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SIDNEY DARLINGTON
1906–1997

A Biographical Memoir by

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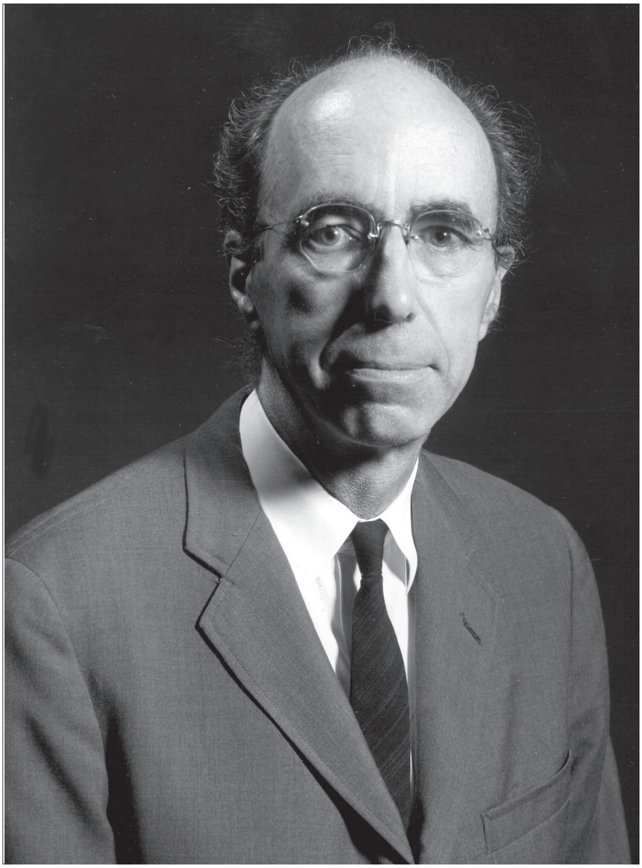

Sidney Darlington

SIDNEY DARLINGTON

July 13, 1906–October 31, 1997

BY IRWIN W. SANDBERG AND ERNEST S. KUH

SIDNEY DARLINGTON, ONE of world's most creative and influential circuit theorists, died at his home in Exeter, New Hampshire, on October 31, 1997, at the age of 91. He was a man of uncommon depth and breath whose first love was circuit theory. He made important, widely known contributions in several areas, including network synthesis, radar systems, rocket guidance, and transistor networks.

Sid was born in Pittsburgh, Pennsylvania. According to Sid, both his parents came from families in southeastern Pennsylvania. His maternal grandfather moved his family from the East to a quarter section of virgin prairie in western Minnesota when his mother was about 12 years old. She saw covered wagons taking settlers to what was then the Dakota Territory. At age 17 she taught in a one-room prairie school, but eventually was able to return to the East and attended Bryn Mawr College. She was determined that her children should have the best possible education. Sid's father was a mechanical engineer. Sid's brother, P. Jackson Darlington, Jr., became a biologist, and was elected to membership in the National Academy of Sciences in 1964. Both Sid and his brother attended Phillips Exeter Academy. There Sid won both of the school's math prizes, as well as the physics prize.

Sid received a B.S. in physics (magna cum laude) from Harvard College in 1928, a B.S. in electrical communication from the Massachusetts Institute of Technology in 1929, and a Ph.D. in physics from Columbia University in 1940. He was strongly influenced by George Washington Pierce at Harvard and by Ernst A. Guillemin at MIT. According to Sid, it was Guillemin who inspired his interest in circuit theory. At Columbia Sid took courses he described as "inspiring" with Isadore Rabi, and sometimes wondered if he might have been even happier as a theoretical physicist.

In 1929 Sid became a member of technical staff at Bell Laboratories, and in 1934 he was transferred to the laboratories' Mathematics Research Center, where his first supervisor was Hendrik W. Bode. Sid remained at Bell Laboratories until he retired as head of the Circuits and Control Department at the then mandatory retirement age of 65. One of us (I.W.S.) was a member of Sid's department for about seven years, starting in 1960. Sid was a member of both the National Academy of Engineering and the National Academy of Sciences. In 1945 he was awarded the Presidential Medal of Freedom, the United States' highest civilian honor for his contributions during World War II. President Truman established the award in that year to reward notable service during the war. He received the Edison Medal of the Institute of Electrical and Electronic Engineers (IEEE) in 1975 and the IEEE Medal of Honor in 1981.

In Darlington's early days at Bell Laboratories there was much interest in electrical filter theory, mainly in connection with the exacting needs of systems using frequency-division multiplexing. Filter theory was very different then from what it is today in that it was marked by ad hoc techniques in which complex filters were designed by cascading less complex filter sections whose attenuation characteristics were specified in graphical form. This was often unsatisfactory for several reasons. For example, the theory available did not adequately take into account the loading of the various sections on their predecessors. Sid's brilliant contribution was to recast the filter design problem as two problems: approximation and network synthesis, and to give a solution to each problem. The approximation problem he addressed is to suitably approximate the desired typically idealized filter characteristic using a real rational function of a complex variable, and here Darlington made significant pioneering contributions involving the use of Tchebyscheff polynomials. His main contribution, which concerned the exact synthesis of a two-port network that realized (i.e., implemented) the rational function, was the introduction of his well-known insertion-loss synthesis method. This work by Darlington led to his beautiful structural result that no more than one resistor is needed to synthesize any RLC impedance.

It is interesting that his results were not widely used until many years after they were obtained. This occurred partially because more exacting computations were required than for the earlier "image-parameter" filter designs. Also, due to its novelty, it was not easy for filter designers at the time to fully appreciate Darlington's contributions. This is easier to understand in the context of the history of the development of lumped-constant filter theory, which originally was an extension of the theory of transmission lines, and in which originally the concepts of a propagation constant, characteristic impedance, reflection factor, etc., played a prominent role.

Sid's work also profoundly influenced electrical engineering education. After World War II the Darlington synthesis of reactance two-ports was taught to a generation of graduate students who learned that linear circuit design could be formulated precisely in terms of specifications and tolerances, and that the problems formulated could be solved systematically. With concurrent advances in communication and control theory, electrical engineers began to appreciate that higher mathematics was a powerful tool for advanced study and research. This helped pave the way for the introduction of system theory and system analysis, and thus further broadened the scope of electrical engineering education.

During World War II, Sid was heavily involved in several studies of military systems. These studies concerned mainly the development of computers for antiaircraft gun control and bombsights. For a seven-month period beginning in 1944 he took a leave of absence to join the U.S. Office of Field Service. He was assigned to the 14th Antiaircraft Command in the southwest Pacific area, where he served as a consultant and technical observer. It was this work that led to his receipt of the Medal of Freedom.

In addition to never losing interest in circuit theory, Sid retained an interest in military systems—and related systems—throughout his tenure at Bell Laboratories. One of his most important contributions was the invention of what is called "chirp radar." The chirp idea is a way to form a pulsed radar's transmitted signal so that relatively high peak power is not needed to achieve long-range and high resolution. This involves transmitting long frequency-modulated pulses. The corresponding reflected and received (chirped) pulses are "collapsed" into relatively short pulses using a network that introduces a time delay that is frequency dependent. The idea has been widely used, and there has been much interest in the design of the needed delay networks—not only at Bell Laboratories, but also at many other companies and at universities. Darlington's IEEE Medal of Honor citation reads: "For fundamental contributions to filtering and signal processing leading to chirp radar."

Sid also did very influential work concerning rocket guidance. In 1954 he ingeniously combined radar-tracking techniques with principles of inertial guidance to develop the highly effective Bell Laboratories Command Guidance System that has launched many of the U.S. space vehicles, including NASA's Thor Delta booster and the Air Force's Titan I missile. The system has proved to be remarkably reliable and has played a central role in placing into orbit many satellites, including the Echo I communications satellite, Syncom, and Intelsat.

Darlington is best known for an idea that he probably developed very quickly: the Darlington transistor, a simple circuit comprised of two or more transistors that behave as a much improved single transistor. As is well known to the circuits and systems community, this idea is widely used and has had a great impact on the design of integrated circuits.

Sid was a visiting professor for periods of time of from one to six weeks at the University of California, Berkeley, from 1960 to 1972, and in 1978 he was a visiting professor at the University of California, Los Angeles, for a month. He gave many lectures and very much enjoyed these visits. Colleagues and students often remarked among themselves about how impressed they were with his keen physical insights, sophisticated mathematical talent, and pursuit of definitive results. After Sid retired from Bell Laboratories he became an adjunct professor at the University of New Hampshire, where he received an honorary doctorate in 1982. He was a consultant to Bell Laboratories from 1971 to 1974. Darlington held more than 40 patents, and was active in professional society activities. During 1959-60 he was the chairman of the IEEE Professional Group on Circuit Theory, and in 1986 he received the Circuits and Systems Society's first Society Award.

Sid was married twice. He had no children with his first wife. He married for the second time in 1965; the marriage produced two daughters. Sid seemed proud that he was over 60 years old when they were born. He said that he "would like to live at least until age 86, so as to see both girls graduate from college." Happily he did. Sid was a man of great personal and professional integrity. He was an intense but gentle man who was surprisingly modest. He was also a gregarious person who knew a lot about many things and had much to say. A colleague once commented that "asking Sid Darlington a question was like trying to take a drink from a fire hose."

In his personal life, Sid enjoyed hiking, snowshoeing, and mountain climbing. He is survived by his wife, Joan, of Exeter, New Hampshire; two daughters, Ellen and Rebecca; and his sister, Celia.

CAREER CHRONOLOGY

1929-71	Bell Telephone Laboratories, Inc., member of the technical staff, department head at the time of retirement.
1944-45	On leave from Bell Telephone Laboratories for seven months, employed by the Office of Field Services and assigned to the 14th Antiaircraft Command in the southwest Pacific area.
1960-72	Visiting lecturer at the University of California, Berkeley, for periods of one to six weeks.
1971	Retired from Bell Telephone Laboratories at the mandatory retirement age.
1971-74	Part-time consultant to Bell Telephone Laboratories.
1971-97	Adjunct professor at the University of New Hampshire and occasional consultant.
1978	Visiting lecturer at the University of California, Los Angeles, for one month.
1980-97	Member of the newly established New Hampshire State Legislative Academy of Science and Technology.

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