Wireless: From Marconi's Black Box to the Audion. *By Sungook Hong.* Cambridge: MIT Press, 2001. 272 pp. Cloth, $34.95. ISBN 0-262-08298-5.

Reviewed by David Hochfelder

Historians of science and technology will regard this book as the definitive work on the scientific underpinnings and technical development of wireless in its first fifteen years (1897–1912). Hong's "main goal is to provide a detailed analysis of engineering and scientific practices" in the early years of wireless, particularly the "transformation of scientific effects into technological artifacts" (pp. x–xi). Thus, business historians are not his primary audience, and he spends little time on topics that would directly interest them, such as the business strategies of early wireless developers or the impact of wireless communications on firms and economies.

However, Hong excels at what he does do, and readers interested in the science and technology of early wireless will find a wealth of new information here. He bases his analysis on extensive and closely detailed research, including previously untapped sources, such as the notebooks of John Ambrose Fleming, Marconi's scientific advisor and inventor of the "valve" or vacuum-tube diode. Hong's depth of research, close attention to detail, and solid command of wireless technology allow him to resolve some long-standing historiographic disputes, most critically Oliver Lodge's claim to priority over Marconi in sending wireless messages and John Ambrose Fleming's role in the invention of the vacuum tube in the first years of the twentieth century.

Hong takes as his starting point Lodge's 1897 claim that British scientists and engineers (especially Lodge himself) had anticipated Marconi in suggesting the use of Hertzian waves for wireless telegraphy. Hong shows that Lodge's claim was inaccurate, since British physicists did not explore this application of Hertzian waves before Marconi. As good Maxwellians, they regarded electromagnetic phenomena as a branch of optics rather than as a potential communications medium. Indeed, Lodge's purported demonstration of wireless telegraphy in 1894 "had nothing to do with telegraphy" (p. 25), but instead demonstrated the relation between electromagnetic waves and light. Hong shows that Lodge's claim to priority, which Hugh Aitken had accepted in his definitive

1976 book *Syntony and Spark*, had little technical merit. Instead, it was "deliberately constructed" (p. 26) in order to preserve the scientific prestige of British physicists and to safeguard British national interests in the new field of wireless communications.

Hong then shifts his attention to the activities of Marconi and his associates, particularly Fleming's grafting of power-engineering technologies onto Marconi's system of wireless telegraphy. This melding allowed Marconi and Fleming to boost transmitter power to send signals over very long distances, culminating in their successful transmission of the Morse letter "S" across the Atlantic in December 1901. Hong compares the engineering styles of Marconi and Fleming, the former a practical, intuitive engineer-entrepreneur and the latter a university-trained scientist-engineer who relied on precise measurement, controlled experiments, and mathematical analysis. Hong sums up their working relationship as usually "complementary and creative" but sometimes "competitive and even antagonistic" (p. 54). In June 1903 the antagonistic elements of their relationship predominated during the "Maskelyne affair." Nevil Maskelyne, a rival of Marconi, interfered with Fleming's public demonstration of Marconi's new tuning system by sending bogus messages from his own transmitter. Maskelyne claimed that his purpose was to show that Marconi's system was incapable of tuning out interfering signals, and this episode eroded Marconi's and Fleming's credibility and led to Fleming's dismissal from Marconi's employ. Hong examines the affair as "a rare case study of the manner in which the credibility of engineers was created, consumed, and suddenly destroyed" (p. 90). This episode spurred Fleming to develop new instruments and techniques in order to reestablish his value to Marconi. In May 1905, after developing a wavelength-measuring instrument (the "cymometer") and, more importantly, the vacuum-tube diode, which could rectify high-frequency AC signals, he resumed his professional relationship with the Marconi concern. In 1906, Lee de Forest improved on Fleming's "valve" by inserting a third electrode, allowing it to be used not only as a rectifier but also as a feedback device for amplification and oscillation. By 1912, de Forest's "audion" had become indispensable for the generation and detection of continuous waves, and it had also become the focus of a bitter priority dispute between several engineers, including Fleming, de Forest, and Edwin H. Armstrong. Hong intervenes in this well-studied dispute by showing that scientific conditions were ripe by

1912 to allow several engineers working independently to transform Fleming's "valve" into a device capable of amplification and oscillation.

Hong is an organized and engaging writer who excels at explaining scientific and technical matters clearly and succinctly. My only criticism of Hong's style and presentation occurs in his section on the vacuum tube's ability to generate continuous radio-frequency waves (pp. 157–61), which relies on second-order differential equations. This section will make sense to very few readers; only those familiar with advanced calculus or AC circuit theory will benefit from it. Here Hong should have sought a simpler, nonmathematical mode of explanation. There are two typographical errors in these equations (p. 158) to boot.

Readers interested in the early history of radio technology and in the relation between scientific theory and technological practice will welcome the addition of Hong's book to their libraries.

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