



Karl von Zeyher

K. UNO INGARD

1921–2014

Elected in 1980

“Contributions to acoustics, fluid dynamics, and noise control engineering.”

BY ALLAN D. PIERCE, ADNAN AKAY, AND WILLIAM W. LANG

KARL UNO INGARD, one of the world’s most eminent acousticians who excelled at theory, experimentation, and teaching, died peacefully at his home on Gerrish Island, Maine, on August 21, 2014, at the age of 93. He was a member of the faculty at the Massachusetts Institute of Technology for almost four decades, in both the Department of Physics (beginning in 1952) and, concurrently beginning in 1971, the Department of Aeronautics and Astronautics, an appointment that gave new vigor to his research in acoustics.

Uno (pronounced “you know”), son of Karl Oscar Ingard and Anna Elisabeth Ingard, was born February 24, 1921, in Gothenburg, Sweden, where he and his older sister, Asta, grew up. From an early age, he excelled both in his schooling and in athletics. In fact, he was selected to be a member of the 1944 Swedish Olympic track team. He did not, however, get a chance to participate in the 1944 Olympics as the games were not held because of World War II. After he came to America he became a passionate devotee of tennis and passed his love of the game along to his children.

In addition to his academic training, he learned from his father, a skilled mechanic in the shipbuilding industry, the great value of being able to do fine toolwork with his hands using simple tools, a skill so important to the experimentalist.

He graduated from the Tekniska Gymnasiet in Gothenburg, entered Chalmers University of Technology in 1940, and graduated as an electrical engineer in 1944, receiving the school's John Ericsson Medal (presented annually to the graduate with the highest academic achievement). He continued at Chalmers, working toward a technologic licentiate degree (a postgraduate degree that may be regarded as an academic step halfway between a master's degree and a doctorate).

Throughout his undergraduate and graduate years at Chalmers, he held a succession of part-time positions—working with an electrical consulting firm in Gothenburg, teaching electrical engineering at the Tekniska Gymnasiet, and serving at Chalmers as a research assistant, teaching fellow, and lecturer. His principal mentor was Olof Rydbeck, who had a doctorate in applied physics from Harvard and later achieved considerable renown for work in radar astronomy.

Although Uno had acquired considerable experimentally relevant skills from his father, he was inclined toward theory, but through Rydbeck he was put on experimental projects as well, and his interests broadened to a combination of experiments and theory.

During Uno's studies at Chalmers, Per Brüel (who had escaped to Sweden from occupied Denmark during World War II) was employed there and tasked with setting up an acoustics laboratory. With the encouragement of Rydbeck, Uno was engaged to work in this laboratory, and it was his work there that sparked his lifelong interest in acoustics.

His graduate studies were interrupted briefly in 1945–46 for service with the Swedish military, which he spent at the National Electronics Laboratory in Stockholm. Not too long after his return to Chalmers, Per Brüel left to return to Denmark (where he cofounded the firm of Brüel and Kjær) and Uno became director of the Chalmers Acoustics Laboratory. One outcome of his work was his invention of the graphic level recorder, which was later commercially produced by Brüel and Kjær. Uno continued his studies toward the licentiate, which he received in 1948.

His position as director of the Acoustics Laboratory was important and entailed a long-term commitment to Chalmers. However, he wanted to receive a high-quality advanced-graduate-level education and decided to seek a doctorate at MIT. He was attracted to MIT partly because, as a follow-up to World War II research activities, it had established a relatively large research laboratory in acoustics and partly because of two books he had studied that were written by MIT physics professor Philip McCord Morse. One of the books was *Vibration and Sound* (McGraw-Hill, 1948), and Uno had actually solved all of the many problems in the book during his time at Chalmers and the National Electronics Laboratory. Solving problems was one of Uno's lifelong "hobbies," and he later recalled that he regularly worked through all the problems in the textbooks that he used during his high school and college studies.

Uno enlisted a colleague, Stig Ingemansson, from Stockholm to take over the Acoustics Laboratory, got a two-year leave of absence from Chalmers, and began graduate studies in the MIT Department of Physics in the fall of 1948, traveling to the United States on the *Queen Mary* with his bride, Doris Karlsson.

His first year at MIT was very stressful because of a long illness caused by a head injury a few weeks before his departure. Nevertheless, with characteristic determination and fortitude, he performed spectacularly during the next two years.

Although Morse had moved on to interests other than acoustics, Uno struck up what was to be a lifelong association with him—probably initiated by his pointing out to Morse various errors in *Vibration and Sound*. Morse was so impressed that he enlisted Uno to go through and critique the extensive notes and manuscripts of what eventually became the two-volume treatise, *Methods of Theoretical Physics* (McGraw-Hill, 1953), which Morse coauthored with Herman Feshbach. An acknowledgment to Uno appears in the preface of the first volume.

Uno's doctoral thesis, "Scattering and Absorption by Acoustics Resonators," was primarily devoted to experiment and was done under the supervision of Richard H. Bolt, who was

then director of the MIT Acoustics Laboratory. However, there are extensive references to theory throughout the thesis and a strong acknowledgment to Morse. The thesis also acknowledged Leo Beranek for “inspiring discussions.”

At the end of his doctoral work Uno was offered a position as an assistant professor at MIT. He asked that the offer be deferred for a year, as he had an obligation to return to Chalmers and teach there. This he did, and returned to MIT in the fall of 1952 as an assistant professor of physics. His classroom teaching was at first that of basic undergraduate courses in physics—for many years he taught the full-year introductory course in physics, required for all MIT undergraduates. He brought a new vigor to the course and illustrated his lectures with many provocative demonstrations. These lectures culminated in a textbook, *Introduction to Mechanics, Matter, and Waves* (Addison-Wesley, 1960), coauthored with his colleague William Kraushaar.

He rose through the ranks at MIT, becoming an associate professor in 1956 and a professor in 1966. Although acoustics was strong in the Physics Department during his initial years at MIT, Bolt and Beranek left in the later '50s to organize their own consulting firm, and Uno became the only member of the department active in acoustics. The subject was popular and he attracted a large number of students over the years.

An undergraduate thesis was required of all physics students at MIT, and the intrinsic appeal and breadth of Uno's research interests, along with the students' high regard for his teaching, led to his directing a large number of undergraduate theses, estimated to be on the order of 100. Many of these students went on to become prominent in engineering and physics. Uno also supervised the doctoral theses of about 50 students; many of these concerned acoustical topics, and others were related to instabilities and waves in weakly ionized gases.

Except for two sabbatical stints in Stockholm and Berlin, he remained on the MIT faculty for 39 years, as a professor of physics and of aeronautics and astronautics. He retired in 1991 at the age of 70.

His research achievements are extremely varied, but he excelled especially in engineering acoustics and physical acoustics. It is perhaps fair to say that he achieved insight in these fields greater than any of his contemporaries. His contributions to other areas of physics and engineering science include seminal papers on propagation and instabilities in plasmas and on the scattering of laser beams. His numerous papers have been extensively cited through the years and have influenced the research of many others. One of his best-known publications is the treatise *Theoretical Acoustics* (McGraw-Hill, 1968), which he coauthored with Morse.

Beyond his academic achievements, he had significant impact as a mentor and educator for scientists and engineers working in industry. He extensively interacted with Dupont, Pratt and Whitney, United Technologies, Industrial Acoustics Company, Stahl Laval Turbine AB, and Mitco Corporation. His consulting activities in noise control resulted in important contributions to duct acoustics, the theory of fan noise in ducts, jet engine noise, jet engine silencers, sound absorptive materials, and sound absorptive structures.

In his later years, especially after his retirement from MIT, he spent considerable time writing books, with an expressed desire to pass on to others what he had learned. These include *Fundamentals of Waves and Oscillations* (Cambridge University Press, 1988), *Notes on Sound Absorption Technology* (Noise Control Foundation, 1994), and *Notes on Acoustics* (Infinity Science Press, 2008).

Uno Ingard received many honors over the years, including the Acoustical Society of America (ASA) Biennial Award (1954; now called the R. Bruce Lindsay Award) and Gold Medal (1997); the John Ericsson Medal of the American Society of Swedish Engineers (1972); an honorary doctorate of engineering from Chalmers University of Technology (1979); election to the US National Academy of Engineering (1980); the Rayleigh Medal of the UK Institute of Acoustics (1981); the Per Brüel Gold Medal for Noise Control and Acoustics of the American Society of Mechanical Engineers (1989); and the Institute of

Noise Control Engineering (INCE) Education Award (1995). He served on the ASA Executive Council (1970–73) and as president of INCE (1973).

Uno's legacy in acoustics is deep and wide. His many papers and books will long continue to be consulted and cited, and those who knew him will cherish their memories of conversations with him and of his excellent lectures.

Uno is survived by his loving wife, Doris; children John (Anne) of Natick, Massachusetts; Sven (Susan) of Lincoln, MA; and Marianne Poling (Jim) of West Point, New York; and seven grandchildren. He was predeceased by his son Karl.

