Tesla, Marconi, and the Race to Develop Wireless Telegraphy, 1890-1905

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Tesla versus Marconi

In the history of radio, scholars tend to either . . .

. . . praise Marconi and dismiss Tesla as a misguided fool. . .

. . . or claim that Tesla invented radio and that Marconi stole his ideas.
An Alternative View

What if we looked simultaneously at Tesla and Marconi?

What if we looked for points where they affected each other?
Hertz and the Discovery of Electromagnetic Waves

In 1887, Hertz used an induction coil [A] to generate sparks at gap [H]. He found that he could detect sparks elsewhere by using the loop [L] as a receiver. Hertz concluded that sparks at L were caused by electromagnetic waves traveling through space.
Tesla’s Early Career

1856
Born to a Serbian family in modern-day Croatia.

1876-1879
Studied engineering at Joanneum Polytechnic School in Graz, Austria.

1884
Emigrated to New York.

1887
Invented practical AC motor.
1889
Tesla visited Paris Exposition and learned about Hertz’ experiments with e-m waves.

1890-91
Repeated Hertz’ experiments;
Scaled up Hertz apparatus to create the **Tesla Coil**.
Tesla discovered that a Geissler tube glows when placed between terminals of Tesla Coil;

Envisioned wireless lighting system in homes with metal sheets on walls.
Wireless Lighting

1892-1893
To extend reach of system, he connected a Tesla coil to large capacitance (antenna) and the ground;

Transmitted signals between lab and his hotel.

Tesla decided that Hertz was wrong and that “electrostatic thrusts,” not waves, passed between the antennas.
Wireless Lighting

1893-1897
Tesla developed equipment to power lights and motors without any wires.

Although he mentioned sending messages in lectures, Tesla primarily concerned with transmitting power.
Promoting Wireless Lighting

Tesla patented his ideas

. . . promoted them through lectures, private demonstrations, and newspaper interviews

. . . then waited for investors to buy or license patents.

But no investors came forward in the mid-1890s.
Working first at his father’s estate in Bologna, Marconi modified Hertz’ apparatus:

- For transmitter, elevated one terminal of induction coil and grounded the other;
- Replaced Hertz resonator loop with receiver consisting of Branly coherer, and relay; and
- Since he was planning to send messages included Morse key and paper tape recorder.
Promoting Wireless Telegraphy

1896
Marconi traveled to England to get help from His Mother’s family (Jamesons) in commercializing his invention;
Worked with William Preece, chief electrician for the British Post Office.
Worried about Tesla

1897

Rather than continuing to work with Preece and the BPO, Marconi persuaded by the Jamesons to create the Wireless Telegraph and Signal Company; As he told Preece:

“I must inform you that I have entered into a contract with an English Company. . . . The vigorous opposition made to me by Lodge in England, Tesla in America and others in Europe [has in part] induced me to take this step.”
From Wireless Lighting to Wireless Power

1895-1897

With little going on the business front, Tesla continued to think about how his system might work.

Like light, e-m waves travel in straight lines, and Tesla thought little energy would actually get from the transmitter to the receiver.

He decided instead to minimize waves generated by his equipment and maximize the ground current.
Two Views of Wireless Communications in 1890s

In the typical view, early radio investigators such as Marconi assumed that the transmitter should generate electromagnetic waves which would be sent through the air to the receiver. The circuit would then be completed because both the receiver and transmitter were grounded, i.e., connected to the earth.

In contrast, Tesla proposed in his wireless power scheme to have transmitter pump electromagnetic waves into the earth's crust. These waves would then be picked up by receiver's ground connection. The circuit would be completed by having some electromagnetic waves radiate back from the receiver to the transmitter.
Tesla’s Wireless Power System

1899
While power would be transmitted through the earth, Tesla completed the circuit by elevating the terminals into the atmosphere by using balloons. In the upper atmosphere, Tesla believed the thinner air would allow currents to be conducted.

Convinced that he now had a feasible system, Tesla persuaded John Jacob Astor IV to invest in it.
Meanwhile, what was Marconi doing?

In March 1899, Marconi successfully sent a message across the English Channel from Boulogne in France to the South Foreland Lighthouse in England, a distance of 32 miles.
Not to be outdone by Marconi, Tesla predicted worldwide messages:

“The people of New York can have their private wireless communication with friends and acquaintances in various parts of the world.

“It will be no greater wonder to have a cable tower [with a balloon tethered to it] than it is now to have [A] telephone in your house.

“You will be able to send a 2,000 word dispatch from New York to London, Paris, Vienna, Constantinople, Bombay, Singapore, Tokio [sic] or Manila in less time than it takes now to ring up ‘central.'”
But the Press Didn’t entirely believe Tesla’s boasts. . .

Tesla, America’s Own and Only Non-Inventing Inventor, the Scientist of the Delmonico Café and Waldorf-Astoria Palm Garden, has been at it again. This time the news of young Marconi’s success in telegraphing through space fired Tesla to feats hitherto undreamed of, and he filled columns in the Herald. . . with profound droolings about volts and resistances and circuits and ampères and things and things. Tesla says he can do everything that Marconi has done. . . . Indeed the actual results of the methods of the two inventors show only this slight difference: Marconi telegraphs through space and Tesla talks through space. [Town topics, 6 April 1899]
Colorado Springs Experiment Station

June 1899
Worried that Marconi was getting ahead, Tesla went to Colorado Springs to conduct experiments on a larger scale.

In particular, he needed to understand how his currents would propagate through the earth.
Colorado Springs

While studying lightning storms, Tesla decided that electromagnetic energy moved through the earth by setting up stationary waves.
Colorado Springs

Tesla conducted experiments that convinced him that he had sent power around the world.

Pursued a confirmatory rather than disconfirmatory strategy. Wanted to believe his dreams could be true.
The Tower at Wardenclyffe

1900
Tesla returned to New York and announced that he would transmit power—and messages--across the Atlantic in 8 months.

Secured $150,000 from J.P. Morgan to build transmitting station at Wardenclyffe, Long Island.
Marconi’s Gamble

1900
Up to now, Marconi had developed his system by increasing transmission distances incrementally;

However, Tesla’s bold claims may have prompted him to decide that he should be the first to transmit across the Atlantic.
Scaling up the System

1900-1901

- For the transmitter at Poldhu in England, Marconi stopped using battery-operated tabletop circuit;
- turned to J. Ambrose Fleming who designed a system with 25 Kw AC generator and series of transformers which stepped up 800 kHz signal to 20,000 V;
- Erected huge antennae at Poldhu and Cape Cod.
Spanning the Atlantic

Fall 1901

- After Antenna Arrays at both Poldhu and Cape Cod were destroyed by storms, Marconi decided to try and receive signals at St. John’s, Newfoundland.
- On 12 December, Marconi and assistant Kemp heard 3 faint dots representing “S.”
Tesla’s Dream Vanishes

1901-1905

• Tesla continued to work at Wardenclyffe, but quickly used up Morgan’s money and was unable to raise additional funds;

• Not clear how Wardenclyffe would have worked. Is the Earth like an ocean or a water balloon?

Interior of Wardenclyffe Station, circa 1903. Hand-colored by Rex Hubbard.
The Earth as Water Balloon

Tesla’s World-Wide Wireless Transmission of Electrical Signals, As Well As Light and Power, Is Here Illustrated In Theory, Analogy and Realization. Tesla’s Experiments With 100 Foot Discharges At Potentials of Millions of Volts Have Demonstrated That the Hertz Waves Are Infinitesimal In Effect and Unrecoverable; the Recoverable Ground Waves of Tesla Fly “Thru the Earth”. Radio Engineers Are Gradually Beginning to See the Light and That the Laws of Propagation Laid Down by Tesla Over a Quarter of a Century Ago Form the Real and True Basis of All Wireless Transmission To-Day.
So should Tesla or Marconi be considered the father of radio?
Who Invented Radio?

It depends what we mean by “radio.” Do we mean:

• a system of transmitting messages using electromagnetic waves,

• the box in our homes that picks up broadcast programs, or

• the basic idea of using electromagnetic waves to do work?

For the first definition of radio, Marconi is the right answer.

For the second definition, we would need to talk about Reginald Fessenden, Lee De Forest, Edwin Armstrong, and David Sarnoff.

But for the third definition, Tesla deserves credit. He was one of the first to work on converting Hertz’ discovery into a technology.
So Why tell the story of Radio with both Marconi and Tesla?

• Would we write a history of the race to the Moon without taking into account the views of both the Americans and the Soviets?

• Because electronics and telecommunications today are so dependent on science, their history is often on the verge of technological determinism. History is constrained by the science.

• Coupled with this determinism is a tendency to fall back on a heroic myth of invention. Great inventions are the product of sole genius.
Another Kind of Path Dependency?

[Apologies to Paul David]

• No one best way to convert science into technology; no obvious path to follow.

• Inventors have to choose what looks like the most promising path, based on prior knowledge and experience.

• As they pursue different paths, inventors are affected by their circumstances and competitors.

• Indeed, some inventors are important to the history since they serve to spur others on.
Wireless Power Today


• At MIT, Marin Soljacic is currently studying how to use resonance to recharge batteries in consumer electronic devices when device comes near its homebase.
Why Didn’t Tesla Succeed with Wireless Power?

- Not enough funding. Tesla didn’t pursue a series of incremental demonstrations that convinced investors;
- Practical Problem. How do you transmit currents through the earth? Does the Earth function like a water balloon or an Ocean?

...But it was not the result of a conspiracy by financiers, corporations, or Marconi.
Why No Investors?

• Panic of 1893.

• Edward Dean Adams and the Nikola Tesla Company [1895-97]; speculative venture.

• **Divergent** versus **convergent** thinking:
  • Tesla—generate lots of alternatives
  • Investors want inventor to focus on most promising alternatives.

• Why did Tesla tend toward divergent thinking?
  • Fire destroyed lab [March 1895];
  • Mental depression.
The Riddle of the Return Circuit

1896-1898

Tesla decided that if he could generate a ground current at the earth’s resonant frequency, then he could transmit power around the world.

But what about the return circuit through the atmosphere?
The Riddle of the Return Circuit

What if you replaced the wire with a Geissler tube?

Isn’t the upper atmosphere with its low pressures like a Geissler tube?

If so, then a current could move back through the atmosphere from the receiver to the transmitter.