In 1963, the IEEE awarded its Medal of Honor to George C. Southworth (Fig. 1). He was cited for “his pioneering contributions to microwave radio physics, to radio astronomy, and to waveguide transmission.” He spent most of his professional career with the American Telephone and Telegraph Company (AT&T). His experiments with waveguide transmission during the 1930s helped lay the foundation for microwave radar systems introduced during World War II.

I. EDUCATION AND EARLY CAREER
George Clark Southworth was born August 24, 1890 in Little Cooley, PA. After graduating from a local high school, he taught in an elementary school for two years. Subsequently, he completed an undergraduate degree in physics at Grove City College in 1914. He went on to earn a master’s degree from Grove City in 1916. He then enrolled at Columbia University for further graduate studies. After a year, he left Columbia in 1917 to accept a position in the Radio Section of the National Bureau of Standards in Washington, DC.

Southworth assisted in the preparation of an influential book titled Radio Instruments and Measurements, published by the Bureau of Standards in 1918. Beginning in September 1918, he taught in a special school for officers of the Army Signal Corps located at Yale University. When the War ended, he remained at Yale where he taught introductory physics and assisted in a laboratory for graduate students. He received a doctorate at Yale in 1923 with a thesis on the dielectric constant of water at frequencies of 15 MHz and above. In his measurements, he used a Lecher line consisting of two closely spaced conductors. He compared the standing wave produced in air with that produced when the line was immersed in water.

Since he already had a family to support, Southworth decided to leave Yale in 1923 to accept a higher paying job at AT&T. His initial assignment was to assist the editor of the Bell System Technical Journal, but he soon transferred to the Development and Research Department. He joined a group engaged in testing short-wave radio equipment at a field station in Netcong, NJ. At the time, shortwave radio was emerging as an attractive alternative to earlier long-wave systems which used radio alternators or arc transmitters for transoceanic communication.

II. RESEARCH ON WAVEGUIDE TRANSMISSION
Southworth was a coauthor with Raymond A. Heising (Fig. 2) and John C. Schelleng of a paper on short-wave transmission, published by the Institute of Radio Engineers (IRE) in October 1926 (Figs. 3 and 4). Heising was an experienced radio-design engineer and an expert on modulation. Born in Minnesota in 1888, he had earned a master’s degree at the University of Wisconsin in 1914 before joining the Western Electric
Company, an AT&T subsidiary. He was the author of an IRE paper on modulation in radio telephony published in August 1921. He was a leading participant in the first demonstration of a single-sideband transmitter over a transatlantic link in January 1923. Schelleng was born in Illinois in 1892 and graduated from Cornell University in 1915. He became a Fellow of the IRE in 1928.

Southworth authored another IRE paper published in September 1930 on factors affecting the gain of directive antennas used in short-wave communication. During 1933, he participated in experiments in connection with what had been designated as an International Polar Year. He reported some results in an IRE paper published in December 1933.

In 1931, Southworth began an investigation of guided waves that soon proved to have significant consequences. Initially, he used apparatus similar to what he had used in his doctoral thesis work at Yale. He observed and measured waves in both bakelite and copper tubes filled with water. He provided a summary of his early results and objectives in an in-house memorandum titled “Transmission through dielectric cylinders” in April 1932.

Theoretical studies related to his project were undertaken during late 1932 and early 1933 by John R. Carson, Sallie P. Mead, and Sergei A. Schelkunoff, mathematicians at AT&T. They identified various possible modes of wave propagation in waveguides and calculated cutoff wavelengths and attenuation. Mead and Schelkunoff independently called attention to an unusual mode that exhibited decreasing attenuation as the frequency increased. This finding captured the attention of previously skeptical officials of the Bell System who now recognized the economic potential of a low-loss wave guide with wide-band characteristics.

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oscillations with a wavelength of about 15 em. He employed the tube to transmit signals through a 20-ft-long metal waveguide with diameter of 4 in. He later recalled that the first message sent through the guide was “send money,” an allusion to the limited support his project had received up to that time. He demonstrated the waveguide to his supervisors in July 1933. Soon afterward, he was authorized to construct an 875-ft-long waveguide for further tests of the feasibility of using long guides for communication. Both telephone and telegraph signals were transmitted through it successfully.

In 1934, Southworth was transferred to a Bell Telephone Laboratory facility located in Holmdel, NJ, to continue waveguide research and development. During the next four years, he directed a small team including two engineers and a technician assigned to his project.

After considerable delay due to issues related to patents, Southworth received permission to publish a technical paper on waveguides in the April 1935 issue of the Bell System Technical Journal. His paper was titled “Hyper-frequency wave guides—General considerations and experimental results.” The same issue included a paper on the theory of waveguides coauthored by Carson, Mead, and Schelkunoff. Subsequently, Southworth published an IRE paper titled “Some fundamental experiments with wave guides” in July 1937. He included sketches of electric and magnetic lines of force for various propagation modes in a metal pipe with a circular cross section. He gave a detailed explanation of the experimental apparatus and measurement technique he had used.

III. AWARDS AND LEGACY

Southworth received the Morris N. Liebmann Memorial Award from the IRE in 1938 in recognition of his investigations of waveguide propagation. He was the coauthor with Archie P. King of an IRE paper titled “Metal horns as directive receivers of ultra-short waves” published in February 1939 (Fig. 5). Southworth was elected a Fellow of the IRE in 1942 and also was elected a Fellow of the American Physical Society.

Southworth authored a paper on microwaves published in the Proceedings of the IRE in July 1943 (Fig. 6). Because of wartime secrecy, he did not discuss military applications such as radar. However, he noted that, among current trends, “perhaps none has been more spectacular than that toward the higher frequencies.” He continued that the high-frequency frontier had “surged forward almost as a flood.” He explained that the adoption of microwaves facilitated the use of very directive antennas and the transmission of information over great distances through the use of microwave relay towers. He mentioned that waveguide transmission might emerge as an alternative, but that it was too soon to predict which of the two systems would prevail. He concluded that radical new systems employing microwave techniques were emerging which were apt to pose new challenges and opportunities for electrical engineers.

Southworth was the author of a seminal paper on microwave radiation from the sun published in the Journal of the Franklin Institute in April 1945. This led to his receiving the Louis Levy Medal from the Franklin Institute in 1946. He also received the Stuart Ballantine Medal awarded by the Franklin Institute in 1947. He authored a book titled Principles and Applications of Waveguide Transmission.

Fig. 5. The complete receiver and mounting (from “Metal horns as directing receivers of ultra-short waves” by G. C. Southworth and A. P. King, Proceedings of the IRE, Vol. 27, No. 2, February 1939).

Fig. 6. Harmonic type of oscillator using a conventional negative-grid tube (from “Beyond the ultra-short waves” by G. C. Southworth, Proceedings of the IRE, Vol. 31, No. 7, July 1943).
published in 1950. He retired in 1955 but continued to do consulting work. He authored an IRE paper titled “Survey and history of the progress of the microwave arts” published in May 1962. The same year saw the publication of his autobiography titled *Forty Years of Radio Research*. He donated a substantial collection of documents and photographs related to his work to the American Institute of Physics in 1965. He died July 6, 1972 at age 81.

JAMES E. BRITTAHN