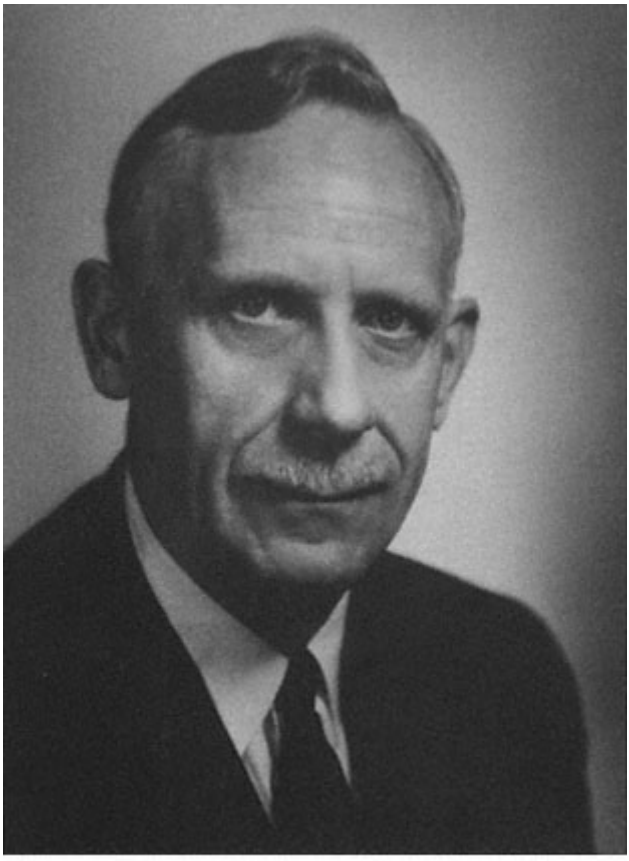

Hendrik W. Bode

Hendrik Wade Bode

1905–1982

By Harvey Brooks

Hendrik Wade Bode was widely known as one of the most articulate, thoughtful exponents of the philosophy and practice of systems engineering—the science and art of integrating technical components into a coherent system that is optimally adapted to its social function. After a career of more than forty years with Bell Telephone Laboratories, which he joined shortly after its founding in 1926, Dr. Bode retired in 1967 to become Gordon McKay Professor of Systems Engineering (on a half-time basis) in what was then the Division of Engineering and Applied Physics at Harvard. He became professor emeritus in July 1974.

He died at his home in Cambridge on June 21, 1982, at the age of seventy-six. He is survived by his wife, Barbara Poore Bode, whom he married in 1933, and by two daughters, Dr. Katharine Bode Darlington of Philadelphia and Mrs. Anne Hathaway Bode Aarnes of Washington, D.C.

Hendrik Bode was born in Madison, Wisconsin, on December 24, 1905. After attending grade school in Tempe, Arizona, and high school in Urbana, Illinois, he went on to Ohio State University, from which he received his B.A. in 1924 and his M.A. in 1926, both in mathematics. He joined Bell Labs in 1926 to work on electrical network theory and the design of electric filters. While at Bell, he also pursued graduate studies at Columbia University, receiving his Ph.D. in physics in 1935.

In 1929 he transferred to Bell's mathematical research group, which was headed by T. C. Fry and specialized in network theory and its application to long-distance communications. His extensive research in this field led eventually to the publication in 1945 of his classic book, *Network Analysis and Feedback Amplifier Design*.

During World War II, Bode participated in the development of electrical fire control devices, receiving the Presidential Certificate of Merit in 1948 for his contributions. After the war, he continued his work on military system development, which included artillery fire control and tracking systems for antiaircraft missiles and later for antiballistic missile systems. He also specialized in command-and-control communications systems.

In 1944 Bode was placed in charge of the mathematical research group; in 1952 he became director of mathematical research for Bell Labs. In 1955 he was named director of physical sciences research (including mathematics). In 1958 he became one of two vice-presidents of Bell Labs and had responsibility for military systems projects. During his career at Bell, he was granted twenty-five patents for innovations in the areas of transmission networks, transformer systems, electrical wave amplification, broadband amplifiers, and artillery computing.

Bode always felt a strong sense of unity in his career development and saw common genealogy in the technologies he worked on: from long-distance communications systems through artillery fire control to tracking systems for surface-to-air missiles. Bode's view was that a tracking system produced information, "and that's a message, and communication theory is concerned with messages and getting the correct message out of something garbled, ... so much of the basic technology of telephone communications did turn out to be applicable, in this sense, to the problems of fire control."

During Hendrik Bode's Harvard tenure, beginning in 1967, he taught courses in communications systems and a

general education course on the management and philosophy of the development of complex technologies. He synthesized the lessons he had learned from his long working life in a book published by Bell Labs in 1971 entitled: *Synergy: Technical Integration and Technological Innovation in the Bell System*. The book is an excellent exposition, in layman's terms, of the philosophy of systems engineering as it was developed, practiced, and perfected in the Bell system prior to divestiture and deregulation. Yet in retrospect, this lucidly written book exhibits not only the enormous strengths but also some of the weaknesses and vulnerabilities of this system of innovation.

Bode received many honors during his career. In 1969 he was awarded the prestigious Edison Medal of the Institute of Electrical and Electronics Engineers "for fundamental contributions to the arts of communication, computation and control and for guidance and creative counsel in systems engineering." In addition, in 1979 he was the first recipient of the Control Heritage Award from the American Automatic Control Council.

He received the Rufus Oldenberger Award of the American Society of Mechanical Engineers in 1975. He was elected to the National Academy of Sciences in 1957 and was a charter member of the National Academy of Engineering, which was founded in December 1964. He was a fellow of the American Academy of Arts and Sciences, the Institute of Electrical and Electronics Engineers, and the American Physical Society, and he was a member of the American Mathematical Society and the Society of Industrial and Applied Mathematics.

Hendrik Bode served the National Academy of Sciences and the National Academy of Engineering in many ways during his career. From 1967 to 1971 he was a member of the Council of the National Academy of Sciences; in addition, he was the representative of the Academy's Engineering Section on the original Committee on Science and Public Policy (COSPUP), which was established under the chairmanship

of George Kistiakowsky in 1965. He was also an active contributor to three widely known COSPUP studies: *Basic Research and National Goals* (1965), *Applied Science and Technological Progress* (1967), and *Technology: Processes of Assessment and Choice* (1969). These reports were the first to be prepared directly by the academy for the legislative branch—specifically, the Committee on Science and Astronautics of the U.S. House of Representatives.

Bode was a modest, private person; yet he was in great demand as a member of important government and private advisory committees. His advice was much sought after, not only on technical matters but also regarding questions of organization, management strategy, and even ethics. He was a lucid writer and expositor and was noted for his broad humanistic approach to engineering and technology.

A colleague has remarked that "he will sit for hours through a long meeting of complex discussion and heated argument without saying a word and then, in the end, in two sentences, will bring the whole argument and the whole meeting to a focus." Although an accomplished mathematician, he never used more mathematics than were necessary to make his point in an explanation, and he was able to translate complex mathematical results into simple physical pictures and analogies.

With the death of Hendrik Bode, the country and the university community lost one of the great engineering philosophers of his time.