# Chapter 2

2. Communication Without Wires

This section is about the invention and evolution of the wireless industry prior to the birth of radio broadcasting in the 1920s. The idea of communications through the "ether" without wires was mysterious and exciting. Guglielmo Marconi made the scientific experiments practical and established wireless telegraphy as a business. Technological progress was rapid, with multiple inventors and entrepreneurs contributing technologies that expanded usefulness from coastal ship-to-shore applications to transoceanic distances and locations where wires could not reach. The British Marconi Company was the industry leader by (like AT&T) refusing to allow ships with its equipment to communicate with ships that used wireless sets sold by other companies. By WW I, General Electric and Westinghouse had developed or bought rights to improved technologies and were selling equipment to compete with Marconi. Wireless was telegraphy, but the vacuum tube made possible wireless transmission of voice. Apart from a few experiments, voice transmission was perceived to be a point-to-point application useful mainly for field operations or locations where telephone wires were not feasible. AT&T thought about using wireless voice to span the US when long distance wire transmission was difficult, but found it not to be useful in the telephone business. When WW I started, the importance of wireless for war efforts was quickly recognized and the government took over all US wireless activities. Wireless technology had developed dramatically, but its future in broadcasting was not perceived.

> *(Note to Reader - Chapter 2 traces the **consolidation** of the powerful telephone and broadcast network monopolies from the 1930s through the 1970s – AT&T's growth from a telephone company into a modern all-purpose national and international telecommunications company, the three radio networks' extension of their monopoly into a monopoly of three national TV networks, and the passage of the 1934 Communications Act that created the FCC to oversee these powerful new monopolies.[1])*

This section is about the invention and evolution of the "wireless" industry prior to the birth of radio broadcasting in the 1920s. The idea of communications through the "ether" without wires was mysterious and exciting. Guglielmo Marconi made the scientific experiments practical and established wireless telegraphy as a business. Almost single-handedly, he took the new phenomenon of radio waves out of the laboratory, developed the technology to send signals over long distances, and made wireless a practical communications business. Technological progress was rapid, with multiple inventors and entrepreneurs contributing technologies that expanded usefulness from coastal ship-to-shore applications to transoceanic distances and locations where

[1] [CTW:] Footnote here to explain the use of the word "monopoly". Qualification of economic meaning for telephone and simpler construction than "oligopoly" in broadcasting. [Milton Mueller, Jr., *Universal Service: Competition, Interconnection, and Monopoly in the Making of the American Telephone System* (Cambridge: The MIT Press, 1997) at 8-9ff.]

wires could not reach. Under Marconi's leadership, the British Marconi Company[2] led the industry leader in technology and business acumen. For a period Marconi tried to parlay its technological and financial strength into a monopoly position by refusing to allow ships using its equipment to communicate with ships that used wireless sets sold by other companies (rather like AT&T's requiring its customers to use only Bell telephones and refusing to connect calls to customers of competing telephone companies). But pressure from competing companies prevented Marconi from sustaining this position, and this practice was eliminated by pressure from other countries with competitive wireless companies by the [International Wireless] Conference of 19[06].[3]

Marconi built the international wireless industry by steadily improving technology, reaching greater distances, and superior service. With the active cooperation of the German government, the Telefunken and Siemens(?) companies provided ship-to-shore service to German fleets, the German navy, and German government installations around the world. The US Navy experimented with American wireless companies, and the XXX company started by the American inventor YYY grew by providing ship-to-shore and long distance links to remote locations.

By the advent WWI, General Electric and Westinghouse had developed or bought rights to improved technologies and were selling equipment to compete with Marconi. AT&T had thought about using wireless voice to span the US when long distance wire transmission was difficult, and had bought the rights to use the vacuum tube for telephone use, but concluded that wireless telephony was not useful in the telephone business. Wireless was telegraphy, and apart from a few experiments, voice transmission was perceived to be a point-to-point application useful mainly for field operations or locations where telephone wires were not feasible.

WWI was a turning point in wireless. The importance of wireless for war efforts was quickly recognized and the government took over all US wireless activities. The combatant countries took over their wireless companies and the foreign-owned wireless stations operating in their country. Armies and navies expanded their use of wireless by creating new demand and searching for new technologies. The US government declared a patent moratorium, cross-licensing of all wireless-related patents with royalties to be sorted out after the war. The US army and navy found the vacuum tube, which had been more or less invented by Lee De Forest before the war, to be useful in wireless telegraphy and for voice communications, and created a big demand for vacuum tube development, standardization, and manufacturing. German and Allied militaries developed improved encryption techniques and pioneered the use of wireless for propaganda and misinformation. By the end of WWI, wireless technology had developed dramatically, but its future in broadcasting was not perceived.

After WWI, governments and companies moved to restore "normal" commercial operations, but much had changed. High power audio transmission for voice and music was practical. Various manufacturers were selling vacuum tubes that could be used for improved reception and low power transmission. But neither of these had much immediate impact on the return to

[2] [CTW:] As with Bell and AT&T, we need to adopt a simplified naming convention.
[3] [Susan J. Douglas, *Inventing American Broadcasting, 1899-1922* (Baltimore: Johns Hopkins University Press, 1987) at 137-39.]

"normalcy"[4] Wireless was still telegraphy, useful for ship-to-shore and communications to remote outposts; Marconi was poised to return to dominance of the commercial wireless market, particularly the lucrative and strategically important North Atlantic US markets. But two factors gave the biggest and most immediate impetus for change. One was the realization, particularly by the US Navy, of the strategic and military uses of wireless. The second was the need to resolve the conflicting and ambiguous patent rights among the various companies that had led the wave(?) of invention before and during the war.

Shortly after the end of the war, the US Navy quietly proposed to General Electric, then the largest manufacturer of wireless equipment**5**, that it acquire the US operations of the Marconi Company.[6] With the benefit of the wartime experience, the Navy took the position that the American Marconi Company should be controlled by the US, not a foreign government. This led to the formation of RCA. Owen Young, Commander XXX, Franklin Roosevelt. Hoover???

Patent rights resolved by industry based on the fundamental idea that wireless was useful chiefly for telegraphy. (Did the government play a roll in this?? It came after RCA was formed.) Digression on the vacuum tube, invented before WWI, developed and standardized during the war, perceived uses in wireless transmission, reception, wireline telephony. [See below.] [CTW inserted these brackets.] In neither the creation of RCA nor the settlement of patent rights did anyone seem to see the importance of the vacuum tube or the potential of voice and music transmission that would provide the basic technical and economic conditions for the invention of the radio broadcasting and the consumer electronics businesses in the early 1920s. Those twin businesses would provide the model for TV broadcasting and later cable TV.

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*The Vacuum Tube Digression*

Vacuum tube as detector, oscillator, amplifier

The vacuum tube was invented in stages. First, the two-element tube. Used in the search for a more effective detector of radio waves. Reception relied on energy from transmitter to produce movement of a recording pen or sound in headphones. But as the radio spectrum[7] was subdivided more and more to accommodate more signals, the energy available for each signal was reduced.[8] It became very important to extract as much energy from the radio signal as

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[4] [CTW:] Didn't Wilson or someone use "return to normalcy" around this time??? [Yes: Warren G. Harding "ran on a promise to 'Return to Normalcy'" during his presidential campaign of 1920. See, e.g., "Warren G. Harding," *Wikipedia*. http://en.wikipedia.org/wiki/Warren_G._Harding. Also, although the phrase is not used, Susan Douglas discusses it in *Inventing American Broadcasting* at 279-85.]

[5] [CTW:] Of just transmission equipment or receivers as well? [Sources unclear on this issue.]

[6] [Douglas, *Inventing American Broadcasting*, 285-86.]

[7] [CTW:] Which we have not yet defined, but we should in a section under the growth of competition in wireless. [Thomas Porter Robinson, *Radio Networks and the Federal Government* (New York: Columbia University Press, 1943) at 214-17 ("The present radio spectrum . . . is from about 10,000 cycles to 500,000,000 cycles.").]

[8] [CTW:] This is probably a technically sloppy description. Is it worth being more precise in the

possible. The device in the radio receiver that performed this energy extraction was called the "detector". Inventors by the score explored chemical, electrical, and physical devices by the hundreds in the search for a better detector.[9] In that search, Lee De Forest got the idea of putting a third element, which he called the "grid", inside the vacuum tube, between the positive and negative ends.[10] He and others found that if the receiving antenna was connected to the grid and the negative end of the tube then a small amount of energy from the radio signal would trigger a [slight amplification of the] flow of electrical energy between the positive and negative ends of the tube. The three-element vacuum tube was indeed a superior detector of radio waves. But it did not work by extracting more energy from the radio signal itself as had other detector technologies, but rather by using the weak input signal to produce a corresponding, but [slightly] more powerful signal in the receiver. This amplification of minuscule levels of energy available in the radio signal into larger levels of energy supplied by the receiver itself marked the transformation of *electrical* communications into *electronic* communications.[11]

Now receiver designers could build radio receivers that worked reliably with very weak radio signals from far away transmitters. But the vacuum tube quickly proved to be more than a superior detector. It could amplify the radio signal itself. It could amplify the detected audio signal. It could produce oscillations at very precise frequencies that could be used to improve both receiver and transmitter performance. It could modulate a radio signal with audio frequencies to transmit voice and music. In short, it allowed receiver and transmitter circuits to be developed that created, detected, and processed at extremely low power levels and then amplified the resulting signal to a usable output level. It also allowed weak signals on a telephone line to be amplified so that telephone calls could be sent over longer distances. It could detect markings on a movie film and provide sound for "talkies." Later in the century, the vacuum tube would be replaced by the transistor in radio receivers (some will recall the innovation of the "transistor radio" in the 1950s that could be carried in one's pocket instead of being plugged into the wall!), and [even] later by the computer chip with thousands of transistors.[12] This processing of signals at minuscule energy levels and the amplification of the resulting output signal with much larger energy levels supplied by the receiver or transmitter itself marked the transformation of *electrical* communications into *electronic* communications.[13]

The versatility of the vacuum tube made the division of patent rights a very important industrial

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text or in a footnote? [Ibid.]

[9] The two-element vacuum tube, invented in Edison's lab in the 1890s, was one entrant in that race that proved useful the years immediately preceding and during WWI. [John A. Fleming invented it. It is also called the "Fleming Valve" and "Fleming Oscillation Valve." W.J. Baker, *A History of the Marconi Company* (New York: St. Martin's Press, 1971) at 106-09; Douglas 169-70, 278. See also Douglas, *Inventing American Broadcasting*, 278 ("[I]t was in the urgent, heady and litigation-free environment of 1917 and 1918 that the tube's full potential was realized. By the end of the war, the vacuum tube had become a much more sensitive, rugged, reliable, and long-lasting detector of radio waves.").]

[10] [Baker, *A History of the Marconi Company*, 120-21; Douglas, *Inventing American Broadcasting*, 170-71.] [CTW:] Boy is this sloppy.

[11] See the concluding sentence of the next paragraph and the footnote there.

[12] [CTW:] This sentence needs cleaning up.

[13] This concluding sentence is an alternative to the concluding sentence of the previous paragraph.

issue, first in the wireless and telephone applications in 1920(?) before the advent of radio broadcasting and then again in 19XX when the importance of the vacuum tube for radio broadcasting became evident.

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At the turn of the century, the idea of using the newly-discovered radio waves for communications through the "ether" without wires was mysterious and exciting[14]. But it was nothing like today's wireless cell phones and wi-fi. It was all Morse code, just dots and dashes - no voice, no music, no web pages.[15] It was called "wireless telegraphy" or just "wireless". Later, called "radio waves" (from the Latin for radiate[16]), but in this section we will stick to "wireless" because it was predominant at the time and because the word "radio" later became a synonym for radio broadcasting, which is the way we still use the word today.

The latter half of the nineteenth century was remarkable for public and scientific interest in electricity and magnetism. Electric lights and signs began to change the city nightscape, and science and pseudo-science grew apace. James Clerk Maxwell developed his famous equations showing that electricity, magnetism, and light were a unified electromagnetic phenomenon carried by waves through an invisible "ether". Heinrich Hertz demonstrated that electromagnetic waves actually existed by showing that an electric spark created a signal in the "ether" that could induce a much smaller spark in a coil of wire across the laboratory[17].

Scientists were fascinated by the parallels between these newly-discovered "Hertzian waves" and light waves were both electromagnetic waves in the ether, only with different frequencies. Their experiments focused on the physical properties of how these new waves behaved like light in the laboratory.[18]

But Guglielmo Marconi was different. He was not a scientist, and indeed had never been to college, but as a young man of [20],[19] he read an obituary of Hertz and was struck by the idea that these new waves could be used for communications. He wondered if this transmission of sparks through the "ether", whatever that was, could be used to send telegraph messages[20] without wires.[21] While scientists were fascinated with laboratory experiments sending the

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[14] To the public, but not to the scientific community. Maxwell's brilliant equations. Hertz spark transmissions

[15] Text was sent and received at perhaps 100 bps.

[16] "Radiato" = radiate? radiating? [See also Gleason L. Archer, *History of Radio to 1926* (New York: The American Historical Society, Inc., 1938) at 100 ("By 1910 the word radio sprang into being.").]

[17] Other scientists further developed spark transmission and reception techniques in the lab before Marconi took an interest. [Baker, *A History of the Marconi Company*, 16-24.]

[18] Hugh G. Aitken, *Syntony and Spark, The Origins of Radio* (Princeton: Princeton University Press, 1985) at 18[4]-189.

[19] [Baker, *A History of the Marconi Company*, 25; Aitken, *Syntony and Spark*, at 183.]

[20] Aitken, *Syntony and Spark*, 183

[21] Hertz b 1857 d 1894 Hertzian waves demonstrated 1888. Baker, *A History of the Marconi Company*, 18. 1888 was the publication date; presumably Hertz actually did the discovery earlier.

Hertzian waves across the laboratory, Marconi was fascinated by how far such waves could be made to travel so they could be used for communications.[22]

[Working in Righi's laboratory and auditing his lectures enabled Marconi to begin experimenting in his "top-floor laboratory – a spare room at the Villa Griffone."] The transmitter was a battery-powered device that would make a spark across a gap between two metal balls. The receiving device - a Bromley coherer - consisted of a small vial of metal filings that would stick together when the transmitter sparked. And like the scientists, Marconi found that he could send a signal . . . across the room.[23]

At this point Marconi's strong points came into play. He was self-educated, never went to college. But he persevered, he tried countless variations on the apparatus for transmitting and receiving. He tinkered, but always with a purpose, and always systematically. Literally and figuratively, Marconi was the first amateur radio operator.[24]

Although he did make several technical inventions, was awarded several key patents, and later won the Nobel Prize in physics, he was not really an inventor. More accurately Marconi was an experimenter with a goal, and that goal was distance.[25] He kept whatever variation on his apparatus improved the communications distance. He moved the receiver outside;[26] he tried [all technologies available to him and pushed their limits.][27] He did not so much "invent" as to "discover" what worked.[28]

Empirical approach rather than scientific.[29] Fortuitous (first of many!) connection to outside vertical antenna (used for thunderstorm detection experiments). Focus on distance.[30] Range greatly improved. [31]

One day he wondered what would happen if he connected the transmitter, not to the small indoor antenna used in scientific lab tests, but to the vertical rod he had earlier put on the roof to detect the static from lightning storms. [32] [33] The longer outside antenna greatly increased the distance

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Aitken, *Syntony and Spark*, 183.

[22] Ibid at 190-191.

[23] [Baker, *A History of the Marconi Company*, 25; Aitken, *Syntony and Spark*, 183-87.]

[24] [CTW:] Trivia: What was the first call sign for a Marconi station?

[25] Aitken, *Syntony and Spark*, [190-92, 198.]

[26] [Gavin Weightman, *Signor Marconi's Magic Box: The Most Remarkable Invention of the 19th Century & the Amateur Inventor Whose Genius Sparked a Revolution* (Cambridge: Da Capo Press, 2003) at 19.]

[27] [Aitken, *Syntony and Spark*, 186-87; Douglas, *Inventing American Broadcasting*, 16; Weightman, *Signor Marconi's Magic Box*, 19-20.]

[28] [Aitken, *Syntony and Spark*, 187-98.]

[29] [Ibid 195-96.]

[30] Ibid [190-92.]

[31] Baker, *A History of the Marconi Company*, 26.

[32] Ibid.

[33] [Lodge] and others had shown that lightning produced Hertzian waves that could be detected by a suitable receiver and a lightning-rod-like antenna. [Aitken, *Syntony and Spark*, 85-88.]

over which signals could be sent and received.[34] He put up still longer and higher antennas and found he got even longer distances, up to several miles.

The spark gap transmitters were crude devices. They generated static-like noise all that blanketed the frequency spectrum, but the antenna length provided a rough tuning device to reinforce a dominant frequency for the transmitter and receiver. The short antennas used in the science lab and in Marconi's attic radiated the very high frequencies, which were fine for physics experiments.[35] But the longer antenna on the roof radiated the lower frequencies[36], and those lower frequencies weren't blocked by trees and hills as were the high frequencies.[37] [38] [39] [40] [41]

Marconi's move to longer antennas, and thus lower frequencies, gave him the longer distance he was seeking.[42] This was the big technological breakthrough that launched radio as a new communications medium.

With his spark gap transmitter, vial of metal filings for a detector, and long wire antennas,

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[34] Which he happened to have as a result of interest in lightning detection tests. Read Franklin. [Orrin E. Dunlap, *Marconi: The Man and His Wireless* (New York: The MacMillan Company, 1937) at 11; Baker, *A History of the Marconi Company*, 26.] Move into text?

[35] [Hertz's lab experiments were impacted by the room's size and objects within it. Aitken, *Syntony and Spark*, 68-69.]

[36] In the early days of wireless, and into the early days of radio broadcasting, it was most common to talk of "wavelength" rather than frequency because wavelength is directly proportional to antenna length. [See, e.g., Baker, *A History of the Marconi Company*, 26; Weightman, *Signor Marconi's Magic Box*, 55-56.] Today, however, wavelength is a purely technical term, so we have translated almost all wavelength references from the early years to frequency for easier comparison to today's use of the radio spectrum. Marvin Bensman, *The Beginning of Broadcast Regulation in the Twentieth Century* (Jefferson, North Carolina: McFarland & Company, Inc., 2000) at 82.

[37] Just as a large bell rings at a lower tone than a small bell, a longer antenna resonates at a longer wavelength or higher frequency. For those interested, the formula translating frequency and wavelength is $\lambda(\text{meters}) = f(\text{MHz})/300$, or $\lambda(\text{meters}) = f(\text{kHz})/0.3$, or $f(\text{kHz}) = 0.3 \cdot \lambda(\text{meters})$, etc.

[38] For a time, he believed the vertical orientation was important. [See, e.g., Weightman, *Signor Marconi's Magic Box,* 55.] But later (Slaby?) he and others recognized that length was even more important than height. [Aitken, *Syntony and Spark*, 196; Baker, *A History of the Marconi Company*, 32-33.]

[39] The higher frequencies more nearly mimicked light waves, traveling in line of sight, blocked by walls and hills, [Aitken, *Syntony and Spark*, 57-59, 68-69, 189-90.] but more readily beamed with small antennas, reflecting lenses, etc.

[40] [CTW:] Footnote on resonance, harmonics, etc? [Aitken, *Syntony and Spark*, 71-74]

[41] [Baker, *A History of the Marconi Company*, 26.] Over the years, Marconi moved to lower and lower frequencies, but it was the early move from the very high frequencies (100 MHz ±, like our current FM broadcast frequencies) to lower frequencies (1,000 kHz ± like our current AM broadcast frequencies) that made the big difference. [Aitken, *Syntony and Spark*, 189-90; 192-96.]

[42] [See, e.g., Aitken, *Syntony and Spark*, 196-97; Weightman, *Signor Marconi's Magic Box,* 55.]

Marconi had built the world's first working wireless telegraph system. There would be debates for years about who had "invented" radio. Several scientists clearly had developed the devices upon which Marconi's work was based, had demonstrated the transmission and reception of radio waves, and had described how they could be used for communications. But Marconi was the first to put it all together and to make a workable technology that could communicate over significant distances.[43]

Experimentation was Marconi's first love[44], and he was a dedicated experimenter throughout his life. But like the internet entrepreneurs a century later, he wanted more. He wanted to build a business, [45] he wanted fame,[46] he wanted fortune,[47] he wanted to build a worldwide monopoly in wireless telegraphy.[48] Encouraged by his mother and her wealthy family in England, he took his apparatus and ideas to England where he was quickly connected to the British scientific, Post Office, and military establishments. Marconi put on a number of successful demonstrations of his wireless capability, and filed for the world's first radio patent for his wireless telegraphy technology, but the government financial support he sought was slow in coming.[49]

However, Henry Jameson Davis of the Jameson Irish whiskey [family][50], who was Marconi's

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[43] [CTW:] Need to get this idea into a footnote somewhere: *The early history of "wireless" is sometimes a bit confusing, because the term "wireless" referred broadly to a number of similar technologies. The earlier "induction" method employed by Preece was able to signal for relatively short distances, but it also required long transmitting and receiving wires, arranged in parallel lines, which were approximately as long as the distances being bridged. Marconi's use of a spark transmitter to produce electro-magnetic radiation (radio waves) was a much more compact and efficient technology, especially when he began to use longer wavelengths than those described in this initial report.* Quote from earlyradiohistory.us/1897sci.htm.

[44] [Baker, *A History of the Marconi Company*, 28.]

**45** [Douglas, *Inventing American Broadcasting*, 16; Baker, *A History of the Marconi Company*, 28.] [CTW:] This was early. When was it?

[46] [Aitken, *Syntony and Spark*, 230; Weightman, *Signor Marconi's Magic Box*, 30, 43, 57; Baker, *A History of the Marconi Company*, 36-37.]

[47] [Douglas, *Inventing American Broadcasting*, 16; Aitken, *Syntony and Spark*, 198; Weightman, *Signor Marconi's Magic Box*, 33, 57.]

[48] [See, e.g., the Marconi Company's orders that its operators were not to communicate with any stations that used other manufacturers' devices and its exclusive contract with Lloyds of London, forcing major shipping companies to equip its ships with Marconi equipment if it wanted access to Lloyd's information network. Aitken, *Syntony and Spark*, 233-237; Captain Linwood S. Howeth, *History of Communications-Electronics in the United States Navy*. 1963 at 15-23. http://earlyradiohistory.us/1963hw02.htm.]

49 [Baker, *A History of the Marconi Company*, 28-29.] 1896 Marconi goes to Britain. 2 March 1897 first patent on wireless telegraphy. (UK) Baker, *A History of the Marconi Company*, 28. Early demonstrations to UK Post Office, military. Important role of Preece. Baker, *A History of the Marconi Company*, 2[8ff.]

[50] Title? Director? President? [Sources do not say that he was involved in the whiskey business, but rather that he was an engineer who specialized in windmills. Weightman, *Signor Marconi's Magic Box*, 22-23.]

cousin and principal supporter[51], became persuaded that the Marconi technology had the potential to be a successful business[52]. Rather than wait for British government financing, Davis raised £40,000 ($XX in 2000 dollars) and together with Marconi formed the Marconi Company[53] backed by family and business connections.[54] [55] Marconi transferred the rights to his patents to the new company and received a majority of the shares. Jameson Davis was the [Managing Director].[56]

Given the strong tradition of government ownership and operation of telephone and telegraph services in Britain, it is remarkable that wireless was set out on a private sector course. It was also fortuitous, because the Marconi Company was free to develop ever-improving technologies, set up shore stations around the world, and enter into contracts with shipping companies.

Marconi's decision to develop his business in the private sector was a breakthrough as important as his discovery of the right range of frequencies. Because of these twin breakthroughs at the outset of the Twentieth Century, radio communications was not only was a practical technology, it was ensconced in the private sector rather than controlled by the government. The venture capital was in place, the founder had the funds to develop the technology, and the business affairs were managed by an executive and board of directors experienced in business.[57] Marconi the experimenter was now Marconi the entrepreneur.

With the infusion of capital and experienced businessmen, the Marconi Company focused on Marconi's twin goals of furthering the technology and developing a successful business. Marconi remained in control of the company, although he seems to have taken little interest in the administrative details of the company. In effect, he seems to have functioned in three roles: One role was akin to what today we might call CEO, and another was akin to Director of Technology Development. In addition, he was also the company's principal spokesman, much like a Director of Public Relations.

Marconi's style of experimentation yielded numerous small and large technological advances over time, which cumulatively advanced the capabilities of wireless communications and provided opportunities for press attention. From the outset, Marconi was a natural showman. He

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[51] [Baker, *A History of the Marconi Company*, 28.] An engineer by training, took an interest. [Weightman, *Signor Marconi's Magic Box*, 22.]

[52] Aitken, *Syntony and Spark,* [222-23].

[53] [CTW:] Name issue again. I use "Marconi Company", but original name was "Wireless Telegraph and Signal Company Limited", changed in 1900 to "Marconi's Wireless Telegraph Company Limited". Douglas, *Inventing American Broadcasting*, 65-66. [Aitken, *Syntony and Spark*, 223; Baker 35.]

[54] Baker, *A History of the Marconi Company*, 28-35; [Aitken, *Syntony and Spark*, 223-24.]

[55] Aitken, *Syntony and Spark,* 222-229; [Baker, *A History of the Marconi Company*, 35.]

[56] [CTW:] Is this the right title? [Aitken, *Syntony and Spark*, 224.]

[57] Maybe in Baker or Dunlap? [See, e.g., Erik Barnouw, *A Tower in Babel: A History of Broadcasting in the United States to 1933* (New York: Oxford University Press, 1966) at 15-16; Douglas, *Inventing American Broadcasting,* 16; Baker, *A History of the Marconi Company*, 35; Weightman, *Signor Marconi's Magic Box*, 43; Harlow, *Old Wires and New Waves,* 445-46; Aitken, *Syntony and Spark*, 222-24.]

had a flair for staging demonstrations that would attract attention.

Soon after arriving in England, he demonstrated his apparatus at a public lecture on his experiments given by the Chief Engineer of the British Post Office, bringing a spate of positive press articles about what reporters thought was an amazing new technology.[58] A few months later, many reporters were gathered at the British port of Bournemouth where Marconi had installed a wireless station. The reporters were there for the arrival of the former prime minister, William Gladstone, when a snowstorm took down the telegraph wires connecting them to London. Marconi shrewdly let the reporters file their stories via his wireless, which earned him more favorable publicity and great credibility with the press.[59]

- Kingstown Regatta

- Queen Victoria and Prince of Wales' yacht.[60]

- English Channel.[61]

- America's Cup yacht races 1901. Marconi comes to America.[62]

- transatlantic "letter S"[63]

With these stories cascading one after another, reporters and readers of newspapers and magazines began to follow Marconi's exploits. Not only did the events themselves seem remarkable and exciting, Marconi had an articulate, understated style in interviews that earned him great credibility Almost overnight, Marconi was famous, and not just famous, but also trusted, almost revered.

- Becomes media darling.[64] [65] Compare to Vail.[66]

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[58] [Baker, *A History of the Marconi Company*, 29.] NY World 3/97, McClures, derivative, 8/97. Times of London. See interview on earlyusradio.com.
[59] Baker, *A History of the Marconi Company*, 36-37.
[60] 1898 Baker, *A History of the Marconi Company*, 3[9-40.]
[61] 1899 Dunlap, *Marconi*, 70-[72.]
[62] [Aitken, *Syntony and Spark*, 246.] Impressed by Marconi's wireless coverage of the Kingstown Regatta, the *New York Herald* invited him to report on the America's Cup Race in October 1899. Barnouw, *A Tower in Babel*, 13. Marconi and the directors of the Marconi's Wireless Telegraph Company, Ltd. decided to use this event as an opportunity to take advantage of business possibilities in the United States and planned to form an American subsidiary. Ibid. Use this in the Intro?
[CTW:] The above is probably from David A. Mindell, *Bodies, Ideas, And Dynamics: Historical Perspectives on Systems Thinking In Engineering*, ESD-MIT Engineering Systems Division working paper (2003) emphasis added by CTW for use in book. See also Douglas, *Inventing American Broadcasting*, 19ff.
[63] [Baker, *A History of the Marconi Company*, 73; Douglas, *Inventing American Broadcasting*, 57-58.]
[64] [Douglas, *Inventing American Broadcasting*, 58;] Aitken, *Syntony and Spark*, 230.

The business side of the company was focused on finding sources of revenue, manufacturing reliable equipment, and building an organization to support the ongoing business. The technical side was focused on reducing interference between nearby stations and achieving greater range.

In his early demonstrations and search for longer distances, Marconi found that his signals traveled better and farther over water than over land.[67] Moreover, the most interest and potential demand for wireless communications was from the British navy and commercial shipping interests desiring communications with ships at sea where there were no telegraph wires as there were over land. So, by 1900 it was clear that ship-to-shore communications was the major and most immediate application for wireless, again for technical and business reasons.

The Marconi Company's first business strategy was to sell wireless equipment to users[68], much like the Bell Company had first tried to do with the telephone. [69]

1900, commercial focus shifts to providing end-to-end service [70]. Reaction to market demand, clever end-run around British telegraphy monopoly to Royal Mail.[71]

they found that what customers wanted was service, not equipment

Set up monopoly structure based on end-to-end service contracts connecting only to ships and shore stations equipped with Marconi equipment, and key contract with Lloyd's that required ships insured by Lloyd's to use Marconi service. Business grew rapidly in spite of technically capable competition.

Importance of commercial company organization & management.[72] For Marconi, allowed him

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[65] [Douglas, *Inventing American Broadcasting*, 17-28, 57-59.] These events span 189[9-1901]. The press apparently grew steadily more enthusiastic. [CTW:] Need to document in footnotes but gloss over date details in text. I think.

[66] [Ibid. 240-41, 248-50.] Vail was not a media darling, but he used press to achieve his goals, [Mueller, *Universal Service*, 92,] as did Marconi.

[67] [Archer, *History of Radio to 1926*, 57; Alvin F. Harlow, *Old Wires and New Waves: The History of the Telegraph, Telephone and Wireless* (New York: D. Appleton-Century Co., 1936) at 440.] This was because water, especially salt water, is a far better conductor of electricity than earth. Although radio signals do not travel through the water, the conductivity allowed better coupling of the antennas to the "ether". Later, and still today, vertical antennas like those used for AM radio stations are surrounded by buried wires to provide the antenna coupling that salt water provides naturally. Source: CTW

[68] Aitken, *Syntony and Spark*, 231[-33.]

[69] [Harlow, *Old Wires and New Waves*, 370-75, 445.] Moreover, the company was not earning any significant revenue. Marconi had received a number of important patents, but lacked the money to enforce them and faced potential competition from other wireless companies in Germany, France, and the US . Baker, *A History of the Marconi Company*, 32ff, 83-84. [CTW:] But is the time frame right?

[70] Aitken, *Syntony and Spark*, 233[-34.]

[71] [Ibid. at 233-35.]

[72] [Douglas, *Inventing American Broadcasting*, 65-68.]

to experiment[73]

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Tech feats, patents,

Competition, tech, crystal(?), patent enforcement,

Spread of wireless, Telefunken, US fruit, …

Ship safety, Titanic, international conferences

CW, voice, vacuum tube, dawn of electronic era

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Developed and patented tuning technology to concentrate power into a narrow frequency range for better transmission and to allow multiple stations to communicate without interference by operating on different frequencies. Continued efforts to see how to reach longer distances. Efforts led to more powerful sparks, longer antennas, lower frequencies, more sensitive detectors.

Sought to extend communications range to ships crossing the Atlantic. Didn't know at the time that longer antennas meant lower frequencies that bounced off ionized layers in the atmosphere. Succeeds in transatlantic communications. Efforts to compete with undersea cables mixed.

Competition from Germany and US. Telefunken, Fessenden, De Forest, United Wireless. International conferences and their effect

By the advent of WWI, the strategic importance of wireless for shipping was apparent, and the major governments all nationalized the wireless companies based in their countries. Being officially neutral in the conflict at the outset, the United States took over German stations in the US that were found to being used for war purposes, but did not take over the shore stations belonging to the British Marconi company until it officially entered the war in 1918. the US government also took over XXX and YYY (?). {put this somewhere}

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****** Following are notes, text fragments to be used above this line. **********

****** Some of these fragments have been deleted below, others are duplicated, **********

****** especially footnotes. **********

[73] Ibid.; Aitken, *Syntony and Spark*, 229.

{Compress between brackets: Early Marconi experiments in Italy. Striving for distance.

Works with British Post Office, fleet. Success over water.

Drawing with transmitter, antenna, receiver.[74]

***higher-energy sparks, longer antennas for lower frequencies, more sensitive receivers. Marconi uses brute force: Higher voltage sparks, bigger antennas, more sensitive receivers.

Marconi comes to America.[75] For America's Cup yacht races 1900. Incorporates Marconi America in November 1899.[76]

1902 magnetic detector – standard on Marconi ships[77]

Vagaries of ionospheric layers not understood – frustrating trial and error[78]

"Syntony" or tuning demonstrated 1903[79]

Early competition – Britain, US, Germany, France [80]

Rental stratagem around British Telegraph Act[s 1868-69] [81]

System engineering, General Orders, Hawaii [82]

Lloyd's Corporation contract 1901 [83]

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[74] Baker, *A History of the Marconi Company*, 27.
[75] [This FN is the same as FN 62.] Impressed by Marconi's wireless coverage of the Kingstown Regatta, the *New York Herald* invited him to report on the America's Cup Race in October 1899. Barnouw, *A Tower in Babel*, 13. Marconi and the directors of the Marconi's Wireless Telegraph Company, Ltd. decided to use this event as an opportunity to take advantage of business possibilities in the United States and planned to form an American subsidiary. Ibid. Use this in the Intro?
[CTW:] The above is probably from David A. Mindell, *Bodies, Ideas, And Dynamics: Historical Perspectives on Systems Thinking In Engineering*, ESD-MIT Engineering Systems Division working paper (2003) emphasis added by CTW for use in book. See also Douglas, *Inventing American Broadcasting*, 19ff.
[76] [CTW:] Changing names issue again. I will use "American Marconi" throughout, but the initial name in 1899 was Marconi Wireless Telegraph Company of America. It was a subsidiary of Marconi's Wireless Telegraph Company Limited. Douglas, *Inventing American Broadcasting*, 64-65.
[77] Baker, *A History of the Marconi Company*, 74.
[78] Ibid at 78.
[79] Ibid at 83.
[80] Ibid at 83-84.
[81] Ibid at 85-86.
[82] Ibid at 86-87.

End of 1902, 25 land stations in operation and 70 ships. [84]

Building the company organization. Compare to Vail for organization as key element of success.

Management changes and organization building.[85] 1899-1902±. Jameson Davis leaves 1899. Cuthbert Hall ends up as Managing Director. Operating departments created, becomes a business even though losing money.

British – German rivalry, Telefunken, Arco-Slaby system. [86]

Wants wireless to compete with undersea cables. Strives for transatlantic range. Succeeds[87]

1902 first transatlantic wireless message[88]

Royal Navy contract 1903. [89]

Lower frequencies, 1903 Poldhu 2,000 meters or 150 kHz. [90]

Magnetic detector allowed matching cable speeds, outpaced wireless rivals.[91]

Innovation: variable (disc) capacitor 1907 [92]

End 1904, 69 land stations and 124 ship installations. [93]

Innovation: directional antenna. [94]

*1906 International conference on wireless requires all ships to intercommunicate. Deprives Marconi of major market barrier to entry. Germany/Telefunken role. [95]

Innovation: Rotating disk discharger 1907. Provided narrowband 200 kHz spark interrupted at audio frequency so it could be heard in earphones. Allowed tuning selectivity not possible with

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[83] Ibid at 87.
[84] Ibid at 88.
[85] Ibid at 88-91.
[86] Ibid at 94-97.
[87] [CTW:] Did he really??? CTW to supply material here. [Archer, *History of Radio to 1926*, 60-63.]
[88] Baker, *A History of the Marconi Company*, 79.
[89] Ibid at 97.
[90] Ibid.
[91] Ibid at 100.
[92] Ibid at 103.
[93] Ibid at 105.
[94] Ibid at 112-113.
[95] Ibid at 115.

broadband conventional spark. [96]

Two obstacles to wireless telephony: stable transmitter frequency and amplitude, and means of modulation. [97]

[In] 1906, [the] Fleming [diode was of] marginal practical use compared to Maggie and crystal. Unclear operation and usefulness of Audion in earliest stages. [98]

Innovation: 1907 Old lab-type shipboard equipment replaced by new standardized design. [99]

1907 Clifden & Glace Bay transatlantic service introduced with NYT publicity, "notables". Much invested. [100]

1908 Financial weakness in all departments. Retrenchment. Marconi becomes temp general manager. Raised £ 250,000 new capital. [101]

1908-1909 touch and go for company. [102]

There was lots of competition[103]; only Marconi built a real company. Like AT&T. Compare.

1910 New Managing Director, Godfrey Isaacs. Took strong patent enforcement position. [104]

1911 Patent victory over United Wireless Company in US allowed Marconi to take over its 500 ["shipping installations"] and 70 shore stations. [105]

Competitive battle with Telefunken. [106]

1912 April 14 Titanic. [107]

191[1-12] Imperial Wireless Scheme. [108] "Marconi Scandal". [109]

1912 Vacuum tube oscillator. Feedback[110] (compare to PA system feedback "squeal".)

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[96] Ibid at 117-[20].
[97] Ibid at 119, 121.
[98] Ibid at 120-121.
[99] Ibid at 123.
[100] Ibid at 123-[24].
[101] Ibid at 124.
[102] Ibid at [124-28].
[103] See Ibid at 129 – 130, but there are other more complete discussions in other books.
[104] Ibid at 130.
[105] Ibid at 130. Better discussion elsewhere.
[106] Ibid at [130-35].
[107] Ibid at 138-140. [CTW:] See [my] note [on post-it-note inside book] about timing and whether Titanic radio operator told Captain about *Californian* report of ice.
[108] Ibid at 137, 143.
[109] Ibid at143-[44].

1913 Marconi establishes pension fund and retirement age.[111] Compare AT&T.

Marconi worked hard alongside his men to get the impossible done. [112]

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Early Marconi interest in atmospheric electricity, read Benjamin Franklin, roof "antenna". [113]

1894 Idea of using "Hertzian waves" to communicate occurs to Marconi. Begins tests. [114]

1895 Marconi assembles known technology into a working wireless communications apparatus with spark transmitter, vertical antenna, coherer receiver. [115]

Marconi had vision, financial resources, surrounded himself with good people, persevered.

Quotes from Jameson Davis regarding helping Marconi in England.[116]

1897 Marconi Company [Wireless Telegraph & Signal Co., Ltd.] established.[117]

1898 Marconi reports Irish yacht races for newspapers, wins favorable press image. [118]

1899 Marconi communicates across English Channel. [119]

1899 America Cup races, Dunlap has a lengthy and colorful report. [120]

1901 Marconi says primary goal of transatlantic tests is communications with ships in mid-ocean. NYT report of famous "S" test. [121]

1901 First transatlantic wireless signal, famous "S" test. Dunlap has extensive quotes from media at time.

190[2] NYT report on transatlantic test shows Marconi's credibility with [other scientists]. [122]

1901 Cable company stocks fall on reports of Marconi transatlantic test. [123]

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[110] Ibid at [150-51].
[111] Ibid at 156-157.
[112] See Ibid at 156 and others.
[113] Dunlap, *Marconi,* 11.
[114] Ibid at [11-12].
[115] Ibid at 14-19, 53.
[116] Ibid at 49-50.
[117] Some details in Ibid at 51.
[118] Ibid at 60-61.
[119] Ibid at 70-71.
[120] Ibid at 76-[81].
[121] Ibid at 99-100.
[122] Ibid at 117-118.

Titanic – lengthy detailed coverage by Dunlap 183 - Ditto *Republic* and *Florida* collision 163 -.

191[4] Marconi had crossed Atlantic more than [4]0 times [in twenty years]. [124]

1914 Marconi patents upheld in US. [125]

Righi influence on Marconi. Righi interest in very high frequency waves, like light. Other scientists also interested in optical properties. [126]

Marconi went to England "in effect a nobody." [127]

Marconi personal characteristics: determination, technical competence, knew his job better than anyone else, attracted good engineers to work with him, could survive discouragement, willingness to try lots of things and learn from them, ingenuity, didn't overstate what he could do, flair for drama and demonstration, … [128]

Jameson Davis, Marconi's cousin, wealthy Irish whisky family, impressed by Marconi's demo early on in his visit to England. [129] Proposes establishment of private company to develop and exploit Marconi's wireless technology. [130] British Post Office acquiesces. Company established July 20, 1897, [131]

Establishment of Marconi Company was very significant for the short-term development and ultimate future of wireless, because Marconi, the preeminent inventor and developer was free to experiment and sell wireless equipment and services free of government bureaucracy. It set wireless on a commercial basis, like in the US, rather than the government-ownership model for telegraphy. He probably could have done so in the US, but he was European and was in England which was at that time the shipping and naval capital of the world.

Marconi's personal charm was such that [despite] considerable animosity between the British Post Office and the Marconi Company, Preece and Marconi remained on cordial professional terms. [132] See similarly Kaiser Wilhelm's friendliness toward Marconi personally while objecting to Company policies regarding intercommunication. [133]

Marconi was significant because he made wireless a practical technology and gave it a

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[123] Ibid at 108.
[124] Ibid at 246-48.
[125] See Ibid [at 227-34] for extensive story.
[126] Aitken, *Syntony and Spark*, 184.
[127] Ibid at 182.
[128] Ibid at [202,] 221, Dunlap, *Marconi,* has lots of examples, some quotes.
[129] Dunlap, *Marconi,* 49-50
[130] Aitken, *Syntony and Spark*, 223.
[131] Baker, *A History of the Marconi Company*, 35. Marconi paid for rights and given 60% of shares. Raised £40,000, Marconi paid £15k, leaving £25,000 for working capital. Far more than £10,000 offered by Post Office. Ibid.
[132] Aitken, *Syntony and Spark*, 22[7].
[133] Dunlap, *Marconi,* 14[7-48].

commercial base. In so doing he stimulated others to imitate and surpass him, both in business and in technology. Although Britain, through Marconi led, other nations built wireless networks to link their capitals to their shipping, navies, and remote outposts. [134] US Navy, United Fruit, …

Amateurs and entrepreneurs took up wireless and developed new technologies, particularly in the United States. Explain why particularly in the US. Notably Fessenden, De Forest, and Armstrong. Marconi was different from the American entrepreneurs in that he built a solid business organization to grow with his engineering accomplishments in providing service to his commercial customers. He probably owes much of this business foundation to Jameson Davis and the board and management he helped bring in to the company. From the beginning, Marconi Company combined search for markets with improvements in tech to serve those markets. [135]

Marconi's "flair for public relations" made him "the very model of a twentieth-century entrepreneur".[136] Compare to Vail in this regard.

Like the early Bell Telephone, the Marconi Company's initial commercial model was to manufacture and sell wireless equipment,[137] and like AT&T later had to respond to the market by providing an end-to-end service.

Selling equipment meant the customer had to build and operate a communications network. In shipping, which was the obvious and primary market,[138] this meant the customer had to build its own shore stations as well as shipboard installations, hire and train morse code operators, hire and train maintenance personnel. This resulted in sales to the British military, but not commercial customers.[139] Commercially, this meant the Company needed to provide its customers an end-to-end service, but there were two further factors that needed to be considered in shaping how that service would be provided. One was the British Telegraphy Act that gave the British Post Office a monopoly in providing telegraph service, and the other was [future potential] competition from [other] manufacturers sell[ing] similar wireless equipment [140].

As a result of this fact of commercial life, the Marconi Company totally reversed its commercial strategy: they stopped selling equipment and instead offered customers only [leases of] end-to-

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[134] [See, e.g., The First International Radio Telegraphic Conference, Berlin, 1903 delegates include Italy, Germany, Austria, Spain, France, Hungary, Russia, U.S. and Great Britain. Howeth, Captain Linwood S. *History of Communications-Electronics in the United States Navy*. 1963 at 547-48. http://earlyradiohistoryus/1903conv.htm. Douglas, *Inventing American Broadcasting*, 120-24 (Germany invites Great Britain, France, Spain, Austria, Russia, Italy, and the U.S. to its international wireless conference.).]

[135] Aitken, *Syntony and Spark*, 229-230ff.

[136] Ibid at 230.

[137] Ibid at 231.

[138] Explain in footnote why over-land wireless was more difficult than over-ocean wireless. [Harlow, *Old Wires and New Waves*, 440.] [The Wireless Telegraph Act of Great Britain gave the] British Post Office [a] monopoly over telegraphy [placing all wireless activities under its control]. [Archer, *History of Radio to 1926*, 76.]

[139] Aitken, *Syntony and Spark*, 232-233.

[140] Ibid at 234[-36].

end wireless communications service.[141] However, the British Telegraphy Acts blocked Marconi from providing wireless telegraphy services to the public for a fee.[142] These acts had been written in 1868 & 1869 to consolidate all wired telegraph and telephone systems in the British Isles into a British Post Office monopoly,[143] and while the Acts obviously did not anticipate wireless, they applied to all "electrical" communications in the British Isles[144] and clearly blocked the company from offering public telegraph service for a fee. But the Acts did permit a company to operate a private system to send its own intracompany messages and similarly could operate a private system for another company so long as there was no direct charge for sending messages.[145]

The effect of this regulatory restriction was that the Company could install Marconi-owned equipment on customers ships along with a Marconi telegraph operator to send and receive messages to Marconi shore stations on the customer's behalf so long as there was no direct charge for carrying the messages. Marconi could thus provide the desired end-to-end service for its customers for an annual contract fee.

As a corollary of the regulatory requirement that the service provided be a private service, the Marconi stations could exchange messages only with other Marconi stations, not with ship or shore stations owned by other companies. Marconi operators were instructed not to accept messages from ships or shore stations with non-Marconi equipment, except for ships in distress. Thus, the Marconi Company communications service was closed to equipment manufactured by any company other than Marconi. This nonintercommunications policy thus served two purposes: it circumvented the restrictions of the Telegraph Acts, and provided an excuse for the Marconi Company as the leader in developing and manufacturing wireless equipment to achieve a monopoly in wireless service.[146]

[Who was the managing director of Marconi Company in 1900? Who invented this new strategy? Marconi? Other?] [CTW inserted these brackets.]

The Marconi Company monopoly position was solidified by the signing of an exclusive contract in 1901 with Lloyd's, the British syndicate that insured almost all commercial shipping in the world. The contract provided that ships insured by Lloyd's could only use Marconi wireless equipment and service. [See footnote for material to include in text about Lloyd's.[147]] [CTW

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[141] Ibid at 233-235.
[142] [Aitken, *Syntony and Spark*, 234.]
[143] Ibid at 234.
[144] Ibid.
[145] Baker, *A History of the Marconi Company*, 59.
[146] Aitken, *Syntony and Spark*, 233-235.
[147] "Lloyds, the marine underwriter's association, maintained over a thousand agents and subagents, who in addition to other duties as representatives of that corporation, were especially charged to transmit, immediately, all the latest maritime intelligence from their respective districts. As the most extensive single system in the world for the collection, transmission, and dissemination of marine information, Lloyds was naturally interested in any means which would facilitate communication with remote areas. In May 1898, it negotiated with the Marconi Co. for the installation of radio apparatus at some of its signal stations. With his usual business

inserted these brackets.] Lloyd's took the position that "one system of wireless telegraphy should be in general use" and wanted that to be a private system, i.e. Marconi, and not a government system.[148] The Marconi Company wireless service business grew rapidly as more and more shore stations were built and ships equipped with Marconi equipment.[149]

This strategy of configuring an end-to-end service around market imperatives and government regulation to establish a near-monopoly would be replicated later by AT&T and others in the satellite television and computer businesses.[150]

The nonintercommunication policy was overturned as a result of the 1907 international radio conference. Pressure from Germany, Italy on behalf of their manufacturers. US???

[Note: "Marconi" can be confused with the man or the company. I will try to use "Marconi

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perspicacity, Marconi incorporated the Marconi International Marine Communication Co. on April 1900, a subsidiary of Marconi Wireless Telegraph Co. Ltd. On 26 September 1901, this new company entered into an agreement with Lloyds. Because of the repercussions which followed, the revelation of the monopolistic ideas of the Marconi interests, and the effect their contract policy was to have in later dealings with the U.S. Navy, a brief outline of the Lloyds agreement is of interest. Among other things, it provided for the erection of a series of radio stations on the English coast, the right of Lloyds to have Marconi, and only Marconi, apparatus installed at all their stations but not the right to utilize it to communicate with ships using radio equipment of other manufacture. Another stipulation required that Marconi apparatus would be used exclusively in equipping ships insured by Lloyds and, except along the coasts of the United States and Chile, these ship stations could not be used to communicate with ship or shore stations not using Marconi apparatus.[26] The contract was to be in force for 14 years, which period covered the life of the Marconi patents then in force. Lloyds found itself unable to establish radio stations at the British colonies of Jamaica, Ceylon, Barbados, St. Helen, Perim, the Straits Settlements and Maritius, because the colonial governments made it a condition of their licenses that intercommunication would be permitted if required by an International Convention.[27]

In its grasping endeavor to establish a monopoly, the Marconi firm was soon faced with a suit over the interpretation of the Lloyds' contract. Lloyds contended, among other things, that the Marconi Co. had refused to equip its shore stations when these were located near Marconi stations. Losing the decision, the Marconi interests entered into a new contract with Lloyds in 1905. Differences were resolved and both organizations agreed to exert their "best efforts" to induce the British and foreign governments to grant no radio licenses to companies other than Marconi and Lloyds.[28]

Credit is due Lloyds for its early faith in and adoption of radio, because until this time communications between passing ships and between vessels and the Lloyds' signal stations had been carried out by flag hoists. To accomplish this, vessels were often required to approach dangerously close to treacherous areas or to make considerable detours from their most direct route." Captain Linwood S. Howeth, *History of Communications-Electronics in the United States Navy*. 1963 at 15-23. http://earlyradiohistory.us/1963hw02.htm.

[148] Aitken, *Syntony and Spark*, 237.

[149] Baker, *A History of the Marconi Company*, 88.

[150] Vail using regulation and long distance service in 1907-19xx. Galaxy. Microsoft DOS and Windows. Others???

Company" and reserve "Marconi" for the man, but this may be difficult. To maintain our narrative, it may be good to keep it simple and allow the possible confusion except where necessary to draw the distinction.] [CTW inserted these brackets.]

Marconi Company paid no dividends at least until after 1910. [151]

[151] Baker, *A History of the Marconi Company*, 290, footnote 51.