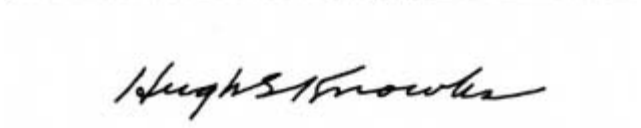

Hugh S. Knowles

1904-1988

By Eugene F. Murphy

Hugh Shaler Knowles, physicist and consulting engineer famous for miniaturization of high-quality microphones and receivers, died in his sleep April 21, 1988, at the age of eighty-three. His work at Jensen Manufacturing Company contributed to early development of high-fidelity loudspeakers for indoor and outdoor use. He formed and headed until his death his own firms, notably Industrial Research Products, Inc. from 1946, and Knowles Electronics, Inc. from 1954, emphasizing successive reductions in size of high-quality transducers. He was active in national and international standardization, an officer and award recipient of professional societies, a wise adviser to government, and a generous supporter of basic and clinical research in hearing problems. He was widely admired for integrity and astute judgment.

Hugh Knowles was born in Hynes, Iowa, September 23, 1904, and spent much of his early years in Mexico, where his father was a mining engineer. His fluency in Spanish, French, and German was very useful in his business and standardization activities. After graduating at the age of fourteen from high school in San Antonio, Texas, he attended Alabama Polytechnic Institute in 1920 and 1921 and served as a radio operator on various ships from 1921 to 1924. By working as a department editor for *Popular Radio,* associate radio editor for the *New York Herald Tribune,* and receiving

a scholarship in radio engineering, he attended Columbia University, receiving an B.A. (professional option) in 1928. He married Josephine Knotts that year. He was a graduate student in physics at the University of Chicago from 1930 to 1934 and a lecturer in graduate physics there from 1935 to 1936. He received an honorary doctor of science degree from Northwestern University in 1982.

With a growing family in the depression years, Hugh began work as an engineer at Jensen in 1931, becoming chief engineer and vice-president, and remaining to 1950. He was credited with the first permanent-magnet moving-coil loudspeakers, two-and three-way speaker systems, and the "bass reflex" vented loudspeaker enclosure improving low-frequency response.

He started, part time, his own consulting engineering practice in 1936, considered himself a consulting engineer, and was a registered engineer in Illinois from the initiation of that program in 1947. Forming Industrial Research Products in 1946 for research and development on a variety of products, he served as its president and director of research. After serving for years as president of Knowles Electronics, specializing in manufacturing hearing aid transducers, he became chairman of its board as well, and then relinquished his presidential responsibilities shortly before his death. Similarly he was president or chairman of subsidiaries in England and Taiwan and of other interests in Illinois.

Knowles was elected to the National Academy of Engineering (NAE) in 1969. He had already served in 1950-1951 as a member of the Physical Science Division of the National Research Council.

Most of his advisory services, though, were directly to the government. During and shortly after World War II he worked on blast-resistant loudspeakers for Navy ships, bullhorns for aircraft carriers, and fuzes for artillery and antiaircraft shells. From 1948 to 1950 he chaired the acoustics panel of the U.S. Department of Defense Research and Development Board.

His miniaturized microphones and receivers were used for lightweight headsets for astronauts, among many other applications. Knowles was proud that the National Aeronautics and Space Administration accepted his routinely stringent quality assurance. However, the Bolt Commission investigating the gap in President Nixon's tapes recorded in the Oval Office found a small hole in the President's desk leading to a plastic tube and a Knowles microphone so badly misapplied that it contributed to the poor a quality of the tapes!

His broad interest in fundamental as well as applied aspects of acoustics led Knowles to emphasize the need for better measurements of loudspeakers, of parameters of the human head at a range of frequencies in relation to bone conductor hearing aids, and of the acoustic impedance of the ear canal plugged by the receiver. He repeatedly urged more realistic methods of measuring hearing aid performance than the usual free-field tests of microphones and the conventional two-cubic centimeter coupler for the receivers.

To simulate use on an average person, he led development of KEMAR, or Knowles Electronics Manikin for Acoustic Research, a full-size head and upper torso with choice of one or two Zwislocki couplers mounted at the eardrum position(s). Nearly three hundred copies are used in many laboratories here and abroad in hearing aid and other studies.

Knowles was particularly pleased that he had contributed to the development of high-quality head-mounted hearing aids, marked improvements over the multipiece body-worn aids still routinely used after World War II. These earlier aids benefited from the printed circuits developed for proximity fuzes, and by 1953 from early transistors, which replaced the large "peanut" vacuum tubes that required more energy and both A and B batteries (usually in a separate pack). However, the users still carried them in a shirt pocket or special undergarment with a cord to the earphone.

Knowles mounted his small microphone and receiver, with impedances compatible with transistors and a transistorized printed circuit, in a thickened eyeglass temple with a short

plastic tube leading to an earmold. This arrangement immediately removed dangling cords, cord breakage, and noise from clothing brushing over a microphone. Many patients wore two aids, over-coming the shadowing of sounds from the opposite side of the head, and localizing sound sources more rapidly. Aids were then mounted behind the ear, in the ear, and finally completely inside the ear canal—thus achieving an old goal.

Knowles did not attempt to manufacture or market hearing aids. Because his transducers were used by nearly all American manufacturers and some abroad, he was in constant touch with the entire industry and aware of its trends. Although he did not publicize this role, he was a very valuable member of the Veterans Administration's advisory committee on hearing aids performance. With his scrupulous integrity, he never betrayed commercial secrets. He provided selfless, impartial, and invaluable insights; broad knowledge of acoustics and of hearing aid measurements; and precise wording of controversial issues.

While at Jensen, Knowles was a member and eventually president of the Radio Engineers Club of Chicago, practically an honorary society of chief engineers. He was a fellow, president, honorary member, and Gold Medal recipient of the Audio Engineering Society; a fellow, president, and Silver Medal recipient in engineering acoustics of the Acoustical Society of America; a fellow and national chairman of the Institute of Radio Engineers (IRE) audio group (predecessor of the present Acoustics, Speech, and Signal Processing Society of the Institute of Electrical and Electronics Engineers); and a member of the IRE board of editors for fifteen years. He was the first American to receive the Alexander Graham Bell Award of the Hearing Aid Society of Germany. Though considering himself an engineer, he was a member of the governing board of the American Institute of Physics and of its executive committee.

Hugh Knowles had a long and distinguished service in standards, starting as chairman of an Acoustical Society of America Electroacoustics Committee from 1938 to 1941.

He was a member of the American Standards Association (now ANSI) Acoustical Standards Board. Long a member, for years he headed, the United States delegation to the International Electrotechnical Commission TC29, emphasizing engineering matters. Also, he chaired the International Standards Organization Committee TC43, concerned with psychoacoustical matters.

Knowles was the author of major chapters on loudspeakers, telephone receivers, and microphones for three engineering handbooks and of many technical articles. He held more than fifty patents.

Hugh and Josephine had three children, James, Margaret (Mrs. Schink), and Katherine (Mrs. Strasburg). Josephine died in 1969. Hugh later married a cousin, Nancy K. Knowles, with whose family he had maintained close contact since childhood.

Hugh was among the first donors to the NAE. He was always a very generous donor, particularly to the Acoustical Society of America, international standards activities, and academic acoustics programs. The Knowles family and companies, continuing and expanding Hugh's long generosity to Northwestern University in support of the audiology program headed by Raymond Carhart, established the Hugh Knowles Center for Clinical and Basic Science in Hearing and Its Disorders. Unfortunately Hugh died just before the dedication ceremony. The gifts and bequest support a substantial part of the basic research and teaching in audiology at the Center. The Center includes the Leadership Fund, the Hugh Knowles Prize, and two chairs focusing on the relation of audiology to medicine and to engineering.

Colleagues routinely describe Hugh Knowles as very honorable, a great friend, modest, demanding of himself as well as of others, a wonderful man to work for, very kind and thoughtful of others, generous, discreet, meticulous in choice of words, and tactful. Those who knew him mourn his loss. Millions of hearing aid users benefited from his work. The world needs more like him.