# Introduction to "Radio Communication"

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*Invited Paper*

## I. INTRODUCTION

The short-wave era in commercial long-distance radio communication began with the revolutionary discovery of the "daylight" wave by Guglielmo Marconi in October 1924, when a series of experiments which had begun in the spring of 1923, systematically culminated in successful daytime transatlantic communication at 32 m of wavelength.

Soon after Marconi's epoch-making discovery, short waves, which in those days were defined as wireless waves below 200 m, began replacing long waves (in the 60 kHz–150 kHz range, or 5 km–2 km waves) for transoceanic communications. Short-wave communication with 15 m was soon found to be better than that with 32 m. Short waves became the workhorse of worldwide communications until the late 1960's, when satellite communications began replacing its functions. Short-wave communication was the main medium with which World War II was conducted.

In this reprinted paper (the record of the address Marconi delivered on October 17, 1927, in New York City), Marconi describes the details of this discovery in the context of the contemporary technological state of wireless communications.

A short time after Marconi's 1927 address, Appleton explained the long-distance propagation of the daylight wave through a new mechanism of ionospheric reflection through the "$F_2$" layer that often goes by his name (as opposed to the ionospheric "E" layer, the Heavyside–Kennelly layer that explained propagation of Marconi's original transatlantic propagation of "long" waves). Appleton received the Nobel prize in physics in 1947 for the discovery of the ionospheric "F" layer, explaining Marconi's achievements.

The reader is urged to read this reprint of Marconi's address thoroughly to get a first-hand glimpse of the excitement generated by his pioneering work.

## II. SHORT WAVES AND THE RADIO AMATEURS

The glory of inaugurating the short-wave era in long-distance radio communication should rightfully belong to Marconi, but it is also shared by the radio amateurs, or ham operators (especially in the United States). The interesting story behind this is as follows.

The short-wave region of wireless waves, that is, waves 200 m and below, was relegated to the growing number of ham operators to keep them from causing interference with commercial operations in the long-wave region. Enthusiastic radio amateurs, in the name of American Amateur Radio and led by E. H. Armstrong of Columbia University (the inventor of the superheterodyne principle and frequency modulation, as well as an admirer of Marconi), ventured a transatlantic communication experiment in December 1921.

Armstrong, in a tribute to Marconi, brings the brilliant achievements of the amateurs to a focus [1]:

> The Radio amateur comes into the story at this point. American and British amateurs had been talking for years about organizing a test to determine whether the wavelengths on which they were allowed to work, the commercially "useless" ones of 200 meters and under, could span the Atlantic—during the hours of darkness, of course. Such a test was finally organized in 1920, on the amateur's standard wavelength of 200 meters. It failed. In the next year, another test was organized. Though all prophecies were that it too would fail, in fact a score of United States amateur call letters were identified in the British Isles in December 1921, two of them from stations with power of less than 100 watts; and one of the stations, station 1BCG in Greenwich, Conn., succeeded also in transmitting a complete message.
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> But the signals could be received only during the night hours of the Atlantic path; they ended with sunrise at its eastern end and did not reappear until after sunset at its western end. While the results caused a flurry of interest for a time, it soon died down. Though everyone was surprised that a 200-meter wave could span the Atlantic, neither the commercial companies nor those who took part in the tests were stimulated to investigate the shorter waves further. I had a hand in the construction of the 1BCG transmitter and also in the decision to dismantle it after the test, when the question of further investigation

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was discussed. But why investigate something with so fatal a defect, a telegraph system that could work only part of the time? Marconi seems to have been the only man in the commercial field whose imagination was fired with the spanning of the Atlantic by the stations of the amateurs.

H. H. Beverage (1893-1993), the inventor of the Beverage Wave Antenna that became the workhorse of long-wave reception from its invention in 1918, designed the successful 200 m receiving antenna for P. F. Godley, an American radio amateur. Godley was actively involved in this experiment by the radio amateurs and discussed the impending experiment with Beverage during their transatlantic travel together to England in November 1921 aboard the S.S. *Aquitania*.

I had the pleasure of knowing Beverage from 1986 until his death on January 23, 1993. During many conversations with him in Stonybrook, NY, Bev recalled with great excitement and pleasure the success story of the amateurs' transatlantic wireless experiment [2] in which his own antenna received the signals "loud and clear" at 200 m across the Atlantic in Scotland (including Bev's own signal from his ham station 2BML in Long Island, NY). Bev also gave me a first-hand account of the excitement generated in October 1924, when the short-wave signals were received across the Atlantic during the day for the first time at 32 m. Bev was in New Brunswick, NJ, with the big transatlantic long-wave station when he heard the signal using the bed spring in his hotel room as the antenna. The next day, when the news was printed, people did not believe Bev's story, wondering how he could have received a transatlantic signal using the bed spring as the antenna.

The credit for the radio amateurs' success had been given to Armstrong and his team. But they did not explore the propagation of shorter waves and had missed the discovery of the "daylight" wave by not going further down on the wave length of communication. Armstrong, in humility and in a show of his admiration of Marconi's achievements, corrects the history and assigns the credit back to Marconi in the following words [1]:

> It is important at this point to call attention to a strange and disquieting circumstance, the failure among our writers of history and our text books to tell the story of this great discovery correctly and to credit Marconi with making it. There are great lessons to be learned from his accounts of the two voyages of the *Elettra*, and the facts have been available, yet our literature on the subject has been either completely silent or downright incorrect.
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> Two outstanding instances appear from the history of this development which reveal Marconi's intuitive sense of what to investigate and where to look for new results. The crossing of the Atlantic by the large number of amateur signals, some of them of extremely low power, meant something more to Marconi than quite evidently it did to the rest of us. He went ahead with his investigation. His observation of the signals in the Cape Verde Islands revealed that the daylight fade and the nighttime rise with long-wave signals. In his July 1924 Royal Society paper the phenomenon was described, and in the discussion Marconi correctly diagnosed the limits of his own knowledge. He stated in response to questions that he did not know whether some other wavelength might not perhaps cover great distances in the daytime. So he made the experiment and found the answer. The rest of us knew too much about the laws of nature to try.

**Fig. 1.** Guglielmo Marconi aboard steam yacht *Elettra* in the wireless research laboratory room.

Seventy-five years later the afterglow of the amateurs' achievement still persists and many ham operators are still reluctant to share the glory of inaugurating the short-wave era with Marconi, to whom the true success rightfully belongs.

## III. *Elettra*—The Floating Research Laboratory

In 1919, after the World War I, Marconi bought a 220-ft-long steam yacht, built in Scotland, from the Archduchess Maria Theresa of Austria. Its name was *Rovenska*, but Marconi christened it with the name *Elettra*. He made it a floating radio research laboratory with the intention of performing radio wave propagation experiments by sailing across the oceans (Fig. 1) [3]. A picture of the steam yacht *Elettra* is shown in the original paper reprinted here. The discovery of the daylight wave was made with this floating laboratory while cruising the Mediterranean along the coasts of Syria, as described by Marconi firsthand in this paper.

Marconi's eldest daughter, Degna Marconi, was displeased by her father's decision to sell one of his homes to buy the steam yacht [3].

## IV. A Personal Note

Marconi's great discovery of the "daylight" wave that opened up the short-wave spectrum for long-distance radio communication came at a considerable sacrifice to his personal family life. Busy conducting wireless experiments in the lands and across the oceans, the wireless wizard was rarely at home.

**Fig. 2.** The author, Dr. Bondyopadhyay, with Mrs. Gioia Marconi Braga, Marconi's second daughter, in 1987.

Marconi was in the midst of a divorce from his first wife when this great short-wave discovery took place [3]. The person who suffered the most from Marconi's frequent absences was his second daughter, Gioia Yolanda Marconi Braga (1916–1996). I had the privilege of knowing Mrs. Marconi Braga personally since 1986 (Fig. 2); it was she who prompted my interest in the wireless history made by her illustrious father, and the history of science and technology in general.

"I did not know him very well! He was a distant father but a good father," she recalled during one of the several conversations I had with her in recent years.

On the occasion of the 75th anniversary of this momentous discovery, we can most certainly observe with gratitude that Marconi's sacrifice was indeed dedicated to the immense benefit of mankind; it is remembered with great admiration by the present generation and will continue to be for generations to come.

## V. An Intriguing Possibility

Soon after the successful daytime reception of 32-m waves, it was discovered that daytime reception of 15-m waves was even better (which led to the observation that this discovery could have been made three years earlier). Referring to transmissions from Marconi's 15-m directed-beam communication system between Birmingham and Hendon in England, Armstrong said the following in his 1953 speech [1].

> We can return now to the Hendon–Birmingham beam already described and contemplate the moral of the story of one of the great missed chances of radio history, the chance that every American amateur and radio experimenter had had to tune in the Hendon–Birmingham beam telephone as early as 1922 and discover the daylight wave before Marconi. The Great Circle course of the Hendon beam lay across eastern Canada and the United States. The 15-meter wave, as was found later, was a better day-light wave than those in the 30-meter range, though it was not effective at night. Full information about the Hendon station was available from Franklin's and Marconi's publications, and all necessary information about the most effective means of receiving such waves, the superheterodyne, had been published.
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> Had any radio experimenter in the United States thought to set up a superheterodyne for 15 meters and listen for the Hendon signals during the daytime, he almost inevitably would have heard them at some time during the day, and he, instead of Marconi, would have discovered the daylight wave. But no one had the imagination to set up a receiver and listen. We all knew too much about propagation; only a madman in those days would have proposed to receive 15-meter signals across the North Atlantic, especially during daylight hours.
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> There is however, a consolation for the American experimenters who missed the chance. The master experimenter, Marconi also missed it. Though for more than 20 years he had made it a practice on voyages to the united States to take along receivers to listen to his British stations, when he crossed the Atlantic in the *Elettra* in 1922 it seems not to have occurred to him to take along a 15-meter receiver and listen to Hendon. Had he done so, and turned the Hendon beam to follow the yacht, he would have discovered the daylight wave two years before he actually did.

We may recall that Marconi's epoch-making first successful transatlantic wireless transmission between Poldhu, England, and Signal Hill, Newfoundland, on December 12, 1901, took place during the daytime (12:30 PM Newfoundland time). Could it have taken place by means of short waves, the "daylight" waves?

This intriguing possibility exists when one sees that the transmitting antenna was a good radiator of short waves, the transmitting signals were broad-band pulses, and the ionospheric conditions were right for the short-wave propagation across the Atlantic during the day. Recently this author has established a *prima facie* case for further detailed analysis of the communication system [4], [5]. The results of the analysis will be reported at a future date.

## References


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