2000, memorial services were held in Jaffrey, which coincidentally is the final resting place of William E. Wickenden, his predecessor at Case.

At Case, John was most effective in working with faculty and administrators through private conversations and negotiations. Those who were mentored by John, as either students or staff, express a deep appreciation for the opportunity and credit John with having had a major influence on their careers. He was the prime mover for many successful programs at Case that were emulated elsewhere, and was recognized for his educational leadership by his election to the National Academy of Engineering.

Personal papers and university documents provided by CWRU Archives.



SHELDON E. ISAKOFF

1925–2012

Elected in 1980

"For leadership in industrial chemical engineering research, especially in the control of unsteady state operations."

BY RICHARD E. EMMERT

SHELDON ISAKOFF, former director of the Engineering Research and Development Division of the DuPont Company and a leading figure in engineering research in the United States, died on January 29, 2012, in Chadds Ford, Pennsylvania, at the age of 86.

Sheldon, or Shelley as his friends called him, was born in Brooklyn, New York, on May 25, 1925. He began his undergraduate career at Columbia University while in the US Navy and received a BS in chemical engineering in 1945. After completing service as an engineering officer aboard an aircraft carrier in the Pacific, he returned to Columbia and earned an MS in 1947 and a PhD in 1951, both in chemical engineering.

After serving as a guest fellow at the Brookhaven National Laboratory, Shelley began his 40-year career with the DuPont Company later in 1951 at its Engineering Research Laboratory. Early in his DuPont career, working in the laboratory's chemical engineering section, Shelley utilized both analog and digital computing (which then was in its infancy in industrial use) to advance knowledge in process dynamics and polymer processing. His research led to many patented developments that were instrumental in the processes critical to the manufacture of nylon, Dacron, Mylar, Cronar, and Lycra.

He advanced through various managerial positions to become director of the Engineering Materials Laboratory, then the Engineering Physics Laboratory, and finally the entire Engineering Research Division, which included the foregoing laboratories as well as those for Engineering Technology and Engineering Development. The engineers and scientists in these organizations spanned a wide variety of disciplines.

In this broader role, he led corporate engineering research and development for 15 years on a broad spectrum of DuPont's products and manufacturing processes. His organization developed many new business opportunities for the company in materials, electronics, and the life sciences and supported existing businesses with advances in technology for processes, mechanical equipment, instruments, and automated production systems. He retired from DuPont in March l990.

A consummate champion of engineering and related professions, Shelley served them in many ways. He had leadership positions in several professional organizations, serving as president of the American Institute of Chemical Engineers (AIChE), chair of the board of the Chemical Heritage Foundation (CHF), and president of the United Engineering Trustees (UET). He also had advisory or governing board roles with the National Science Foundation, the American Association of Engineering Societies, the Federation of Materials Societies, the Engineering Council at Columbia University, the University of Pennsylvania Mechanical Engineering Department, the University of Delaware Research Foundation, the Chemical Engineering Advisory Board at Columbia University, and the Center for Advanced Studies at the University of Virginia.

A fellow of AIChE, he was a founder and chairman of its Materials Engineering and Sciences Division (MESD). He served on its council in the late 1970s and on its executive committee in the 1980s. He received its Founders Award for Contributions to the Profession in 1980, the Institute Lectureship in 1984, the MESD's Stine Award, the Chilton Award from the Wilmington Local Section in 1994, the Management Division Award in 1996, and the Van Antwerpen

Award for Service to the Institute in 1997. He authored a book in the AIChE monograph series, *High-Tech Materials: Challenges and Opportunities for Chemical Engineers*.

For nearly three decades, Shelley was a significant figure in the governance of CHF, joining its board in 1982, just two years after the organization was founded. He served as a director for 15 years, including three years as its chairman. He followed that with 15 years on its Heritage Council. Arnold Thackray, CHF's founder and chancellor, had these words to say upon Shelley's death: "Sheldon Isakoff, CHF's second board chair, was a gentle, thoughtful friend who yet possessed the steel of character to steer CHF through tempestuous times with skill, grace, and imagination. His presence and his crucial contributions to the foundation's growth and success will long be remembered."

After retirement from DuPont, Shelley served on the board of the UET, an organization founded at the turn of the 20th century by ASCE, AIME, ASME, IEEE, and AIChE with the support of Andrew Carnegie to support engineering and education. The UET provided central offices for these societies, operated the United Engineering Library, and provided grants in support of engineering education. He chaired that board during a time of transition to a more limited role as a grant-making organization.

Sheldon Isakoff received many honors during his lifetime, starting with his election to Tau Beta Pi and Sigma Xi when he was in college. In addition to those from AIChE mentioned earlier, he was the Regents Lecturer in Chemical Engineering at the University of California–Los Angeles in 1987, the Reilly Lecturer in Chemical Engineering at Notre Dame University in 1989, a fellow of the American Association for the Advancement of Science, and a recipient of the Columbia University Alumni Association's Egleston Medal for Distinguished Engineering Achievement in 1993. In 1996, he established the Sheldon E. Isakoff Scholarship in Chemical Engineering at Columbia.

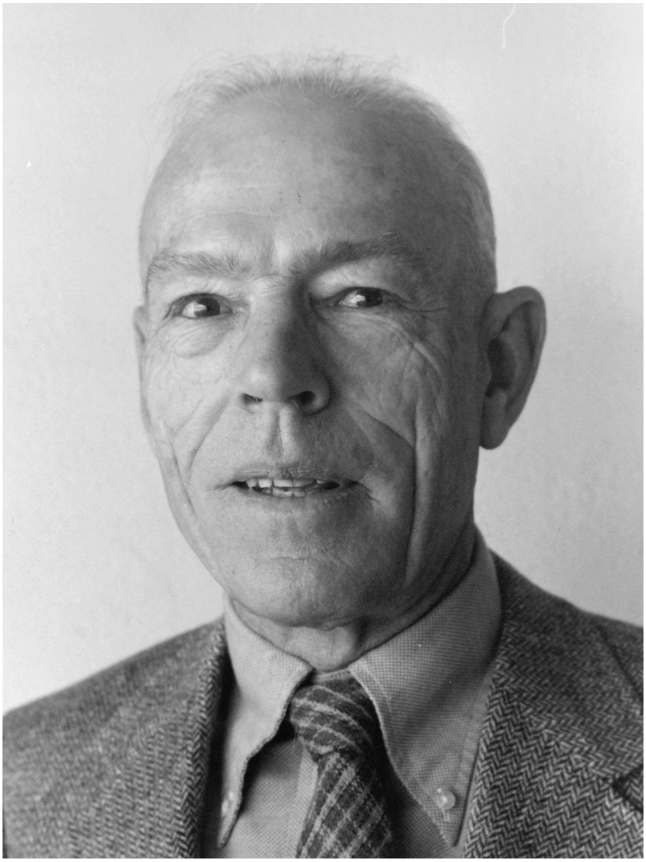
He was elected to the National Academy of Engineering in 1980 and served on the Chemical/Petroleum Engineering Peer Committee (1982–1985), the Panel for Chemical Technology

(1983–1985), the Committee on Chemical Engineering Frontiers: Research Needs and Opportunities (1984–1988), the Awards Committee (1991–1994), the Committee on Critical Technologies: The Role of Chemistry and Chemical Engineering in Maintaining and Strengthening American Technology (1991–1992), and the Committee on Review and Assessment of Alternative Technologies for Demilitarization of Assembled Chemical Weapons (2000–2003). He also was a member of the US national committee for the International Union of Pure and Applied Chemistry (1989–1990) and of the National Materials and Manufacturing Board (1980–1982).

A personal note: I had the good fortune, beginning in 1954, to work with Shelley in many roles in DuPont, with the American Institute of Chemical Engineers, and with the Chemical Heritage Foundation. He was a kind and considerate associate and yet a forceful manager whose style was highly effective. He left an imprint in all those organizations. He will be missed.

Shelley's interests were by no means limited to chemical engineering. In the years following his retirement from DuPont, he continued to pursue lifelong interests in music, the arts, world travel, and growing both orchids and the world's tastiest tomatoes. And he always relished his role as host of the beautiful parties he and Anita, his wife of 64 years, put on year-round.

Anita passed away in 2011. Sheldon is survived by his son Peter, his daughter-in-law Jill, and his two grandchildren Nick and Emma.



DONALD J. JORDAN

1916–2008

Elected in 1976

"For design contributions to jet engines that now power many of the world's transport and military aircraft."

BY EDWARD M. GREITZER AND THEODORE G. SLAIBY

DONALD J. JORDAN, a pioneer in the development of jet engines in the US aircraft industry and former engineering manager at Pratt & Whitney, died November 10, 2008, at Holyoke Medical Center in Holyoke, Massachusetts.

Born in New York City on January 1, 1916, Don graduated from New York University in 1937 with a BS degree with honors in aeronautical engineering. After graduation he went to work for Chance Vought Aircraft, progressing from apprentice engineer to chief powerplant engineer, responsible for the design and development of powerplant installation of a number of aircraft. In this position he played a major role in the process of selecting the engine for the Vought F4U (Corsair) Navy fighter during World War II, the P&W R2800. The Corsair was one of the outstanding US aircraft in the war in the Pacific. He was also a member of the Chance Vought team for the first Navy jet-powered fighter.

Don had by then achieved recognition as an outstanding engineer, with excellent technical capability, in the aviation industry, and when Chance Vought left Connecticut and moved to Texas he was welcomed at Pratt & Whitney, entering into the deep engagement with the design and development of the jet engine that was a hallmark contribution of his career. He soon became a development engineer with senior management responsibility for the development of the J57, a turbojet engine used in a number of applications including the B-52, the U-2, and the F-100 Super Sabre; over 21,000 were built. The commercial version of the engine was the JT3C, the engine that powered the Boeing 707, the first American jet transport, which was then developed into the JT3D low bypass ratio turbofan. The J57 was also the forerunner to the J75, the engine for the F-106. A commercial version was developed into the FT4 engine for power generation.

During the early 1960s, Don played a critical role in getting the JT8D turbofan engine adopted for the Boeing 727. The center engine for the aircraft had a long S-duct, and Don's installation experience from Vought was key in not only giving him the confidence to support this configuration but also making sure that it would not pose a problem.

Don rose rapidly through the company, becoming an assistant chief engineer in 1957, chief engineer, Advanced Gas Turbine Engines in 1967, and engineering manager in 1969 with responsibility for the commercial engineering programs. Through the 1960s he was part of the senior engineering executive team involved in the process of selecting Pratt & Whitney's new engines to design and develop for both military and commercial aircraft. He was directly involved in the design and development of the JT9D turbofan engine, a high bypass ratio engine that powered the first wide-body "jumbo jet," the Boeing 747.

In 1974 he became engineering manager of the Power Systems Division of United Technologies Corporation, in charge of the design and development for the FT50 industrial gas turbine.

What one of the authors (TGS), who was a colleague at Pratt & Whitney, remembers most about Don Jordan was his love of tackling major technical problems, and his ability to generate fresh ideas on how to solve them. An example was the encounter with "backbone bending" of the engine, which created variations in clearances and serious problems for the engine, early in the JT9D installation on the 747. Don played a key role in the design of a backbone stiffening structure between the engine mounts in the nacelle to overcome this problem.

Don was a strong force behind Pratt & Whitney's development of high-strength, high-temperature metal material for use in turbine blades and vanes. The work that he supported led to directionally solidified material for turbines and then to single crystal blades, making it possible to achieve higher turbine operating gas temperatures, reduce the cooling air requirement, and thus improve fuel consumption efficiency.

He was a contributor to many committees, including a NASA subcommittee on internal flow, the National Research Council Aeronautics and Space Engineering Board, NASA advisory committees for airbreathing propulsion and advanced supersonic technology, and the Air Force Scientific Advisory Board. He holds seven patents related to different gas turbine engine components including thrust reversers, variable area nozzles, and coolant injection systems.

After his retirement from United Technologies Corporation, Don was a consultant to the aircraft industry and an active participant, for ten years as a senior lecturer at MIT, in the teaching of undergraduate and graduate subjects in principles of gas turbine engines. The view held by students and faculty was that the professors lectured to the students on how the engine components were supposed to perform and then Don would show the students what actually happened. He did this through sharing his knowledge about gas turbine technology, with reference to parts whose critical features he would evaluate, and with incisive diagrams that made complex engine layouts intelligible to undergraduates. One of us (EMG) cotaught two subjects with him for several years and remembers not only learning a great deal from classes that Don led, but also feeling envious of the attention students paid and their subsequent end-of-term written reviews of the instructors.

In retirement he enjoyed activities with his wife, Ruby (Brown), children, and grandchildren. His interests included singing with the Glastonbury (CT) Chorus, tennis, and sailing.

In connection with the last of these, he developed a storm survival device for seagoing sailing yachts and fishing boats that is used in many parts of the world.

He was predeceased by his first wife, Anne Willcox Jordan. He is survived by Ruby; daughter Lucy Jordan, of Utah; three sons and daughters-in-law—Donald and Jennifer Jordan of Massachusetts, Matthew Jordan and Kathy Holland of North Carolina, and Peter and Susan Jordan of Massachusetts; nine grandchildren; and three great-grandchildren.

ALFRED A.H. KEIL

1913–2002

Elected in 1966

"For ship structures and explosion research."

BY PAUL E. GRAY

ALFRED A.H. KEIL, contributor to ship design for two navies, and head of the Ocean Engineering Department and later dean of engineering at the Massachusetts Institute of Technology, died at the age of 88 on January 9, 2002. He had suffered for several years with Alzheimer's disease.

In Germany

Alfred was born on May 1, 1913, in Konradswaldau, Silesia, Germany, a country village in a farming area near Breslau. He attended a private school until age 13, when he transferred to the public high school at Freiburg. In 1931 he enrolled in the University of Breslau; his education was interrupted for a year (1935–1936) when a draft of all able-bodied young German men was ordered, and he graduated in 1939 with the degree of Doctor of Natural Sciences (physics). His doctoral thesis, addressing a shift in the spectrographic fine structure of the hydrogen atom, was submitted on August 16, 1939.

Four days later, on August 20, before he could defend his doctoral thesis, he was ordered to report for active duty in the German army. He was assigned to a horse-drawn artillery regiment. On September 1, 1939, his regiment participated, behind the Panzer division, in the invasion of Poland—the beginning of World War II. The Panzers moved into Poland so swiftly that his horse-drawn regiment did not participate in the fighting. However, a horse stepped on Alfred's foot, which led to an infection and hospitalization—and made it possible for him to complete his doctoral examination. An understanding and sympathetic physician from Breslau University, who had been called up to serve in the army, arranged a pass that enabled Alfred to return briefly to the university. His thesis committee assembled quickly and his doctoral degree was awarded summa cum laude.

In November 1940 Alfred was released from the army and told to report to Keil to join the Chemisch Physikalische Versuchsanstalt (CPVA). The physics department to which he was assigned had two research groups, one for basic explosives and the other for underwater explosions. Their principal concern was the effect of underwater explosions on ship structures. Alfred's work focused on shaped charges for use on the hulls of ships and on the propagation of the shock wave. Experiments were conducted on unused ships to understand the nature of explosion damages on the hull and on the heavy machinery. This work led to his invention of more effective shock mounts for propulsion and other machinery

He had access to a very-high-speed camera that could make a succession of spark-illuminated images of moving bullets, and he adapted it to make schlieren (shadow) photographs of the propagating shock waves in a pressurized chamber used to simulate a range of depths. This work preceded by two years the shock wave research being done by the United Sates Navy.

Alfred was soon promoted to chief scientist for the group working on underwater explosives. Twice the German Admiralty decorated him in recognition of the importance of his work.

By 1944 the Allied air offensive in Europe made research at CPVA more difficult. In early 1945, when Russia moved into Germany, the CPVA moved to a less vulnerable location. Soon after the move the organization was ordered to destroy all research files and documents. Before that was done, Alfred reviewed all the files and took 35-mm photographs of documents he regarded as key. Shortly after the destruction of documents, all the CPVA personnel became captives of the advancing British Army.

After the end of hostilities the American, British, and French forces commenced a search for key German scientists and engineers. The Russian forces were doing the same, and the denial of German expertise to the Russians was a vital concern of the United States. A federal program (called Operation Paperclip) was created in 1946 to import German experts of value to US national interests. Between 1945 and 1952 this program imported 652 specialists, including 111 contracted for by the American Navy. One of those was Alfred Keil.

The laws of the time prohibited issuance of visas to German nationals. Each of these persons of interest was placed under a contract issued by the appropriate federal agency, which took full responsibility for and control of the expert in the United States. Each had an assigned military escort. Upon completion of the contract, each would return to his or her native country.

The US Navy was aware of the general nature of the explosives work done at CPVA. In June 1945 a naval officer interviewed the group led by Alfred. He brought documents recovered from a German navy yard and asked the Keil group if they would, for pay, write a summary of each document, which the group did. Impressed by this effort, the officer asked the group about their work at CPVA. Alfred and two other members of the group began writing, using as their primary source the photos of important documents taken when CPVA was shut down. When this task was completed, the naval officer in charge concluded that Alfred was the key person and placed him on a priority list for Operation Paperclip.

In the United States

In May 1946 Alfred was offered a 10-month contract to come to the United States. His family would be relocated to a camp in Bavaria where they would live and receive all his earnings. He would have quarters in the United States and receive a per diem allowance for his meals and incidentals. In February 1947 he arrived by steamship in New York City for transfer to the Bureau of Ships Headquarters in Washington, DC, to resume life and work in a new setting.

His initial status in the United States was as a foreign national supervised by an assigned personal military escort.

He was expected to be returned to Germany at the end of his 10-month contract.

In March 1947 he was assigned to the Design Division Ship Protection Branch, Code 423—the Bureau of Ships Underwater Explosions Research Division (UERD) at the Norfolk (Virginia) Naval Shipyard. He quickly learned that there was very little research and no science done there. The staff of 14 was skilled in instrumentation and data recording, but there was no analysis of test results—the recorded data were sent elsewhere for study. He reorganized the work in UERD, creating test plans and analyzing test results onsite before passing the data up the assigned channels. Also, he had built a hyperbaric research tank modeled after the tank he used in Germany to study the pulsations and migrations of the shock waves caused by underwater explosions. His high-speed photos showed that the shock wave damaged the hull and left an expanding gas bubble, void of water, outside the hull. This void was quickly filled by a battering ram of water, which did more structural damage to the hull. This was the first research undertaken on behalf of the US Navy.

His colleagues and supervisor soon recognized that he had "more experience and knowledge in the field of underwater explosion damage than anyone in the business." In August 1947 he (still an alien) was appointed acting chief scientist in the division. Two months later he was joined by his wife, Ursula, and their two sons, Michael and Juergen.

In May of 1949 arrangements were made to get a visa for Alfred. Through the joint efforts of the US Military and the US State Department, the "enemy alien scientist" was taken to the US consulate on the Canadian side of Niagara Falls, where he was issued an entry visa. He immediately crossed the bridge to the United States. A year later Alfred and his family decided to apply for citizenship, and on November 11, 1954, the Keil family became US citizens. In the same year, the quality of his work was recognized by the Navy with the first of several Meritorious Civilian Service Awards.

His work on hull designs more resistant to underwater explosions continued. His group continued testing scale models of ships and submarines (including the Nautilus), and in 1959 he went to Eniwetok Atoll to study the effects of nuclear weapons on ships, with particular reference to the consequences of shock wave reflections from the sea bottom. By 1959 Alfred was the highest-ranking civil service employee in all of the Navy's shipyards.

A Change of Venue

In July 1959 Alfred was chosen to be the technical director of the Structural Mechanics Laboratory of the David Taylor Model Basin (DTMB) in Carderock, Maryland. The laboratory had four sections: hydromechanics, aeromechanics, applied mathematics, and structural materials. As soon as he arrived at the lab, he visited with each of the section heads. The existing work arrangements required that test reports be independently reviewed four times, with changes made after each review. Reports were usually delivered late.

Alfred substantially changed the report process. The supervisor who drafted the test report presented it orally to all the supervisors in the approval hierarchy. All comments and questions were resolved at that time and were reflected in the final version and publication of the report, usually in weeks, no longer in months. Only persons who had personally participated in the effort signed reports. Soon Alfred further revised the test reporting process: Before the test, the supervisor prepared the test report with the results blank. With the test data in hand the report was filled in, the commentary written, and the review process occurred within a few days.

An important test involved a fully manned and operating diesel-electric submarine of a new design, the USS *Trout*. The explosive charges were suspended from a moored buoy and the explosions were fired when the submarine at periscope depth was abeam of the buoy. After each explosion the distance from the buoy was reduced. Six explosions were planned, but the test ended with the fifth. One week after the completion of the tests, Alfred and the DTMB researchers briefed the Secretary of the Navy and delivered a preliminary report.

Alfred's most important unclassified publication was for the Society of Naval Architects and Marine Engineers in November 1961, entitled *The Response of Ships to Underwater Explosions.*

The results of many of the tests done at DTMB showed that the shock isolation of heavy machinery in the holds of ships was very deficient. As a result of his attention to this concern much better mountings were devised and employed.

Another Promotion

In March 1963 Alfred was appointed the first technical director of the DTMB, reporting to the codirector, a senior naval officer.

He brought to DTMB greater coordination among the several research activities, operating as a single functional entity, producing test reports that would benefit the entire laboratory. In Alfred's three years as technical director, DTMB nearly doubled its staff and increased its budget by a factor of four, driven in part by the addition of a fifth laboratory concerned with acoustics and vibrations. In late 1963 he prepared a report forecasting the Navy's deep ocean strategic objectives for the next quarter century.

In July 1963 the Navy honored Alfred again:

> Through his unique combination of administrative and technical ability, Dr. Keil organized and directed the professional activities of the Structural Mechanics Laboratory of the David W. Taylor Model Basin in a manner which has achieved world wide recognition in the field of structural mechanics research. His personal contributions in the area of air blast resistant ship structures, the Navy's shock-hardening program, deep-diving submarines, nuclear weapons effects, and noise reduction of submarines have been of paramount significance to the Navy and to the defense of the Nation. For achievements of such a high order Dr. Keil is eminently deserving of the Navy's Distinguished Civilian Service Award.

During his entire career of 19 years with the Navy he received performance reports from the naval officers to whom he reported in three categories: Quality of Work; Quantity of Work; and Adaptability. For every period and every officer he was rated "Outstanding." The four Navy officers to whom he had reported nominated him for the Gold Medal of the Society of Naval Engineers, the highest professional award in its field, which he received in 1964. Throughout the last half of the 20th century, Alfred Keil's research leadership and technical achievements were responsible for all major improvements in damage resistance, shock protection, and the survivability of US Navy ships and submarines.

Massachusetts Institute of Technology

During his years with the Navy, Alfred met Gordon S. Brown, the dean of the MIT School of Engineering. A new head for the Department of Naval Architecture and Marine Engineering (NAME) was needed, and Alfred was Brown's desired nominee. Alfred had, since his time in Germany, ambitions to work in a university, and this opportunity came at the right time. On April 5, 1966, he was appointed head of the MIT department effective July 1, 1966, and on April 22, 1966, he resigned his position at DTMB.

Alfred began his work as head of the department in characteristic fashion; he talked with faculty and staff in NAME and with his counterparts in the other engineering departments. His first official act was to write the department's contribution to the President's Report for the 1965–1966 academic year. Although he was not at MIT during that year, he took on the task to study and understand the departmental and Institute budgets and administrative processes. It enabled him to ask probing questions about past happenings.

His first priority was to strengthen the research base of the department beyond ships and shipping to include all aspects of ocean resource utilization. His second priority included upgrading the technical range and expertise of the faculty, expanding and strengthening the graduate program, and addressing engineering problems using a systems approach. His third priority was to revitalize the undergraduate curriculum. New subjects were introduced; one of the first was Hydrospace Vehicles and Their Use. Computer applications received new emphasis, and in 1967 Alfred introduced a new graduate program in ocean engineering (OE).

Also in 1967, a year after his election to the National Academy of Engineering, the National Academy of Sciences presented Alfred with the Gibbs Medal for his outstanding contributions to naval architecture and marine engineering (the Gibbs Medal had been awarded only once before.) His honors and awards also include the Coast Guard's Meritorious Public Service Award, the Gold Medal Award of the American Society of Naval Engineers, the Lockheed Award for Marine Science and Engineering, and the Officers Cross of the Order of Merit of the Federal Republic of Germany. He was an active member of the National Academy of Engineering, serving on its Committee on Ocean Engineering and the Panel on Ocean Transportation, as well as several professional organizations.

In 1967 the National Sea Grant Program was established at the National Science Foundation. Alfred saw this new program as an opportunity to broaden research support. The MIT Sea Grant Program began in 1968 with a grant issued to Alfred Keil as principal investigator. The program has grown in size and scope and is now a permanent component of the Institute.

In 1970, following a year of conversations between Alfred and all imaginable stakeholders, the department changed its name to Ocean Engineering, within which was the Program in Naval Architecture and Marine Engineering. The name change reflected more accurately the scope of the department and appealed to a broader range of student interests.

Late in 1971, Alfred was asked (by this writer) to serve as dean of the Engineering School, and he accepted with two entirely reasonable conditions. He wanted a full month off duty, and he wished to appoint an associate dean.

Dean of Engineering

After careful assessment of possible candidates, Keil appointed Professor James D. Bruce, then executive officer of the Department of Electrical Engineering. This team proved to be a fine asset for the Institute. At his first meeting with his associate dean and the department heads of the School of Engineering, Alfred announced that their mode of operation with the Council of Deans would change. While each department head had responsibility for the administration of his department, as a group in the Council they would be expected to collaborate and function as a "board of directors" for the school. Their first responsibility would be to work for the good of the school as a whole. His leadership in this respect was essentially the same as his practice in each of his three leadership positions during his 19 years working with the US Navy.

He soon put forth a broader challenge for engineering education, based on his conviction that the school should take into account the growing problems of a society that has become more dependent on technology and too frequently suffers from its abuse. Engineers should be prepared to analyze the needs for and the likely impacts of new technology. His view was that the scope of the engineering profession must evolve and broaden to encompass four types of engineers: innovative technologists, practicing designers, engineering scientists, and systems engineers.

In his first year as dean, Alfred revolutionized the way faculty salaries were administered in the school. Previously, department heads distributed salary increases to the faculty so that each individual received the same percentage increase. Alfred insisted that each department head generate lists, separately for assistant, associate, and full professors, based on their contributions, broadly construed, in teaching, research, and public service. The sizes of the increases were expected to correspond to the lists, with individuals at or near the top of the rankings receiving the largest percentage increase while those at the bottom may not receive any increases. In spite of considerable grumbling by the department heads, this merit-based allocation was enforced. In a year or two it was widely recognized as an improvement, and it became the standard pattern in the Engineering School and eventually spread to other schools at MIT. Managing this change of practice was seen as one of Alfred's most significant contributions to the Institute.

In 1974, Alfred hosted representatives of the Doherty Foundation for briefings on the Sea Grant Program's use of the funds provided in 1970. The visitors were impressed and hinted that a new proposal would be looked upon favorably. He suggested a grant that would support research for two or three years on any marine-related topic by promising untenured faculty. This idea was approved by the foundation in 1974 and since then two or three junior faculty have held Doherty research grants each year. Alfred seldom missed the chance to raise research funds.

During his time as dean he, at Jim Bruce's suggestion, created a summer program for underrepresented minority students at MIT. The program was named MITE—Minority Introduction to Engineering. The program, now known as MITES, continues at the Institute. Other lasting educational programs include the Center for Technology, Policy and Industrial Development and a Program in Technology and Policy.

In 1973 the Center for Transportation Studies, drawing on faculty from several engineering departments and headed by Professor Paul Roberts, was inaugurated. In 1973, the Technology and Policy Program, led by Professor Richard de Neufville, was created, drawing on faculty from other schools and from the School of Engineering. These continuing new foci for research and education reflect Alfred's lifelong desire to shake up the status quo.

By the mid-1970s several new issues affected the Institute, including relatively high inflation and flattening federal research support. Alfred recognized that there would necessarily be constraints on appointments of new faculty. He and Jim Bruce developed an early retirement program that was adopted Institute-wide, and effectively employed by the School of Engineering. In his belief that an alternative to the present primary structure of eight departments in the school would provide greater opportunities for faculty collaboration and better alternatives for teaching and research, Alfred put together a proposal for a structure built on four organizational units: electrical, information and computer sciences; materials and chemical sciences; mechanical and thermal sciences; and engineering sciences related to civil systems and their engineering applications. In spite of many discussions and Alfred's efforts to address all questions, faculty support in 1975 was insufficient to depart from the historical departmental structure.

The pace at which Alfred operated, and the continuing constraints on resources, took a severe toll, and he asked in

December 1976 to be relieved of his position by June 1977. On August 31, 1977, he was relieved as dean and appointed Ford Professor of Engineering, a position he held until his retirement in July 1978.

In his capacity as Ford Professor of Engineering, Dr. Keil became increasingly concerned about what he called the "wiser use" of science and technology and the importance of considering their interrelationship and resulting impacts on broad societal issues such as quality of life, economic development, preservation of resources, and national security. Reflective of his deep commitment to MIT and education, he prepared a November 1984 document for MIT titled "Wiser Use of Science and Technology: The Theme for Providing Coherence, Unity and a Shared Purpose for MIT." He remained an active participant with MIT throughout the 1980s when health issues caused direct interactions with MIT to cease.

Alfred Keil, in his service to two navies and to MIT, brought to every enterprise he touched exceptional energy, a deep interest in and commitment to his colleagues, unusually effective administrative skills, and a mind always searching for new and better ways to address every question or problem.

Karl Taylor Compton, president of MIT from 1930 to 1949, had this motto: *Leave every campground better than you found it.* Alfred may never have heard that expression, but his entire career reflects Compton's saying.

Author's Note

I am deeply grateful to Dean A. Horn, retired Captain in the US Navy, alumnus of MIT, and director of the MIT Sea Grant Program. Together with Byron Laursen, he authored *Alfred Keil, Multiple Genius*, published by the MIT Sea Grant Program in 2001. I relied on this book for factual information about Alfred's life before his arrival at MIT.


Clyde E Keeler

CLYDE E. KESLER

1922–2011

Elected in 1977

"For contributions to the understanding of fatigue, fracture, creep, shrinkage, and relaxation of concrete."

BY WILLIAM J. HALL

CLYDE KESLER was born on May 7, 1922, in Condit Township, Illinois, to Roy and Helen Kesler. He graduated from Champaign High School in 1939 and from the University of Illinois at Urbana-Champaign (UIUC) with a BS in civil engineering in 1943.

After earning his undergraduate degree, Kesler enlisted in the US Army, serving during World War II in General Patton's Third Army and attaining the rank of captain. After the war, he served until 1946 in the US Army Corps of Engineers Reserves with the ultimate rank of major. He received his UIUC MS degree in 1946 in civil engineering with an emphasis on structural engineering.

Kesler married Mary Anne Kirk on July 20, 1947. They had two sons, two granddaughters, and five great-grandchildren.

Beginning in 1947, Kesler held positions in the University of Illinois Department of Theoretical and Applied Mechanics (TAM), becoming a professor in 1962. Thereafter he held appointments in TAM and civil engineering jointly, and retired in 1982 with the rank of professor emeritus.

During his career Kesler was active in a number of technical and professional organizations, including the American Concrete Institute (president in 1967), the American Society of Civil Engineers, and the American Society of Engineering Education. He was also active in community affairs, for example, the Champaign School District Board of Education. He was a member of Wesley Church in Urbana.

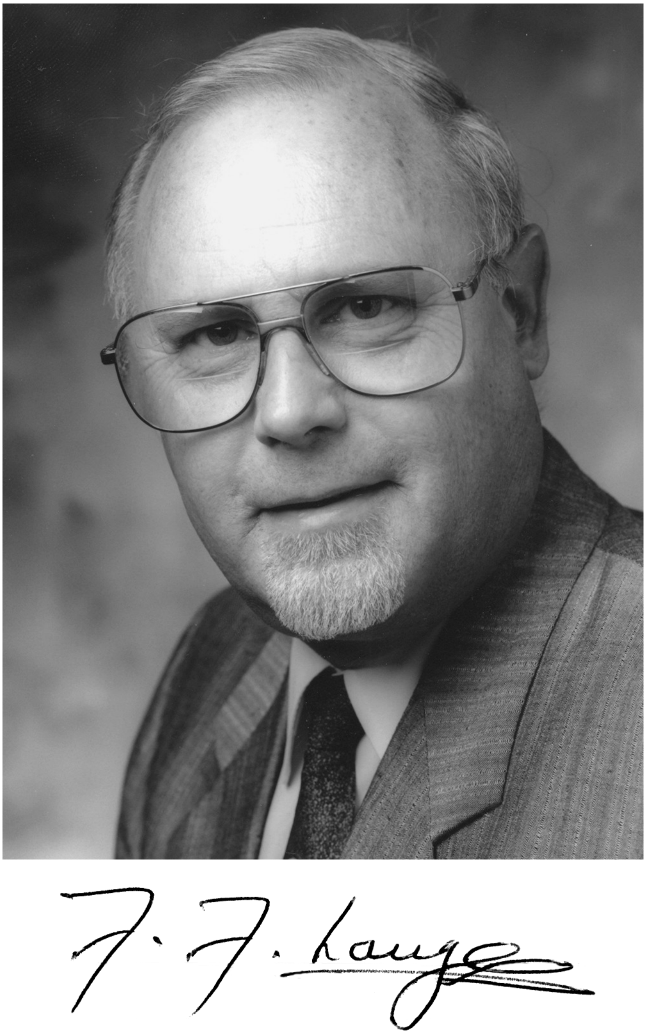
Kesler was an expert in the properties of cements, additives (for example, fibers, for which he held a patent), and aggregates of many kinds for reinforced concrete. He carried out basic research on fatigue strength, cracking, and durability of concrete materials. He was called to be a consultant in such matters by scores of companies in the United States and overseas.

Kesler was honored with many awards, including the prestigious American Concrete Institute Lindau Award in 1971 and the Halliburton Education Leadership Award from the UIUC College of Engineering in 1982. In 1977, he was elected to membership in the National Academy of Engineering, the highest honor an engineer can receive.

Kesler achieved national and international fame when, in 1970, instead of having his concrete class cast the usual cylinders and small beams, he challenged them to build a concrete canoe as a class project. A year later Purdue joined in the building and racing competition, and the concept thereafter blossomed nationally and internationally, today involving thousands of college students worldwide. In 1987 the American Society of Civil Engineers agreed to manage the competitions. The Illinois team, named the Boneyard Yacht Club after a creek going through campus, marked its 40th year in 2011. Kesler remained a supporter of the team until his death, and he is known at the University of Illinois as the Father of the Concrete Canoe.

Clyde was an outdoorsman and avid fisherman. He pursued angling as you might imagine an engineer would, customizing his bass boat, making his own rods and lures, and studying the habits of his prey. He loved nature and wildlife in general. He spent countless hours working in his yard, which contained a wide variety of trees that were home to numerous birds. His other personal interest was genealogy. He compiled the Kesler family tree, which he traced back to Westerberg, Germany, in the 1600s.

Kesler died December 30, 2011, in Champaign County, Illinois. He will be sorely missed by his family and colleagues.



FREDERICK F. LANGE

1939–2010

Elected in 1992

"For innovative contributions to the understanding of ceramic processing."

BY SHELDON M. WIEDERHORN AND SUBHASH C. SINGHAL

FREDERICK F. LANGE, an outstanding personality in the world of ceramic science and engineering, died on April 2, 2010, at the age of 70. He was recognized as one of the great contributors to the field of ceramics by all who knew him and greatly earned their admiration.

Fred, as he was known to his friends and colleagues, was born in Montclair, New Jersey, on June 8, 1939. He spent his formative years in New Jersey, graduating from Verona High School in 1957 and from Rutgers University with a bachelor of science degree in ceramic engineering in 1961. He earned his PhD from Pennsylvania State University in the field of solid state technology in 1965.

In 1961, Fred married MaryAnn Kleissler and they remained devoted friends for the next 49 years. They had four children, David, Heather, Laura, and Helena, and two grandchildren, Jessica and Joshua. Fred and MaryAnn were attending their daughter Helena's PhD (nursing) thesis defense at the University of Arizona in Tucson when he suddenly died. In addition to his scientific work, Fred enjoyed woodworking, wine making, and telling stories to his grandchildren. He also enjoyed traveling worldwide with MaryAnn.

His first job after graduation was in the United Kingdom at the Atomic Energy Research Establishment in Harwell. There he worked with Roger Davidge studying the mechanical behavior of ceramic materials. This position was memorable in two regards: it shaped the first half of his career as an expert in the mechanical behavior of ceramics, and it established the first international connection of his career.

Fred had good ideas and an attractive way of explaining them, which made him desirable in the international ceramics community as an expert collaborator and lecturer in ceramic science. This expertise eventually bloomed into positions throughout the world where he spent time teaching, learning, and collaborating with his foreign colleagues.

At the end of his stay in the United Kingdom, he went to work at the Westinghouse Research Laboratory in Pittsburgh, Pennsylvania, where he studied structural ceramics for high-temperature operation. During this phase of his career, he improved the creep resistance of silicon nitride; he showed that minimizing the amount of impurity was essential to good high-temperature behavior, and that the toughness of these materials depended on the size of the grains in their structure. These contributions were seminal to our understanding of the mechanical properties of ceramics at high temperatures, as many of the lessons learned could be applied to other ceramic materials. During his work on silicon nitride, he came to appreciate the role of processing and gradually focused on it in his research.

Beginning in the late 1960s and into the 1980s, Fred recognized the importance of the new and emerging field of fracture mechanics to ceramic materials and was one of the original editors of the conference proceedings *Fracture Mechanics of Ceramic Materials*. This series of conferences occupied a central position in the field of structural ceramics for as long as fracture mechanics was a new and expanding field. Of the 14 volumes in the series, Fred was a coeditor of the first eight.

In 1976, Fred moved to California to join the Rockwell International Science Center, where he became a group leader and a principal scientist. He was named Engineer of the Year in 1980 for his work on the space shuttle tile problem: tiles were becoming "unstuck" during space flights, and he developed a strategy to make sure they remained in place.

In 1986, he joined the faculty of the University of California at Santa Barbara with a joint appointment in the Departments of Materials and Chemical Engineering. He became chairman of the Materials Department in 1998 and was appointed Alcoa Chair and professor of materials in 1999. It was here that his research changed to processing research with an element of mechanical behavior, and later involved the interrelations between processing, phase relations, microstructure, and properties. His principal contributions included the development of ways of processing ceramic materials with higher crack growth resistance and improved reliability. He became world renowned for his work on powder processing, transformation toughening of zirconium oxide, mechanical behavior of silicon nitride, and colloidal processing of ceramic materials.

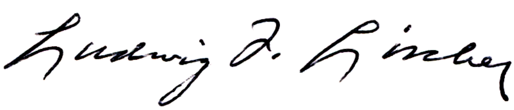
Fred Lange published more than 350 technical articles and is one of the most frequently cited authors in the field of ceramic materials. He also coauthored 32 patents dealing with ceramic materials and their processing. His outstanding work earned him 29 distinctions, honors, and awards, including membership in the National Academy of Engineering. He was a Humboldt Senior Fellow in 1993, won the Max Planck Research Award in 1997, and in 2009 was selected for the Richard Brook Prize by the European Ceramic Society and the W. David Kingery Award by the American Ceramic Society.

Paraphrasing from an editorial by Richard Brook, editor of the *Journal of the European Ceramic Society*, Fred Lange's research was distinguished by three characteristics. First, he tackled problems of practical significance. He recognized the importance of structural faults in powder bodies and concentrated on ways of eliminating them. He presented his conclusions in ways that were helpful to the practical engineer. His was not "ivory tower" research but a sound response to practical problems.

Second, Fred's research results were rapidly transferred into teaching. All who heard his research absorbed the results and wanted to hear more. Fred made a particular effort to be sure that he was understood. He concentrated on research outcome rather than initial uncertainties of the results. He was also generous with colleagues at the beginning of their careers, taking time to see that they understood him and giving help where it was sought.

The third aspect of his work was its international scale. He participated fully in international meetings and held a number of important positions in countries outside the United States, including at the following institutions: Max Plank Institute in Stuttgart, Germany; Chalmers University, Sweden, as Jubilee Professor in 1983; University of Tianjin, China, in 1985; University of Melbourne, Australia, as a Miegunyah Distinguished Fellow; Institute of Materials Research and Engineering (Singapore) as a member of its Scientific Advisory Board; and National University of Singapore as a visiting professor.

At Fred's 65th birthday celebration, Prof. Anthony Evans, friend and colleague for more than 40 years, complimented Fred by saying that if you wanted to know where the important work was being done in processing or in the mechanical behavior of ceramic materials, look to see what Fred Lange was working on. Fred was unique; he will be sorely missed in the ceramics community.



LUDWIG F. LISCHER

1915–2005

Elected in 1978

"For contributions to knowledge of electric utility systems for the development of government and industry energy policy."

BY GERALD T. HEYDT

LUD LISCHER'S office on the 37th floor of the First National Bank Building in Chicago was where many of the most important decisions of long-term energy resources and electric power transmission in the Midwest United States were made. But the background of this engineering leader was simpler and had its roots in Germany and small towns in Indiana.

Ludwig F. Lischer was born on March 1, 1915, in Darmstadt, Germany, and came with his parents Ludwig and Paula Lischer and sister Ilse to the United States in 1923. He progressed through the public school system in Michigan City, Indiana, graduating from the Michigan City High School in 1933. In view of his excellence in mathematics and science, he went on to the electrical engineering program at Purdue University, where he graduated with a bachelor's degree in electrical engineering in 1937. Upon leaving Purdue, he joined the Commonwealth Edison Co. in Chicago where he spent almost his entire engineering career of 43 years.

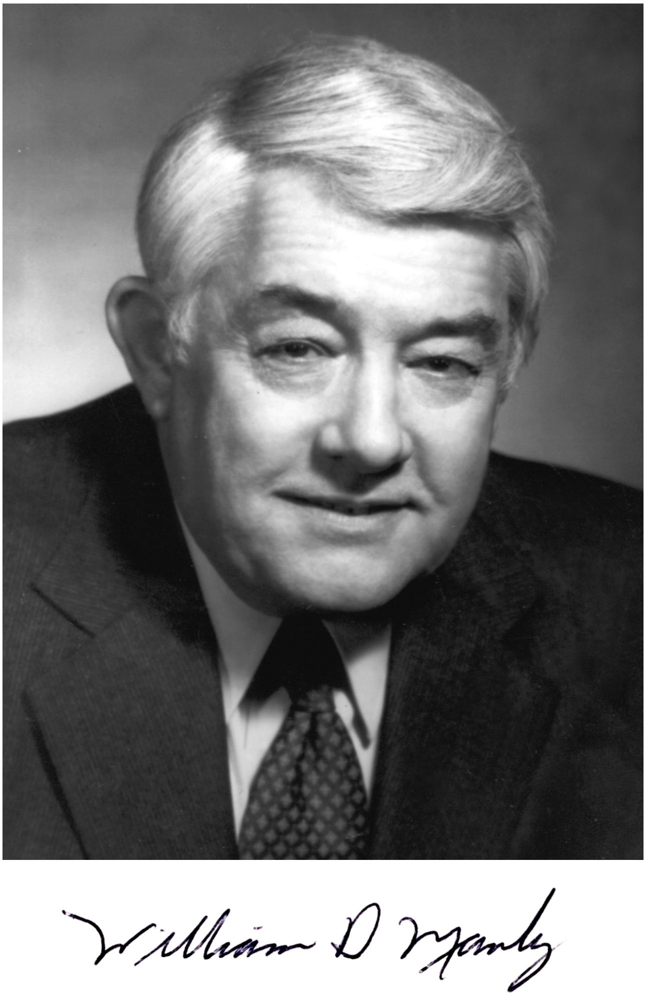
Lud had visionary thoughts of the power industry, and he was recognized at Commonwealth Edison by being appointed assistant head planning engineer in 1958, progressing to manager of technical services in 1962, and then vice president of engineering and production in 1964. In this position he headed all the electrical and mechanical engineering at Commonwealth

Edison, including transmission and distribution, power operations, and research and development. His career was interrupted during World War II when he served in the Army Signal Corps, the Army Air Corps, and the US Air Force (1941–1945), where he was promoted from first lieutenant to lieutenant colonel. He also worked for two years at Argonne National Laboratory, where he assisted in the design and initial operation of the experimental boiling water reactor II.

Lud was active in several professional societies, especially the American Institute of Electrical Engineers (AIEE). He authored technical papers on series capacitors for transmission circuits and generator stability. He was a fellow of the AIEE and later the IEEE. He served in advisory positions for the Edison Electric Institute, the Electric Research Council, the University of Illinois-Chicago Circle, Eta Kappa Nu, Tau Beta Pi, the Western Society of Engineers, American Society of Mechanical Engineers, and others. He was a cofounder of the Purdue Electric Power Center at Purdue University in 1970, where he was named a distinguished engineering alumnus in 1965 and was awarded an honorary doctorate in 1976. He was elected to the National Academy of Engineering in 1978.

Lud Lischer was best known for his service on national boards relating to energy policy. He was a founding member of the Commerce Technology Advisory Board (CTAB), and he led Project Independence (1974–1975) in preparing a roadmap for energy independence for the United States. He also was a visionary leader in the National Academy of Sciences and National Academy of Engineering for nuclear and alternative energy systems.

Lud was preceded in death by his wife Helen and his sister Ilse. He was a resident of Wheaton, Illinois. His daughter Linda is a resident of Glen Ellyn, Illinois.


William D Manly

WILLIAM D. MANLY

1923–2003

Elected in 1974

"For contributions in metallurgical development for reactor applications"

BY MURRAY ROSENTHAL

WILLIAM D. (Bill) MANLY, one of the nation's leading metallurgists and a recipient of the National Medal of Technology, died November 22, 2003, at the age of 80.

Bill was born in the village of Malta-McConnelsville, Ohio, on January 13, 1923. During the summers he worked in his family's plow factory where he poured molten metal into plow molds, thereby beginning his lifelong involvement in metallurgy.

After high school he went part-time to Antioch College, but, with World War II under way, left and joined the Marine Corps. The Marines sent him to the University of Notre Dame for a period, then to officer training and on to the Pacific where preparations were being made for invading Japan. When the atomic bombs brought the war to an end, his unit was sent to China to disarm the Japanese troops there.

Upon discharge from the Marines after three years of service, Bill returned to Notre Dame to study metallurgy, finishing with an MS degree in 1949. In graduate school he worked on the phase diagram of a nickel-cobalt-chromium system, excellent preparation for his later work on high-temperature alloys.

Bill learned about the metallurgy program that had been established to support nuclear reactor development at Oak Ridge National Laboratory and joined ORNL after his graduation in 1949. He initially worked on the ductility of beryllium and on problems with the aluminum cladding of uranium slugs used in plutonium production reactors.

His first involvement in a major project began with his leading the materials effort for ORNL's Aircraft Nuclear Propulsion Program, which built the Aircraft Reactor Experiment in which a molten fluoride salt containing uranium was circulated at 1580°F. This involved a multitude of materials problems, and Bill established a large research and development program that involved welding and brazing, powder metallurgy, creep and corrosion, nondestructive testing, and, ultimately, the development of a new nickel-base alloy called INOR-8. The state of the art was advanced in each of these areas, and ORNL's Metals and Ceramics Division was expanded into a materials R&D powerhouse whose output has been felt around the world.

The advent of long-range rockets brought the need for nuclear-powered aircraft to an end, but the development of molten-salt power reactors continued at ORNL, and another reactor, the Molten Salt Reactor Experiment, was built. It was fabricated of INOR-8 (now marketed as Hastelloy N), which performed as designed and operated corrosion-free at 1225°F for four years. During this period, Bill also became involved in the fusion program, and when asked how to create a neutron-absorbing blanket around the plasma, made the enduring reply that "if they could solve the plasma and wall problems, we could solve the blanket problem on a Sunday afternoon."

In directing the very successful materials program for molten-salt reactors, Bill had found his role as a leader of advanced development. With the expiration of the nuclear aircraft program, ORNL became responsible for supporting a new Atomic Energy Commission (AEC) program on gas-cooled reactors using stainless-steel-clad uranium-oxide fuel elements. To demonstrate the concept, the Experimental Gas-Cooled Reactor (EGCR) was built in Oak Ridge, and Bill again had the materials role, with the fuel elements his major responsibility. After several years, he was advanced to director of the entire gas-cooled reactor program at Oak Ridge, which included support work for the concept of a pebble-bed reactor based on the newly developed coated-particle fuel elements.

Largely as a result of its negative commercial outlook, the AEC's gas-cooled reactor program was terminated. However, by then Bill had left ORNL and become director of materials research for Union Carbide Corporation, which at the time managed ORNL for the AEC. In 1965 he was named director of technology for Carbide's Haynes Stellite Division in Kokomo, Indiana. Stellite was a world leader in the development and production of super alloys and thus was an ideal place for him. He made major changes in the division and advanced rapidly to become its general manager.

Stellite was purchased by the Cabot Corporation in 1970, and Bill transferred with it, remaining its chief executive officer. Soon after, he became Cabot's group vice president for engineered products, which included responsibility for a number of operations in the United States and abroad. He later was made a member of the Cabot board and moved forward rapidly, eventually becoming executive vice president of the corporation.

Bill retired from Cabot in 1986, returning to the Oak Ridge area and his hobbies of blacksmithing, collecting antique tools, and fishing. And he began serving as an advisor to ORNL on technology transfer.

Throughout his career Bill felt a strong obligation to his profession and the country, serving on many advisory committees and playing leading roles in professional organizations. He was honored as a fellow of the American Institute of Mining, Metallurgical, and Petroleum Engineers; was a fellow and recipient of a Merit Award from the American Nuclear Society; and was a fellow of the National Society of Corrosion Engineers.

Bill served as president of the American Society for Metals and received the Medal for Advancement of Research from ASM International. He was a member of the President's

Metals Properties Council for four years, served on several AEC technical committees and was a member and chairman of the important Advisory Committee on Reactor Safeguards, and was a consultant to the President's Science Advisory Committee. In addition, he served on the boards of many corporations and nonprofit organizations in Tennessee, Indiana, and Massachusetts.

Bill maintained a close relationship with Notre Dame throughout his life and received a College of Engineering honor award. Later he was presented with an honorary doctorate of engineering by the university, which noted that "In both the public and private sectors he has been at the forefront of technology transfer and cross-fertilization in American industries…and has devoted his career to improving lives the world over by making science and engineering work for people." The governor of Indiana declared him a "Sagamore of the Wabash" for his contributions to the state. And from the College of Engineering of the University of Tennessee, he received the prestigious Nathan W. Dougherty Award.

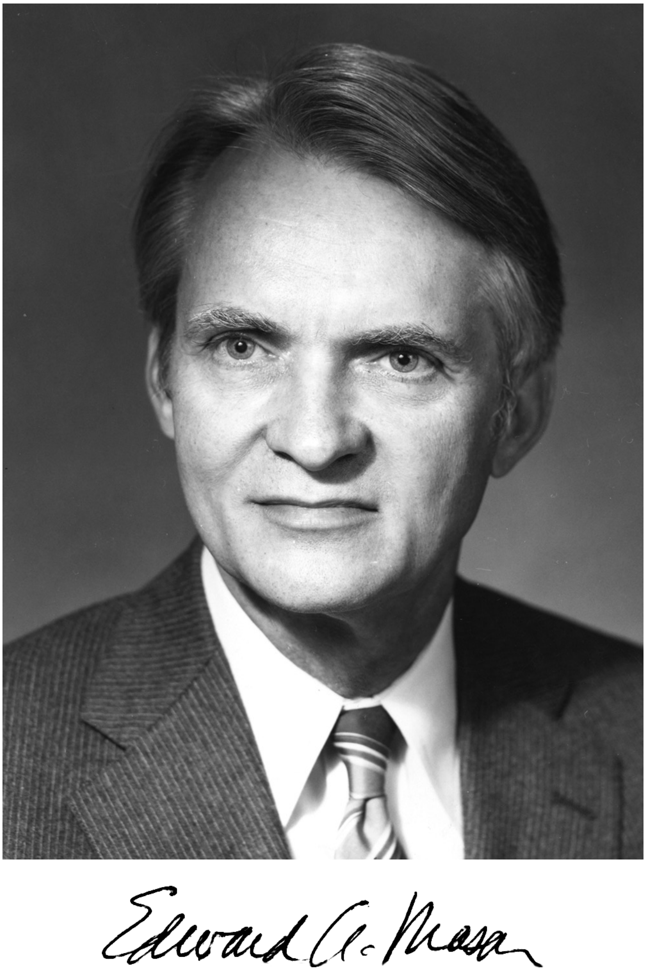
Capping his honors were his 1974 election to the National Academy of Engineering and his receipt in 1993 of the National Medal of Technology from President Clinton. The presidential citation read, "For his outstanding success in the development and processing of advanced high-temperature and high-performance materials, and the transfer of this technology to a variety of American industries."

The Manlys' generosity was widespread. At Notre Dame, two endowments for materials research bear his name, and at the University of Indiana in Kokomo, the Jane Manly scholarship aids women returning to college in their middle years. In Oak Ridge, much of the Manly philanthropy centered on the Methodist Medical Center. Special contributions were the Manly House, where families of patients can stay, and the Jane Manly Quiet Room, where relatives can confer in the hospital. Bill was a major benefactor of Roane State Community College in Oak Ridge and donated his extensive collection of Oriental art, which is displayed in the Jane and Bill Manly Gallery. He was also an active supporter of the Boy

Scouts, giving not only money but also a lot of his time, which was recognized by the prized Silver Beaver Award.

While still at Notre Dame, Bill had asked Jane, then the secretary of the Metallurgy Department, for a date. They were soon married and in 1999 celebrated their 50th wedding anniversary. Jane died shortly thereafter.

At his death, Bill was survived by his sister Sonya and by four children, Hugh Wilkinson, Ann Slautterback, and Marc and David Manly, and by numerous grandchildren and great-grandchildren.



EDWARD A. MASON

1924–2010

Elected in 1975

"For contributions to research on fluidized solids, organic-cooled reactors and power system optimization and leadership in complex nuclear projects."

BY NEIL TODREAS

EDWARD A. MASON, a leader in chemical engineering and nuclear power technology and practice, died on June 23, 2010. Ed was both versatile and accomplished in his career. He sequentially served as the director of research for a startup chemical company, Ionics, Inc.; professor and head of the Department of Nuclear Engineering at the Massachusetts Institute of Technology (MIT); member of the five-man commission directing the US Nuclear Regulatory Commission; corporate vice president for research of the Amoco Corporation; and director of several small high-technology companies as well as Commonwealth Edison, a large electric utility.

He was born on August 9, 1924, in Rochester, New York. After graduation from high school he enlisted in the US Navy and served for three years. A superior and hardworking student who had to finance his own education, he received the Rochester Prize and New York State Regents fellowships, enabling him to complete his undergraduate degree in chemical engineering at the University of Rochester in June 1945. With teaching and research assistantships he went on to complete an SM in chemical engineering practice in 1948 and an ScD in chemical engineering in 1950, both at MIT.

In June 1950 he started his academic career as an assistant professor of chemical engineering at MIT, with his first assignment as director for two years of the MIT Chemical Engineering Practice Station in Bangor, Maine. This was one of four such experimental stations operated by the Chemical Engineering Department to provide an opportunity for graduate students to obtain field experience in an industrial atmosphere. In June 1952 he returned to serve in MIT's Chemical Engineering Department until in 1953 he joined Ionics, Inc., where he soon became the director of research. At Ionics he directed research in a variety of chemical engineering processes—ion exchange, electrodialysis, electrochemistry, high-temperature chemistry and engineering, gas-solids fluidization, heat and mass transfer, chemical kinetics, analytical and radiochemistry, and water treatment. His clients were firms and agencies working in the sucrose, dextrose, gelatin, photographic, pulp and paper, caustic chlorine, power, titanium, thorium, uranium milling and refining, and nuclear reactor industries.

Mason was recruited back to MIT in 1957 to join the newly formed Nuclear Engineering Department as an associate professor. He played an influential role in the early years of the department in the development of the nuclear engineering discipline. Together with Manson Benedict and their students, he shaped the field of nuclear chemical engineering through their seminal text with Thomas Pigford, *Nuclear Chemical Engineering.* Even after leaving the department, Ed continued over many years to provide valuable advice and counsel to its evolution.

While active at MIT, his research and teaching interests were in the fields of nuclear chemical engineering, effects of radiation and heat on organic coolants for nuclear reactors, nuclear reactor design and safety, nuclear system optimization, and economics. He supervised 80 theses during his 24 years as an MIT faculty member. In 1965 he was awarded a National Science Foundation senior postdoctoral fellowship and, while on a year's sabbatical leave from MIT, carried out research at the Euratom Laboratory in Ispra, Italy. In 1967 he became director of a large international study at Oak Ridge National Laboratory on the beneficial uses of nuclear power for the production of energy-intensive materials and water desalting for large-scale agriculture in developing regions of the world. This study produced a multivolume report covering economic, technical, and sociological issues connected with the establishment of large nuclear power and desalting stations; the production of metals, fertilizers, plastics, and agricultural products; and the establishment of communities to support the entire operation.

Ed was appointed head of the MIT Nuclear Engineering Department in 1971, succeeding Manson Benedict. It was at that time that I joined the department as an assistant professor and came under Ed's guidance in teaching and research directions. He was of immense help in mentoring my development as a faculty member with his very broad background and willingness to be always available for discussions and advice.

During this period he served for four years as a member of the US Atomic Energy Commission's Advisory Committee on Reactor Safeguards. When the AEC's mandate for both development and regulation of atomic energy was split, he took leave from MIT to accept an appointment from President Gerald Ford as one of the first commissioners of the new Nuclear Regulatory Commission, beginning his government service in January 1975.

In January 1977, he accepted the position of corporate vice president of research at the Amoco Corporation and resigned from MIT and the NRC. At Amoco he was responsible for oversight of all company research and development (R&D), for senior management of all alternative energy development, and for the startup, growth, and direct management of a corporate research department. In addition to his responsibilities for coordination of research throughout Amoco, he served as the senior technical advisor to corporate management. Furthermore, under his direction at Amoco, R&D programs in genetic engineering and optoelectronics were planned, staffed, and carried out. As a result Amoco established four commercial high-technology ventures, which reported to Ed for the first four years until Amoco set up a business unit encompassing these activities. He was also responsible for the operation of Amoco's Research Center at Naperville, Illinois.

He retired from Amoco in June 1989.

Mason's honors and professional and community service activities were extensive. In addition to membership in the National Academy of Engineering and the American Academy of Arts and Sciences, he was a fellow of the American Nuclear Society, American Institute of Chemical Engineers (AIChE), and American Association for the Advancement of Science, and a member of Phi Beta Kappa, Tau Beta Pi, and Sigma Xi. In 1978 he received AIChE's Robert E. Wilson Award. Over the years he served on several National Research Council committees, including the Committee on Science, Engineering, and Public Policy, the Energy Engineering Board, the Steering Committee of the NAS/NAE China Initiative on Technology and Industrial Development, and the Board on Chemical Sciences and Technology (BCST). He cochaired the BCST's four-year study that in 1988 produced *Frontiers in Chemical Engineering Research: Research Needs and Opportunities*, which addressed the role of chemical engineering in new technologies, principally biotechnology and chemical processing for the information industry, as well as processing of energy in natural resources and environmental protection, process safety, and hazardous waste management.

Mason's service on the boards of several universities included multiple departmental visiting committees of MIT; the University of California–Berkeley Advisory Board, Department of Chemical Engineering; University of Chicago Visiting Committee, Division of Physical Sciences; National Advisory Board, Georgia Institute of Technology; and the University of Texas Engineering Foundation Advisory Committee. His service on boards and advisory committees of industrial organizations included Commonwealth Edison Company (now Exelon), where he chaired the board's Nuclear Operations Committee; XMR Inc.; GENE-TRAK Systems; Cetus Corporation; the Electric Power Research Institute Advisory Council; and the ASME Industrial Advisory Board. In addition, he gave of himself to civic service through the Council of the Crerar Library Associates, the board of directors of the Family Services Association, and the Robert Crown Center for Health Education.

Throughout his life Mason strongly influenced those whose careers he touched. His student Richard Alami, upon hearing of Mason's passing, wrote:

> Coming from Paris with a European cultural background, I soon found myself immersed in that wonderful American culture of 1958 and drawn to that temple of science—MIT. We were young, thirsty for knowledge, enthusiastic, excited by that new science—nuclear engineering—and by riveting, dynamic, friendly and brilliant professors: Manson Benedict, Kaplan, Evans, Brownell…and Edward Mason.
>
> Edward Mason—young, warm, with a legendary friendliness and always approachable—was never too busy to help, advise, and offer clear, simple and practical explanations. I was very fortunate to have had Edward Mason as my thesis supervisor, and, throughout our many exchanges, to appreciate his knowledge and technical and scientific advice. To this day, I have kept the first few pages of technical advice he gave me with his explanations on the well-known "Bucklings."

Another student, Phillip Choong, wrote:

> When I was at MIT in the late sixties (1965–1969), Prof. Ed Mason had been a rising star in the department. In my memory, Prof. Mason was always very bright, very energetic, very modest and very sensitive to students' self-respect. He gave me NASA-provided funding and turned me loose to explore the potentials of nuclear energy for space applications. In his very busy workload, he somehow managed to set aside a half-hour time slot during his lunch time weekly for me to update him on research progress. His hands-off approach really helped me gain the self-confidence that has been very beneficial throughout my career in both industry and academia. Prof. Edward Mason was a great engineer like his mentor, Prof. Manson Benedict. But more importantly, he was a very good down-to-earth gentleman just like his mentor. It is people like them that make MIT a great place for training engineers. In retrospect, I feel very fortunate to have had these two great men as my professors and thesis advisors at MIT. To this day, almost half a century later, I am still trying to emulate and replicate many of the good things I learned from them on the other side of the globe in Peking University.

Ed was a great golfer—at one point his handicap was 7—and a very good sailor, a skill he learned on Lake Ontario as a teenager. He was also a great competitor, whether it be tennis, bridge, or his favorite sport, golf, as your partner or your opponent. He loved competition. This was instilled in him during his early years when he learned that to advance or be successful he had to commit all his effort. As his children noted, he didn't always win but he gave his best every day. He was always ready to lend a helping hand, whether to serve on a committee, give some advice, help solve a problem, or be a handyman to repair something.

Mason's children recall that through these and his other interests, they as a family learned to ski, sail, golf, go camping, travel, and have adventures. His children may not have always wanted to do all these things when they were young, but he knew they needed to be exposed to new things and to push themselves. When one spent time with Ed, it was time well spent. One could expect a good tennis match or golf game from him, or he might tell a good story or joke, or maybe one would learn something about nuclear energy. You knew you were going to have a good time. Either way, by doing these things together, as a family, the relationships in the Mason family grew strong.

Edward Mason is survived by his wife of more than sixty years, Barbara, three sons, three daughters, and fifteen grandchildren. His "rules of life," which he taught his children and followed himself, and which they shared at his funeral, were:

1. Do your work before you play.
2. Always say your prayers at bedtime.
3. A gentleman always carries a handkerchief.
4. Treat other people the way you want to be treated.
5. Always read the owner's manual first.

Frank A. McClintock

FRANK A. McCLINTOCK

1921–2011

Elected in 1991

"For pioneering and sustained contributions to the understanding of the process of ductile fracture of engineering materials."

BY ALI S. ARGON

FRANK A. McCLINTOCK, a pioneering professor of engineering, died on February 20, 2011, at the Briarwood Health Care Facility in Needham, Massachusetts. He was 90 years old.

Frank was born on January 2, 1921, in St. Paul, Minnesota, son of Professor Henry Lacy McClintock and Charlotte Smith. He was educated in St. Paul before going on to earn an SB (1942) and SM (1943) in mechanical engineering from the Massachusetts Institute of Technology. During World War II he worked for three years at the Pratt & Whitney Aircraft Company, where he was one of eight engineers working on the development of the company's first jet engine. In 1946 he moved to California, where he earned a PhD in 1949 at the California Institute of Technology with a doctoral thesis on "The Fatigue Properties of Single Crystal Iron," the beginning of a lifelong absorption in the fundamental performance-limiting characteristics of engineering materials.

In 1945 he married Mary Whitmore and they raised a daughter and three sons in Concord, Massachusetts.

In 1949 he was attracted back to MIT as an assistant professor in mechanical engineering to start a distinguished academic career in mechanics and materials. He was promoted to professor of mechanical engineering in 1959 and taught and conducted research at MIT until his retirement in 1991. In 1968 he was also an honorary visiting research associate at Harvard University and in 1969 a visiting research professor at Brown University.

McClintock's research and professional activities, from the early 1950s to the late 1990s, revolutionized the understanding of the major design-limiting failure processes in advanced engineering structures and replaced much empiricism and data gathering with a search for understanding the fundamental mechanisms of fracture and fatigue. His landmark publications of that era started with the presentation of a paper on "The Growth of Fatigue Cracks Under Plastic Torsion" at the International Conference on Fatigue of Metals in 1956 in London. The paper was awarded the James Clayton Prize of the Institution of Mechanical Engineers of Britain. This was followed in short order by an equally trendsetting publication, on the plasticity of the growth of fatigue cracks in 1963, that introduced the first mechanistic rationale on the growth of fatigue cracks by irreversible cyclic crack tip distortions in ductile metals. In an equally significant paper McClintock published the first mechanistic theory of ductile fracture of metals by the growth of holes nucleated from adventitious inclusion particles. Other allied developments on "crack growth in fully plastic, grooved tensile bars" followed in 1969. These pioneering fundamental developments were summarized in 1971 in a comprehensive chapter in volume 3 of *Fracture,* part of a series of books with the same title edited by H. Liebowitz. This chapter, combining the mechanics of crack tip plastic strain distributions under local concentrated stress and negative pressure with microscopic fracture criteria involving cavitation at inclusion particles, was a model of breadth and conciseness, wedding theory with probing experiments. It quickly became a classic for creating order in a previously ill-understood, very important field of engineering.

These and other pioneering developments that brilliantly clarified complex phenomena in engineering structures to both contemporary professionals and graduate students were best put into context by Morris Cohen, the "grand old man of physical metallurgy," in a letter supporting the nomination of

McClintock for a prestigious award in 1976. Cohen wrote:

> In my opinion, Frank McClintock should be recognized as one of the world's leading authorities on the fracture of materials. I have had a special opportunity to observe his effectiveness and scope in this respect through our joint membership on the DARPA Materials Research Council. This is a group of some twenty-five experts in materials science and engineering, drawn from various disciplines such as mechanics, metallurgy, ceramics, physics and chemistry. From that vantage point, I have come to appreciate that Frank is truly extraordinary in his ability to combine many branches of knowledge, ranging from atomic forces and dislocation dynamics to continuum mechanics and macro-behavior of materials, in elucidating the nature and control of fracture. He is virtually in a class by himself in being able to interact with, stimulate and understand the foremost engineers and scientists in relevant fields, who have all important, but otherwise disconnected contributions to make in relation to the fracture phenomenon and the elastic-plastic stages leading up to the fracture event.…

McClintock's pioneering research in the mechanics and mechanisms of fatigue and ductile fracture represents only one facet of the man. Unlike many successful researchers who might be content to let their publications speak for themselves, McClintock took on with missionary zeal the task of disseminating the fundamental developments in the mechanisms of inelastic deformation and fracture of engineering materials to both students and professionals alike in the field.

In the early 1960s, I had the pleasure to collaborate with him together with Ali Argon, in thoroughly modernizing the teaching of mechanical behavior of materials to undergraduates in mechanical engineering. This involved the outfitting of a modern undergraduate laboratory and the introduction of project-type laboratory exercises where students learned to apply directly the micromechanical and mechanistic approach to complex mechanical behavior problems of their own choice. This effort also led to our coauthorship of a text on

Mechanical Behavior of Materials (Addison-Wesley, 1966) that was recognized the world over as the most authoritative educational treatment of this newly developing subject and has been translated into several foreign languages, including Russian.

McClintock's other educational innovations included the development of teaching programs for self-study of the principles of limit analysis and slip-line solutions of plane strain plasticity. In addition, he pioneered a totally new teaching concept of a "desktop experiments kit" containing common materials such as chalk, paper clips, Plasticine, silicone putty, rubber bands, and balloons with which fundamental phenomena of brittle fracture, yielding and fatigue in torsion, rubber elasticity, and strain rate effects in fracture could be investigated by the students, literally on "the tops of their desks" at home. This successful idea, which he had pilot-tested on his young children, was adopted by other educators of materials science.

McClintock gave numerous invited lectures and keynote lectures at international and national conferences, special workshops, and many universities both in the United States and abroad. He was active as a consultant to industry and introduced his consulting experiences into his teaching. In midcareer he gave his time generously to professional service activities such as the ASTM Committee E-24 Task Group on Fracture Mechanics. He served for nine consecutive summers on the Materials Research Council of Advanced Research Projects Agency (ARPA), considering a far-ranging set of materials problems of national interest in both the civilian and military sectors. In the mid-1970s he chaired a National Research Council study committee on the Mechanical Properties of Infrared Transmitting Materials for the Defense Department and another on erosion.

After his formal retirement in 1991 from active academic duties McClintock continued to make signal contributions to the understanding of the fracture phenomenon in highly important large-scale engineering applications. In one of these, in collaboration with Professor David Parks of the MIT

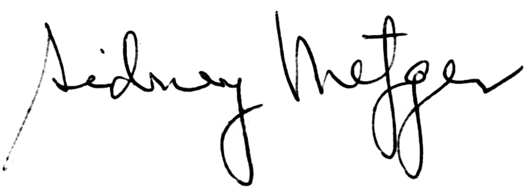
Mechanical Engineering Department, he participated in a DOE-supported three-way research activity pairing him with a group at the Idaho National Engineering (and Environmental) Lab (INEEL) and another of the DOE Savannah River Lab. In this collaboration the task was to deal with potentially catastrophic fracture problems in old rusting and corroding massive storage tanks of liquid radioactive waste at the DOE Hanford Reservation. McClintock's contributions were considered key. In another postretirement activity McClintock collaborated extensively with Professor Tomasz Wierzbicki of MIT's Ocean Engineering Department in research on the impact and crash-worthiness of naval structures. In that research, supported by the US Navy as well as by some automotive companies and the aluminum industry, McClintock's contributions were also considered decisive.

In addition to the James Clayton Prize mentioned above, McClintock's professional accomplishments were recognized by a series of prestigious honors and awards, including fellowship in the American Academy of Arts and Sciences in 1959, the Arpad Nadai Award of the ASME in 1978, an honorary doctorate of law degree from the University of Glasgow in 1981, an honorary fellowship of the International Congress on Fracture in 1989, the Howe Medal of the ASM in 1991, election to the National Academy of Engineering in 1991, the Griffith Medal of the European Structural Integrity Society in 1999, and the Daniel Drucker Medal of the ASME in 2004.

He was a member of ASME, ASM, ASTM, and ASEE. In all his activities, whether research on fracture or teaching or professional service, McClintock always strived uncompromisingly for perfection and set very high standards of achievement for himself and for his colleagues and students alike.

Throughout his life, Frank passionately enjoyed skiing, competing as a young man in downhill and cross-country skiing as well as ski jumping. He was equally devoted to hiking and rock climbing in the East and throughout the West. As a boy he learned technical rock climbing with his father, an elected member of the American Alpine Club, particularly in the San Juan and Needle Mountains of southwestern Colorado as well as the Tetons in Wyoming, where McClintock Peak was named to honor the first ascent made by Frank and his father. He shared his love of Colorado rock climbing and route finding with his children on many summer camping trips, centered around the mining town of Ouray, Colorado, nestled in the mountains. A former Eagle Scout, he served as a Boy Scout leader in Concord. He was active in the First Parish Meetinghouse as a member of the Humanist Group and served in diverse ways including as usher, church school teacher, member of the standing committee, and deacon.

He is survived by his wife of 66 years, Mary, his daughter Martha and her husband Joel Charrow of Chicago, Illinois, and his three sons: Roger and his wife Jane Jeffries who are sailing the world, currently in Borneo; David and his wife Nancy of Lyman, Maine; Richard of Denver, Colorado; as well as five grandchildren and a great-granddaughter.



SIDNEY METZGER

1917–2011

Elected in 1976

"For development of early radio relay systems and communication satellite systems."

BY DAVID METZGER, PHILIP METZGER, AND SALLY FASMAN
SUBMITTED BY THE NAE HOME SECRETARY

SIDNEY METZGER, a pioneer in the field of communication satellites, died on December 22, 2011, at the age of 94.

Sid, as he was called by all who knew him, was born in New York City on February 1, 1917, the third of four children. He was a bright, very hard working student and graduated with honors from New York University's uptown campus in 1937. He was a member of Tau Beta Pi and Tau Kappa. In 1948 he received his master's in electrical engineering from the Polytechnic Institute of Brooklyn. He started his career at the US Signal Corps at Fort Monmouth, New Jersey, in 1939. While there he helped develop radio-relay communications technology for the United States. He was the only civilian on the committee that oversaw the development and implementation of SIGSALY, the secure communications systems used by Churchill and Roosevelt during World War II.

After the war, Sid continued his pioneering work in communications technology. In 1946, while working for ITT, he was division head in charge of the development and initial production of commercial and military radio relay systems. These included early installation of 24 voice channel time-division multiplexing, 2000 MHz equipment in Canada, Mexico, Belgium, and several states in the United States. This design was later produced by various ITT companies worldwide.

In 1954, Sid and his family moved to Princeton, New Jersey, where he worked for RCA. From 1954 to 1957 he worked on satellite studies for the RAND Corporation and later for Dr. Wernher von Braun's group in Huntsville, Alabama. From 1957 to 1963 he was manager of the Communications Engineering Department of the newly formed RCA Astro Electronics Division, with technical and administrative responsibility for the communications engineering (system and equipment) for satellite projects SCORE (1958), TIROS (1960), and RELAY (1962). It was also during this time that he developed the idea for an orbital post office, which would use satellite technology to send messages over long distances. The idea was presented to the American Rocket Society in November 1958; alas, it never came to fruition (because of privacy concerns), but it was a precursor of today's email and fax technology.

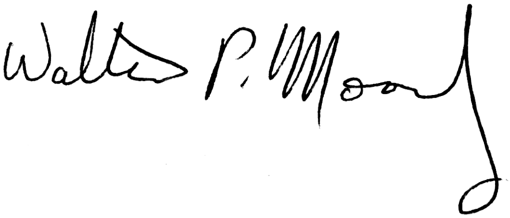
In 1963, Sid Metzger was one of the first people to join the newly formed Communications Satellite Corporation (COMSAT) as manager of the Engineering Division. His responsibilities included the engineering aspects of planning for the satellite and earth station equipment for INTELSAT I through INTELSAT IV. He was also involved with the successful development and tests of a dual polarized antenna, which formed the basis of AT&T's agreement with COMSAT for a domestic satellite.

When he retired from COMSAT in 1982, Sid was vice president of engineering and chief scientist. He then formed his own consulting firm, specializing in communications satellite problems such as radiation from both terrestrial and maritime earth stations.

Sidney Metzger was the recipient of many awards and honors. He was a member of the National Academy of Engineering, a fellow of the Institute of Electrical and Electronics Engineers (IEEE), and he received the IEEE's award for International Communications and Aerospace Electronics. In 1984 he received the Aerospace Communications Award from the American Institute of Aeronautics and Astronautics, of which he was a fellow. He served on NASA's Space Applications Advisory Committee (Communications Group), the National Research Council's Air and Space Engineering Board and its ad hoc Committee on Space Station Engineering and Technology Development as well as the NRC Committee on National Communications Systems Initiatives, and the board of Sigma Xi. In 1985 he was the recipient of the NEC Foundation's inaugural C&C Award for integration of computers and satellite technology. He was inducted into the Society of Satellite Professionals International Hall of Fame in 1993.

Mr. Metzger was well known for his regular 14-hour workdays throughout his 45-year career and for his ability to sustain such hours by taking quick naps during any nonworking activity. He would nap during meals, at concerts and Washington Senators baseball games, and once while sitting in the front row of a Manila auditorium during a lengthy speech by then-President Ferdinand Marcos of the Philippines—which led to a receiving-line snub the next day by Marcos' wife Imelda.

He took great joy in his family. He is survived by Miriam, his beloved wife of 67 years; a younger sister, Mildred; three children: David, an architect retired as principal from the firm of Heller and Metzger; Sally, a retired special-education professional in the Montgomery County (Maryland) School System; and Philip, counselor to the deputy administrator at the US Environmental Protection Agency; five grandchildren: Jonathan, Benjamin, Rebecca, Diana, and Lily; and two great-grandchildren: Leo and Zephyr. He deeply grieved the death in 1999 of his adored grandaughter, Sarah Emily. His family remember him with love for his serious dedication to work and commitment to inquiry lightened by a dry but gentle sense of humor; his consistent calm under stress; the values of diligence, honesty, and thoroughness, which he lived as much as he imparted; and for his dignity, modesty, and loving-kindness.



WALTER P. MOORE JR.

1937–1998

Elected in 1991

"For leadership in improving the quality of creative designs."

BY JOSE ROESSET

WALTER P. MOORE JR., an internationally known structural engineer and chairman of the board of Walter P. Moore and Associates Inc., died on June 21, 1998, of injuries suffered in an automobile accident on April 4 of the same year.

Walter was born in Houston, Texas, on May 6, 1937. His father, Walter P. Sr., had founded in 1931 a one-person structural engineering consulting practice where Walter Jr. started to work in 1953, becoming deeply interested in structural design and in learning more about it. Motivated by his experience in the firm he attended Rice University, where he obtained a bachelor of arts degree in 1959 and a bachelor of science in 1960. This was followed by a master of science in civil engineering at the University of Illinois at Urbana-Champaign in 1962 and a PhD from the same institution in 1964.

After serving as a captain in active duty in the US Army Corps of Engineers, Omaha Division, and technical director of the Protective Structures Branch from 1964 to 1966, he joined his father's firm. The company had gained national recognition due to its involvement in the structural design of the Astrodome, and was incorporated in 1967 with Walter Jr. as a principal. Since then the company has grown in size and reputation both nationally and internationally. In addition to its headquarters in Houston, it now has offices in Atlanta, Austin, Dallas, El Paso, Kansas City, Las Vegas, Los Angeles, Orlando, San Francisco, Tampa, Tulsa, and Washington, DC, and is recognized as a leader in the design of tall buildings, sports arenas, and unusual innovative structures. It was ranked among the top three engineering firms to work for by Structural Engineer for six years in a row, and number 1 in 2008.

Walter P. Moore Jr. received a large number of awards during his life. He received the Distinguished Alumnus Award of the University of Illinois in 1990 and the corresponding award in 1991 from the Civil Engineering Department of Rice University. In 1991 he was also inducted into the National Academy of Engineering and in 1992 he was an honoree of the Houston chapter of the Achievement Rewards for College Scientists and received the Alfred E. Lindau Award of the American Concrete Institute. He was an honorary member of the American Society of Civil Engineers, the American Consulting Engineers Council, and the American Institute of Architects. In 1995 he was named Master Builder by the Associated General Contractors.

Walter was extremely active in professional societies. A registered professional engineer in 28 states, he was a member of 12 different professional groups. He served in numerous technical as well as management committees of the American Society of Civil Engineers (including an executive committee), the American Concrete Institute (including its board of directors), and the Consulting Engineers Council of Texas (member of the board of directors, vice president, and president). He was equally active in civic and religious commissions and boards. He was an active member of St. John the Divine Episcopal Church, and was a member of the boards of directors of the Houston Engineering and Scientific Society, the Harris County Heritage Society, the Kiwanis Club of Houston, and the Forest Club. He chaired the finance committee for the sesquicentennial of the state of Texas and the United Way architects and engineers group.

He was also involved in the activities of various universities: the Rice University Engineering Alumni Association and Engineering Advisory Council, the University of Illinois Advisory Committee on the Effects of Earthquake Motions on Reinforced Concrete Buildings, the Civil Engineering Visiting Committee of the University of Texas at Austin, and the Engineering Advisory Council of Texas A&M University. While serving the two rival Texas universities he maintained his allegiance to his alma mater. When asked once what team he favored when UT and TAMU played against each other his answer was straightforward: "I do not care which one wins; I am a Rice alumnus."

In addition to his advisory positions, he lectured at Rice University as an adjunct professor from 1975 to 1982, at Cornell University in 1986, and at the University of Illinois in 1988–1989.

In 1993 he retired from the day-to-day operations of the firm and took a full-time position at Texas A&M University, with a joint appointment in the College of Architecture and in the Civil Engineering Department of the Dwight Look College of Engineering as holder of the Thomas A. Bullock Endowed Chair. In this capacity he clearly illustrated the value to engineering education and to society in general of a prominent practicing engineer taking early retirement and joining the academic ranks as full-time faculty. Walter provided a link between the architecture and the civil engineering programs, two complementary but unfortunately all too often disjoint undertakings. He also founded the Center for Building Design and Construction, directed the Center for Construction Education, and revitalized the Structural Laboratory.

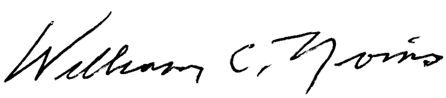
Whereas many young faculty members join universities directly after completion of their doctoral studies without any practical exposure to real-life engineering, and in particular to design and construction, Walter was able in his classes to provide unique insight into the creative and practical aspects of design, emphasizing the integration of the analysis, design, and construction processes and of the activities of architects and structural engineers. He also placed particular emphasis on the need to communicate effectively. Equally important was his contribution mentoring young faculty just as he had mentored his coworkers at the firm. His achievements at Texas A&M University endure but one can only imagine what the civil engineering program might have become were it not for his tragic and untimely death.

When the Moores moved to College Station in 1993 they were immediately a very popular couple. They were both extremely sociable and open. Walter was equally at ease talking to professional and academic architects and engineers and he knew through his experience at the firm how to successfully involve persons with different backgrounds in common activities. He frequented equally the favorite local restaurant of the civil engineering faculty and that of the architects (a better one). He was very popular on the golf course not only because of his classic and distinctive attire and his tendency to slice the ball but also because of his joyful disposition.

His achievements as an engineer are there for anybody to see: in Houston, there's the Miller Outdoor Theater, known for its striking exposed cantilever roof framing; the First City Towers, a 49-story building with a very specialized structural system; the 46- and 42-story office buildings of One and Two Houston Center; the Summit Arena; the Astrodome World park; the Southwestern Bell Houston area headquarters building, a 665-foot long building without expansion joints; the Exxon Chemical Americas headquarters; and the Hyatt Hotel; as well as the 60-story NCNB (now Bank of America) Tower in Charlotte, North Carolina, and the IBM Tower at Atlantic Center in Atlanta, Georgia, among others.

Walter P. Moore Jr. was survived by his wife, Mary Ann Dillingham Moore, his high school sweetheart whom he married in 1959 and who died in 2004; by his children Walter Parker Moore III, MD, and wife Sarah, Melissa Moore Magee and husband Michael Magee, and Matthew Dillingham Moore and wife Valerie; his brother Robert Laurence Moore and wife Lauris McKee; four grandchildren; and his coworkers at Walter P. Moore and Associates and colleagues at Texas A&M University who admired, respected, and loved him.

Walter was never pretentious, arrogant, or overbearing. He was always a humble man, open, caring, and ready to help anyone. He was an outstanding engineer with great creativity, initiative, and originality, and a successful entrepreneur, a born leader, who gave generously of himself.



WILLIAM C. NORRIS

1911–2006

Elected in 1988

"For leadership in the design and manufacture of powerful, high-speed computers, primarily for engineering, scientific, and military applications."

BY JAMES WINTERER
SUBMITTED BY THE NAE HOME SECRETARY

WILLIAM C. NORRIS, a giant in the development of the nation's computer industry, was widely regarded as a pioneer in the development and use of technology, the role of business in addressing social problems, and the importance of entrepreneurs in developing small businesses. He died on August 21, 2006.

Norris was the founder and chairman emeritus of the famed Control Data Corp. and helped launch dozens of Minnesota companies. He founded Control Data in 1957 and retired as chairman and chief executive officer in 1986.

From 1988 through 2000 he chaired the nonprofit William C. Norris Institute, which supported efforts to improve education through the use of technology, to stimulate technical training in Russia, and to help launch technology-based small companies in disadvantaged neighborhoods of St. Paul and Minneapolis.

In 2001 the institute merged with the University of St. Thomas' Opus College of Business and moved to the university's downtown Minneapolis campus. The mission of the institute has been to support the commercialization of innovative, socially beneficial technologies by Minnesota entrepreneurs.

"William Norris knew Monsignor Terrence Murphy (the late president of St. Thomas) for many years," explained Michael Moore, director of the Norris Institute. Their friendship, and the

College of Business' programs in entrepreneurship, provided a good setting and permanent home for the institute, Moore said. "The institute is one of Mr. Norris' lasting legacies," he added.

"Throughout my business career I have seen how innovation and creation of good new jobs begin at the entrepreneurial level, yet management and capital resources for start-ups are woefully inadequate. This relationship with St. Thomas will provide the full range of resources to help entrepreneurs start innovative companies in the various communities of our state," Norris said in 2001.

Born July 14, 1911, with his twin sister Willa (who died in July 2006) in Red Cloud, Nebraska, Norris grew up on his parents' cattle, hog, and corn farm, which his grandfather homesteaded in 1872. Bill, Willa, and an older sister attended a one-room country school, where physics became his favorite subject. He was fascinated with the new field of electronics and built a mail-order radio set, becoming an avid ham radio operator. He graduated from the University of Nebraska in 1932 with a degree in electrical engineering.

His first job with Westinghouse Corp. was followed by five years of service in the US Navy during World War II, where he became involved in electronic equipment that was the forerunner of today's computers.

Norris became an entrepreneur after World War II, when he started Engineering Research Associates Inc. (ERA) in St. Paul. ERA pioneered the development of the digital computer and in 1951 merged with Sperry Rand Corp. Norris headed the Univac Division of Sperry Rand through mid-1957, when he and other engineers left to start Control Data.

Under his leadership, Control Data pioneered large-scale scientific and engineering computers, computer services, and the use of technology in education. Its PLATO computer-based education and training program was the world's major pioneering effort in applying computer technology in education. Norris also pursued new business opportunities by working with the public and nonprofit sectors to address major social problems such as unemployment, blighted inner cities, and declining rural economies. Small-business incubators and Job Creation Networks supported by Control Data across the country led to more than 1,000 new companies and 13,000 jobs. And Control Data assisted its own employees to develop and spin off more than 80 new technology-based companies.

During his 29 years as CEO of Control Data, Norris led many collaborative initiatives involving government, universities, and business and industry. For example, in 1983 he conceived and initiated the Microelectronics and Computer Technology Corp. based in Austin, Texas; the company currently has more than 60 members and associate members that collaborate on research and development with each other and with government laboratories and universities.

Norris was instrumental in the drafting and passage of the National Cooperative Research Act of 1984 and the Technology Transfer Act of 1986, leading to the creation of the federal grant programs for Small Business Innovative Research and Small Business Technology Transfer Research. In Minnesota, Norris helped organize and lead the Northwest Growth Fund, Minnesota Seed Capital Fund, Minnesota Cooperation Office, Minnesota Wellspring, and the Greater Minnesota Corporation (now Minnesota Technology Inc.), and with Control Data's help he established the William C. Norris Institute. All of these initiatives supported entrepreneurship and sought to improve Minnesota's economy by assisting small companies in creating jobs.

In 1986, Norris was awarded the National Medal of Technology and Innovation by President Reagan, who cited him for "substantial contributions to the development of digital computer technology, leading to the founding of a successful computer and computer services company, and for his innovative application of computers to societal needs, as well as his initiation of cooperative efforts which promise to maintain US competitiveness in microelectronics and computer technology."

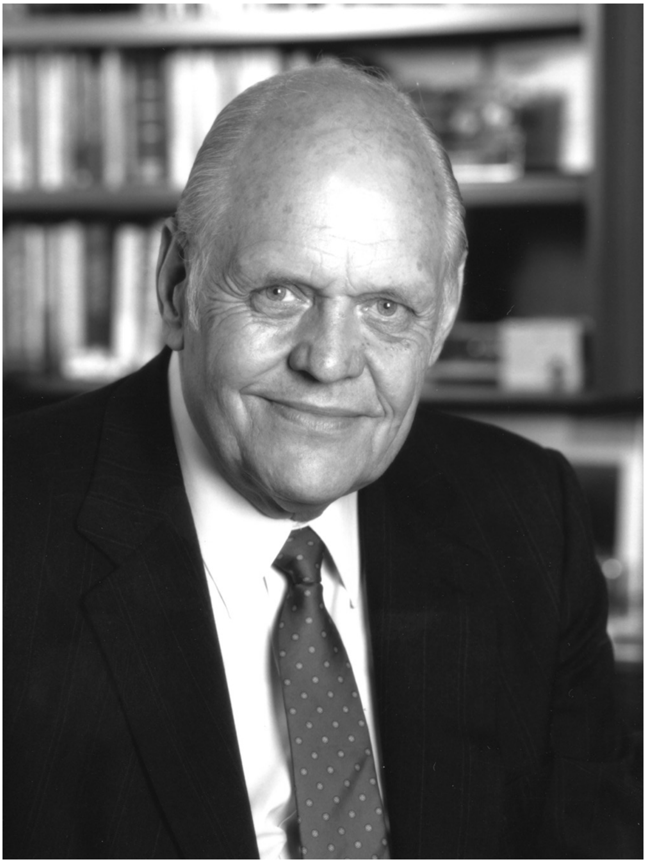
Norris also received the Institute of Electrical and Electronic Engineers' Founders Medal and the National Business Incubation Association Founders Award. In 1995 he received the Lifetime

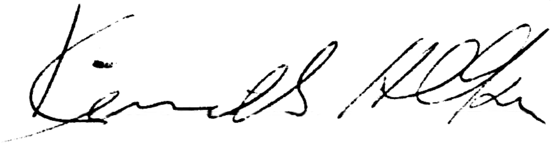
Achievement Award of the Minnesota High Technology Council, and in 2001 he received a lifetime achievement Tekne Award from the Minnesota High Technology Association and Minnesota Technology Inc. In 2005, he received the Ellis Island Medal of Honor for outstanding contributions to the United States, and in 2008 he was posthumously inducted into the University of Nebraska's Computing Hall of Fame.

Bill was an avid fisherman and loved to read and work crossword puzzles. He kept physically active his whole life through daily walks or swimming and believed in the importance of exercise. He had an active interest in the lives of his children and many grandchildren.

Bill is survived by eight children; his wife Jane passed away in 2009.

This slightly modified write-up originally appeared in the online publication Bulletin Today on August 21, 2006. It is reprinted with the permission of the University of St. Thomas.





KENNETH H. OLSEN

1926–2011

Elected 1977

"For leadership in the design and manufacturing of computers."

BY ROBERT R. EVERETT

KENNETH H. OLSEN, one of the great pioneers in the development of digital computers and the computer industry, founder and former CEO of the Digital Computer Corporation, died on February 6, 2011, at the age of 84.

Ken was born in Bridgeport, Connecticut, in 1926 and raised in Stratford, Connecticut, where he showed an early interest in electronic devices, including repair of radio sets. Following service as an electronic technician in the US Navy during World War II, he entered the Massachusetts Institute of Technology (MIT), where he earned a BS (1950) and an MS (1952) in electrical engineering.

He joined the MIT Lincoln Laboratory where he worked on the development of computers for the SAGE Air Defense System. He contributed to the development of Jay Forrester's Magnetic Core Memory and built his first computer, the MTC, designed for testing the first core memories as well as many other SAGE components. He spent time as a representative of Lincoln at the IBM Corporation, which was building the SAGE computers. While at IBM, he saw an opportunity to start a company to design and market computers that were smaller and less expensive than the large mainframes then being produced by IBM.

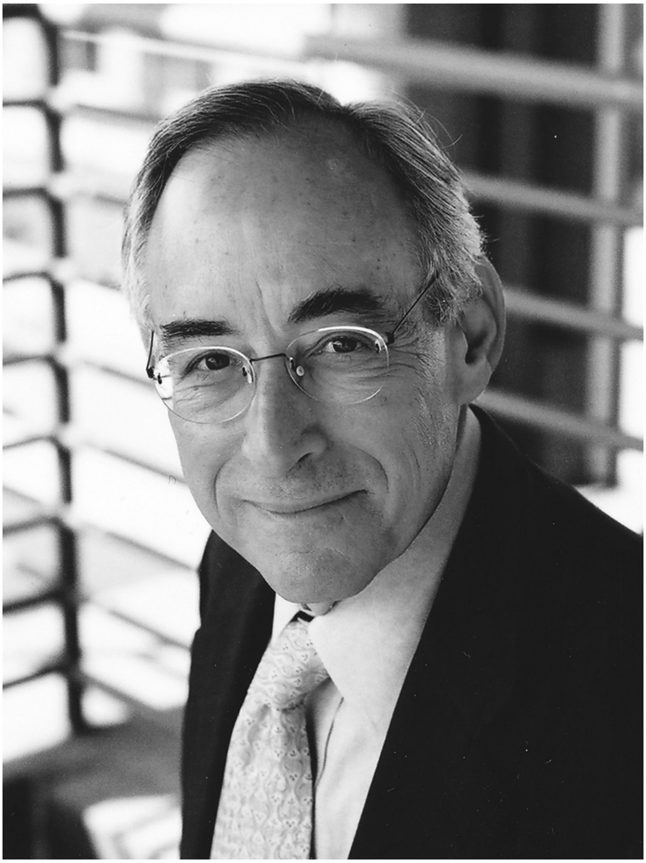
In 1957, Ken left Lincoln to form, with Harlan Anderson, the Digital Equipment Corporation (DEC) where Ken served as CEO for 35 years until his retirement in 1992. DEC became a great success under his vision and leadership. *FORTUNE* Magazine named him "America's Most Successful Entrepreneur." At its peak, DEC was the second largest computer company in the world.

Ken and DEC created the minicomputer industry by developing small, inexpensive, but powerful computers that found wide use in almost unlimited applications throughout commerce and industry, including manufacturing, control, and design. They were widely used as components in other makers' devices. Ken and his company pioneered in other aspects of the development of computing, including interactive computing, operating systems, networking, application software, manufacturing, and business processes. Ken set the culture of his company, insisting always on quality, customer focus, employee empowerment, and, above all, honesty and integrity.

Ken received many honors, including the National Medal of Technology, and was named to the Inventors Hall of Fame. He served as chair of the Computer Science and Engineering Board of the National Research Council and as a member of the President's Science Advisory Committee, the MIT Corporation, and the board of trustees of Gordon College.

Ken was an active member of the Park Street Church in Boston. He had a strong commitment to his faith that meshed with his values, business ethics, and scientific inquiry. In his quiet way he was an active philanthropist and generous contributor to worthy causes. Among his many gifts is the Ken Olsen Science Center at Gordon College.

Ken's wife of 59 years, Eeva-Liisa Aulikki Olsen, died in March 2009.



M. KENNETH OSHMAN

1940–2011

Elected in 1982

"For outstanding innovation and engineering of digital-computer-controlled, private-branch telephone systems."

BY BOB MAXFIELD
SUBMITTED BY THE NAE HOME SECRETARY

M. KENNETH OSHMAN, a Silicon Valley icon, died on August 6, 2011, at the age of 71 from complications of lung cancer.

He was an original Silicon Valley entrepreneur whose personal vision and passion created not one but two industry-leading companies that developed revolutionary technologies. One, ROLM Corporation, paved the way for today's voice communication technology, and the second, Echelon, is a major player in control networks and the smart grid. Ken was a brilliant leader who served as an inspiration to everyone around him, and he created a culture where hard work and collaboration just came naturally.

Commenting on his impact on Silicon Valley, the *New York Times* wrote: "With a gentle, understated style, Mr. Oshman stood apart from other well-known leaders in Silicon Valley, many of whom were seen as capricious and even tyrannical. He was a mentor to a generation of Silicon Valley technologists and able to inspire a kind of loyalty in his employees not frequently seen in high-tech industries."

Ken was born in Kansas City, Missouri, on July 9, 1940, but grew up in the small community of Rosenberg, Texas, just outside Houston. Rosenberg was home to a close-knit Jewish community, and Ken attributed much of his business acumen to lessons learned from his uncle, Milton Robinowitz, a larger-than-life cowboy and rancher who gave Ken the opportunity to learn the cotton-trading business as a teenager.

Ken was at the top of his class as an engineering student at Rice University, where he earned a BA in 1962, summa cum laude, and a BS in electrical engineering in 1963. He married his high school sweetheart, Barbara Daily, in 1962. He was accepted into the Harvard MBA program, but was recruited instead to move to California to work for Sylvania Electronic Products in the brand new field of lasers.

He worked as a member of Sylvania's technical staff from 1963 to 1969 while earning an MS EE (1965) and a PhD EE (1968) from Stanford. His dissertation advisor, Steve Harris, described Ken as a brilliant off-the-charts student and, at the same time, a kind and gracious human being.

Ken's PhD dissertation was entitled "Studies of Optical Frequency Parametric Oscillation" and was completed in the exceptionally short time of two years (October 1965–December 1967). The major contribution of this work was the first observation of what is now termed optical parametric fluorescence or parametric down conversion. Ken's paper was published just four months ahead of comparable work at Moscow State University. Over the years parametric fluorescence has become the near-standard light source for experiments with entangled photons, Bell inequalities, and quantum information. In 2011 alone, more than 40 years after it was published, Ken's paper was cited 11 times.

In 1969, Ken cofounded ROLM Corporation with three partners: Walter Loewenstern, Robert Maxfield, and Gene Richeson. All four had undergraduate degrees in EE from Rice and EE graduate degrees from Stanford. ROLM's initial business was making rugged "milspec" minicomputers for military applications. Within three years the company had built a highly profitable business bringing an "off-the-shelf" standard product approach to a defense industry accustomed to designing new computers from scratch for each new application.

But Ken was concerned that the market was not large enough to build a major company, and he pushed his team to identify new market opportunities in the commercial sector for computer technology. The decision was made to enter the telecommunications market by pioneering the application of digital switching and computer control to PBXs (private branch exchanges—corporate telephone switching systems). In this market, the primary competitor would be AT&T, then the largest corporation in the world. Needless to say, many people, including some of ROLM's venture capital backers, believed the management team had gone mad.

When the ROLM CBX (computerized branch exchange) came to market in 1975, ROLM had annual revenues of about $6 million in its milspec computer business and about 100 employees. Within five years the company's annual telecommunications revenues were well over $100 million and it was one of the top three players in the PBX market. ROLM's many innovations to modern voice systems included integrated voice messaging, digital telephones, and integrated voice-data terminals.

Although ROLM was a great business success, its chief contributions to the evolution of Silicon Valley were cultural. Under Ken's leadership, the management team created the best example of an emerging Silicon Valley management style that effectively broke down the barrier between work and play. The philosophy was that by focusing on making the company a great place to work (known to all as "GPW"), the company would be able to recruit the best and brightest employees. Examples of its innovations include a company-paid three-month sabbatical for every employee after six years, cash profit sharing for all employees, and an on-site recreation center with a pool, racquetball courts, exercise rooms, and other amenities. Variations of these pathbreaking innovations are now widely incorporated in Silicon Valley culture.

Ken was a charismatic leader who was intensely loyal to his employees and treated them as extended family, and they reciprocated. He inspired everyone with his unfailing optimism and great sense of humor, especially when times were tough.

In 1984 ROLM was acquired by IBM at a valuation of $1.8 billion. Ken Oshman became a vice president at IBM and a member of its corporate management board until he left in 1986.

In 1988 Ken joined forces with A.C. (Mike) Markkula, an early Apple investor, to build Echelon, a control networking company that pioneered peer-to-peer networking of devices, such as thermostats and lights, using a tiny programmable control chip called the Neuron. He served as Echelon's CEO and chairman until 2009, when he became executive chairman. To date over 100 million devices have been installed with this technology in many applications, most notably in recent years as a critical component in the "smart grid," enabling energy-efficient systems for utilities, business, and homes. And of course Echelon is known as a great place to work.

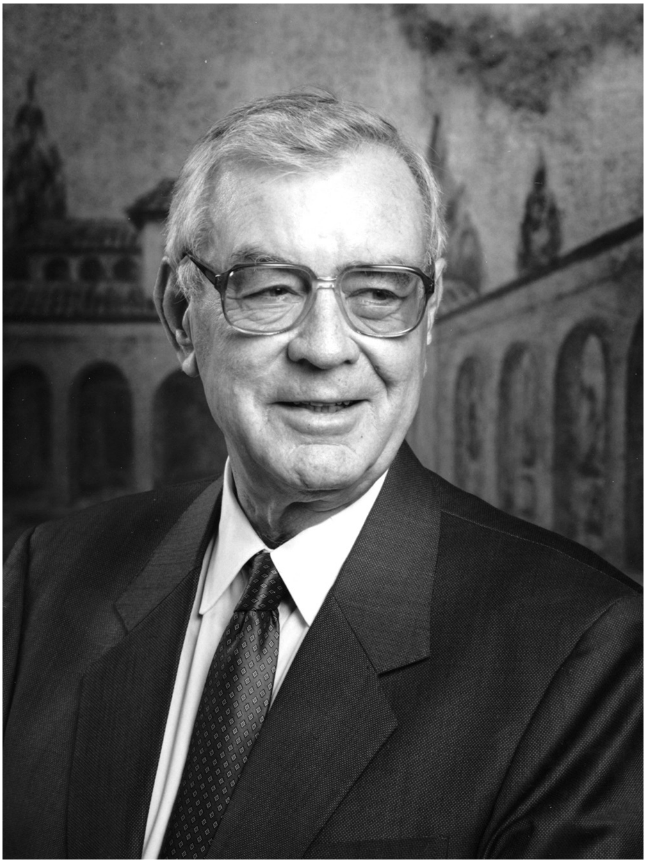
In spite of the demands of being CEO of high-tech companies, Ken made time for numerous leadership roles in the community and industry. He served as president of the board of the Stanford Alumni Association and was a member of the Advisory Council of the Stanford Graduate School of Business, the Stanford Associates, and the board of directors of the Community Foundation of Santa Clara County. He was an American Electronics Association director for five years, serving as its chairman in 1977; a director and chairman of the Santa Clara County Manufacturing Group; and a member of President Reagan's Economic Policy Planning Committee and the Committee to Advise the President on High-Temperature Superconductivity. He served on Rice University's board of governors from 1984 to 1988 and its board of trustees since 2004. He lent his business expertise on the boards of Sun Microsystems, Knight Ridder, ASK Corporation, StrataCom Inc., Charles Schwab Corporation, and Just Answer, among others.

Ken Oshman was elected to the National Academy of Engineering in 1982. He was a recipient of Rice University's Distinguished Alumnus Award in 1984 and the Rice Outstanding Engineering Alumnus Award in 1993. He was a member of Phi Beta Kappa, Tau Beta Pi, Sigma Xi, and Sigma Tau honorary societies.

He was an extremely generous philanthropist, supporting a wide range of worthwhile causes. He endowed engineering chairs at both Stanford and Rice and made the lead gift to establish the Oshman Engineering Design Kitchen at Rice, a state-of-the-art design facility that enables students to realize their required design projects through cross-disciplinary collaboration and cross-technology training. His family foundation was the lead donor in a campaign to build Palo Alto's new Jewish Community Center, which opened in 2009 and was named in the family's honor.

Ken enjoyed golf, opera, good cigars, fine wine, and spending time in Hawaii.

Even with all of his professional accomplishments, Ken felt the most important thing in life was his family, whom he loved dearly. He is survived by his wife of 49 years, Barbara, his sons Peter and David, their wives, and four grandchildren.



CHARLES J. PANKOW

1923–2004

Elected in 1997

"For contributions to the application of innovation in construction engineering."

BY DEAN E. STEPHAN

CHARLES J. PANKOW JR., a leading innovator of building techniques in the construction industry, a pioneer in the integration of design and construction processes in commercial construction, and founder and CEO of Charles Pankow Builders, died on January 12, 2004, at the age of 80.

Charlie was born in Indianapolis, Indiana, on October 6, 1923, to Bess and Charles Pankow. He was the middle child in a family of three siblings. His exposure to the construction industry occurred early in life. His father, a graduate of the University of Illinois in architecture, spent his career managing major construction projects. Most of Charlie's childhood was spent in South Bend, Indiana, and he took great pride in the fact that his father was the superintendent for the construction of the Notre Dame stadium, a complex project completed in record time for that era.

Charlie responded to his boyhood interest in engineering design and construction by entering Purdue University to study civil engineering. As with so many at that time, his education was interrupted by World War II and he entered the US Navy as an ensign. His tour ended in Japan in 1946 and he returned to Purdue to complete his studies. Upon receiving his bachelor of science degree in civil engineering in 1947, he and bride Doris traveled to Los Angeles, California, to start his career in the construction industry.

His first job was in the structural engineering office of S.B. Barnes as a junior engineer designing public infrastructure buildings. In 1951 his love of construction led him to accept a position with the Peter Kiewit Construction Company in its Arcadia, California, office. While there his keen engineering mind, construction and management skills, and creative energy became apparent and he soon rose to become the manager of Kiewit's building division.

Charles Pankow's hallmark was determination, and that determination spawned numerous innovative solutions to difficult construction engineering problems. Thin shell construction of the San Diego Convention Center, horizontal slip forming of the concrete piles for the Hayward Bridge across the San Francisco Bay, slip forming of the vertical structural concrete elements of high-rise buildings, molding complex architectural concrete shapes for building exteriors, and the use of prestressed reinforcement in precast concrete structural elements are achievements that bear witness to his belief that "if you are good, you can find solutions; anyone can find problems."

During this time Charlie's growing awareness for the need to integrate the design and construction process if innovative building techniques were to be efficiently incorporated into construction projects caused him to leave Kiewit in 1963, at age 39, and form his own construction company. There was no work in hand or in sight, just his reputation for finding solutions to difficult design and construction problems. Operating out of the basement of his home, with Doris keeping the books, he proceeded to build a company whose projects have reshaped skylines from Long Island, New York, to the Hawaiian Islands.

Two keys to the success of the company are, first, his belief that the application of innovation in construction engineering could beneficially impact the cost and quality of commercial buildings. The company formed alliances with architectural and engineering firms to design and build projects that incorporated innovative technologies and construction practices and provided owners with a single source of responsibility for the on-time and within-budget delivery of their project.

The second key was his ability to transfer to the culture of the company his determination to succeed through innovation and creative solutions. In managing his company, he didn't dictate his concepts or solutions to others. In fact, it was unwise to present a problem and request a solution. He had his own ideas but he wanted you to present yours, reflecting his belief that your only limit should be your imagination. That approach to design solutions and construction means and methods resulted in unfettered participation by all parties to the construction process and created a special company with a major impact in a very traditional industry.

Charles Pankow had a restless energy and always felt that everything could be improved on and more could be accomplished. A saying in the company captures his refusal to rest on past achievements: "Others seek to copy what we have long since made obsolete."

Charlie's accomplishments have been recognized over the years by awards and accolades, including an honorary doctorate of engineering from Purdue University (1983); the distinguished Alumnus Award, Purdue University (1970); the American Society of Civil Engineers' Presidents' Award (1994); the American Concrete Institute (ACI) Roger H. Corbetta Award for "Innovative methods of construction leading to significantly increased efficiency and economy in the use of concrete" (1974) and its Henry C. Turner Medal (1990); election to the National Academy of Engineering by his peers (1997); and it was with great pride that he lent his name to the prestigious Civil Engineering Research Foundation's Pankow Award for Innovation.

He sought to advance the competence and professionalism of the construction industry by actively participating in various industry organizations. He was president of ACI in 1983 and served on its board of directors from 1974 to 1984; he was also a founding member of the Civil Engineering Research Foundation, serving from 1988 to 1993, and an active member of the Construction Industry Presidents Forum, American Society of Civil Engineers, Engineers Club of San Francisco, Structural Engineers Association of Southern California, American Society of Concrete Construction, and Urban Land Institute.

Charlie continued to mentor young construction engineers and led his beloved construction company until the day of his death. Other than the scores of young engineers he inspired and whose careers he helped mold, perhaps the greatest testament to the construction engineering skills of this extraordinary man are the thousands of housing units and millions of square feet of office buildings, retail space, hospitals and healthcare facilities, hotels, and recreational facilities that his company built. These are buildings that enhance society and enable its commerce—silent monuments across this land that bear testimony to the ingenuity, honesty, and perseverance of this remarkable man. He is greatly missed.

His son wrote:

> Quiet and focused, confident and determined, I remember noting when I was around 21 years old, he was the most disciplined man I knew; today he is the most disciplined man I have ever known. My Dad was unique, he didn't teach with words, but through example—his life being one. I recall one time when I was 19 on a visit to New York City; he took us boys down to the Bowery to meet some of the more unfortunate souls on this planet. It was an uncomfortable experience, but one I never forgot—exactly what he wanted.
>
> My Dad believed in a few basic axioms that he carried with him throughout his life:
>
> - whatever you can imagine you can do
> - the word CAN'T should be removed from the dictionary
> - true leadership is leading first and creating consensus last
> - the United States of America is the greatest example of freedom and hope the world has ever seen
> - telling corny jokes is OK
>
> My mother was by his side from the day they left Illinois through all the adventures of pioneering a career and life in California, including raising a family of four children. When we were growing up, his work kept him from home quite a bit, but in spite of his demanding schedule, he managed to recruit every single sponsor for

our town's first Pony and later Colt baseball leagues. Even as a young baseball player, I never really appreciated that until I was older.

Many years ago I asked my grandmother, his mom: when did he know what he wanted to do? And she said, one summer when the family took their vacation they drove out of South Bend on one side of town and returned two weeks later driving back in on the other side. When he realized where they were, he actually asked to go back to the other side of town before going home so he could see the progress being made on the only building under construction at the time in South Bend—he was six years old.

He was the champion of the CAN DO spirit and attitude that if something is worth doing it's worth doing right the first time. Yet, for as long as I can remember he kept a sign over his desk that said "The worst day of fishing is better than the best day at work." This is the only sign he ever kept.

Photo courtesy of Special Collections, Sheridan Libraries, Johns Hopkins University

OWEN M. PHILLIPS

1930–2010

Elected in 1996

"For analyses of multivaried ocean, atmospheric, and geological flow processes of importance in ocean and environmental engineering."

BY MARSHALL P. TULIN

OWEN MARTIN PHILLIPS, Decker Professor of Science and Engineering at the Johns Hopkins University (JHU), chairman of the JHU Department of Earth and Planetary Sciences, widely known for his penetrating fluid dynamical studies of important ocean and geophysical problems, beloved teacher, mentor, colleague, beloved husband of Merle, and father of Lynette, Christopher, Bronwyn, and Michael, died on October 13, 2010, in Chestertown, Maryland, at age 79.

The son of an Australian veteran of both world wars, Owen was born December 30, 1930, in Parramatta, New South Wales, a small, prosperous agriculture-based town near Sydney that dates to 1788, the year of the earliest British presence in the new Australian colony. He grew up in the countryside in a family of four children and entered the University of Sydney in its engineering program in 1948, graduating in 1952 with a bachelor's degree in applied mathematics with highest honors. Thereupon he traveled to England to undertake doctoral studies in fluid mechanics at Cambridge University.

Centered in the Cavendish Laboratory, the field was then in a constructively growing and fruitful stage under the inspiration and leadership of the Australian George Bachelor, and under the most beneficial influence of Professor (later Sir) G.I. Taylor, then in his 70s and legendary for his innovative and physically trenchant solutions to engineering and scientific problems. Bachelor and Allen Townsend had traveled to Cambridge from Australia in 1945 to study turbulence under Taylor, who had in preceding decades initiated the statistical approach soon dominating that field. They remained in Cambridge, Bachelor carrying out elegant mathematical studies culminating in the classic "Theory of Homogeneous Turbulence" (1953), and Townsend carrying out extensive experimental studies in small wind tunnels culminating in the ground-breaking "Structure of Turbulent Shear Flows" (1956). Their research led to the inauguration of the *Journal of Fluid Mechanics* (JFM) in 1965 by Bachelor; it remains the most respected journal in its field 50 years later.

It was to this particularly exciting and stimulating place and to these highly gifted and original scientists that Owen Phillips came, becoming part of Bachelor's Turbulence Group, soon receiving his doctorate (1955) and quickly initiating his own distinctive research reported in 10 papers between 1955 and 1958. In these earliest papers Phillips already displayed the exceptional characteristics that marked all his future works: a ready dedication to real and substantial physical problems needing explication; an ability to combine physical understanding and simplification with lean but elegant and cogent mathematical analysis; refined scholarship; a readiness to provide useful answers; a curiosity and ambition for extending and broadening his scientific inquiries; and a specific interest in and attraction to scientific problems of the ocean. In addition, he showed a remarkable tendency and capacity for work, all the more notable in view of his calm, sunny, and genial nature.

Scientific attention to the then unanswered question, "How does wind generate ocean waves?," was drawn in a decisive *Review* (1956) by Fritz Ursell, a mathematician working with G.I. Taylor in Cambridge and later successor to Sir James Lighthill as chair of mathematics at Manchester University. The question had not been on the agenda of the Cambridge Turbulence Group, but Phillips responded immediately with his 1957 paper "On the Generation of Waves by Turbulent Wind" (JFM) and, in 1958, went on to bring scientific order to the broader question of the nature of the newly described spectral disposition of ocean wave energy with "The Equilibrium Range in the Spectrum of Wind-Generated Waves" (JFM). In this paper, the equilibrium ocean wave energy spectrum is deduced from dimensional considerations alone after a breathtaking physical simplification, i.e., that the slope of individual waves is uniquely determined and universally limited by wave breaking. Almost immediately, and thereafter, the "Phillips Spectrum" dominated the description and understanding of the distribution of energy among ocean waves, even as the question became of greatly increased importance in the approaching age of great ocean structures and of ocean remote sensing from space.

Phillips moved on from Cambridge in 1957 to the Johns Hopkins University, Baltimore, where he remained until his retirement in 1998 apart from a multiyear break in Cambridge as an assistant director of research (1961–1964). On his return to Hopkins he resumed and steadily broadened his studies of surface and internal ocean waves, culminating in his classic book *The Dynamics of the Upper Ocean* (Cambridge University Press, 1966; 2nd edition, 1977), dedicated to George Bachelor. It has been translated into Russian (1980) and Chinese (1983).

In the forefront of his many developments and discoveries is his explication, beginning in 1960, of nonlinear multiwave interactions of surface gravity waves, and particularly the theory of four-wave resonant interactions, allowing the transfer of energy between spectral elements. This surprising discovery had an immediate and profound influence on the rational study of ocean wave dynamics, leading in subsequent decades to the development by oceanographers of computer-based and rational large-scale wave forecasting. Owen's initial papers (1960) on nonlinear wave interaction marked the beginning of a new age of understanding of ocean wave dynamics, and his subsequent books provide even today the theoretical basis for our modern understanding of ocean and internal waves.

He was awarded the Adams Prize by the University of Cambridge for his book in 1966 and in 1968 was elected fellow of the Royal Society of London. In 1975 he received the Sverdrup Gold Medal of the American Meteorological Society. In 1996 he was elected a member of the National Academy of Engineering.

Phillips' fundamental ocean studies and discoveries continued in ensuing years, including his description of the spectral balance process. There are, indeed, few natural phenomena involving surface or internal waves arising in nature to which he did not give his attention, including internal wave generation, spectra, and propagation; circulation and mixing in estuaries; clear air turbulence; extreme and rogue waves; V-shaped ship wakes; and radar remote sensing of the ocean surface.

His interest in geological processes led to "assembling fragments of evidence" in *The Heart of the Earth* (1968; translated into Italian in 1970), and his curiosity and concern about the future of the world's hydrocarbon supply and the question of "peak oil" resulted in *The Last Chance Energy Book* (1979; translated into Japanese in 1983). Research on the physical nature of permeable rocks and the motion of fluid elements through the medium led to the publication of *Flow and Reactions in Permeable Rocks* (Cambridge University Press, 1991) followed by *Geological Fluid Dynamics* (Cambridge University Press, 2009).

He was much sought after as an engineering consultant and provided valuable analyses on far-ranging questions about, for example, nuclear waste disposal in rock formations, the feasibility of locating a nuclear plant near the Chesapeake Bay, the prospects for the magnetohydrodynamic propulsion of ships, and detection through ocean remote sensing.

He was a faithful and diligent member of his scientific community, serving as president of the Maryland Academy of Sciences and as a longtime editor of the *Journal of Fluid Mechanics* and the *Proceedings of the Royal Society*. His balanced judgment and wisdom were widely appreciated, and he in turn contributed generously, serving on many government boards and committees throughout his career.

His widow, Merle, wrote:

> Understanding his geophysical surroundings was of consuming interest to Owen, but this was tempered by a range of pursuits. When at home, Owen was present for his family. His workshop was a favorite haunt where a child's toy was mended, items of furniture built, and the broken made to work. Growing lettuce under cold frames in February was a challenge as was detecting chemical deficiencies in plants. Frequently Owen was invited to lecture or read a paper at international meetings, and this led to world travel with me and at times with the family. For almost 40 years, Owen and I enjoyed a summer home on Cape Cod just up the road from the Woods Hole Marine Biological Labs where Owen had done some work.

This kind, gentle, brilliant man is much missed, beyond his beloved family and his university, by his admiring colleagues throughout the world, including his former students, many of whom are researchers themselves. His passion for research and rare ability to analyze and explain the complexities of the oceans and the earth will not easily be replaced.

Edward W Price

EDWARD W. PRICE

1920–2012

Elected in 2000

"For critical contributions to the understanding of solid propellants combustion and solid rockets developments."

BY BEN T. ZINN, MICHAEL MASSICOTT,
AND CAROLYN MASSICOTT

EDWARD WARREN PRICE, a world-renowned expert in the fields of solid propellants combustion and solid propellants rockets, passed away on June 11, 2012, in Atlanta, Georgia, at the age of 91. His wife, Mary-Kate, passed away in 1992. He is survived by his children, Douglas Price of Ridgecrest, California, Carolyn Massicott of Atlanta, and Allison Tamara Parks of Alpharetta, Georgia.

Ed, as he was known to friends and colleagues, was born December 6, 1920, in Pontiac, Michigan. He was raised in the Arizona desert in an impoverished homestead located in the "Apache Country," in a single-room home now known as the Landmark Stafford Cabin near Faraway Ranch. The home and the ranch have since been placed on the National Register of Historic Places in what is now part of the Chiricahua National Park and Wilderness Area. Ed and his family were allowed to live on this property by its kind owners in exchange for light work. This act of generosity strongly impacted Ed's outlook on life, prompting him to be kind to those around him for the remainder of his life.

Upon graduating from a twelve-grade single-room school in 1938 at age 17, Ed joined the Civilian Conservation Corps (CCC), which provided young men with room and board during the Depression in exchange for work. Although his high school was among the most impoverished in the nation, Ed attributed his successful career to the town's only teacher, a young lady who was good at teaching math, an experience that made Ed a lifelong supporter of public school education. His modest upbringing, educational experience, and involvement with the CCC galvanized Ed's personality, providing him with a great appreciation for the importance of a strong work ethic and economic and intellectual independence.

Upon completion of a year of service with the CCC in 1939, Ed enrolled in Pasadena Junior College, where he studied mathematics and competed in track and field. He left school in 1941 for financial reasons and started working at Caltech on static firing of rocket motors. In 1944 he left his job at Caltech to enlist in the Navy when the Selective Service ordered him to report. The Navy assigned him to work on solid propellants charge design and combustion at the Naval Ordnance Test Station (NOTS) in China Lake, California. He received an honorable discharge in January 1946 and continued working in China Lake until October, when he enrolled at UCLA and went on to earn a double bachelor's degree in mathematics and physics in 1948.

Upon graduation, Ed returned to China Lake to work as a physicist at NOTS, which eventually became the Naval Weapons Center (NWC). In 1955, he became the head of NWC's Research Department Gas Dynamics Branch and was assigned to work on the design and testing of propellants charges and internal ballistics. During his years at NWC, Ed became an internationally respected expert in the fields of solid propellants combustion and solid propellants rockets. He made seminal contributions to the understanding of internal ballistics of solid propellants rocket motors, combustion instabilities in solid propellants rockets, ignition and combustion of solid propellants, aluminum and other metals, and the development of the "T-burner" testing method that has been further investigated by researchers and adapted by companies throughout the world. Ed also developed novel approaches and devices for controlling combustion instabilities and regulating thrust in solid propellants rockets and improving the combustion of solid propellants.

In 1974, after 30 years of service, Ed left the NWC to become a full professor at the Daniel Guggenheim School of Aerospace Engineering at the Georgia Institute of Technology (Georgia Tech). Notably, although he never earned any advanced degrees or studied engineering, he was hired as a full professor of aerospace engineering! In fact, Ed was a "self-made" PhD in engineering whose outstanding contributions to the understanding of solid propellants combustion and solid propellants rockets, along with his widely quoted publications, provided Georgia Tech with the justification needed to hire him as a full professor. Ed proceeded to develop an outstanding research program on solid propellants combustion at Georgia Tech while educating many undergraduate and graduate students. For his contributions to research and education, he was promoted in 1986 to the rank of Regents' Professor, an honorary professorship. He retired from Georgia Tech in 1991, but continued to do research until nearly the end of his life.

Ed contributed to the advancement of solid propellants rockets technology in the United States by serving on important government and professional society committees. He was nominated as a member of the AIAA Solid Rockets Technical Committee in 1961 and became its chairman in 1963. He was also selected in 1963 to chair the Solid Rocket Combustion Instability Subcommittee that was established in the Department of Defense Interagency Chemical Rocket Propulsion Group. In 1964, he was invited to serve on the AIAA Publications Committee, and in 1965 he was appointed to the AIAA Technical Activities Committee. He was elected in 1966 as one of the directors-technical of the AIAA Board, and as AIAA vice president in 1967. Ed also served on the National Research Council's Panel on the Technical Evaluation of NASA's Proposed Redesign of the Space Shuttle Solid Rocket Booster, following the 1986 explosion of the Challenger.

Ed's contributions to science, engineering, and the literature were recognized with the following awards: the L.T.E. Thompson Award (1960), NWC's highest individual achievement award, for "his outstanding research in internal ballistics, for his contributions to the understanding of the fundamental design parameters of rocket motors, and for his timely research in combustion stability"; the AIAA Dryden Lectureship in Research Award (1967) for "initiation and sustained leadership of research efforts designed to elucidate the mechanisms of ignition and the burning characteristics of solid propellants"; the AIAA's Pendray Aerospace Literature Award (1972) for "continued outstanding contributions to the literature of solid rocket internal ballistics and combustion, particularly for his contributions on combustion instability and ignition"; the Navy Superior Civilian Service Award (1974), the Navy's highest honorary award; the coveted AIAA Goddard Award (1975), which is presented to a person "who has made a brilliant discovery or series of outstanding contributions over a period of time in the engineering science of propulsion or energy conservation"; the Joint Army-Navy-NASA-Air Force (JANNAF) Interagency Propulsion Committee Certificate of Recognition (1985) for "outstanding contributions to chemical propulsion technology and service to JANNAF"; and the Space Flight Awareness Silver Snoopy Award (1989). He was elected to the NAE in 2000 in recognition of his "critical contributions to the understanding of solid propellants combustion and solid rockets developments."

Ed's long and productive life serves as an example that with intelligence and hard work, any person can succeed in life. Through his hard work and dedication, Ed rose to become one of the world's foremost solid propellants combustion and rockets experts.

It is appropriate to close this tribute to Ed with the following quotes from his colleagues and students.

From Fred Culick, professor emeritus at Caltech:

> I am forever indebted to him for giving me my first break in 1964 in the research area of solid propellants rockets. And that was only the beginning! Ed continued to help me in so many ways for more than

forty years. I could always count on him for insightful advice and encouragement. Above all, Ed was totally forthright and honest. Ed will always remain a superb example of how to be with other people. One especially good attribute of Ed is that he totally biased my view of really dedicated civil servants! I don't see how anybody can ever surpass his dedication and belief in principles. He was remarkably alert and productive to the end...an example for all of us.

From Professor Satyanarayanan R. Chakravarthy in the Department of Aerospace Engineering at the Indian Institute of Technology, Madras (IITM):

Professor Price means a lot to me. It wouldn't be an exaggeration to say that he has shaped me. His approach to science and life has left deep impressions and has influenced my behavior since my association with him for several years in the 1990s as his graduate student and a post-doctoral fellow. His general knowledge and sense of history was overwhelming. I consider myself fortunate to have not only learned science at his feet but also a first-person account of how America grew during the tumultuous period through the Depression, war, and growth, stuff we can only think about and gasp! He was a fine human being; he took it upon himself to stop especially for me at a second place to get my lunch for our research group meetings because I am vegetarian. Even now I unhesitatingly share my hotel room with my grad students when attending conferences primarily because he did it for me when I was his grad student.

And from Thomas L. Boggs, retired Chief Scientist for Energetics and head of the Research Department Engineering Sciences Division (the old Aerothermochemistry Division) at China Lake:

I always felt deeply honored to be asked to lead the Engineering Sciences Division in the Research Department because it was the merger of Ed's old Aerothermochemistry Division and John Pearson's old Detonation Sciences Division. There were many diverse research studies going on, with Ed involved in all of them. He led the efforts in some, while playing a supporting role in others through his keen insight and probing questions. Ed was always encouraging people to seek out the basic physics and chemistry of combustion and to not be afraid to make a mistake. Ed made sure that we understood that when you are doing research, you will make mistakes and that is just part of the process.… Ed was a great leader, wonderful mentor, and a good friend.

ROBERT A. PRITZKER

1926–2011

Elected in 1991

"For innovative use of industrial engineering and management principles in the growth and development of diversified product-based manufacturing operations."

BY ROBERT M. NEREM

ROBERT ALAN PRITZKER, an industrial engineer, industry leader, and philanthropist, died on October 27, 2011, in Chicago, the city where he lived most of his life, at the age of 85.

Bob, as he generally was called, was born on June 30, 1926, in Chicago. He was the grandson of Nicholas J. Pritzker, who came from the Ukraine to Chicago in 1891 at age 10. Nicholas Pritzker worked in menial jobs, taught himself English, and eventually earned a law degree. He married and had three sons who all joined him at the firm Pritzker & Pritzker. One of his sons was Bob's father, known as A.N. Bob's brothers, like his father and uncles, also became lawyers. Thus, Bob was to become the first engineer in a family of lawyers.

In his youth Bob played the drums in a jazz combo called Swing and Jive with the Foul Five. Bob says that "the band was every bit as good as its name," and this may quite possibly explain "why none of its members went on to a career in music." Bob did, however, go on to a career in engineering, graduating in 1946 at the age of 19 from the Illinois Institute of Technology (IIT) with a degree in industrial engineering. This was after a short stint at Caltech. He also attended the University of Illinois and the Case Institute of Technology, but it was IIT that held his loyalty for his entire life.

Early in his career, Bob Pritzker held various positions in the manufacturing industry. In 1953, at age 26, he bought the Colson Company with his older brother Jay (a lawyer and businessman). This led to the acquisition of other manufacturing companies, and in 1964 these were joined as members of the Marmon Group. Under Bob's leadership as president and CEO, the Marmon Group grew from $3.5 million in revenues to $6.5 billion at the turn of this century, and at that time was the 19th largest private company in the United States. In 2002, as the head of the Group, Bob acquired several caster, hardware, and medical device companies. With these, he created Colson Associates, Inc. and, at age 76, took on the challenge of building this group of companies.

Bob Pritzker's success was due to his principles on how you do business and his creative and astute business judgment. His management style was based on the belief that his managers should be trusted to run the business with which they have been entrusted, a philosophy that decentralized decision making, thereby empowering the managers and granting them the authority to achieve the goals of their unit.

Bob was a professional lecturer on business management at the University of Chicago Graduate School of Business. He was coeditor of a book published in 1960, *Modern Approaches to Production Planning and Control*, and his philosophy was captured in his 2006 book *Thoughts on Management*. The foreword of this book was written by Bob Galvin, an NAE member, a good friend of Bob's, and an individual who also passed away in 2011. In the foreword, Bob Galvin, describing Bob Pritzker, stated that "he wanted to make things—not just money," that he "acquired companies as an enlightened investor and steward," and that "best of all, he brought most of these companies' leaders into his family of companies." Bob Galvin went on to say that he served his companies and customers "faithfully and with uncompromising business integrity."

Bob Pritzker was a philanthropist over his lifetime and extremely generous. There is no greater evidence of this than his dedication to IIT. As chair of the IIT board of trustees for many years, Bob presided over the reinvigoration of the institution. This involved his personal leadership, his management advice, and his extraordinary philanthropic support. Evidence of this financial support is the gift of $60 million to IIT in 1996. He was also involved in the creation of IIT's Camras Scholars Program and Pritzker Institute of Biomedical Science and Engineering, which became the focus of the institution's research and education programs in biomedical engineering. Because of his many contributions, IIT bestowed on Bob an honorary doctor of humane letters and science degree in 1984. This was followed in 2002 with his induction into the university's Hall of Fame.

Bob served in many other ways as well, including through his involvement in the National Association of Manufacturers, which at one time he chaired. He also was very dedicated to the city of Chicago, and served on many civic and cultural boards there. He was a life trustee of the Chicago Symphony Orchestra, an honorary director of the Lincoln Park Zoological Society, and chaired the board of trustees of the Field Museum of National History. He was elected to the National Academy of Engineering in 1991 and over the years served on a number of NAE committees. In 1999, he was elected to the NAE Council, serving two terms. He also was a member of the National Academies' Presidents' Circle up to the time of his death.

Bob Pritzker was a modest person, but a giant in the area of manufacturing. In a *Forbes* interview in 1988, he was described as a person who could be characterized as one of "pleasant rationality." He told Forbes that how things were made fascinated him—"the idea that materials and people came in two doors and something of value went out the third."

Bob is survived by his wife Mayari, five children: James, Linda, Karen, Matthew, and Liesel; 10 grandchildren, and two great-grandchildren. As his friend Bob Galvin said, "he was one of those rare self-made men, a leader of leaders," someone who will be very much missed, not only by his family but by all who were fortunate enough to know him.

ADEL F. SAROFIM

1934–2011

Elected in 2003

"For advancing our understanding of the mechanisms and modeling of processes that control radiation in and pollutant emissions from combustors."

BY GERALD B. STRINGFELLOW

ADEL FARES SAROFIM, a professor emeritus in the Departments of Chemical Engineering at the Massachusetts Institute of Technology and University of Utah, passed away on December 4, 2011, in Norfolk, Virginia. He was born on October 21, 1934, in Cairo to a family that was prominent in Egyptian, and especially Coptic, affairs. His maternal grandfather, Morcos Pasha Simaika, was the founder of the Coptic Museum in Cairo, and his father, Fares Sarofim, was the recipient of an OBE from the British Crown. Upon graduation from the English School in Heliopolis at age 13, three years too young to be eligible to enter Magdalene College at Oxford University, Adel attended the Tunbridge School in England. He received a BA in chemistry from Oxford in 1955 and then studied chemical engineering at MIT, where he received his MS in chemical engineering practice in 1957 and ScD in 1962. His doctoral thesis, conducted under the supervision of Professor Hoyt C. Hottel, was on the subject of radiative heat transfer in furnaces. Upon completion of his thesis, Dr. Sarofim continued to work closely with Professor Hottel. The success of this collaboration through the years that followed is evidenced by more than 1,200 citations to their 1967 book on radiative transfer.

Dr. Sarofim was appointed an instructor in the MIT Department of Chemical Engineering in 1958 and thereby discovered a talent for teaching and a love for the profession. He joined the regular faculty as an assistant professor in 1961 and rose to the rank of professor in 1972. From 1989 until 1996 he was the Lammot du Pont Professor of Chemical Engineering. He retired in 1996 to join the University of Utah as Presidential Professor, a ranking "reserved for selected individuals whose achievements exemplify the highest goals of scholarship as demonstrated by recognition accorded to them from peers with national and international stature, and whose record includes evidence of a high dedication to teaching."

In 1990, Dr. Sarofim cofounded Reaction Engineering International, based in Salt Lake City. He played an important role in REI business for over 20 years, serving on the board of directors for 10 years and as a general consultant for the company and its customers in areas related to industrial combustion processes and R&D for next-generation combustion systems.

Focusing on energy efficiency and pollution reduction, Dr. Sarofim spent more than 50 years working on combustion science, which led to advances in the reduction of pollutants released from fossil fuel combustion. His research covered radiative heat transfer, furnace design, circulation patterns in glass melts, the freeze process for desalination, nitric oxide formation in combustion systems, combustion-generated aerosols, soot and polycyclic aromatic hydrocarbon formation, and the characterization of carbon structure and reactivity.

A particular focus of Dr. Sarofim's work was energy and the environment and the interdisciplinary research needed to address these issues. At MIT he served on steering committees for three interdisciplinary research centers: the Hazardous Substances Group, the Energy Laboratory, and the Center for Environmental Health Sciences. He was also cofounder and director of MIT's EPA Center for Airborne Organics (1992–2002).

Dr. Sarofim was the recipient of numerous US and international awards, including the Kuwait Prize for Petrochemical Engineering (1983); the Sir Alfred Egerton Gold Medal from the Combustion Institute (1984); the Walter Ahlstrom Environmental Prize of the Finnish Academies of Technology (1993); Senior Thermal Engineering and the Townend-BCURA Awards of the Institute of Energy (1994); the University of Pittsburgh Award for Innovation in Coal Conversion (1995); the Department of Energy Homer H. Lowry Award in Fossil Energy (1996); the ASME Fuels and Combustion Technology Division Percy Nicholls Award (1996); the Lawrence K. Cecil Award of the American Institute of Chemical Engineers, Environmental Division (1998); the American Institute of Aeronautics and Astronautics Energy Systems Award (2000); and the ASME George Westinghouse Gold Medal (2004).

His many colleagues all over the world included those who visited his research groups at MIT and the University of Utah and those he visited abroad over the course of his career. He was a "collaboration builder," and through him his colleagues at the University of Utah developed, either directly or indirectly, friendships and collaborations with researchers throughout the world, including Italy, Hungary, Colombia, China, Germany, and the United Kingdom. Dr. Sarofim's mentorship, wit, wisdom, and friendship were truly his most important contributions to those who knew him.

According to colleagues, Dr. Sarofim always said the best indication of scholarship was the combination of students and publications. He supervised and mentored more than 80 PhD students, many of whom now hold prestigious academic, industrial, and governmental positions, and his more than 350 peer-reviewed papers and documents have had almost 5,000 citations. His 1996 US DOE Homer H. Lowry Award citation reflects well the sentiments of his colleagues, students, and friends: "Adel Sarofim is a compassionate human being who inspires students and colleagues, and who contributes significantly across the full spectrum from fundamental science through real-world design concepts."

In addition to his professional and academic achievements, Adel's personal qualities included a variety of admirable attributes: a strong sense of familial devotion and compassion that justified a late-life relocation from Salt Lake City to Virginia where three of his closest kin lived; an enduring interest in genealogy that enabled him to fulfill a long-time promise of supporting and advising his cousin Dr. Samir Simaika in the editing and publication of their grandfather's memoirs; a dry and irrepressible sense of humor that could unexpectedly surface in the wake of medical crises (when recuperating from the removal of an intestinal polyp he received a copy of *The Gas We Pass*, which he enjoyed so much that he sent it to his sister liberally annotated with personal underlinings and comments in the margins); and never ever missing an opportunity to combine elements of work, travel, and adventure (such as donning an aviator's pressurized flight suit and helmet for a transfer by Navy fighter jet both to and from the flight deck of the nuclear-powered aircraft carrier USS Theodore Roosevelt [CVN-71] at sea off the Virginia Capes to enable his participation in a conference of the National Research Council on shipboard pollution control).

Perhaps as a result of his many travels, Adel took pleasure in sampling diverse cuisines; he particularly grew to love pasta during a 6-month sabbatical at the University of Naples. During breaks from research he would play squash with students or go hiking with his family. And everywhere he went he always had a book with him, whether a student's thesis to correct or a biography of Lyndon Johnson to enjoy. He was gentle, generous, and modest. Even his closest colleagues were not aware of the entire spectrum of his contributions. These are but a few of his qualities and attributes; the complete list is seemingly endless.

In addition to his wife Mary Ellen, he is survived by his sisters Lola Beck and Nabila Harris, his brother Nabil Sarofim, and Marcus C. Sarofim, his son to his former wife Leticia Sarofim. They, his colleagues, and his students are in his debt.

KLAUS SCHOENERT

1927–2011

Elected in 1991

"For contributions to fracture physics and fragmentation fundamentals leading to innovative technology for size reductions in ore processing."

BY DOUGLAS W. FUERSTENAU

KLAUS SCHOENERT, who died on September 24, 2011, was universally regarded as the world's leader in comminution science and engineering, that is, the size reduction of solid materials. The objective of crushing and/or grinding may be to liberate minerals in ores, produce particles of controlled size, produce fine particles, or increase the surface area of the material. Hundreds of millions of tons of materials—ores, cement, aggregate, coal, ceramics, grain, and even chocolate—are comminuted annually. Whoever he interacted with professionally in the world of comminution found Klaus to be a true friend.

Klaus Schoenert was born on June 18, 1927, in Döbeln, Saxonia, Germany, a small city west of Dresden, where his father managed a small cooperative dairy. Nearing completion of his studies in the gymnasium (equivalent to an American high school) in early 1945, he was drafted into the German army at age 17 and sent to the eastern front in Austria. After being captured by the US Army and spending a couple of months in an American prison camp in Austria, he and a friend eventually made their way back to Saxonia.

Schoenert had an arduous four years trying to start his university education. Upon returning to Döbeln, he completed his studies at the gymnasium, but at that time the communist party took over the government and began to arrest all who ran businesses or large farms, including Schoenert's parents, although they were released from prison because the cooperative dairy that his father had managed was not large. Klaus was not home at the time of their arrest and escaped capture. He went to live with relatives near Weimar, where he took the final gymnasium examination (called the Abitur).

In the spring of 1946 Klaus returned to his family and applied to enter a university to study electronics. He was denied entrance because the regime allowed admittance only to the children of workers and small farmers. He applied to several Western German universities but only older veterans were being granted admission at that time. So he studied to be an electronics technician and worked in that capacity until 1948, when he received a letter from the University of Karlsruhe (then called the Technische Hochschule Karlsruhe) stating that he would be admitted upon passing an examination. With a colleague he walked at night across the border into West Germany and went on to Karlsruhe. He passed the examination, but each student had to work six months cleaning up the bombed-out campus before they could enroll. During that time, the great devaluation of German currency took place and his money became worthless. Fortunately, he was able to get a job as an electronics technician for Siemens to support himself. In 1950 he finally was able to enroll in the physics program at Karlsruhe and in 1957 completed his studies for the Diplom Physiker. He began doctoral studies in physics, but within weeks his professor (Christian Gerthsen) suddenly died.

At this very time, Professor Hans Rumpf (1991 NAE foreign associate) had come to Karlsruhe from industry to establish an institute called Mechanische Verfahrenstechnik, that is, the mechanical processing of particles. Rumpf wanted a physicist to join the institute as his assistant and interviewed Klaus for the position. Although Schoenert's real interest was in electronics, he said that he was so impressed with Rumpf as an influential, challenging person that he decided to join the institute and served as Rumpf's scientific advisor from 1960 to 1966. Research areas at the institute included the characterization of particles, comminution, classification (size separation), mixing of powders, and the agglomeration of powders. The institute eventually grew to some 200 persons, and for two decades or so was perhaps the leading laboratory in particle science and technology worldwide.

Professor Rumpf considered comminution to be the major problem in particle production. He estimated that 3.5 percent of the world's electrical energy was consumed in the comminution of cement, minerals, coal for power plants, and chemicals. In a mineral processing plant about 80 percent of the energy is for comminution of the ore. So Schoenert started his research in the fundamentals of comminution. Rather than investigating comminution in mills, they undertook research on fundamental breakage phenomena of single particles. The objective was to ascertain how a particle is formed, how it breaks, how breakage depends on size, the energy needed to break the particle, the probability of particles breaking at different energy levels, the fragment size distribution after breakage, and the newly created surface. In some cases they determined fracture patterns and investigated how the pattern progresses through the particle.

Schoenert's initial investigation involved the breakage of spherical glass balls, and then moved to study of the comminution of particles of calcite, limestone, quartz, and cement clinker, investigating what happens in the breakage of very fine particles because it is the production of small particles that consumes energy. The largest particles that they studied were 2 millimeters in size and the smallest were 10 microns. Study of the loading and breakage of 10-micron particles under a microscope was tedious and required the design and construction of specialized apparatus. Through the years there have been numerous approaches on how to measure the energy efficiency of a grinding mill. Based on his single-particle research, Schoenert nicely defined a meaningful measure: the most efficient method of comminution is the mechanical breakage of single particles, and this should be the baseline against which to quantify process efficiency of industrial machines.

In 1966 he received the degree of Doktor-Ingenieur from the Faculty of Maschinenbau (Mechanical Engineering) und Verfahrenstechnik of the Technische Hochschule (TH) Karlsruhe for his dissertation on single particle compression and comminution dynamics. It was after this that TH Karlsruhe was renamed the University of Karlsruhe and the Department of Chemical Engineering was established. From 1966 to 1977, he served as supervisor of the Comminution Division of the Institute in the Chemical Engineering Department at the university.

All through these years Schoenert (and Rumpf) published extensively on the results of their research on comminution. Rumpf established the European Comminution Symposium under the auspices of the German Chemical Engineering Society to disseminate and discuss research results. From 1966 to 2004, I participated in European Comminution Symposium meetings. I first met Professor Rumpf and Klaus Schoenert in 1965 when they attended the Engineering Foundation Research Conference on Particulate Systems in Milwaukee. This was the first occasion where many Americans and others met Rumpf and Schoenert. After that Klaus participated actively in Engineering Foundation Conferences and other technical meetings.

In 1969–1970, Schoenert spent six months as a visiting associate professor in the Department of Materials Science and Engineering at the University of California, Berkeley. He taught an undergraduate course on particulate materials and I suggested that he also teach a two-unit graduate seminar course on fracture physics. I told him that there would be a few graduate students in the seminar course. Klaus said that when he walked into the classroom he was shocked to see that it was nearly full of students plus three other professors. He said he never worked so hard in his life preparing lectures as he did for these weekly two-hour sessions. His family was with him and our families became close friends from that time onward.

To become a professor in Germany, an additional dissertation after the doctorate is required, called the habilitation. After returning from Berkeley, Schoenert began to work on his habilitation in chemical engineering. His dissertation, completed in 1971, was on the mathematical simulation of comminution processes in continuous mills, which was a step toward his study of the behavior of actual grinding mills. In 1973, he and a colleague, Fritz Loeffler, were both appointed (ausserordentliche) professors in the University of Karlsruhe and, together with Professor Rumpf (ordentliche professor), ran the Institute as what they called a three-member Directorium. When Professor Rumpf retired in 1977, Schoenert became the speaker of the Directorium, but he could not be the director since only ordentliche professors can hold that title, and in Germany you cannot become ordentliche professor in the university from which you received your doctorate unless you have held a regular appointment elsewhere.

After Schoenert's group had thoroughly studied the breakage of single particles, they investigated the breakage of confined beds of particles in a piston-die press. Breakage of particles in a confined bed is less efficient than single particle breakage, but still far more efficient than comminution in ball mills. In particle-bed comminution, energy is supplied directly to the material by compression. The workhorse of fine grinding is the ball mill, a huge rotating tube filled with balls to about 35 percent of its volume. Rotating the tube provides energy to the balls as they are lifted inside the mill. When the material to be ground is fed into the mill, the balls strike the particles to be broken by a hit-and-miss process—a highly stochastic process that results in a lot of wasted energy.

Schoenert considered that he might use particle-bed comminution as a process by passing the particles between two counterrotating rolls at very high pressure. To test his ideas, he designed and constructed a laboratory-scale high-pressure roll mill. When the bed of feed particles pass through the gap between the rotating rolls, they are compacted and fractured with the very high pressure. However, he found that the material came out from the rolls as an agglomerated cake of broken particles. He said that at first he was perplexed that instead of making small particles, they were making agglomerates! But it turns out that very little energy is required to deagglomerate the material and to classify it.

With the small lab-scale machine, they investigated the operating variables to determine the performance of the system. After finding the same results as those predicted from the piston-die press, Shoenert applied for a patent, because this new high-pressure process could save significant energy. The university released the invention to Schoenert and the original German patent (Deutsches Patent DE-2 708 053) was issued in 1977, with an essentially identical patent issued in the United States in 1982 (US Patent 4357287). These patents proved valid in court because they were process patents and not machine patents.

Schoenert first approached Polysius (now called Krupp Polysius) to license the patent because he had had earlier contact with them about cement clinker comminution, and they eventually agreed to design and manufacture an industrial-scale machine. After about three years the first industrial application was achieved in the cement industry, and eventually about 300 machines were sold in the industry. Schoenert told me that he thought that the real success of the high-pressure grinding roll (HPGR) was because the cost of electrical energy is so high in Germany. He then negotiated with a second company, KHD (Klöckner-Humboldt-Deutz), a well-known name in the manufacture of processing equipment in Germany, to manufacture HPGRs for application in the mineral industry. Although wear of the rolls was low, it still was a major problem that each company worked on extensively and solved satisfactorily.

The first application of HPGRs in the mineral industry was at the diamond mines of DeBeers, where the rolls were installed not for energy but for diamond liberation. Better liberation of the diamonds from the matrix rock is attained because of the shear forces acting between the gangue matrix material and the hard diamonds as the ore passes through the gap between the rolls. The compressed diamond ore forms a cake that can readily be broken down by putting it into water, freeing the diamonds. With the roll mill, not only is diamond liberation increased but big diamonds are not broken (standard crushing machines cannot avoid breaking some of the larger diamonds). The first high-pressure roll mill delivered to DeBeers was a massive machine with rolls 2.8 meters in diameter. They were so successful that eventually DeBeers installed about a dozen such roll mills.

Late in 2006, at Cerro Verde in Peru, Freeport-McMoRan Copper and Gold Inc. commissioned a new 125,000-ton-per-day concentrator that uses four 2.4-meter diameter HPGRs instead of two 12.2-meter diameter SAG (semiautogenous grinding) mills. This is the first base-metal application of HPGRs. About that, John Marsden (NAE, 2010) and his colleagues wrote, "Since SAG milling is a mature technology, limited gains or improvements are expected in the future. HPGR, being a relatively new technology, is expected to offer excellent opportunities for operational and maintenance improvements." The comminution energy consumed by the HPGR/ball mill system is only 64 percent of that required for a traditional SAG/ball mill system! A great deal of test work is under way worldwide for further mining industry applications.

In 1981, Schoenert received a call to join the faculty at the Technical University of Clausthal as ordentliche professor and director of the Institut für Aufbereitungstechnik (Institute for Mineral Processing). The university is in Clausthal-Zellerfeld in the Harz Mountains, a major mining region going back to the Middle Ages. Nearby in Goslar was the very rich Rammelsberg Mine, which closed in 1989 after continuous operation for 1,000 years.

At Clausthal, Schoenert was in the Department of Mining Engineering, not chemical engineering as he had been at Karlsruhe. He taught mineral processing, which involved all of the physical (but not chemical) processes used in the recovery of minerals from ores, more than just a course on comminution and the particulate processing operations of agglomeration and classification that he had taught at Karlsruhe. Similarly, he broadened his research, though still heavily involved with comminution, to include such topics as electrical separation of minerals, magnetic separation of minerals, classification, and the separation of minerals based on differences in their density. In each area his research was innovative and showed the Schoenert touch. From 1989 to 1991, he was dean of the Department of Mining and Raw Materials. In 1992, he retired as professor emeritus.

Thanks to Klaus Schoenert, I was awarded in 1984 a Senior American Scientist Award from the Alexander von Humboldt Foundation, through which we spent a year or more in Clausthal spread out over 1984, 1987, and 1996. During that time, I was involved in research on HPGR comminution and several joint publications with Schoenert.

A characteristic of Rumpf's and Shoenert's laboratories was that they designed most of their own research apparatus and had outstanding machinists and technicians to construct the equipment. While I was in Clausthal, Schoenert was planning on constructing an improved laboratory high-pressure roll mill, so I decided to have them construct a similar small-scale high-pressure roll mill for my laboratories in Berkeley. The Clausthal machinists constructed the rolls, their housing, and gear drive for me, and the rest of our system was designed and assembled in Berkeley. Our HPGR was used for several research projects related to particle-bed comminution and increasing energy efficiency for the comminution of minerals and coal.

Schoenert was very active in professional society affairs in Europe. From 1975 to 1993 he chaired the German Working Party on Comminution of the GVC, and from 1977 to 1994 he chaired the European Working Party on Comminution, Agglomeration, and Classification of the European Federation of Chemical Engineering. He organized and chaired numerous symposia on comminution and particle technology during this period and delivered a large number of invited and plenary lectures around the world.

Klaus Schoenert was widely recognized for his contributions. In 1970, he received the Arnold-Euken-Preis, DECHEMA (Gesellschaft für Chemische Technik), Frankfurt; in 1971 the Venia Legendi für Mechanische Verfahrenstechnik, TH Karlsruhe; in 1987 the Antoine M. Gaudin Award (named after A.M. Gaudin, a founding member of NAE), Society of Mining Engineers, American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME); in 1991 the Hans-Rumpf-Medaille, DVCV (Deutschen Vereinigun für Chemie und Verfahrenstechnik). In 1991 he was elected a foreign associate of the National Academy of Engineering. In 1994 he received the Distinguished Service Award, International Comminution Research Association (ICRA); in 1996 the Frank F. Aplan Award of the US United Engineering Foundation; in 1997 the International Mineral Processing Lifetime Achievement Award, International Mineral Processing Congresses; in 2002 the Ehrenmedaille, VDI (Gesellschaft Verfahrenstechnik und Chemieringenieurwesen); and in 2004 a Doktor-Ingenieur Honoris Causa, TU Bergakademie Freiberg.

Klaus married Annelene (Anna Magdalena) Werner in 1960 in Karlsruhe. She was a wonderful and giving hostess to students, colleagues, visitors, and their many professional and personal friends. Klaus's lovely and caring wife predeceased him. He is survived by his three sons Axel, Stefan, and Frank, their wives, seven grandchildren, and many friends worldwide. For more than 40 years, we were close family friends, visiting in Germany, Berkeley, and elsewhere together.

Klaus Schoenert leaves a huge technical legacy with regard to raw materials processing. Frank Aplan (NAE, 1989) stated, "In my opinion, in terms of advancement in processing, Schoenert's high-pressure grinding rolls are equal to what flotation did a century ago. What is so impressive to me is that Schoenert's success came from a careful study of the first principles of particle breakage."

In March 2012 in Bad Dürkheim, the ProcessNet-Fachgruppe Zerkleinern und Klassieren of DECHEMA held a Gedenkkolloquium in honor of Prof. Dr.-Ing. Klaus Schoenert and announced the establishment of the Klaus Schoenert–Preis in recognition of his tremendous contributions and stature in research and education.

MAURICE M. SEVIK

1923–2011

Elected in 1994

"For leadership and contributions leading to quiet US Navy ships and nuclear submarines."

BY WILLIAM B. MORGAN

MAURICE MOIZ SEVIK, a leader in the US Navy's combatant ship and nuclear submarine acoustic silencing, died on October 20, 2011, at the age of 88.

Maurice was born in Istanbul, Turkey, on January 19, 1923. He was an alumnus of the Deutsche Schule (1928–1938). Although he had scarlet fever at age 7, which left him with severe hearing loss in his right ear and no hearing at all in his left ear, he graduated with top honors, receiving as prize a copy of *Ein Kampf um Rom* by Felix Dahn. The true prize, however, was his enrollment, thanks to the Deutsche Schule, at Robert College in Istanbul, from which he graduated, again with top honors, in engineering in 1943. To further his education, at the height of World War II he took a train from Istanbul to Cairo, where he boarded a ship, part of a convoy, and traveled to Liverpool, England. In 1946 he received a diploma in aeronautics from the Imperial College of Science and Technology, London, while fighting firebombs. Although homesick for his family, he remained in England and obtained his first position as a junior engineer with Bristol Aeroplane Company before opening his own aerodynamic consulting firm, Premier Industrial Consultants (Preminco). For business reasons, he opened an office in Canada.

He met his future wife, Jacqueline (Jacquie) Delannoy, an au pair from France, in Bristol through mutual friends. Maurice was homesick and wished to meet people who spoke French, the language he spoke at home in Turkey. On June 2, 1953, he and Jacquie were married. Shortly after, he moved to Canada, followed a few months later by Jacquie.

Preminco didn't do well in Canada, and Maurice went to work for Canadair and then Avro Aircraft Company to help develop a supersonic jet fighter for the Canadian government. When the government cancelled the supersonic jet fighter, even though he was one of the few engineers still employed by Avro, he saw the writing on the wall and decided to move on.

Due to his work at Avro and a previous visit to the Pennsylvania State University, the university's Department of Aeronautical Engineering looked like a good opportunity to Maurice. In 1959 he and Jacquie moved to Penn State, where he received his PhD in engineering mechanics in 1963. He became a US citizen in 1965 and a full professor in 1968. While at Penn State, he was employed by the Applied Research Laboratory (ARL), where he became assistant director and head of the Garfield Thomas Water Tunnel. This position accelerated his interest in cavitation and the physics of mechanisms that cause vibration and sound radiation from ships and submarines.

As a result of his work at ARL, in 1972 he was hired as the fourth head of the Ship Acoustics Department of the David Taylor Model Basin (now the Naval Surface Warfare Center, Carderock Division). He came to Carderock as a teacher, mentor of young scientists, and with a strong interest in ship and submarine silencing.

In the beginning at Carderock, Maurice's focus was on acoustic signatures. He initially carried over from ARL many of his research interests, while also broadening his interest in the other areas of ship and submarine acoustics that were important to the Navy. He maintained his interest in propulsor acoustics, but initially as related to the use of acoustic trial data and the use of data analysis to achieve understanding. In the years before the mid-1980s when Navy interests were in search of new concepts in submarines and surface ships, Maurice led several projects to identify new concepts in silencing technology, including innovation in surface ship silencing, submarine hull structures, a ship silencing laboratory, several concepts in submarine propulsors, propulsor-hull concepts, and a large-scale vehicle (LSV) for acoustic evaluation of propulsors. Along the way, he provided innovative guidance to the department's ongoing buoyant vehicle programs in sonar self-noise and flow noise. In these and all of his endeavors, Maurice would bring in expertise from disciplines in other departments as well as outside in private industry and academia. As he felt necessary, he built personal bridges to all of the Carderock departments, to ARL, and to the ship design community. At the end of the day, however, it was always propulsor acoustics that dominated his interest.

Throughout his career at Carderock Maurice sustained a personal interest in and devotion to the acoustic trials program. Although his own research methods were principally analytical, he had a high regard and commitment to obtaining physical data as an enabler to the development and proof of hypotheses. The acoustic trials program was always his highest priority. As department head, he personally read (and even edited!) every trial report and became well informed of the acoustic signature characteristics and source mechanisms of every ship and submarine class. He met each of his specific interests in full-scale trials with the same intellectual rigor that he devoted to fundamental concepts in his prior research. Under his guidance came upgrades at the East Coast measurement facilities, and the development of a new acoustic range in Ketchikan, Alaska. All these range installations were developed to meet needs of the next fleet that were consistent with the design objectives being pursued in the parallel signature reduction programs.

Maurice provided leadership in the development of advanced quiet propulsors for submarines. In 1978, he served on a committee commissioned by Naval Sea Systems Command (NAVSEA) that culminated in a report documenting the acoustics signature mechanisms and their connectivity to propulsor hydrodynamics, and recommended concept solutions.

Further, this report recommended a development program that included the design, construction, and utilization of a quarter-scale, free-running submarine model (LSV) for acoustic evaluation of propulsor concepts. Maurice subsequently led the development, implementation, and use of the LSV. Throughout the following years, Maurice made the propulsor concept selection and development for the USS *Seawolf* (SSN-571) and *Virginia* propulsors his passion. The success of these efforts was due largely to his vision and tenacity.

In the early 1990s, the Ship Acoustics Directorate was expanded to include a variety of nonacoustic signatures and renamed the Ship Signatures Directorate. Maurice taught himself the nonacoustic technologies and became an effective leader in the broader signatures arena.

Maurice said many times that he was a "roll-up-your-sleeves" engineer. In the various developmental programs, he regarded himself as one of the leaders of a team whose membership shared the same commitments to design goals and schedule as he did. To those who worked for him, he was affectionately referred to as "The Boss." He never vocally acknowledged this term as a title per se, but one could tell that he liked being recognized as the boss and enjoyed being so-called.

He sought and received well-thought-out critical input on work in progress. Key words here are "well-thought-out," because he also needed reasons to accompany that critical input. This combination of intellectualism, dedication to purpose, self-discipline, and similar expectation of colleagues made him an exceptional steward of the Navy's Signatures Directorate and an undeniably unique instrument of the Navy's interests. His personal commitment to the US Navy and to maintaining its signature supremacy is without parallel. He was a real friend to those who knew him best and a visionary to the welfare of his department and all of the staff that worked in it. He was admired by all for his intellect, integrity, and kindness.

Maurice was the author or coauthor of approximately 24 publications (including 4 books) and 6 patents. He was elected a fellow of Churchill College, University of Cambridge, in 1971, and received numerous awards, among them the Navy's Superior Civilian Service Award (1981), Presidential Rank Award (1983), Gold Medal Award from the American Society of Naval Engineers (1990), National Security Industrial Association's Charles B. Martell Award (1992), ONR's Capt. Robert Dexter Conrad Award for Scientific Achievement (1995), American Society of Mechanical Engineers' Per Bruel Gold Medal for Noise Control and Acoustics (1996), and the *Ordre du Mérite* from the Government of the Republic of France (1997). In addition, the M.M. Sevik Acoustic Data Analysis Center was named after him at Carderock when he retired in 1999. He is also listed in a number of Who's Who.

For NAE, Maurice served on the Audit Committee (1998–2001), Committee for Naval Hydromechanics Science and Technology (1999–2000), and Gibbs Brothers Medal Selection Committee (2000–2001).

Maurice retired in 1999 and he and his wife moved to Hilton Head Island in 2001. He is survived by his wife, Jacquie, and two daughters, Michele and Martine, as well as a large extended family he cherished, good friends, and respected colleagues.

The author wishes to acknowledge the assistance of Martine Sevik, William K. Blake, and Robert J. Boswell in preparing this tribute.

ABE SILVERSTEIN

1908–2001

Elected in 1967

"For aeronautical and space systems."

BY ROBERT S. ARRIGHI
SUBMITTED BY THE NAE HOME SECRETARY

ABE SILVERSTEIN was a visionary engineer and leader whose accomplishments during his 40-year career continue to impact the aerospace community. He was instrumental in the design of a massive subsonic wind tunnel (the Full-Scale Tunnel), study of complete engine systems, development of the nation's early jet engines and ramjets, creation of large supersonic wind tunnels, use of liquid hydrogen as a propellant, the foundation of NASA, formation of the Mercury and Apollo Programs, the success of the Centaur second-stage rocket, and a great deal more. He excelled at instantly grasping the essence of a problem, proposing a likely solution, and delegating the task to the experts to resolve. His off-the-cuff acumen and decisiveness inspired both fear and intense loyalty from staff and colleagues. Abe Silverstein died on June 1, 2001, at the age of 92.

Abe was born on September 15, 1908, in Terre Haute, Indiana, to Joseph and Eva Silverstein. His father advised him at a young age to pursue engineering, and Abe claimed that his mother's insistence on perfection in his school work provided him with the mindset required for future space engineering. Abe graduated from Terre Haute's Rose Polytechnic Institute in 1929 with a BS in mechanical engineering. He returned to earn a degree as a mechanical engineering professional in 1934.

Abe had been offered a position with General Electric pending his 1929 graduation. While finishing the coursework, he and several classmates opted to take a general civil service examination. Soon thereafter, Abe received an offer from the National Advisory Committee for Aeronautics (NACA). He researched the mysterious organization in the school library and became intrigued. He soon accepted a position at the NACA Langley Memorial Aeronautical Laboratory in Hampton, Virginia.

Despite his mechanical engineering degree, Abe was assigned to the aerodynamics group to help Smith DeFrance's team design a massive new test facility, the Full-Scale Tunnel (FST). When it began operations, the facility was the world's largest wind tunnel, the first with two side-by-side propellers, and the first with an open throat. Abe was able to design the tunnel's supporting framework to be on the exterior so as to not cause turbulence in the airstream. He remained at the FST as a researcher after it began operating in May 1931. His initial investigation utilized a Clark-Y airfoil to demonstrate that turbulence in the FST was nearly as low as in free air, thus making the FST more practical than Langley's other wind tunnels for certain types of tests.

Abe was involved in aerodynamic research but, as early as 1937, he began engine-cooling studies that were a harbinger of his future propulsion research. He demonstrated that using internal baffles to direct airflow over hot cylinders results in improved engine cooling.

In August 1940, Abe was promoted to chief of the FST after Smith DeFrance's transfer to NACA's new Ames Aeronautical Research Laboratory. During World War II, the FST was used to increase the performance of nearly all military aircraft: researchers systematically covered all openings and removed protuberances in order to reduce drag. During this period, Abe accelerated his engine-cooling research at the request of the military; cooling studies on the XP-39 fighter's Allison V-1710-85 engine and on the B-24 bomber's Pratt & Whitney R-1830 engine were particularly important. Abe's engine studies melded his mechanical engineering background with his aerodynamics work at Langley.

Although George Lewis, director of NACA aeronautical research, had mildly chastised Abe for his engine studies while in the aerodynamics group, he considered Abe one of NACA's bright young stars. When NACA began creating the new Aircraft Engine Research Laboratory (AERL) in Cleveland, Ohio, George selected Abe to manage its premier facility, the Altitude Wind Tunnel (AWT). It was a bit of a controversial decision since the AWT would be used to study full-scale engines, and there were some who felt that it should have been placed under someone from the Langley Powerplants Division.

Abe transferred to the AERL in the fall of 1943 just as the AWT was being completed. Soon thereafter, he was asked to meet secretly with Colonel Donald Keirn to discuss testing the nation's first jet aircraft, the Bell YP-59A Airacomet. The development of the jet engine was a top secret project known to only a few in NACA. The military felt that its development was important enough to delay the long-awaited AWT testing of the engines for the new B-29 Superfortress, which had been overheating. Instead, Abe made arrangements for the Airacomet with its General Electric I-16 engines to be the subject of the first AWT study. Despite the resulting engine improvements, the aircraft remained too problematic to be used for combat in World War II. It did, however, herald the future of aeronautics. When the B-29's R-3350 engine was then analyzed, Abe called upon his experience at Langley to develop a baffling system to combat the overheating. He and his staff concentrated on other early turbojet engines throughout the remainder of the war. He was also instrumental in the 1945 operation of the nation's first afterburner. In October 1945, he was promoted to chief of the AERL's new Wind Tunnels and Flight Division.

From that first meeting with Colonel Keirn, Abe seized on the concept of high-speed flight and the new turbojet technology. In 1944, he was appointed to NACA's High-Speed Research Panel along with John Stack, Russell Robinson, and Julian Allen. He initiated a series of evening classes so that the staff could educate one another on these topics.

During this period, Abe began planning several supersonic wind tunnels. The first two, constructed in the summer and fall of 1945, were small facilities that used the AWT's air-handling system. He and his colleagues immediately began planning what would then be NACA's largest supersonic tunnel, the 8′ x 6′ Supersonic Wind Tunnel. The tunnel, which was operational in 1948, was large enough to be used for both propulsion and basic aerodynamic studies. Following the 1949 Unitary Plan Act, Abe and his colleagues began designing what is still today the nation's largest propulsion tunnel, the 10′ x 10′ Supersonic Wind Tunnel.

In 1949, Abe was named chief of research for the entire lab (the AERL had been renamed the NACA Lewis Flight Propulsion Laboratory), and in 1953 he was promoted to associate director, where he had oversight of all facilities and research projects at the lab. As associate director, Abe began shaping the future of aircraft and rocket propulsion, particularly in regards to high-energy alternative fuels. He was an early advocate for liquid hydrogen, nuclear, and electric propulsion. He formed the Nuclear Section at Lewis to study nuclear propulsion, and by 1955 he had successfully convinced NACA to build a test reactor on a large remote tract of land to investigate the effect of radiation on nuclear aircraft and rocket engine components. The site, Plum Brook Station, would include numerous test facilities in the 1960s to study liquid-hydrogen and liquid-fluorine propellants. Two later facilities included the world's only test stand capable of firing full-scale rockets in a space environment and the world's largest vacuum chamber. Abe contributed key elements to the design of both.

The development of liquid hydrogen may be Abe's most important accomplishment. Although the concept had been investigated years before by Konstantin Tsiolkovsky and Robert Goddard, Abe Silverstein was the first real advocate of its use for modern rocketry. Liquid hydrogen aided the Apollo missions and remains a key element of space flight today. The lab had a small clandestine rocket research group that had concentrated on the development of high-energy propellants. As chief of research, Abe elevated the group's status and took a personal interest in their work. He was aware of Robert Goddard's research and suggested the use of a liquid hydrogen and liquid oxygen combination to the group.

In 1953 Abe asked Eldon Hall to run a series of calculations to determine the parameters for the use of liquid hydrogen as an aircraft fuel. Their report foretold of liquid hydrogen missions that far surpassed those using traditional hydrocarbon fuels. On the basis of these findings, the Air Force asked Abe to develop an actual flight version of the system. After two years of ground tests, the system was integrated into a B-57 Canberra so that one engine could be run on either jet fuel or liquid hydrogen. Beginning in February 1957, the B-57 successfully flew several flights in which the engine switched over to liquid hydrogen. Although the concept of a liquid hydrogen aircraft fell from favor with the development of intercontinental missiles, the program did demonstrate that the high-energy fuel could be handled safely.

During this period Abe and several Lewis colleagues foresaw the nation's entry into space. In the mid-1950s they created documents outlining the requirements for a new laboratory dedicated exclusively to space flight and the role of NACA in space research. In the aftermath of Sputnik, NACA Director Hugh Dryden requested Abe's assistance in creating the new National Aeronautics and Space Administration (NASA). After several months of commuting, Abe transferred to Headquarters in May 1958.

At Headquarters, Abe—along with Robert Gilruth, Morton Stoller, Edgar Cortright, and Newell Sanders—devised a fiscal year 1960 budget by mid-July and began planning missions that included both satellites and manned spacecraft. The National Aeronautics and Space Act was approved and signed by President Eisenhower on July 29, paving the way for the new agency. When NASA began operation on October 1, 1958, T. Keith Glennan was its administrator, Hugh Dryden was deputy administrator, and, as chief of space flight programs, Abe was third in command.

In this role, Abe directed mission planning, spacecraft design, launch operations, manned space missions, and unmanned probes. These included the first orbiting observatories, weather satellites, communications satellites, planetary flybys, and lunar landers. In addition, Abe requested the creation of the NASA Goddard Space Flight Center to concentrate on space science research. He initially acted as NASA Goddard's temporary director and negotiated with the Navy to transfer the Vanguard team there. Abe became a frequent figure in the press during this period.

The Space Task Group was created in October 1958 to oversee Project Mercury, and then Apollo. Although it was based at NASA Langley, the group reported to Abe at NASA Headquarters. Just 17 days after the official foundation of NASA, Abe's group presented detailed plans for the Project Mercury Program. Abe chaired NASA's Source Selection Board in 1959, which selected McDonnell to perform the Mercury work. In 1960 he worked with the Space Task Group to outline the Apollo Program. He is credited with naming both the Mercury and Apollo Programs. There are varying accounts of why he selected the names, but the one most frequently cited is that Mercury denoted a swift messenger of things to come and Apollo the greatest of the gods.

The Saturn Vehicle Team, informally termed the "Silverstein Committee," was created in late 1959 to select upper stages for the Saturn rocket. While serving on this team, Abe was able to persuade Wernher von Braun to consider stages that could use liquid hydrogen; during the initial discussions, he had Eldon Hall make the technical arguments for hydrogen. At a later meeting, Abe passionately explained the importance of hydrogen for future space missions and the logic of its present use for Saturn. Wernher von Braun conceded the point and later thanked Abe for paving the way for Saturn's success.

Abe later recalled a meeting with Vice President Johnson in early May 1961. On behalf of President Kennedy, Johnson asked Abe, Hugh Dryden, James Webb, and Abraham Hyatt what type of space program NASA could implement to demonstrate the United States' superiority over Russia. Abe suggested that a manned lunar landing did not require any scientific breakthroughs, just additional engineering work.

During a break for lunch, he and Abraham Hyatt compiled a two-page summary on Apollo to indicate that it would require $20 billion to put a man on the Moon within the decade. Weeks later, on May 25, 1961, President Kennedy presented his Urgent National Needs speech to Congress, in which he vowed to send a man to the Moon by the end of the decade.

Just as Project Mercury was coming to fruition, Abe decided to leave his post at NASA Headquarters. James Webb, named NASA administrator on January 7, 1961, sought to have those working on Apollo at the NASA centers report to a new Headquarters program office, not to the head of the Apollo Program. Abe later claimed that he had been asked to either assume the top Apollo position or to serve as head of the new Manned Spacecraft Center in Houston. Disagreeing with the new organizational structure, Abe instead requested to be appointed to the vacant center director position in Cleveland.

Abe returned to Cleveland as director of the NASA Lewis Research Center on November 1, 1961. In addition to the overall administration of Lewis and its research facilities, he assumed responsibility for several large development programs. This involved oversight of the incredibly complicated contracts with the companies involved with NASA's developmental programs. Abe implemented a cost-reduction program, renegotiated major cost-plus-fixed-fee contracts into incentive-type contracts, and successfully created a dual research and development center.

Another of Abe's major accomplishments was the resurrection of the Centaur second-stage rocket program. Centaur was a liquid hydrogen rocket developed to send the Surveyor spacecraft on their missions to land on and explore the Moon during the early stages of the Apollo Program. The NASA Marshall Space Flight Center was responsible for the program. After the first Centaur flight exploded shortly into the May 1962 launch, Marshall was ready to cancel the program. The cancellation would likely have delayed the Apollo schedule. Instead, Abe agreed to have the program transferred to Cleveland where his liquid hydrogen experts could get it operating. Abe was the unofficial head of the Centaur program and was deeply involved with day-today operations during the program's troubled initial phase. By November 1963, NASA Lewis had remedied most of the problems and successfully launched the Centaur. There were setbacks, but Centaur not only successfully completed the Surveyor missions, it went on to send probes to Venus, Mars, and the outer solar system. It continues to be used today.

Abe's managerial philosophy was to select the best people for the most important projects, even if they were not involved in that field; stay ahead of the ever-evolving research areas; and test full-scale items in the conditions in which they would operate. He had been put in an awkward aerodynamics position when he started at Langley, but he grew to excel in the field. In the early 1950s, he pulled the turbine and compressor experts into the new field of nuclear propulsion; and in the 1960s, many in the rocket programs had jet engine backgrounds. Abe had been involved early on with turbojets and supersonics. In the 1950s, he was among the vanguard for high-energy propellants, nuclear propulsion, and the ion engine. He also was early to see that space was a natural extension of NACA's purview. Through his experience in the AWT, he came to appreciate the need to create test facilities that could replicate conditions encountered in flight or space. He helped to design a number of these facilities and pushed his staff to conduct tests to be as similar as possible to an actual flight or mission.

Abe seemed to be omnipresent, particularly during his first few years back in Cleveland. He did not hesitate to call meetings in the evenings or on weekends. He also seemed to know everybody by name and what they were working on. He would routinely question the calculations or engineering work of his staff. Though sometimes irritated by or fearful of his comments, it appears that almost everyone respected his judgment and looked to him for technical direction.

Abe retired in the summer of 1969 just as the Apollo Program was reaching its apex. After 40 years with NACA and NASA, he sought new challenges. At the time, the Federal Aviation Administration (FAA) wanted to consolidate the airline industry into a handful of superhubs. In 1969, Abe proposed to place one of these hubs five miles from downtown Cleveland. The city wanted to revitalize itself and saw the superhub as a key ingredient. The $2.5 billion proposal was analyzed in depth throughout the early 1970s. Despite the promise on paper and Abe's influence as technical advisor, the jetport project was assailed by political, financial, and environmental groups. After nearly 10 years, the proposal was finally laid to rest in May 1978.

From 1970 to 1977, Abe also served as a part-time director of environmental planning at Republic Steel. From an office in Cleveland, he directed pollution control in over a dozen plants throughout the country.

Abe was active in community and civic affairs, particularly after his return to Cleveland in 1961. He served as a trustee of Cleveland State University, Case Western Reserve University, the Cleveland Natural Science Museum, and the Carnegie Mellon University Mechanical Engineering Visiting Committee. He also was actively involved with the Boy Scouts of America and the local Jewish community. In 1954 he worked to establish the Beth Israel-West Temple, whose members included a number of NASA employees. He also established and led a Cleveland Council on Soviet Anti-Semitism in 1965. With the Scouts, Abe served as a leader at both city and district levels, established an Explorer Post at NASA, and sponsored a national jamboree in Cleveland in 1969. He was recognized repeatedly for his contributions.

Abe contributed to at least 50 technical reports during his career and presented many significant papers. He presented a paper to the Institute of Aeronautical Sciences annual meeting in January 1939, provided findings of in-depth turbojet engine studies at General Electric's Aircraft Gas Turbine Engineering Conference in May 1945, was the American representative to the Joint Meeting of the Institute of the Aeronautical Sciences and the Royal Aeronautical Society in London in 1947, delivered the annual Wright Brothers Lecture before the Institute of the Aeronautical Sciences in 1948, delivered the 49th Wilbur Wright Memorial Lecture in London in 1961, presented a paper to the International Council of the Aeronautical Sciences

Fifth Congress in London in 1966, and delivered the Biennial Theodore von Kármán Memorial Lecture at the Tenth Israel Annual Conference on Aviation and Astronautics in Tel Aviv, Israel, in 1968.

Abe was awarded an honorary engineering degree by Case Institute of Technology in 1958, an honorary doctor of science degree by Rose Polytechnic Institute in 1959, an honorary doctor of humane letters degree by Yeshiva University in 1960, and an honorary doctor of applied science degree by John Carroll University in 1967. He was presented with the Air Force Exceptional Civilian Service Award in 1960, the NASA Medal for Outstanding Leadership in 1961, the National Civil Service League's Career Service Award in 1962, the Sylvanus Albert Reed Award of the American Institute of Aeronautics and Astronautics (AIAA) in 1964, the Louis W. Hill Space Transportation Award of the AIAA in 1967, and the Boy Scout Silver Beaver Award, NASA Distinguished Service Medal, and Rockefeller Public Service Award in 1968. In 1997, Abe received the prestigious Guggenheim Medal for his "technical contributions and visionary leadership in advancing technology of aircraft and propulsion performance, and foresight in establishing the Mercury and Apollo manned space flight activities."

In 1994, the 10′ x 10′ Supersonic Wind Tunnel was renamed to honor Abe: its official name is now the Abe Silverstein 10′ x 10′ Supersonic Wind Tunnel. The Abe Silverstein Award was instituted at that time to annually honor a NASA Lewis individual performing outstanding research with practical applications.

Abe was a member of Tau Beta Pi; a fellow of the American Institute of Aeronautics and Astronautics, the American Astronautical Society, and the Royal Aeronautical Society; and a member of the International Academy of Astronautics and the National Academy of Engineering. He spent four years in the Reserve Officers' Training Corps (ROTC, 1925 to 1929). As a Second Lieutenant in the Air Corps reserves, he was activated for two weeks at Wright Field in July 1931.

Abe married Marion Crotser, a NACA technical editor, in December 1950 and resided in a nearby Cleveland suburb. They had three children in the 1950s—Joseph, Judith, and David. Marion passed away in 1998 after 48 years of marriage. Joseph lives in Thousand Oaks, California; Judy Cook in Columbia, Maryland; and David in Maumee, Ohio. Abe had five grandchildren at the time of his death.

Abe remains the seminal figure in the history of the NASA Glenn Research Center. Although he is best known for his efforts in the establishment of NASA in the late 1950s, his contributions to World War II piston aircraft, early jet and ramjet propulsion, high-energy fuels, the design of test facilities, and the airline industry are also important. He expected high levels of performance from himself and his staff. He often took engineers away from their niche fields and pushed them into new areas in which they could excel. Although sometimes demanding and gruff, he was also known to be very caring, concerned with the well-being of others, and involved with the community. He summed up his philosophy in an October 5, 1984, interview with Virginia Dawson:

> You make the future. It's not predicting the future. That's what I have told people many times. People who say, "How did you figure out what to do?" Well, you are making the future because the only thing that you have to go on when the future arrives is what you have stored up from the past.

W. DAVID SINCOSKIE

1954–2010

Elected in 2000

"For contributions in packet switching for integrated networks."

BY STEWART PERSONICK

We note with deep regret the death of our respected colleague, W. David Sincoskie, who passed away on October 20, 2010, at age 55. He was born in Wilmington, Delaware, in 1954, and received his bachelor's (1975), master's (1977), and PhD in electrical engineering (1980) from the University of Delaware.

A fellow of the International Electrical and Electronics Engineers (IEEE), Dave was a pioneering contributor for more than three decades to the field of computer communications and, in particular, to the emergence of today's ubiquitous Internet and its many applications. He was a member of the community of researchers who early on recognized that rapid advances in electronics, signal processing, and high-capacity communication systems would enable a single, integrated telecommunications network to economically provide transport of data, voice, and video information in the form of packets.

He worked for many years (1980–2008) in the telecommunications industry, at Bell Laboratories and at Bellcore (now Telcordia Technologies), before transitioning to a second career as a full professor and the founding director of the Center for Information and Communications Sciences at the University of Delaware.

During his career as a researcher and research manager in the telecommunications industry, Dave organized research groups and research initiatives in the then emerging areas of local area networks, packet switching, packet network architecture, Internet telephony, and packet video. His research activities and contributions also extended to packet network management, mobile and ad hoc networking, all-optical and wireless networking, and network security. He made many seminal contributions to the science and technologies of packet communications networks, including the first demonstration of a voice-over-packet telephone, the first virtual local area network (LAN), the first description of a digital video server, and the first wide area gigabit-data-rate computer network (the Aurora network). He cofounded the subfield of active networking. During the transition, circa 1995, of the US government-sponsored NSFnet (previously ARPAnet) to today's commercial Internet protocol (IP) networks, Dave played a key role in encouraging and assisting the traditional telecommunications carriers to establish network access points (NAPs) to enable them to accept and deliver Internet traffic.

From 1996 to 2008 he was group senior vice president of Telcordia's Networking Systems Laboratory where, among other achievements, he did much to advance Internet telephony. From 1989 to 2008, he was also an adjunct professor of computer and information science at the University of Pennsylvania.

Dave's record of service to the US Department of Defense through the National Research Council included membership on the Board on Army Science and Technology (BAST) and committees of the Air Force Studies Board. He served on the BAST Committee on Strategies for Network Science, Technology, and Experimentation, which recommended the creation of a government-sponsored research center in network science, directly contributing to the decision to create the Army Research Laboratory Network Science Collaborative Technology Alliance. He also served for many years on the US Defense Advanced Research Project Agency's (DARPA) Information Sciences and Technology group and the Internet

Architecture Board. In addition, as a Special (US) Government Employee since 2002, he provided technical and management advice to senior executives at the National Security Agency.

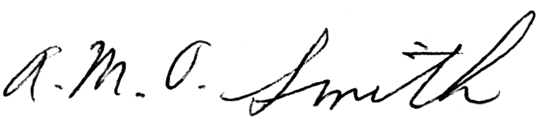
Dave received the IEEE Communication Society's Fred W. Ellersick Prize in 2003 for his paper "Broadband Packet Switching: A Personal Perspective," which detailed his research contributions over two decades to the development of the broadband Internet. In 2006 he was inducted into the University of Delaware's Alumni Wall of Fame. He was a member of Tau Beta Pi and Eta Kappa Nu.

His colleagues remember Dave as a dedicated and persistent researcher and research manager. He was also a conscientious mentor and generous research collaborator. People all over the world who are using high-performance and low-cost packet communications for business, education, entertainment, personal activities, and participation as informed citizens in democratic societies are the beneficiaries of his life and work.

Dave is survived by his wife JoAnn, who wrote that he enjoyed travelling around the world and gourmet dinners at home with her and their cats.

> Dave and I enjoyed spending our 25th anniversary in Paris and Cannes, France. He and I also spent a pleasurable time in Tokyo, Japan, and for several years had fun hiking in Austria and Switzerland. We had good memories of times in Boston after Dave's business trips to Woods Hole. His most recent hobby had been playing golf and he enjoyed it in Taiwan, Palm Springs, and at Hartefeld Country Club near his home in Delaware.

He was a wine connoisseur and his wife, a gourmet cook, added that they enjoyed dinners at home. She wrote that "Dave valued his friends and colleagues, who during nice weather would visit and dine outdoors" on their deck, but he also enjoyed an occasional pizza night with his wife and her father and aunt on their deck in Delaware.



A.M.O. SMITH

1911–1997

Elected in 1989

"For practical contributions to aerodynamics and rocketry and especially for many pioneering advances in computational aerodynamics."

BY ROBERT LIEBECK

APOLLO MILTON OLIN SMITH, chief aerodynamics engineer–research at the Douglas Aircraft Company and creator of the fundamental techniques for the calculation of aerodynamic flows, died on May 1, 1997, at the age of 85. "AMO," as he was known, passed away in his home in San Marino, California, where he lived for 54 years.

AMO was born in Columbia, Missouri, on July 2, 1911, and his early years were spent in Missouri, Oklahoma, Kansas, and Indiana. His father was a chemist, working primarily for oil companies. While living in Oklahoma and in the fifth grade, AMO came down with phlebitis and typhoid fever. To quote AMO, "This is certainly the sickest I have ever been. I seemed to be unconscious, and my mother called our doctor and said 'you better come over right away; he's dying.' I was not really unconscious and said 'huh?' This shook her up a bit."

In 1925 AMO's father became chief engineer at Skelly Oil Company, a consequence of the cracking stills he helped develop. This led to a move to Long Beach, California, in 1927, where AMO entered Woodrow Wilson High School. He joined the orchestra, played 2nd clarinet, and considered becoming a professional musician. By the time he became a senior his focus turned to mathematics and engineering with a goal of entering Caltech. A classmate was John Pierce (winner of the National

Medal of Science and member of the NAE), and AMO, John, and two others set about building a glider. The glider can now be regarded as a cornerstone for AMO's career in aeronautics.

Following a steep learning curve, including stalls and crashes, AMO and John Pierce both entered a contest at Pacific Beach near San Diego. AMO won three cups—distance, endurance, and altitude. To quote AMO: "My altitude launch was peculiar. Launchings were with a shock cord pulled by about 20 Navy seamen. The glider was anchored to a truck and released by a trigger. The acceleration was 4Gs so that the glider was flying in about four feet. Our control stick had a bicycle grip for a handle. In my winning flight, the acceleration was so great that the grip came off the stick. There I was climbing steeply with a free control stick. By the time I had recovered and gained control, I had won the altitude contest. The temporary lack of control is probably why I won the contest. People on the ground said I uttered a startled 'gosh.'" AMO summarized his Woodrow Wilson High School career by stating, "In my senior year I made all As without ever taking a book home."

AMO was accepted at and entered Caltech in the fall of 1929, planning to become a chemist like his father. His first year did not go well and his grades were mostly Cs. He left Caltech and went to work at Western Oil & Refining, where his father was superintendent. At the same time he went to Compton Junior College where he focused on improving his math and did very well. When he reapplied to Caltech in the fall of 1931, he was welcomed back. On his return he decided to major in mechanical engineering, hoping to eventually major in aeronautical engineering—but there were no aeronautics classes for undergraduates. On completing his junior year, he again left Caltech to work and earn the money to continue. He returned to complete his BS in mechanical engineering in 1936.

AMO then entered graduate school and obtained a job helping Frank Malina prepare illustrations for a book being written by Theodore von Kármán and Maurice Biot. Because many of the figures were graphs of mathematical functions, AMO had to learn and understand the functions themselves.

In the end, AMO made the majority of the illustrations and it was a valuable experience. At the same time, Malina was also working on rockets, and AMO became interested and joined in.

A rocket motor was built in the fall of 1936 by Malina, John Parsons, and Edward Forman, and AMO went along for the first test in an isolated area above Devil's Gate Dam. There is a historic picture of the group with AMO wearing peculiar headgear. In fact it was an explorer's helmet that AMO had modified to improve ventilation. Said improvement was made from his mother's pepper box using tin snips and a soldering iron. This initial firing of a rocket motor in the Arroyo Seco resulted in the Jet Propulsion Laboratory (JPL) being built there. And there is a bronze plaque referencing the Malina group and a replica of the now famous photo.

Smith graduated from Caltech in 1938 with master's degrees in both mechanical and aeronautical engineering. He went to work for the Douglas Aircraft Company, El Segundo Division, as assistant chief aerodynamicist, a position he held until 1942. His early work included wind tunnel testing of the A-20 light bomber, performance analysis of the DC-5 transport, and aerodynamic design (particularly of the wing) of the A-20 (later called the B-26). He was largely involved with the aerodynamic design of the D-558 Phase 1 airplane, a world speed record holder. This was a jet-powered research airplane that pioneered the investigation of the transonic flight regime.

One of AMO's early challenges was to resolve a performance issue with the Douglas SBD *Dauntless* Navy dive bomber. The first prototype had flown very well, and the second prototype came off the line with a striking Navy paint job (dark blue fuselage and bright yellow on the upper surface of the wing, with the entire lower surface of the airplane Navy grey). The first airplane was plane aluminum as it was intended solely for flight test. The second prototype did not fly well—its stall speed was higher and the airplane was difficult to fly at low speed, dropping one wing or the other. The Navy was scheduled to take delivery of the second airplane to begin its own flight testing in a few days. A careful check of the airplane's geometry and rigging showed no defects. AMO was called in to fly in the back seat of the SBD and observe the problem firsthand. As he walked up to the airplane he noticed a masking tape line on the wing's leading edge that separated the yellow on the top from the grey on the bottom. AMO took out his pocket knife (a device he felt all engineers should carry) and began to remove the ridge left by the tape. A Douglas marketing man became concerned and asked AMO to stop because he was tarnishing the striking paint job. AMO prevailed and then asked the test pilot to try the now-tarnished SBD. After a short flight, the test pilot returned all smiles. The tarnished airplane flew just like the first prototype—very well! AMO explained that the tiny tape ridge was in effect a stall strip that disturbed the thin boundary layer just aft of the leading-edge stagnation point. Later, he expressed disappointment that his ingenuity precluded an opportunity to fly in the SBD.

From 1942 through 1944, AMO had a brief recess from the Douglas Aircraft Company. At the written request of Gen. H.H. Arnold, he was loaned from Douglas to become chief engineer of the Aerojet Engineering Corporation. Under AMO's guidance, the engineering organization at Aerojet was established and grew within 18 months from 6 people to more than 400. He developed and saw into mass production the first JATO-type rocket. This was based on his earlier work on the GALCIT project that led to the founding of JPL. For his work at Aerojet, AMO received the Robert H. Goddard Memorial Award of the American Rocket Society in 1954.

AMO returned to Douglas in 1944 and resumed his work involving aerodynamics and preliminary design. He was responsible for the detailed aerodynamics of the D-558-1 Skystreak research airplane, which for a period held the world speed record. His role in this work is covered in the book *Supersonic Flight—Breaking the Sound Barrier and Beyond*, by R.P. Hallion, published by MacMillan and Co. in association with the Smithsonian Institution. Another of his designs won the competition for a night fighter that became the F3D-1 Skyknight.

At the end of World War II, AMO was a member of the US Naval Technical Mission in Europe. As an indirect consequence of this work, he proposed and began studies of a tailless aircraft. These studies culminated in the F4D-1 Skyray interceptor that for a period held six official FAI World Records, one for absolute speed and the others for climb performance.

In 1948, AMO became supervisor of design research at the Douglas Aircraft Company, a position he held until 1954. During this period he conducted a considerable variety of studies, mostly with an aerodynamic bias. The work receiving the most effort was the field of laminar flow control, but perhaps the most important accomplishment was the development of a very general method of calculating the low-speed flow about bodies of arbitrary geometry. This method is called the Douglas Neumann Program.

In 1954 AMO rejoined the Douglas Aerodynamics Section as supervisor of aerodynamic research, and his work—dealing with aerodynamic problems of a research nature—remained in this area until he retired. The main accomplishments were development of practical methods of analyzing laminar and turbulent boundary layer flow, the hydrogen bubble technique of flow visualization, potential flow analyses, analysis of stability and transition of boundary layers, and introduction of the e^n method of predicting transition. AMO pioneered the application of computers to many of these problems.

From 1969 to his retirement from Douglas in 1975, AMO had the title of chief aerodynamics engineer–research. For his work in the development of potential flow methods, he received the Douglas Engineering Achievement Award in 1958. This may have been his most treasured award—and may yield some insight into the challenge of his early contributions.

AMO was the recipient of numerous honors and awards, including the Wright Brothers Lecture in 1974, an honorary doctor of science from the University of Colorado, honorary fellow of the American Institute of Aeronautics and Astronautics, the Casey Baldwin Award of the Canadian Aeronautics and Space Institute (CASI), and member of the National Academy of Engineering.

Today, AMO's career may appear inverted. He began designing and testing airplanes at the Douglas Aircraft

Company, and experienced the technology needs of the day firsthand. This turned out to be the ideal preface for his next job in 1954 as head of the Aerodynamics Research Group at Douglas. At that time aerodynamic analysis tools were approximate, based primarily on linear methods. AMO initially set about developing a method to analyze a laminar boundary layer, and this was followed by his development of an integral method for solution of the turbulent boundary layer. A very significant contribution to boundary layer theory is AMO's e^n method for predicting transition of a laminar boundary layer to a turbulent one.

What may be one of AMO's most significant contributions is his development of the panel method for the exact calculation of the potential flow about a body of arbitrary geometry. The initial solution, sponsored by the Navy, was an axisymmetric body. Next came two-dimensional flow about an airfoil, and finally three-dimensional flow about a body with wings and lift. AMO named this capability the Douglas Neumann Method after the German mathematician whose boundary value problem it solves. That he did not include his own name in the method says much about AMO's character.

AMO's insight into the physics of fluid flow, coupled with his background and experience in airplane design, enabled him to lead the establishment of the field that is today called computational fluid dynamics (CFD). If CFD is defined as the accurate calculation of the flow about a body of arbitrary geometry, the combination of the Douglas Neumann Method, AMO's laminar and turbulent boundary layer solutions, and the e^n transition prediction can be regarded as the origin of CFD. The aerodynamic design of airplanes entered a new era where the wind tunnel would ultimately become a verification of the CFD calculations.

A thorough documentary of AMO's life and contributions is given in the book *Legacy of a Gentle Genius: The Life of AMO Smith*, by Tuncer Cebeci (Horizons Publishing, Long Beach, California, 1999). Tuncer and the author of this memorial were indeed fortunate to have been members of AMO's Aerodynamics Research Group.

Finally, one of AMO's most special qualities was the scholarly imagination and creativity that he focused on aerodynamics and fluid mechanics. It was typical for him to come up to one of his engineers in the Aero Research Group and say, "Hey, I've been thinking about—." And thus a new aerodynamic concept would be born. An array of these concepts ultimately culminated in his classic 37th Wright Brothers Lecture, "High-Lift Aerodynamics," which has become a required "text" for many aerodynamics courses. It is symbolic of the canonical contributions of Apollo Milton Olin Smith to aerodynamics and the design of airplanes.

LOUIS D. SMULLIN

1916–2009

Elected in 1970

"For contributions to microwave electronics and to engineering education."

BY PAUL PENFIELD JR.

LOUIS DIJOUR SMULLIN, electrical engineering educator and specialist in radar and microwave systems, died June 4, 2009, at the age of 93. During most of his career he was on the faculty of the Massachusetts Institute of Technology in the Department of Electrical Engineering and Computer Science.

Lou (or Louie, as some called him) was born in 1916 in Detroit, Michigan. After two years at Wayne University in Detroit, he transferred to the University of Michigan in Ann Arbor, where he received the BSE degree in electrical engineering in 1936. Following two years of industrial experience, he enrolled at MIT, where he earned an SM degree in 1939; his thesis, "The Acceleration and Focusing of Electrons in Multi-Stage Tubes," was written under the supervision of John G. Trump. In June of that year he married Ruth Frankel, starting almost 70 years of married life (she died in 2011).

His early industrial experience spanned what was at that time a broad range of electrical engineering. After a few months in 1936 as a draftsman at Swift Electric Welder Company in Detroit, he worked for two years for the Ohio Brass Company, in Barberton, conducting and analyzing impulse tests on transmission-line insulators at high voltage. He also operated a radio-interference testing station, subjecting transformer bushings to voltages up to 150 kV.

With his new MIT master's degree he went to Farnsworth Television Company, Fort Wayne, Indiana, to design and test photomultiplier tubes. In 1940 he joined the Scintilla Magneto Division of Bendix Aviation Corporation in Sidney, New York. While there he designed instruments for testing ignition systems and the VHF radio interference they caused and worked on various aspects of magneto design. It was in Sidney that the first of his four children, Susan, was born.

Like many of his contemporaries, Smullin altered his career to fit his country's needs during World War II. He was called to the MIT Radiation Laboratory in 1941 by Prof. Trump and served as head of the Radiation Laboratory TR and Duplexer Section. This group developed methods for testing microwave TR (transmit-receive) tubes for 3 GHz and above, most of the radar duplexer systems in use at the end of the war were based on its designs. Lou coauthored one of the 28 books in the famous MIT Radiation Laboratory Series.

After the war, in 1946, Lou moved his family (now including two sons, Frank and Joseph) to Nutley, New Jersey, and joined the Federal Telecommunications Laboratory. As head of the microwave tube group, he supervised the development of a continuous wave (CW) 5 GHz magnetron and other microwave components for communications systems.

Then, in 1947, he returned to MIT to organize and head the Microwave Tube Laboratory in the interdepartmental Research Laboratory of Electronics. Later he joined the newly formed Lincoln Laboratory, a federally funded off-campus MIT laboratory, as head of Division 4 (Radar and Weapons). He served there for three years before returning to MIT as an associate professor in 1955. By this time his family was complete with the birth of the fourth child, David.

At MIT Lou was promoted to professor in 1960 and served as department head from 1966 to 1974. In 1973 he was named Dugald C. Jackson Professor, filling a chair named for an earlier, very influential MIT Electrical Engineering Department head. After retiring in 1986, he remained actively involved with departmental affairs until he suffered a stroke in 2001.

Smullin was one of the last of a dying breed: faculty members without a doctorate. Today this would be unusual at any leading American research university, but in the 1950s and earlier it was not. During his years on the faculty, including when he was department head, his ideas were never questioned for this reason. His industrial and wartime experience more than made up for any lack of paper credentials. He was held in such high esteem that although he was a stutterer his entire life, people always listened to him attentively, never impatiently, knowing that his ideas were well worth waiting for.

When Lou joined the faculty in 1955, his technical expertise was in microwave systems, especially vacuum tubes. His style was to combine a sound theoretical base, excellent experimental skills, and an appreciation of practical needs, so that problems chosen for research would be sure to be important. In subsequent years, he expanded his technical interests to include high-power radar systems, noise in electron beams, high-bandwidth high-power microwave amplifiers, and highly ionized plasma dynamics. His ability to exploit novel theoretical ideas experimentally allowed him to make important contributions to all these fields. His group's work on high-temperature plasmas helped define the subsequent international effort on fusion energy.

In 1962 he led a group that bounced a laser beam off the moon and detected the reflection in a project they whimsically called "Luna See." A year later, his laser radar observations of the upper atmosphere were found to be consistent with the theory that the Earth continually receives small meteors that do not burn up but instead fragment into smaller particles that eventually settle to earth.

As department head, Smullin led the discussion of what was probably the most important strategic issue the department ever faced. Recognizing that he could not, with his background, effectively lead a department as broad as his had become, he appointed two associate department heads to help him, one from the electrical engineering side of the department and one from the computer science side. Then, considering the growing interest in digital systems, computer technology and applications, and discrete mathematics, he asked whether it would be better to remain as one department or split into two, one for the growing field of computer science. There were arguments on both sides, but in the end a departmental consensus developed that the two fields would not drift apart but instead retain their strong ties. (This conclusion was repeatedly validated in subsequent years by advances in digital circuits and digital signal processing in the 1970s, very large-scale integration [VLSI] in the 1980s, networking in the 1990s, embedded computing in the early 2000s, and today's proliferation of smart consumer products.) It was therefore deemed prudent to remain one department and encourage the growing computer activities. The name of the department was changed to Electrical Engineering and Computer Science, and subsequent department heads followed Smullin's example of appointing two associate department heads.

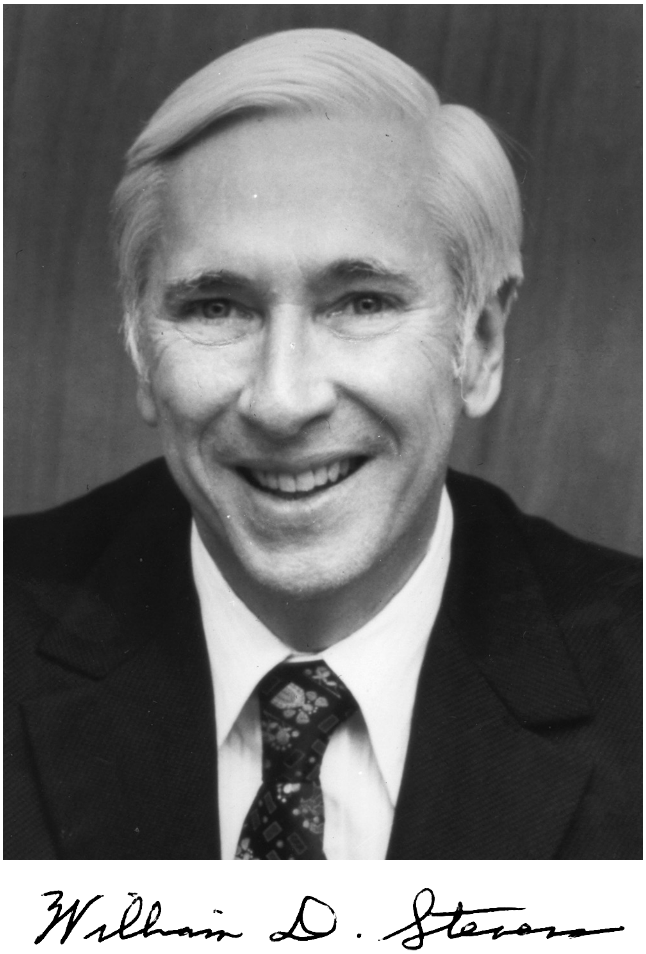
During his later career, as elder statesman, Lou produced a series of short, thoughtful unpublished positions on such topics as undergraduate engineering education, national energy policy, continuing education, and the professional status of engineers. He was a member of the IEEE Economic Analysis Committee in 1971. He tried to understand a few controversial technical topics, including electromagnetic radiation hazards and cold fusion, so he could be a resource for those contemplating working on them. His reasoning was that, at this stage in his career, he had nothing to lose if his research was not successful, but his perspective might be useful to junior colleagues.

Lou shared his wisdom broadly. The Smullins spent the 1965–1966 academic year in India, where nine US universities including MIT helped set up the academic and research programs of the newly established Indian Institute of Technology in Kanpur. From 1969 to 1992 he served on the board of governors of the Technion, from which he received an honorary doctorate in 1986. Between 1969 and 1973 he was on the board of trustees of the Cambridge School of Weston, a private school near Boston.

Smullin received many honors during his career. Besides being a member of the NAE (elected in 1970), he was a fellow of IEEE, APS, and AAAS (American Academy of Arts and Sciences), and a member of Eta Kappa Nu and Sigma Xi.

Lou always took an interest in those he worked with. People in his research group—colleagues, students, technicians, and support staff—appreciated the annual tradition of time with Lou and Ruth at their vacation home on Cape Cod. Many of his students viewed him as a father figure and kept in touch long after graduation.

For 15 years after his retirement Lou continued to ride his bicycle between home and office, a distance of 5 miles. In this and many other ways he was a source of admiration and inspiration, both to his children and grandchildren (and great-grandchildren) and to his many colleagues and friends.


William D. Stevens

WILLIAM D. STEVENS

1918–2007

Elected in 1983

"For major contributions in fossil and nuclear power and innovator of managerial and financial techniques for large engineering projects and organizations."

BY ERNEST L. DAMAN

WILLIAM (Bill) D. STEVENS, retired chairman of Foster Wheeler Corp., died November 5, 2007, at his home in Livingston, New Jersey. He was born August 4, 1918, in Bayonne, New Jersey.

He received a BS in mechanical engineering from the Rensselaer Polytechnic Institute in 1940, and attended the Case Institute in 1958 for a management development program. He was a member of Tau Beta Pi, Pi Tau Sigma, and Sigma Xi.

Bill joined Babcock & Wilcox Co. as a student engineer and advanced to manager proposition engineer by 1961. His tenure at B&W was interrupted in 1943 by service in the US Navy (1943–1945), where he served as engineering officer on destroyer escorts and finally as assistant material officer to the Commander Destroyers, Pacific Fleet.

In 1962 he joined the Foster Wheeler Corp. as manager of the Steam Department, progressing to executive vice president in charge of all electric utility, marine, and industrial steam generators, condensers, feed water heaters, and auxiliary equipment. In that capacity he was responsible for proposals, design, manufacturing, and construction worldwide. In 1978 he was elected chairman of the board. He retired in 1981 but continued as a director.

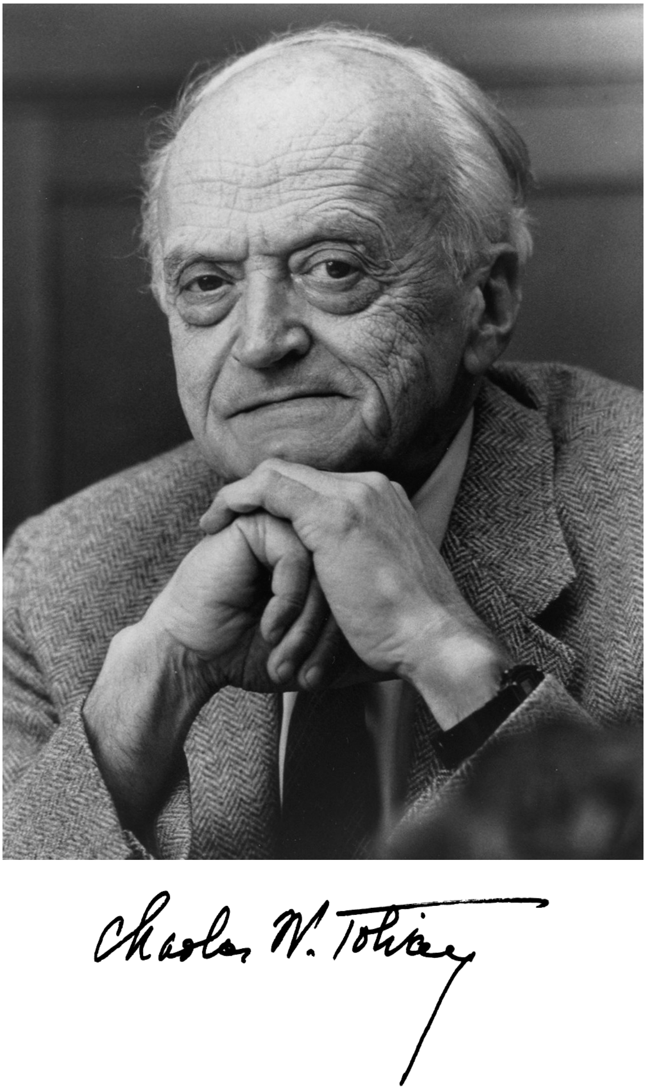
Bill's arrival at Foster Wheeler in 1962 coincided with a trend toward a large increase in the unit size and steam pressure of utility steam generators. Efforts to address that change required major developments in materials, structures, heat transfer, and combustion technology as well as manufacturing processes. This is where Bill's great contributions as manager and innovator came to the fore. As a result of his efforts Foster Wheeler emerged from its position as a minor player in the supply of utility steam generators to capture a major share of that business.

His talents extended to the development of nuclear steam generators and auxiliary equipment for gas-cooled and breeder reactors and most importantly to the development of fluidized bed combustion steam generators. The latter resulted in Foster Wheeler's world leadership in that technology.

Bill was elected to the National Academy of Engineering in 1983. He was also a fellow of the American Society of Mechanical Engineers and a member of the board of overseers of the New Jersey Institute of Technology (NJIT) and the Rensselaer Council. In 1986 NJIT awarded him an honorary doctorate.

He held 20 patents and was the author of five major publications. He was a licensed professional engineer in New York, New Jersey, Florida, and Massachusetts. While living in Hackensack, New Jersey, he served on the planning board and the board of the mental health consultation center, and led the Hackensack Red Cross Fund Drive for a year.

His wife remembers that he enjoyed spending time at their home on Cape Cod and fishing and boating there. He also especially enjoyed spending time with his family. He is survived by his wife, Mary E. Stevens; his daughter Sandra A. Melin and her husband, Jeffrey N. Melin; his son-in-law Dennis J. Gallagher; his son William K. Stevens; his grandchildren Michelle M. Niemeyer, Cynthia A. Melin, David Gullo, James D. Gallagher, Michelle Gallagher, Timothy A. Gallagher, Carol Gallagher, Lisa Kerrigan, Edward Kerrigan, Jessica Stevens, William J. Stevens, Tara Stevens, Christopher Stevens; and his great-grandchildren Parker Kerrigan, Katie Kerrigan, Mason Kerrigan, Jenna Gallagher, Lauren Gullo, Mary Gullo, Andrew Gullo, and Cora Stevens. His daughter Barbara E. Gallagher is deceased.



CHARLES W. TOBIAS

1920–1996

Elected in 1983

"Outstanding pioneer and leader in the development of electrochemical engineering into a quantitative discipline based upon fundamental principles."

BY C. JUDSON KING

CHARLES W. TOBIAS, professor of chemical engineering at the University of California, Berkeley, and principal architect of the modern field of electrochemical engineering, died on March 6, 1996, at the age of 75.

Charles was born in Budapest, Hungary, on November 2, 1920. He received his diploma in 1942 and his doctorate in 1946 from the University of Technical Sciences in Budapest. In 1947, following his brother Cornelius who was a faculty member in medical physics at Berkeley, Charles left Hungary for the United States and Berkeley, California. Shortly thereafter, he was hired by Dean Wendell Latimer of the College of Chemistry at Berkeley to join the faculty of the nascent Chemical Engineering Group.

Tobias carried out a stellar program of research relating to electrochemical processes and phenomena for almost 40 years, for most of that time as a faculty senior scientist at the Lawrence Berkeley Laboratory. Among his many accomplishments were the development of methods for measuring mass- and heat-transfer rates in both forced and natural convection situations, the use of interferometry to elucidate mass-transfer phenomena in the vicinity of electrodes, interpretation of the nature of conductivity in two-phase systems, and enhanced understanding of the effects of electrode resistance on rates of reaction. His work on deposition from nonaqueous solvents directly underlay the future development of the now pervasive long-life lithium and lithium-ion batteries.

Charles's graduate students produced 32 master's theses and 34 doctoral dissertations. His PhD graduates have literally populated the academic electrochemical engineering faculty of the succeeding generation. Thus in many ways he was the father of his field. He had more than 150 publications and patents.

As chair of the Berkeley Chemical Engineering Department from 1967 to 1972, Charles placed strong emphasis on broadening the department to cover the newer subfields of chemical engineering, in particular the processing steps involved in semiconductor manufacture. This interest meshed well with the development of Silicon Valley and led to close ties between Berkeley chemical engineering and that growing industry. He also was acting dean of the College of Chemistry in 1978.

Charles was elected to the National Academy of Engineering in 1983 and served shortly thereafter on NAE's Committee on Electrochemical Aspects of Energy Conservation and Production. He was president of the Electrochemical Society (1970–1971), a fellow and honorary member, and recipient of the society's Acheson Award (1972), the first Henry B. Linford Award for Distinguished Teaching (1982), and the Vittorio de Nora Diamond Shamrock Award for Electrochemical Engineering and Technology. He was president of the International Society for Electrochemistry (1977–1978). From the American Institute of Chemical Engineers he received both the Alpha Chi Sigma Award for distinguished research and the Founders Award.

Charles met his first wife, the former Marcia Rous, while living in Berkeley's International House after his arrival. They had three children, Carla, Eric, and Anthony. After Marcia's untimely death in 1981, Charles married Katalin Voros, who survives him.

A mentor to many, Charles was a warm and caring person who was deeply invested in the development of younger faculty colleagues and the careers of his graduates. He took a special interest in helping refugees from Hungary, beginning with the 1956 Hungarian revolt, and brought many to the United States and Berkeley. One of these, Louis Hegedus, is now an NAE member.

Charles grew up with the classics and arts, and he made them important parts of his life. He studied violin at the Municipal Conservatory of Music in Budapest and graduated with a major in violin performance. He kept his love of the violin all his life, often playing with chamber groups. He was also closely involved with the Berkeley Art Museum, and served as its acting director in 1972 and chair of its board for two terms, 1972–1973 and 1974–1975.

Robert V. Whitman

ROBERT V. WHITMAN

1928–2012

Elected in 1975

"For pioneering in soil dynamics, especially in predicting and controlling earthquake effects on constructed facilities."

BY CHARLES C. LADD

ROBERT V. WHITMAN, professor emeritus of civil and environmental engineering at the Massachusetts Institute of Technology (MIT), died of Parkinson's disease on February 25, 2012, at his home in Lexington, Massachusetts, at age 84. He was world-renowned for his expertise and leadership in soil dynamics and geotechnical earthquake engineering, as an engineering educator, and for his dedication to public service.

Bob Whitman was born of academic parents on February 2, 1928, and raised in a small town near Pittsburgh, where building small dams in a backyard creek prompted his desire to become a civil engineer. After earning a BS degree (1948) in civil engineering from Swarthmore College, he attended MIT for his graduate studies in civil engineering, in hydraulics and structural engineering (SM 1949) and in structural dynamics for his doctorate (ScD 1951). He then joined Professor Donald Taylor's geotechnical group, which sought his knowledge of dynamics to study the effects of nuclear blasts on underground structures for the design and construction of long-range missile facilities. This switch initiated Bob's illustrious career in the new discipline of soil dynamics, which included service on Air Force advisory panels for the earliest of the hardened missile complexes and then for developing stable foundations for long-range radar stations to track incoming missiles. His research then expanded to the general problem of designing foundations with vibrating loads. Two ASCE (1967) papers coauthored with the late F.E. (Bill) Richart Jr., which treated the problem as a rigid disk resting on an elastic half-space, represented a fundamental breakthrough in the understanding of foundation dynamics. Bob became one of the pioneers and leading experts in the area, and generations of MIT students benefited from drafts of his book on soil dynamics.

After two years with Taylor as a research engineer/associate, Bob was appointed assistant professor of civil engineering and remained on the MIT faculty for the next 40 years until he retired in 1993 as professor emeritus. Early on at MIT, he met a draftswoman–interior designer, Elizabeth (Betsy) Cushman, whom he married in 1954 shortly before attending the Navy's Officer Candidate School in Newport, Rhode Island. They moved to Hawaii where he served in the Civil Engineer Corps at the Pearl Harbor Naval Shipyard until late 1956.

The devastating 1964 earthquakes in Alaska and Niigata, Japan, stimulated research on the effects of ground shaking on the potential liquefaction of water-saturated sand (i.e., its loss of strength and load-bearing capacity) and associated damage to buildings and related infrastructure. Bob's initial technical contributions to this new discipline of geotechnical earthquake engineering included developing the analytical method (in 1953 when hired by Professor Taylor, who was consulting on slope stability problems along the Panama Canal) that was adopted for the well-known and still widely used Newmark "sliding-block analysis" to estimate the movement of earth slopes during earthquakes. He then went on to independently develop a method similar to the Seed-Idriss Simplified Procedure to predict the potential for soil liquefaction based on in situ tests for assessing the sand's resistance to shaking; draw the first national earthquake hazard maps (i.e., contours of equal probabilities for peak ground acceleration) utilizing probabilistic predictions developed by the USGS; and draft the 1985 National Research Council (NRC) report *Liquefaction of Soils During Earthquakes*, which still serves as a general guide for earthquake liquefaction analyses. Bob also served for five years as chair of ASCE's Technical Council on Lifeline Earthquake Engineering and received its C. Martin Duke Award (1992).

During his transition from soil dynamics to earthquake engineering, Bob coauthored with MIT colleague Professor T. William (Bill) Lambe the classic textbook *Soil Mechanics* (1969). Its unique organization, developed by Bob, had three principal parts, treating dry soil, wet soil with steady state flow, and wet soil with transient flow (e.g., consolidation). Of Bob's many accomplishments, he was "probably proudest of that book," which many believe provides even today the best reference for teaching and learning the fundamental principles of soil mechanics.

Bob pioneered in the application of probability-based risk analyses to earthquake engineering by considering the uncertainties both in the occurrence and magnitude of earthquakes and in the resulting damage as a function of building type and local soil conditions. This approach was initiated in cooperation with Bob's MIT colleague, the late C. Allin Cornell, who had unique expertise in using stochastic models to represent earthquake loadings on and damage to buildings. Together, they developed damage probability matrices that ingeniously integrated the likelihood of occurrence of seismic events (the hazard matrix) and the resulting levels of damage to different types of buildings (the damage matrix). This new seismic-design decision analysis framework enabled rational risk assessments, i.e., comparison of the cost of earthquake damage with the cost (level of seismic design) to mitigate the damage. This approach formed the basis for new seismic provisions in building codes, the first outside California being the 1975 Massachusetts code headed by Bob, and eventually led to the current probability-based design practice. Awards recognizing this work include Bob's election to the NAE in 1975, followed by Allin Cornell's election in 1981.

Bob was one of the brightest stars in the Earthquake Engineering Research Institute (EERI), which was established in 1948 by the late George W. Housner and several others to promote earthquake engineering and now has some 3,000 members. He was the only person, other than Housner, to have been EERI's President (1985–87), Distinguished Lecturer (1994), Honorary Member (1997), and Housner Medal recipient (2010). Bob used his term as president to further promote a nationally applicable, standardized methodology for estimating losses from earthquakes (prior work had been largely confined to California). He chaired the NRC panel that prepared the 1989 report *Estimating Losses from Future Earthquakes*, which laid the groundwork for the new loss methodology structure. Bob then led the committee that oversaw the development of the computer-based software program called HAZUS Earthquake. This program, funded by the Federal Emergency Management Agency (FEMA), was intended to guide government agencies in both earthquake mitigation (i.e., seismic provisions in building codes) and disaster response planning, but it was soon also adopted in engineering practice. The program calculates seismic hazard, evaluates the likely damage to buildings and other infrastructure facilities, and estimates both direct and indirect losses resulting from this damage. Bob's technical and policy contributions played a key role in the development of HAZUS, which FEMA expanded to include floods and hurricanes.

Bob Whitman was widely admired for his leadership and commitment to public service. His brilliant analytical and insightful mind enabled him to identify key issues, express them clearly, and then present viable solutions to problems ranging from the highly technical to largely political. His leadership at the national level included more than 40 years of near-continuous service on committees, advisory boards, panels, and workshops for the NAE, NRC, National Science Foundation, Department of Defense, and other agencies, in addition to the EERI and ASCE. At MIT, he headed the geotechnical and structural groups and was also well known for his role as parliamentarian at faculty meetings, especially during the Vietnam War–era student uprisings. And for his hometown of Lexington, Massachusetts, Bob spent countless evenings over four decades as an elected member of the annual town meetings and as chairman of either the Zoning Board of Appeals or the Permanent Building Committee. When asked why he engaged in so many activities, he replied “they were interesting challenges and I couldn’t stay away from them.”

Bob Whitman’s contributions, beyond those associated with soil dynamics and earthquake engineering, included development of one of the first computer programs for slope stability analyses; pioneering application of probabilistic concepts for risk analysis in geotechnical engineering as set forth in his ASCE Karl Terzaghi Lecture (1981); and leadership in establishing centrifuge testing facilities in the United States for geotechnical research.

Honors included the Karl Terzaghi Award (1987) for contributions to geotechnical engineering, the Croes Medal (1994) recognizing an outstanding paper from all civil engineering disciplines, and the Seed Medal (2007) for contributions to geotechnical earthquake engineering, all from ASCE, and an honorary doctorate from Swarthmore College (1990).

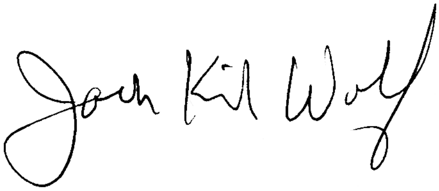
Although admired for his sharp mind and dedication to teaching, research, and public service, because of Bob’s modesty few knew the full extent of his activities and contributions, even among his family and faculty colleagues. But his graduate students appreciated his warmth and mentoring, and, if from abroad, holiday meals with his family. The MIT geotechnical faculty and alumni fondly remember the annual end-of-school celebration parties hosted by the Whitmans, which were always blessed with gorgeous spring weather to supplement wine and badminton.

Notwithstanding Bob’s hectic schedule, he was an ideal companion for wife Betsy and always a caring father. The Whitmans spent summer vacations, and then entire summers after his retirement, on a small island off the southern coast of Maine, with lots of sailing, tennis, and golf, and a cottage with ample room to house the expanding family. Bob was also a train buff. He and Betsy travelled extensively across the United States and Europe, and Bob was the proud builder of an elaborate HO scale model train system.

In addition to his wife Betsy of 57 years, Bob is survived by two married daughters (a middle daughter, Martha, died at age two). Jill Whitman Marsee has two sons, followed an academic career in earth and marine sciences, and lives near Tacoma, Washington. Gwen Whitman Kaebnick has two daughters and specialized in university administration until she switched to teach 4th grade in White Plains, New York.

Acknowledgments

Charles C. Ladd acknowledges that substantial information about the career of Robert V. Whitman was obtained from the *Oral History* Series published by the Earthquake Engineering Research Institute, No. OHS-17 (2009) and the obituary in the *EERI Newsletter* 46(3), March 2012. He also acknowledges the assistance of John T. Christian, Ricardo Dobry, James K. Mitchell, Andrew J. Whittle, and Mishac K. Yegian in preparing this tribute.



JACK KEIL WOLF

1935–2011

Elected in 1993

"For contributions to information theory, communication theory, magnetic recording, and engineering education."

BY ROBERTO PADOVANI AND PAUL H. SIEGEL

JACK KEIL WOLF, a pioneer and technical leader in information theory, coding theory, communication theory, and their applications in modern information technology, died on May 12, 2011, in San Diego, California, at age 76. He had amyloidosis.

Jack Wolf was born in Newark, New Jersey, on March 14, 1935. After "surviving" high school in Newark, as he would say with a smile, he received his BS in electrical engineering from the University of Pennsylvania in 1956. He completed his graduate studies at Princeton, where he received MSE, MA, and PhD degrees in 1957, 1958, and 1960, respectively.

Jack's first job was as a lieutenant in the US Air Force, working at the Rome Air Development Center in Rome, New York. At the same time, he was a part-time instructor at nearby Syracuse University, which offered graduate courses at the Griffiss Air Base where Jack was stationed.

After leaving the Air Force, Jack entered a long and illustrious academic career, beginning with a position at New York University, where he was a member of the Electrical Engineering Department from 1963 to 1965, when he joined the Polytechnic Institute of Brooklyn. In 1973 he left to chair (for two years) the Electrical and Computer Engineering Department at the University of Massachusetts, Amherst, where he stayed until 1984.

In 1984 he joined the faculty in the Department of Electrical and Computer Engineering at the University of California, San Diego (UCSD), in La Jolla. He was appointed to an endowed chair at the newly established Center for Magnetic Recording Research. In 1993, at Jack's suggestion, the chair was renamed the Stephen O. Rice Chair in Magnetic Recording Research in honor and memory of Stephen Rice, another pioneer in communication theory and a UCSD colleague. Jack was also vice president of technology at Qualcomm Incorporated; he joined as a consultant in 1985 and became a part-time employee in 1991.

Over the course of his career Jack published more than 100 journal papers and was granted patents on 23 inventions in communications and storage technology, many of which were embodied in commercial products.

Jack Wolf received many awards recognizing his technical contributions in the broad range of areas captured in the NAE citation: information theory, communication theory, magnetic recording, and engineering education. In 1975 he was co-recipient (with David Slepian) of the Information Theory Group Paper Award for the paper "Noiseless Coding for Correlated Information Sources." The main result of the paper, generally known as the Slepian-Wolf theorem, establishes fundamental limits on efficient distributed source coding and is considered one of the pillars of information theory. It has inspired numerous advances in both the theory and practice of data compression, with new and unforeseen applications—such as in sensor network design—that are still emerging.

In 1990, Jack was honored with the IEEE Communications Society E.H. Armstrong Achievement Award for "outstanding contributions over a period of years in the field of communications technology." He also shared (with Brian Marcus and Paul Siegel) the 1993 IEEE Communications Society Leonard G. Abraham Prize Paper Award for "Finite-State Modulation Codes for Data Storage." In 2001 he was awarded the highest technical honor bestowed by the IEEE Information Theory Society, the Claude E. Shannon Award, and in 2007 his long record of leadership and service to the

Information Theory Society was acknowledged with the Aaron D. Wyner Distinguished Service Award.

Jack Wolf's sustained contributions to the two engineering disciplines of digital communications and magnetic recording were recognized by major IEEE-level awards: the 1998 IEEE Koji Kobayashi Computers and Communications Technical Field Award, for "fundamental contributions to multi-user communications and applications of coding theory to magnetic data storage devices," and the 2004 IEEE Richard W. Hamming Medal, for "fundamental contributions to the theory and practice of information transmission and storage." In 2005, he was elected a fellow of the American Academy of Arts and Sciences.

In 1993 Jack was elected to membership in the National Academy of Engineering and in 2010 the National Academy of Sciences, earning him the rare distinction of membership in both. In 2011, he and Irwin M. Jacobs were named the winners of the Marconi Society Prize and Fellowship in recognition of "lasting scientific contributions to human progress in the field of information technology."

Jack Wolf dedicated time and energy to professional service on numerous committees of the IEEE, International Union of Radio Science (URSI), and NAE. He served on the board of governors of the IEEE Information Theory Society (then "Group") from 1970 to 1976 and 1980 to 1986, and was appointed president in 1974. He was international chairman of Committee C of URSI from 1980 to 1983. His service to the National Academies included participation in the Committee on Telecommunications Research and Development, the 2003 Nominating Committee, Electronics Engineering Section Liaison to the NRC, Section 7 Executive and Peer Committees, Committee on Tactical Battle Management, Committee on National Communications Systems Initiatives, and US National Committee for URSI.

Jack was not only an outstanding researcher but also a dedicated and wonderful educator. He was passionate about teaching, and he had a gift for expressing even the most difficult subjects in simple and clear terms. He brought to the classroom a wealth of practical experience gained through his many years of consulting and employment in the telecommunications and storage industries. With his unique perspective, Jack inspired his students by successfully linking elegant theory with exciting technological applications. His excellence in teaching was recognized in 2000 with the UCSD Distinguished Teaching Award.

Jack maintained a close relationship with his alma mater, the University of Pennsylvania. In fact, studying at Penn is somewhat of a family tradition: 17 members of Jack's extended family—his father, two uncles, numerous cousins, and daughter Sarah—received degrees from Penn, and a grandson and granddaughter are carrying the torch for the next generation. Jack and his daughter have also made philanthropy at Penn a tradition: a number of endowed scholarships and student awards bear the Wolf family name, and two laboratories are named in honor of Jack Keil Wolf. In 2006, Jack received the D. Robert Yarnall Award from the University of Pennsylvania Engineering School, an award presented annually to a distinguished member of Penn Engineering's alumni for outstanding contributions to society in the field of engineering or technology.

Jack Wolf is deeply missed by his family, friends, and colleagues, including his many students, past and present, affectionately known as the "Wolf Pack." What Jack brought to the classroom and research advising was much more than his gift and passion for teaching: he inspired generations of students to excel, to work hard and with integrity, and most of all to have fun in the process. He will be remembered for the friendship and support he and his wife Toby offered so freely, his smile and sense of humor, his vision and wisdom, his words of encouragement, and his contagious optimism. He was a generous, thoughtful, and unpretentious man, an exceptional human being dedicated to bettering our world through progress in engineering.

A devoted husband, father, and grandfather, Jack is survived by his wife Toby; his children Joe, Jay, Jill, Sarah and her husband Charles; and his grandchildren Rachel, David, Rebecca, Aaron, and Julia.

APPENDIX

Members	Elected	Born	Deceased
Paul M. Anderson	2009	January 22, 1926	April 26, 2011
Neil A. Armstrong	1978	August 5, 1930	August 25, 2012
Edward J. Barlow	1968	September 5, 1920	February 3, 2010
Robert R. Beebe	1990	April 21, 1928	June 11, 2011
Seymour M. Bogdonoff	1977	January 10, 1921	January 10, 2005
Seth Bonder	2000	July 7, 1932	October 29, 2011
Y. Austin Chang	1996	July 1, 1933	August 2, 2011
Bei T. Chao	1981	December 18, 1918	March 2, 2011
Floyd L. Culler	1974	January 5, 1923	September 29, 2004
Leonard S. Cutler	1987	January 10, 1928	September 4, 2006
George C. Dacey	1973	January 23, 1921	November 27, 2010
Ruth M. Davis	1976	October 19, 1928	March 28, 2012
Robert C. Earlougher Jr.	1996	June 26, 1941	August 19, 2011
Kenneth McK. Eldred	1975	November 25, 1929	January 30, 2012
Richard G. Farmer	2006	November 5, 1928	March 26, 2012
John D. Ferry	1992	May 4, 1912	October 18, 2002
Sir Charles Frank	1980	March 6, 1911	April 5, 1998
Maurice C. Fuerstenau	1991	June 6, 1933	October 7, 2012
Elmer L. Gaden Jr.	1974	September 26, 1923	March 10, 2012
Alan J. Goldman	1989	March 2, 1932	February 13, 2010
Nicholas J. Grant	1980	October 21, 1915	May 1, 2004
Sir William R. Hawthorne	1976	May 22, 1913	September 16, 2011
Claude R. Hocott	1974	November 16, 1909	September 9, 2001
John A. Hrones	1975	September 28, 1912	June 14, 2000
Sheldon E. Isakoff	1980	May 25, 1925	January 29, 2012
Donald J. Jordan	1976	January 1, 1916	November 10, 2008
Alfred A.H. Keil	1966	May 1, 1913	January 9, 2002
Clyde E. Kesler	1977	May 7, 1922	December 30, 2011
Frederick F. Lange	1992	June 8, 1939	April 2, 2010
Ludwig F. Lischer	1978	March 1, 1915	February 21, 2005
William D. Manly	1974	January 13, 1923	November 22, 2003
Edward A. Mason	1975	August 9, 1924	June 23, 2010
Frank A. McClintock	1991	January 2, 1921	February 20, 2011
Sidney Metzger	1976	February 1, 1917	December 22, 2011

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Members	Elected	Born	Deceased
Walter P. Moore Jr.	1991	May 6, 1937	June 21, 1998
William C. Norris	1988	July 14, 1911	August 21, 2006
Kenneth H. Olsen	1977	February 20, 1926	February 6, 2011
M. Kenneth Oshman	1982	July 9, 1940	August 6, 2011
Charles J. Pankow	1997	October 6, 1923	January 12, 2004
Owen M. Phillips	1996	December 30, 1930	October 13, 2010
Edward W. Price	2000	December 6, 1920	June 11, 2012
Robert A. Pritzker	1991	June 30, 1926	October 27, 2011
Adel F. Sarofim	2003	October 21, 1934	December 4, 2011
Klaus Schoenert	1991	June 18, 1927	September 24, 2011
Maurice M. Sevik	1994	January 19, 1923	October 20, 2011
Abe Silverstein	1967	September 15, 1908	June 1, 2001
W. David Sincoskie	2000	December 21, 1954	October 20, 2010
A.M.O. Smith	1989	July 2, 1911	May 1, 1997
Louis D. Smullin	1970	February 5, 1916	June 4, 2009
William D. Stevens	1983	August 4, 1918	November 5, 2007
Charles W. Tobias	1983	November 2, 1920	March 6, 1996
Robert V. Whitman	1975	February 2, 1928	February 25, 2012
Jack Keil Wolf	1993	March 14, 1935	May 12, 2011