Scientists, Inventors, and Tinkerers

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The Discoveries and Inventions as Precursors that Led to Philo Farnsworth's Invention of Television

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Preface

Introduction, Scope, Purpose of the Monograph, and Credits

In his Nobel Prize acceptance lecture, Guglielmo Marconi stated, "The discoveries connected with the propagation of electric waves over long distances and the practical applications . . . have been . . . . the results of one another . . . After . . . preliminary experiments with Hertzian waves I became very soon convinced that if these waves . . . could be reliably transmitted and received over considerable distances a new system of communication would become available possessing enormous advantages over flashlights and optical methods . . ."

Marconi was not the first to discover wireless communication. But he was the first to develop it successfully. He did so through trial and error. Thomas Edison favored the trial and error tinkering technique in his panoply of pragmatic inventions that also changed forever the civilized world, including the motion picture camera and projector. Marconi's sea change invention was the very model that sent and received coded and voice communication ship to ship, ship to shore, and, ultimately, the working model for radio.

Throughout the nineteenth century, the elements leading to electromagnetic wave propagation and the mechanical and chemical elements leading to the recording of visual imagery, these seemingly separate fields charged toward one discovery: to transmit and receive voice and picture together. Marconi's success in wireless voice transmission set in or increased the search for lip synchronized talking pictures—an electronic or mechanical media holy grail.

Indeed, in April 1926, a full year before Farnsworth developed true television, John L. Baird announced he had invented the device, which he called the "Televisor."[1]

Even a full century earlier, this quest had become manifest. Again the road to its realization divided into two paths.

Upon one path scientists developed work with colleagues, developed insights in conflict with colleagues, and sought each other's discoveries. They produced the current of electricity, the control of this power, and the manipulation of its forms from which Television emerged. As these scientists persevered through laboratory experimentation and experimental oscillations of the phenomenon, they became most fascinated by the appearance of an eerie luminescence, a beauteous and mysterious glow within their glass tubes. It is a claim by the several supporters of the schools of Plucker, Braun, and Crookes that each champion dubbed this glow's presence Cathode Rays.

Upon the other path inventor-artists developed the concept of using still photographs in rapid succession to acquire the illusion of movement in pictures and of moving pictures that talked. It may not be mere coincidence that these paths converged in 1927.

The scope of the present work is to follow these two pathways to their confluence. This convergence resulted in visual movement and speech in synchronicity. The two advances occurred virtually at the same time. Nonetheless the ultimate synthesis was Philo Farnsworth's invention.

Although considerable amount of material by scholars and writers exists concerning the invention itself, little is available to demonstrate its linear evolution: Of brilliant suppositions; Of ingenious conclusions; Of false starts; Of rethinking; Of flawed attempts; Of success that propelled the charge along—this progression that allowed the inventor to piece the elements together for his fateful "aha" experience one day while he was in his farm field upon his tractor dragging his mower and baler behind.

I propose to follow these two paths, forming the necessary basis for the invention.

As a monograph, the limitation upon the study can only produce an outline of the development. The present writer or a future scholar may wish to develop a more complete investigation.

Karl Braun, who shared the Nobel Prize with Marconi, said in his lecture: "I set myself the task of obtaining stronger effects from the transmitter."

So did they all.

For this treatise and its humble results, I wish to thank the fine librarians at The Community College of Baltimore County, at all campuses, but especially the Essex campus, in particular Michele Meisart, Wendy Sears, and Joan Donati, without whose assistance in obtaining somewhat rare research materials and books through inter-library loan, I could not even have begun this work. The fine librarians at Towson University deserve mention, especially Shana Gass who also in her institution assisted me in retrieving historical documents.

I would be remiss if I did not thank those officers of the college, who encouraged me to develop this project and determined that it would realize perhaps somewhat of a decent contribution to the field—F. Scott Black, Mark McColloch, and Sandra Kurtinitis. To the members of the Board of Directors who also sanctioned the project, I also offer my humble gratitude.

And to Ann, with whom I watch a few good programs and who takes a very pretty picture.

DRS, Baltimore, Maryland, January 30, 2009

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The Charge

Prelude

Although the phenomenon of attraction by a mysterious force had been known for some time, the beginning of disciplined investigation into this natural and seemingly supernatural occurrence can be traced to 1746. Thirty years before the Declaration of Independence Benjamin Franklin began his experiments. With the famous kite experiment and others of his design accomplished, Franklin published two remarkable suppositions. These fundamental concepts have held up unto today as descriptors of electricity: It has a flow, called current; current exhibits positive and negative characteristics.[2]

Even before Volta's pile, Franklin assembled a rudimentary battery. It produced sparks, accommodating a fanciful and thrilling entertainment of the time. It would be some decades before full electric generation.

Even so, Franklin used his shocked-gained healthy fear of the sparks and of the flow, in concert with his famous kite experiment to invent a device that would benefit homeowners and commercial properties then and now—the lightening rod.

In 1780 Luigi Galvani, by stimulating dead frogs' legs and observing them twitch, came to believe that animal tissue (and, thus, that of people) could generate or, at least, conduct, electricity.

In 1799 Alessandro Guiseppe Volta deduced that two metals—steel and tin—upon which the frog rested (thus the tissue connected them) had generated or could generate electric flow (current). This led to Volta's invention of the first true battery, the Voltaic Pile or Cell. Volta's invention, once he placed a conducting wire, was the moment it was determined electricity could be generated and conducted (controlled) in a closed circuit. Andre-Marie Ampere in 1820 and Georg Simon Ohm in 1826 completed the triumvirate begun by Volta, as they explained severally the manner of current as it encounters and acquires—actually, requires—resistance.

Thus, Voltage generates amperes (current) whilst an object desired (a light bulb, a vacuum cleaner, a television set) is dependent upon providing ohms in a completed or closed circuit, the basic principle understood at that time and today as Ohm's Law.[3]

Thus the stage was set for the linear advances that would lead to the world of the twentieth and twenty-first centuries. Throughout, there were many other scientists and inventors than those imposed by the limitation of this study. That is, we concentrate herein on those whose results delineate the inexorable march toward Farnsworth's invention that changed the world—the scanning Cathode Ray Tube[4] and those whose results produced at the same time lip-synchronization talking motion pictures.

Chapter 1

Electric Waves

Michael Faraday

Although it had been suspected by Hans Christian Oerstered as early as 1820, it was Michael Faraday who, a decade later, developed the principle upon which, excepting the battery, all electrical production is based. To develop the magneto, the necessary invention for electricity to be generated on a large scale, Faraday reasoned and placed into practical effect this connection.

"Nowhere is there a pure creation or production of power without a corresponding exhaustion of something to supply it," Faraday said. His impeccable reasoning represents in its simple elegance one of the most important scientific discoveries: If electricity can produce magnetism, magnetism can produce electricity.

From this reasoning, it was a short series of steps until the wound coil, a generator, was produced. From here, the reasoning continued—if electricity can generate magnetism, and magnetism, it was known, produced lines of force, therefore electricity produces lines of force.

In the latter part of the nineteenth century, Faraday's "lines of force" would become known as electromagnetic wave radiation, the controlled process for the production of radio and television (and, in our own day, the telephone).

But Faraday's contribution, as immensely significant as it is, does not end there. Years later, in 1840, Faraday discovered the link between light and electromagnetism. The Faraday Effect, as it is called, is complex; however, in essence, a beam of light is shone through an opaque light sensitive apparatus of a specific conductor design, and stimulates a magnetic field.

Without discussing other implications, Faraday, prior to light appearing within glass tubes, demonstrated that light can be generated and can generate an electromagnetic flow. The search for light and its imagery would be forever linked with electromagnetic generation, again, later known as electromagnetic wave radiation.

Faraday also coined the terms that the scientists, inventors, and tinkerers would need to develop their own work and design their own experiments: Electrode; Anode; Cathode; Ion.

Michael Faraday was born on the outskirts of London in 1791. Due to his father's chronic illness, the household was impoverished. At fourteen, the boy was apprenticed to a bookbinder. Books and treatises entered the shop, enabling the aspiring scientist to sate his appetite of reading voraciously the subjects of science and electricity which consumed his interest.

As a young man Faraday attended the renowned lectures of Sir Humphrey Davy at the Royal Institution. Within a short time, Davy, impressed with Faraday's extensive self-taught scientific knowledge and his interest in this new discovery ensured he had an apartment and a laboratory.

Throughout his life, in this domicile and work space Faraday conducted his history changing experiments.

Faraday retired from laboratory research in 1855. By demand he would be brought back to lecture until 1861. He died in 1867 at the age of 76. He is buried in Highgate Cemetery in London.[5]

Johann Heinrich Wilhelm Geissler and Julius Plucker

Johann Heinrich Wilhelm Geissler received a tradesman's apprenticeship, a journeyman's award, and the accomplishment of a master; but he acquired no scientist's education significant to discern the nature of electricity. Of course, he could not know that the elegant materials he produced ultimately would lead to television. But he had the serendipitous good fortune to be acquainted with a physicist most interested in Faraday's work, Julius Plucker. It is this chance and developing relationship that led to the precursor of the very picture tube itself.

Geissler's family business had been glass blowing. How far back the family's trade extended, even the members of the family didn't know for certain. Glassblowing is one of those crafts that is very old.

It extends back even into the ancient near east. It has been largely practiced in much the same fashion through the ages, even unto today. So Geissler may have gone on, producing his familiar wares.

But in 1852, Geissler was approached by one of his countryman—a mathematician and physicist. The scientist stated an odd request. Still, Geissler had known many strange orders. His reputation for his skill was probably what prompted the scientist to knock on his door.

Julius Plucker had already established his reputation as a leading mathematician and scientist of the day. In 1847, Plucker received an appointment of Professor of Physics at Bonn. About this time he became interested in Faraday's work. Faraday had begun to experiment with electrical discharge in gases, noting the spark effect. For some reason, Faraday did not pursue a manner to control the spark effusion. It occurred to Plucker that if the gases could be contained in an enclosure, the discharge effect should be observable for a length of time.

At first Geissler blew to create small devices. In time, they received practical expression as thermometers. Finally, in 1858, Geissler invented the vacuum glass tube. When Plucker generated the discharge, an eerie, mysterious, and beautiful greenish glow appeared. It remained for a persistent time.

Geissler had invented the eponymous Geissler Tube. It would evolve into the Cathode Ray Tube. It would become the picture tube of television. Plucker the complete scientist recognized that this fluorescence within the tube responded to an electromagnet on the wall of the tube; he discerned that these expressions of light were rays or beams of some electrical property.

Crookes would later refine and identify the Cathode Ray Tube; Thomson would understand these rays were electron beams. At this time, however, Geissler and Plucker had propelled Faraday's Effect into a visual manifestation. For that, the game was afoot.

Heinrich Geissler was born in Igelshieb in Saxe-Meiningen, Germany in 1814. He died in 1879.

Julius Plucker was born in Elberfield in 1801. Prior to his appointment at the University of Bonn, he held lectureships at the University of Warburg, University of Halle. Plucker died in 1868. The next year, a student, Johann Hittorf, continued his professor's work and demonstrated that the phosphorescent glow must be rays, coalescing as they were formed from one end, propelled through the length of the tube.[6]

James Clark Maxwell

One of the greatest minds of the nineteenth century never worked in a laboratory to develop his concepts. Yet this mere theorist presumed to investigate Faraday's electromagnetic force, and the Plucker school's identification of Cathode Rays literally to shed light on the entire phenomenon. His resulting proposals transformed even modern and contemporary thought.

James Clark Maxwell emerged as the singular brilliant mathematician of the nineteenth century. Between 1850 and 1856, he immersed his mathematical investigations into this new and challenging arena of electromagnetic wave propagation. Through a series of highly complex and sophisticated mathematical formulae, Maxwell developed a startling conclusion. He realized the possibility of a unified field theory.

Using only his powers of induction and deduction, through higher mathematics, deriving himself some of the theorems, Maxwell calculated his ultimate series of equations. They described nothing less than two theories which gave the scientists, inventors, and tinkerers who followed him the bases for their own work: Electromagnetic waves propagate through space; Light consists of electromagnetic waves.

They proved Faraday's suppositions. Through his publications they established a proof-text. They provided a theoretical clarity to what occurred visibly within Geissler Tubes.

Vast implications spread at the conclusion of the formulae. At last, scientists and experimenters realized potential answers to their questions concerning the curious nature of the effect, when the voltage was raised. At last this profound realization was understood: Light consisted of this same process; all electromagnetic waves race at the speed of light. Thus Maxwell achieved, through higher mathematics alone, a dynamic theory of the electromagnetic field (1864). Though the equations are quite complex, understood fully only by those trained and read in higher mathematics, Maxwell elegantly expressed their treatise coherently: "We can scarcely avoid the conclusion that light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena."

Years later, Albert Einstein considered Maxwell the genius non pareil of the nineteenth century, from who all else comes; he stated that without Maxwell, he could not have developed his Special Theory of Relativity. The scientists and inventors who followed

Maxwell placed so many heritages in his work they referred to themselves as Maxwellians.

James Clark Maxwell was born in Edinburgh, Scotland, in 1831. A prodigy, he attended the Edinburg Academy when only eleven years of age. In 1850 he attained an appointment at the University of Cambridge. Later he lectured at Trinity College. Maxwell was appointed to King's College in 1860. Maxwell died in Cambridge in 1879, never seeing his theories, equations, and conclusions put into practical use.

But those who followed him knew to whom they owed their own discoveries.[7]

Heinrich Hertz

"I have attempted to demonstrate the truth of Maxwell's equations . . . (I) infer without error that . . . (they are) certainly to be preferred."

Heinrich Hertz wrote this humble yet startling conclusion in 1884, having realized the nature and profound meaning of his discovery. For Hertz was the scientist who produced what Maxwell had predicted—electromagnetic waves, waves along the entire spectrum of invisible lines of flux and force. These were the waves that could produce wireless communication.

Through his experiments, Hertz demonstrated wave properties as wavelength, reflection, interference, refraction. With this spectrum revealed, within a few decades, those who followed produced amplitude and frequency modulation for wireless communication, AM and FM radio, and, ultimately, television.

In 1879, Hertz won a prize sponsored by the Berlin Academy of Science's Philosophical Faculty. The sponsorship was interested in determining whether electric current possesses mass. Hertz did not reduce his findings to an answer of this question (none of the contestants were able to); but the manner in which he conducted his investigation determined his victory.

What he had done was to modify a contemporary apparatus to produce effects not seen before. He published a paper from this series of findings: "Kinetic Energy of Electricity in Motion."

By 1883 Hertz moved into a new laboratory. In the interim Hertz had studied Maxwell's equations and conclusions. He set himself the task to realize in practicality the master's theorems. He increasingly became amazed and comforted perceiving he seemed to be the only scientist in the world engaged in this pursuit. He was!

Interestingly, he was teaching a class of students when the moment occurred. It was what would become standard in any class of college physics, continuing in classrooms today: A demonstration designed to amaze and inspire students—spiral coils that produced sparks across their gaps.

Certainly Hertz knew well of Faraday's findings as well as Maxwell's equations.

However, through a series of circumstances not quite known, Hertz had to place his coils farther apart than he desired or had prepared in his pedagogy. Thinking it would never work, he was surprised when the second coil, farther apart than he had designed in his lesson plan or had wished, reacted with an induced current. That is, the spark and current flow in the primary coil had induced current in the second a considerable distance apart.

Hertz at once recognized a new line of investigation opened, as a previously unopened book, before him. In the main, how far apart could the induction coils be when current would still be induced successfully and undeniably from the primary to the secondary?

For awhile his puzzlement over the small voltage kept him from his ultimate conclusion. When he realized that no matter how he manipulated the coils and the spark gaps, current was induced, he finally came to the conclusion that only waves traveling across the distance could be the cause. By 1887 he was certain.

He had uncovered the propagation of electromagnetic waves. Now, through his more sophisticated designed experiments, he understood the waves could traverse walls. Perhaps they might travel a distance, perchance conquering even an extended geography. They may cavort over hill and dale. He also realized that a manifestation of light propagated and was fully related to these waves—just as Maxwell had elegantly predicted. Indeed, Hertz went on with this realization to discover the photoelectric effect, by concluding that ultraviolet light made the spark gap more conductive on a device he called quite logically the detector.

Hertz also became most interested in the work of Eugen Goldstein, who was developing the Cathode Ray Tube.[8] Perhaps but for his early death, Hertz, with his accumulating insights from his investigations, might have brought about the radio or television age sooner. But perhaps not—for Hertz, as this study reveals of scientists again and again, was interested merely in the process of discovery. That is, his intense curiosity alone drove him to experimentation and supposition. Interest in pragmatic application beyond theory did not often occur to him.

Heinrich Hertz was born in Hamburg in 1857. At an early age he already excelled in science and studied the discipline along with Arabic and Sanskrit at the University of Hamburg. He studied under Hermann von Helmholtz, who counted among his other protégés Albert Michelson, who first measured the speed of light, and Max Plank, who began the discovery of quantum physics. It was a talented department, to be sure. Hertz was encouraged in his pursuit by his esteemed professor, truly a discoverer in his own right—of talent at the highest level.

Tragically, Heinrich Hertz died from blood poisoning brought on by a jaw infection in 1894. He was thirty-seven years old.[9]

Oliver Lodge and William Crookes

Oliver Lodge's biographers and Lodge himself credit the scientist the first to put into some pragmatic effect Hertz's theories and suppositions. Only a few months following Hertz's early departure from this mortal coil Lodge prepared his reverberating demonstration.

Even before Hertz identified the phenomenon, it had been used in America as early as 1842 and in the 1880's to an admittedly lesser extent by Granville Woods, Thomas Edison, and Lucius Phelps, enabling stations briefly to communicate with close passing trains. Albeit workable, these were feeble attempts. They were not always dependable. Soon these more primitive inventions were discarded.

With Hertz's full identification of the principles and potentials inherent in the phenomenon, Lodge set about to design for public view the practical effect that Marconi would read about, so becoming stimulated to begin his own inventive process.

Lodge had invented a device he called a coherer. Simply put, metal filings would cohere in the secondary coil when the primary coil was activated across the room. The flashing spark that began the experiment resulted in full success chillingly accompanied by a resounding boom. Marconi later relied upon this spark-induced thunderous burst for his initial endeavors. Hertz's theories received instant validation. After all, they were visually apparent. Lodge should continue his work. There was speculation he might produce wireless voice transmission, perhaps even visual transmission.

Alas, Lodge harbored a certain tendency, or, ironically, perhaps, an uncertain tendency. Once he proved or came close to proving a principle, he turned his attention to a different focus of wireless communication—searching for a way to transmit and receive messages with the departed. Or, if not involved in investigations of the arcane, Lodge would precede typically to other scientific investigations—that is, the next project. Although Marconi worried that Lodge would beat him to the punch, he need not have been so concerned.

Oliver Lodge was born in 1851 at Penkhull, Stoke on Trent. Lodge was a sibling of a large family but his father was quite successful at business, so the many mouths were fed with little or no concern.

As a young man, Lodge enrolled in King's College in Mathematics, Mechanics, and Physics. He soon became most interested in electricity, by now of itself a well known phenomenon and useful principle.

In 1881 he received appointment as Professor of Physics at University College, Liverpool. Here was his laboratory that produced considerable influential work for twenty years.

Oliver Lodge died in 1940, a long and fruitful life lived on this sphere and searching for those beyond. His several investigations plowed groundwork for future discoveries, including Einstein's. They exceed the limitations of this study. For this purpose, however, his work formed the basis for the later development of long range wireless telegraphy and radio, his coherer eventually evolving into the vacuum and audion tubes.[10]

If Lodge may have come close to inventing wireless and radio, Sir William Crookes, Lodge's contemporary colleague and friend, may have just missed discovering television.

Crookes's interest in the Geissler Tube and Cathode Rays occurred early in his scientific career. Although his investigations of the apparatus and his attempts to uncover the mystery of its phosphorescence did not occupy solely his attention, he continued to return to it. About the same time his colleague and friend was proving Hertzian Waves, he identified and even invented the device that would be instantly recognized today—the (precursor of) the Cathode Ray Tube.

As early as 1878, Crookes wrote in a letter to his early collaborator, George Gabriel Stokes: "I have been constantly thinking about the ultra-gaseous . . . state of matter in the "green" vacuum . . . (Perhaps) the . . . space is filled with . . . molecular matter . . . a chain of molecular impacts may carry the force along in a straight line . . . the . . . colour . . . is the phosphorescence."

Though even he did not fully recognize this implication until later, Crookes had determined that it is a stream of energy from one point of the tube to the other that illuminated the glass. Later, when Thompson discovered or was the first to induce the reality of the electron, Crookes understood this stream well. He referred to the stream as them, as though predicting their revelation, electrically charged particles.

Although Plucker and Hittorf and, more so, Goldstein, had recognized and coined the term Cathode Rays, what Crookes had done is to identify definitively what occurred in the tube. It could now be designed to produce the effect in a more controlled, perhaps even desired fashion.

Further, Crookes analyzed the process within the tube so fully, he was able to map it. That is, he developed tubes which operated more effectively. Almost as if "tuning" them, he discovered he could, to an appreciable extent, control the phenomenon. The handle these objects went by then and go by now is the eponymous nomenclature of "Crookes Tubes."

At one end of the tube, say looking at its left side, was the Cathode. The voltage then cast the particles through a mysterious, unlit space, again receiving an eponymous name, "Crookes Dark Space"; thence moving right, not yet at the center of the tube, a hesitant but constant illumination, termed the "negative glow"; more toward the center is observed the curious darkening Faraday once noted, also appropriately identified as the "Faraday Dark Space"; from here, then, proceeding to the Anode. The illumination took on what appeared to be striations moving one after the other. This appearance was termed the Positive Column.

Today the precise manner of the necessity of these several parts and how, at the sub-atomic level, the energy distribution for the production of electromagnetic wave radiation in the spectrum of light is realized is more fully understood.

Crookes now had everything he needed to develop the invention further. Like his colleague Lodge, however, he set off in pursuit of communicating with the dead, in séances and other supernatural venues.

Yet his many achievements and this one in particular, established precisely what was needed for the telegraphy of instant pictures.

In 1892, two years before Lodge's world changing demonstration, Crookes observed:

> . . . electrical vibrations of a yard or more in wave-length will pierce (walls). Here is revealed the bewildering possibility of telegraphy without wires, posts, cables . . . an experimentalist at a distance can receive some, if not all, of these rays on a properly constituted instrument . . .

Did Crookes's analogous interest in wireless inhibit his further investigation and development of the Cathode Ray Tube? It is an interesting question, which must remain part of the enigma of William Crookes.

In any event, as Lodge and Crookes diverted their fancy to their more arcane investigations, the field was then open for the man who would at last cross the boundary and produce wireless and radio.

Sir William Crookes was born in London in 1832. In 1854 he received appointment at the College of Science in Chester, Cheshire. Soon thereafter he came into his father's considerable estate. With this fortune, he was able to develop his laboratory. Through the late 1880's into the last decade of the century he used this lab to conduct his Cathode Ray Tube experiments and investigations and in his attempt to penetrate the world beyond. Perchance he saw them as one and the same.

Crookes died in 1919, nearly a decade before his tube—rather the inventive and incisive modification of it—produced the first true televised image.[11]

Guglielmo Marconi

In 1844, a message was sent instantaneously from Washington to Baltimore. Anne Ellesworth requested the transmitting operator tap out the series of dots and dashes that produced the words, "What hath God Wrought!" Samuel F. Morse had invented the telegraph. Within a few years the familiar poles and wires criss-crossed the country and soon the civilized world. The profound nature of this achievement cannot be overestimated. In 1776 John and Abigail Adams's correspondence, only a few hundred miles apart in Boston and Philadelphia, could take days and in winter, even weeks.

Communication across the Atlantic might take months. More often than not, letters crossed. Before the middle of the next century, messages could be delivered within hours, even, for all practical purposes, instantaneously.

Morse's invention changed the world.

From the middle of the century into the time of Lodge, Crookes, and Thomson, especially since Hertz's discovery, the search progressed for this instantaneous communication, without the inconvenience of cords or wires. As we have seen none of the scientists, brilliant and ingenious and important as their discoveries were, developed the practical model, nor seemed concerned to.[12]

Guglielmo Marconi admitted he was not a trained scientist. Like Edison, he was an inveterate tinkerer. As Edison invented the light bulb in a series of stops and starts, so Marconi invented the first working model of wireless over considerable distances through trial and error.

Marconi followed the scientific news of Lodge's spark and electromagnetic wave radiation from a transmitter to a coherer (receiver). At once he recognized that if wireless waves could be sent across a room, a larger spark and larger equipment could transmit wireless messages across the countryside, perhaps across the ocean.

Toward the end of the same year of Lodge's spark-gap transmission, Marconi built his own apparatus. He may have been aware that in 1892 William Preece almost by accident had discovered induction wireless communication. Preece was able to transmit a little over three miles. Later Preece would welcome Marconi to England, recognizing the Italian was on the right track.

Although Marconi at first reasoned that the larger the spark—the further the waves could propagate, thus setting "thunder," as it came to be called, he induced that the larger his transmitter and receiving wires, the larger the range. He soon found this was so. Incredulous that no one had thought of it before him, he had invented the two necessary components to transmission and reception—the transmitter tower and the receiving antenna. In 1895, he transmitted a wireless message—the Morse Code "S." The dots and dashes transmitted several miles, including over hill and dale. The transmission was received. Marconi knew it was time to patent his invention. Recognizing the greatest potential probably lay in maritime communication, Marconi departed for England in 1896. The Italian ambassador introduced him to Preece, now Engineer-in-Chief of the General Post Office.

Upon witnessing the effect Preece became convinced. Marconi received investors' funds (they would realize excellent returns); he began with naval and commercial shipping's intense interest in his expansion and perfection of his invention.

In time, again by tinkering he recognized how to design the coil of magnetized wire, and perhaps his ultimate discovery—that the increasing size of the towers and antenna didn't matter as much as their architecture—the complex "map" of the wire design. The spark effusion became less important, the coils and intricate antennae design more so.

In 1926, as television was being invented, Marconi, in a special to *The New York Times*, recounted 25 years earlier his transatlantic success. In other words, in only 7 years, he had gone from his bedroom experiments in Italy to ship to shore and ship to ship communication to transmission and reception across the ocean. Even the transatlantic cables resting on the bottom of the ocean floor to convey telegraphs had become then obsolete.

> In 1895 and 1896 I had proved the possibility of transmitting signals to a considerable distance by means of raised antennae and an earth connection. In 1899 I had proved that the curvature of the earth did not interfere with a propagation of ether waves over short distances and in 1909 I felt that the time had come to venture further afield. Having regard to the many improvements I had lately introduced into the methods of tuning the transmitter and receiver, I was absolutely convinced that transatlantic wireless telegraphy, not merely as an experiment but as a sound commercial proposition, was possible . . .

On Dec. 12, 1901, in a room of a disused barracks on Signal Hill, St. John's Newfoundland . . . on a table stood some instruments . . connected (to) a telephone, in which shortly after noon were heard sounds constituting evidence that in far-distant Cornwall rhythmical signals that corresponded to the letter S in the Morse code had been projected into the ether of space and had actually crossed the Atlantic.

Over the course of that 25 year period, wireless communication evolved into radio and the beginning of television. But it was Marconi the inveterate tinkerer who had brought wireless connection to the world, and began the process.

Guglielmo Marconi was born at Villa Griffone in 1874. However much of his life and career was spent in English speaking countries, England and America. His invention was always scrutinized by military general officers.

Toward the end of his life, he returned to his homeland. With his wealth (for, unlike the scientists who progressed mainly for intellectual curiosity, Marconi, like Edison, ensured his patents and his investors' returns) he lived in a sumptuous Rome apartment complex. Unable or unwilling to perceive fascism as evil, probably due to his resurgent ethnocentric patriotism, he aligned with Mussolini. However, he died in 1937, a full two years before war broke out, and the road to catastrophe began. He had witnessed the full development of radio and the fledging origins of television. His funerals (there were two) were, as Lodge and Crookes might have opined, lavish to his liking.[13]

(Karl) Ferdinand Braun

"I found in 1902 that an antenna, inclined at somewhat less than 10° to the horizon, formed a kind of directional receiver . . . a clearly defined maximum for waves . . ."

". . . the Cathode Ray Tube which I described in 1897 . . . provided a visual picture of current—and voltage-waveforms . . ."

So Karl Ferdinand Braun described in his Nobel acceptance address his two contributions that led to radio and television. Braun received his prize the same year as Marconi. It was a shared prize. The physicist has walked in the shadow of the tinkerer ever since. Perhaps Lodge and Crookes in the afterlife are aware of his frustration. In any case, two things are evident. Marconi wears the rightful crown as the inventor of wireless and radio; radio and television as we know them could not have been invented or developed without Braun's discoveries. In his presentation Braun recounted his improvement of Marconi's system. He invoked his invention of the oscilloscope, still used by electronics technicians today to diagnose equipment malfunction.

Braun was appointed Professor Extraordinaire of Theoretical Physics at the University of Marburg in 1876. In 1885 he established or helped to establish the new Physical Institute. Here and at other labs Braun became fascinated with the Geissler apparatus and Crookes Tubes.

As he wrote, by 1897 he recognized that the CRT could phosphoresce a direct image. Braun modified the shape of the tube into the narrow to wide profile, one that has become an icon of the modern and contemporary world. The energy produced propelled the electron wave from the narrow end toward the larger glass at the opposite end. As the device fired this controlled beam of energy