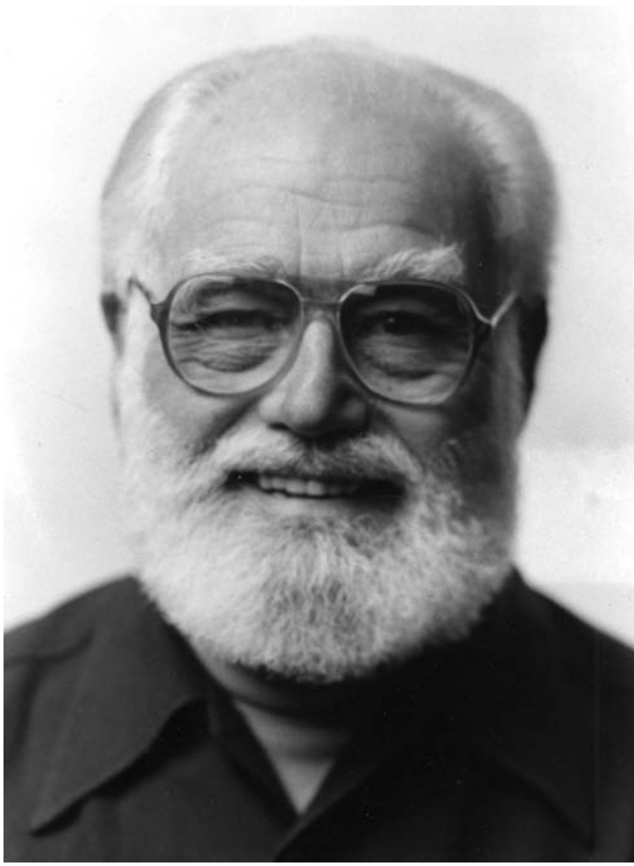

# ARTHUR R. KANTROWITZ

*1913–2008*

Elected in 1977

*"For leadership in the fields of gas dynamics, magnetohydro-dynamics, and bioengineering."*

BY FRANCIS E. KENNEDY
SUBMITTED BY THE NAE HOME SECRETARY

ARTHUR R. KANTROWITZ, an innovative and forward-looking physicist and engineer whose accomplishments ranged from aviation and space to medicine and public policy, died on November 29, 2008, at the age of 95. He had been the founder and longtime director of the Avco-Everett Research Laboratory and was professor emeritus at the Thayer School of Engineering at Dartmouth College.

Arthur Kantrowitz was born in New York City (in the Bronx) on October 20, 1913, the eldest child of Bernard and Rose Kantrowitz. During his youth he developed a love of science in general and physics in particular. He graduated from DeWitt Clinton High School in the Bronx and went on to study physics at Columbia University, receiving his B.S. in 1934 and M.A. in 1936. He then went to work for the National Advisory Committee for Aeronautics (NACA), the predecessor of the National Aeronautics and Space Administration (NASA), at Langley Field in Virginia. One of the experiments he did while at NACA was the first known attempt of a thermonuclear fusion reaction. In 1938, Arthur and his supervisor, Eastman Jacobs, heated hydrogen with radio waves while constricting the gas with a magnetic field in order to achieve fusion. Although the experiment was not successful, and the project was canceled by the laboratory director before further attempts could be made, it was the first of many research activities in which Arthur was well ahead of others in his research fields. While at NACA, Arthur also designed the first meaningful supersonic wind tunnel in the United States (which achieved Mach number 2.5 in 1942), and his research on shockwave formation, propagation, and stability in supersonic flows made important contributions to turbine engine development and the war effort. During his time at NACA, he continued his graduate studies at Columbia on the subject of gas dynamics. His dissertation adviser was Edward Teller, and his doctoral research involved the measurement of vibrational relaxation times of carbon dioxide molecules using simple aeronautical instrumentation. His Ph.D. in physics was awarded by Columbia in 1947.

In 1946, before completing his Ph.D. dissertation, Arthur Kantrowitz was appointed to a faculty position in the Departments of Aeronautical Engineering and Engineering Physics at Cornell University. He established a very active laboratory at Cornell, where he and his students did groundbreaking research on supersonic nozzle flows, high-temperature (over 10,000 K) shock tubes, and molecular beams. The supersonic high-intensity "nozzle beam" method developed by Arthur and his students at Cornell was critical to the research of at least nine Nobel Prize winners, most notably Yuan Tseh Lee and Dudley Herschbach (1986) and John Fenn (2002). Arthur proved to be an inspiring teacher and research adviser at Cornell. A number of his outstanding students later played important roles in the aerospace industry and in higher education.

While at a cocktail party at Cornell in 1954, Arthur met Victor Emanuel, chairman of Avco Corporation, who told him about a difficult problem being encountered in the design of ballistic missiles. The missiles would have to be able to survive reentry into the atmosphere, where frictional drag could cause surface temperatures to reach 7,500 K or higher, but American missile engineers had not yet been able to duplicate those high-temperature conditions in the laboratory. Arthur informed him that he and his students had been able to achieve even higher temperatures in their laboratory using shock tubes, which had the added advantage of producing shock waves of the type that might be encountered by the missiles during reentry. Mr. Emanuel immediately set up a meeting with General Bernard Schriever, head of the U.S. Air Force ballistic missile program, who agreed to fund a six-month "crash program" to investigate the shock tube idea. Avco set up a new research lab, the Avco Everett Research Laboratory (AERL), at which the work would be carried out. Arthur took a leave of absence from Cornell to direct the laboratory and oversee the research program, and he recruited a number of his recent Cornell graduate students to carry out the work. The research was so successful that AERL accelerated the research program on reentry physics, and in 1956 Arthur resigned from his tenured faculty position at Cornell to remain as director of AERL and to become a vice president of Avco. Subsequent research under Arthur's guidance at AERL on shockwave kinetics, heat transfer rates for blunt body stagnation points, and nonequilibrium radiation contributed greatly to further development of ablative heat shields for missiles and later for manned spacecraft, and Avco became a leading producer of heat shields for space applications.

During the 1960s and 1970s, Arthur Kantrowitz recruited many outstanding engineers and scientists to AERL. He mentored and motivated them to significant achievements in a number of research areas. Dr. Kantrowitz always maintained that while most universities engaged in pure research, he was interested in "impure research"—that is, work that would lead to practical results, science that made an impact on the real world. Under his guidance, AERL researchers attempted to focus their activities on areas in which they could create a unique capability. He provided overall guidance for each research project, and important technical contributions in many cases, and he ensured that innovation and professional excellence were hallmarks of all research at AERL. Among the many areas in which significant advances were made at AERL under Arthur's guidance were magnetohydrodynamic (MHD) power generation, superconducting magnets, high-power laser development, laser propulsion, and artificial heart assist devices.

MHD research at AERL was aimed at developing a highly efficient electric power generator that used hot gases flowing at supersonic speeds to produce megawatts of electric power. The concept was proven at AERL in 1959; subsequent research and development efforts at AERL and Avco resulted in a combustion-powered MHD generator that laid the foundation for much of the later development of MHD generators in the United States and elsewhere. During the development of MHD power generation systems at AERL, research there under Arthur Kantrowitz's guidance also resulted in a stabilized superconducting magnet, the first demonstration of which occurred at AERL in 1964.

Under Arthur's leadership, AERL pioneered in the development of high average power lasers. Gas dynamic lasers, electric discharge lasers, and chemical lasers were developed at AERL, many of them to the megawatt class, in the 1960s and 1970s. Many of these advances emanated from the basic principles of gas dynamics that Arthur had developed in his Ph.D. research. The research expertise at AERL in chemical kinetics and plasma physics and the experimental capabilities in shock tube studies of high-velocity, reacting flow fields proved to be well suited for the nascent field of high-power lasers. After successful development of high-power lasers at AERL, Arthur turned his attention to using the newly developed lasers for rocket propulsion, in which a ground-based laser would be used to move a payload into low-Earth orbit. His far-reaching vision had high-powered lasers providing the key to affordable access to outer space. A proof-of-concept experiment and scaling analysis were accomplished at AERL in the 1970s.

When Arthur Kantrowitz was a young man, he and his brother Adrian, who became one of the world's foremost cardiac surgeons, had a dream that they could design an artificial heart. Arthur continued to pursue that dream while at AERL, where he assembled a multidisciplinary team to work toward the goal of an implantable cardiac replacement device. They initially collaborated with Adrian Kantrowitz on the development of an auxiliary left ventricle, which suffered from blood clotting problems after being implanted in humans for the first time in 1966. Arthur and his team decided to explore the relationship between fluid mechanics and the chemistry of blood clotting to solve the clotting problems. This led to the intra-aortic balloon pump, a streamlined counter-pulsation pump that required minimal surgery for use in humans. Though a balloon concept had been attempted earlier, development of a safe and reliable device relied on understanding the dynamics of using a light fluid, in this case carbon dioxide, to move blood, a heavy fluid, around the body. The intra-aortic balloon pump developed at AERL in 1967 resulted from the unique contributions in engineering, fluid mechanics, chemistry, and medicine from members of the team Arthur had assembled and led. The AERL balloon pump was brought to clinical use by a close collaboration with Massachusetts General Hospital and is still in clinical use today, more than four decades after its introduction. The device has been used in more than 3 million patients around the world, including Arthur Kantrowitz himself after he suffered a heart attack in November 2008.

In 1978, Arthur reached Avco's mandatory retirement age, and he left to take a position as professor of engineering at the Thayer School of Engineering at Dartmouth College. He continued to give lectures on gas dynamics, MHD, and lasers, but his primary focus moved to the role of the scientific and engineering communities in the public perception of technology. He proposed a new norm for the scientific community: "Any scientist who addresses the public or lay officials on scientific facts bearing on public policy should stand ready to publicly answer questions not only from the public, but from expert adversaries in the scientific community." To implement this norm, he proposed and tried to develop scientific adversary procedures, known as the "Science Court." In those procedures, anyone making an allegedly scientific assertion that was important for public policy could be challenged to publicly answer scientific questions from an expert representative of those who opposed the assertion. As a member of President Gerald Ford's Advisory Group on Anticipated Advances in Science and Technology and chairman of his Presidential Task Force on the Science Court (1978), Arthur had the opportunity to develop his idea to help provide a factual basis for policymaking. While at Dartmouth he continued to advance the Science Court procedure as a means to find the best-available scientific facts, and the limitations of scientific knowledge, to bear on important controversial issues.

Arthur Kantrowitz was the recipient of many awards and honors during his lifetime. In addition to the National Academy of Engineering, he was a member of the National Academy of Sciences and was a fellow of the American Academy of Arts and Sciences, the American Physical Society, the American Institute of Aeronautics and Astronautics, the American Association for the Advancement of Science, and the American Astronautical Society. He was both a Fulbright and a Guggenheim fellow, and in 1967 he was presented the Theodore Roosevelt Distinguished Service Medal by President Lyndon Johnson. He was an honorary trustee of the University of Rochester; an honorary life member of the Board of Governors of the Technion (Israel Institute of Technology); and an honorary professor of the Huazhong Institute of Technology in Wuhan, China. He was a member of the advisory board of television's popular *Nova* program and a director of the Hertz Foundation. He served the U.S. government on advisory boards for President Ford's White House, the U.S. Department of Commerce, NASA, the U.S. General Accounting Office, and the National Science Foundation. He was granted 21 U.S. patents and published extensively.

A man of many interests and talents, Arthur developed a love for classical music, literature, and sailing. He was as well versed in Beethoven and Shakespeare as he was in gas dynamics. He relished sailing off the coast of Maine on his beloved 33-foot sloop, *ARK.*

Arthur is survived by his second wife, Lee Stuart (of Hanover, New Hampshire, and Amelia Island, Forida); three daughters—Barbara Kantrowitz (of New York City), Lore Kantrowitz (of Lexington, Massachusetts), and Andrea Kantrowitz (of Pelham, New York); and six grandchildren.

Arthur Kantrowitz was a compassionate and gracious person and was generous to his colleagues and employees. His innovative spirit, visionary instinct, outstanding achievements, and courage in breaking new ground will long be remembered.