VHF HISTORICAL NOTES

(Working Title)

ON THE ULTRA HIGHS

- A History of Amateur Radio VHF Activities -

(Formal Title)

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PREFACE

The material presented in this text has taken on a life of its own. It started as a bullet-point, outline type of supplement to the VHF Contest Records that I had put together for the Society of Midwest Contesters. It was thought that the VHF Contest Records should be kept in an historical perspective, with particular reference to major changes in the VHF contest rules. From there, this document then gradually moved to a historical review of all VHF activity on the amateur bands, and began to be known as the "VHF Historical Notes". Pictures were added along the way, and the outline format was changed to regular text. Intensive research was also done on the explanatory factors for VHF contest log variations, resulting in the publication of several articles on the topic. Most recently, the material has been broken up into chapters, so that it can be more easily handled and downloaded from the SMC web-site. In its current format, the quality of the material has been so upgraded in terms of regular text, pictures, extensive footnotes, and references, that I have developed a more formal title to the document. While the "VHF Historical Notes" is still an apt description of the document on a working basis, I am currently referring to the text formally as: "On the Ultra-Highs - a History of Amateur Radio VHF Activities". This formal title is in honor of the early VHF experimenters and the original VHF column in *QST* that started in December 1939.

Every effort has been made to be as historically accurate and thorough as possible. Every VHF historical reference available from the American Radio Relay League has been reviewed, including all *QST's* back to 1922, and several books relevant to VHF amateur radio activities. Various VHF conference proceedings of the regional amateur radio societies, ARRL Handbooks, VHF manuals of both the ARRL and the RSGB, FCC Rules and Regulations, and Federal Law pertinent to amateur radio have also been reviewed.

The first few chapters are available on-line by clicking on the hyperlink in the Table of Contests. The bulk of material is still in outline form, and can also be accessed by clicking the hyperlink "Outline of Remaining Material, 1930's to present".

Please note that I have taken many pictures from either *QST* or other ARRL publications, with permission from the League. In using the pictures, I have retained the text box describing the picture in the original article. Original text boxes nicely convey the manner in which pictures were initially presented in the articles, so efforts have been taken to copy the text messages as well as the original pictures.

Chapter 1 - A Scientific Inquiry of Electricity

Before there could be radio, there had to be electricity. A very brief summary of the great milestones towards the full development of electrical phenomenon is therefore in order.

The Greeks initially discovered electricity almost 2500 years ago when Thales of Miletus noticed that amber attracted small objects when rubbed with fur or silk. The Greeks called amber "electron", and the word "electric" was described as "being like amber", or having the ability to attract other objects.[1] While Thales had inadvertently stumbled upon static electricity, he and other Greeks of the era believed that certain inanimate substances, such as magnetized rock and amber, possessed a psyche, or soul, that was responsible for attraction of objects. Many centuries elapsed before this "soul" would be identified as static electricity and magnetism.[2]

While the Greeks were describing a psyche to electrical phenomenon, the ability of the ancients to communicate long distances involved much more traditional methods. The Bible (Jeremiah 6:1) notes that signal flares were used around Bethlehem. In 522 BC, the Persian army used a relay message system by shouting from hilltops. A few years' later, Athenian runners sent messages between battlefields. The great lighthouse at Alexander used a reflecting mirror of burnished metal. Mirrors were also employed to signal messages across distances – using what was known as a heliograph.

Beacon fires were used in 427 BC to warn a military fleet of Spartan vessels that Athenian triremes were heading towards them and preparing to attack. Beacon fires were also noted in Homer's Iliad. Rudimentary forms of optical telegraphs and "torch" telegraphy used in and around Greece for similar military activities were in existence by 150 to 360 BC. Roman Legions may have used signal beacons around 113 AD. Lantern-carrying kites were used in 500 AD as communication devices during the siege of Nanking, China. On the North American continent, Mississippian Indians built signal mounds around 1100 AD to communicate to their central cities, such as the massive urban complex at Cahokia, as well as at other locations.[3] Back on the Asian continent, Genghis Khan in 1206 used horse or pony stations spaced 25 miles apart to send messages across his vast empire. In 1588, beacon fires were used to mobilize the English against the Spanish Armada.

Scientific study into the properties of electricity began in 1600 when William Gilbert, a physician to the royalty of England, published the first treatise on electrical and magnetic properties.[4] Gilbert had read the observations of Thales, and began experimenting with the attraction and repulsion of non-metallic rods. Gilbert coined the term "electricity" from these experiments. He may have been the first person to suggest a connection between static electricity and magnetism.

A century later, Sir Isaac Newton penned his famous "Optics", in which he set forth his theory of light. Newton thought that light involved wave-like behavior that could cause vibrations in "ether". Newton's work was the beginning of numerous studies on the properties of light.

During the 1700's, several observations piqued the curiosities of scientifically inclined minds. Iron-laden rock known as lodestone could make a magnetic compass needle move. Two metal plates placed in an acid solution could heat up a wire connected to the plates, and a nearby compass needle would swing back and forth. Some people felt that electricity and magnetism had to therefore be related in some manner.

Then, in a simple but ultimately very important discovery, it was found in 1729 that that static electricity could be stored for later use and experimentation in what were known as Leyden jars. These jars were simply glass containers filled with water charged by a source of friction. The word "Leyden" generally came from the University of Leiden, where the discovery occurred.[5] Benjamin Franklin, experimented with Leyden jars, and made several contributions to science in the process. In 1748, Franklin and William Watson, of Britain, together developed the principle of conservation of charge: the total quantity of electricity in an insulated system is constant. By 1752, Franklin observed that this electricity had the same properties as the static electricity produced by friction, when he was said to have charged a Leyden jar from a kite flown during a thunderstorm. The next two people who attempted the same experiment died from electrocution, according to folklore. Shortly before the American Revolution in 1770, John Cuthbertson, an English instrument maker living in Amsterdam, made a form of an electric battery out of 135 Leyden jars. Within a few years, Count Alessandro Volta, a physicist at Pavia, Italy, developed a keen interest in Leyden jars and static electricity, when he began generating static electricity through the use of friction. Leyden jars were also involved in the experimentation of what amounted to the world's first vacuum tube. In 1774, Henly of London when he demonstrated the glow at a negative electrode of a glass tube drained of air when it was wired to a leyden jar. Modern tubes and lights evolved from this simple device two centuries ago.

Sunspots had been known by the civilizations of the ancient Greeks and Chinese. Galileo was the first European to recognize that they were on the solar surface.[6] In a discovery that is of great interest to all amateur radio enthusiasts, the first eleven year solar cycle was observed in Zurich, Switzerland between 1749 and 1755. In an interesting historical note, the numbering of our solar cycles (as in cycle 22, 23, and so forth), all date back to this first observed cycle in the mid 1700's, which is now known as Cycle 1.

The first practical electromechanical type of telegraph was proposed in 1753, when an individual signing only as C.M published a letter in *Scot's Magazine*. The device was to be powered by the discharge of static electricity from Leyden jars. George Louis Lesage then demonstrated an electrostatic telegraph in Geneva, Switzerland in 1774. He built a device composed of 24 wires, with a pith ball being located at the end of each wire. The pith ball was repelled when a current was placed on that particular wire. Each wire stood for a letter of the alphabet.

Ancient relay methods were adapted to more modern forms of visual relays and telegraph systems in Europe with development of the semaphore, or optical telegraph. Towers were constructed on large hills, and large T-type moving arms were positioned in particular ways so as to signify certain words and messages. The Chappe Telegraph Line was built between Paris and Lille in 1794. Optical telegraphs would eventually run throughout France, covering over 4800 Km and having some 556 stations.[7] Over 300 different types of words or phrases could be sent, and semaphore devices were installed along the French coastline to signal ships at sea. An optical semaphore telegraph system was even established in the US in 1801, between Martha's Vineyard and Boston. A semaphore was also tested on ships in the English Channel, and this effort proved to be successful. As a result, by the early 1800's, a semaphore system had developed along the coast of England.

By 1800, Volta discovered that dissimilar metals could generate electricity when placed in Leyden jars. He placed zinc and copper sheets in acid to produce a continuous flow of electricity. He referred to it as a "continuous current pile". The more refined version was known as the Voltaic Pile, and this was the first practical battery. Volta never fully understood the operation of his cell, believing that current flow was due to the contact between the two metal sheets, instead of realizing that is was from the chemical reaction on the metal plates. Count Volta's contribution to science is considered so great however that the one of the basic measurements of electrical force, that of the "volt", is named after him.

Other important discoveries were also occurring at the turn of the 19th century. Coulomb of France measured electrostatic forces in 1800, and concluded that whenever electrical charges are separated, electrical fields exists in the vicinity. Sir William Herschel, a famous British astronomer, discovered the existence of infrared rays and the infrared region of the light spectrum in 1801. Building on Newton's earlier work, Cambridge scientist Thomas Young proposed the wave theory of light. This theory was instrumental in more fully understanding how light waves traveled though space. It would be expanded upon many years later to explain how radio waves traversed space.

A voltaic pile was used in an electrolytic telegraph that was demonstrated at Munich in 1810. The telegraph was composed of 35 wires (one for each letter of the alphabet and each number) that were connected to an acidic solution. When the circuit was completed, the voltaic pile caused hydrogen bubbles to emerge from the solution. The various bubbles corresponded to different letters or numbers. Joseph Henry proposed a single wire telegraph in 1816, and Sir Francis Ronald built such a system in his garden at Hammersmith, England. Ronald offered his telegraph to the British Admiralty, which generally ignored the invention.

Hans Christian Oersted, of the University of Copenhagen, connected the concepts of electricity and magnetism through an accidental discovery made during a lecture. A wire from a battery fell onto a compass, causing the compass's needle to deflect. This inadvertent finding may have been the first demonstration and experiment of electromagnetic induction.[8] From there, further developments in electricity and magnetism quickly took place. In 1820, it was shown that electrical current naturally formed around the outside of a wire. In the same year, Sir Humphrey Davy first showed that electricity could be used to produce light when he connected carbon rods to a battery-like device, and the tip of the rods turned a bright white. The next year, the galvanometer was invented. Electrolysis was then scientifically observed and analyzed. Thermoelectricity was discovered in 1822. Then, William Sturgeon in 1824 found that a magnetic field could be produced when an electric current was passed though copper wire coiled around soft iron. Shortly thereafter, Andre-Marie Ampere developed the mathematical principles behind electrodynamics and further accelerated the mathematics of electromagnetism. Ampere's mathematical computations proved so significant that the measurement of current, the ampere or amp, is named in his honor.

A professor of mathematics in Cologne, Georg Simon Ohm, then developed the mathematical properties behind current, electromotive force, and resistance. Known as Ohm's law, the calculation of $I = E / R$ was considered so important that the basic measurement of resistance, that of the Ohm, is named after him.

In the late 1820's, English inventor Charles Wheatstone designed a device for the conduction of audio. It was referred to as a "micro-phone". Wheatstone went on to popularize other devices, including the Wheatstone Bridge. Around the same time, Joseph Henry discovered electrical self-inductance. The unit of inductance known as the "henry" is named after him. A professor of Chemistry at the Royal Institute in London, Michael Faraday, and Joseph Henry then independently discovered the basics of electromagnetism. Faraday and Henry both observed that an electric current was induced in a closed coil of wire when a magnet was passed through the coil. The generation of electricity could now be done through the use of a wire coil rotating through a magnetic field. From these experiments, Faraday developed the notion of a magnetic flux field, or lines of force to explain currents induced through a magnetic field. He eventually came to believe that space was immersed in magnetic, electrical, thermal and gravitational fields. Faraday thus developed a theory explaining both electricity and magnetism.

During his deliberations on magnetic fields, Faraday also proposed a single wire telegraph.[9] Improvements were steadily made to the telegraph by many individuals. Drawing upon Oersted's earlier experiments with compass needles, a Russian diplomat, Baron Schilling, in 1832 developed a system using only six wires, with compass needles being used to indicate the letters. In 1837, William F. Cooke and Charles Wheatstone patented an improved version of Schilling's telegraph, using only five wires and needles.

American painter and artist Samuel F.B. Morse developed a telegraph in 1832 using electromagnets and only two wires to complete the circuit. The use of electromagnets in the system was a major improvement on earlier telegraph systems, and allowed the telegraph to become a practical, working communication device. Within a few years, K.A. Steinheil of Munich, proved earlier beliefs that one of the two wires Morse used could be eliminated if an earth ground was also utilized (although the theoretical understanding for using an earth ground was still a mystery). By 1837, Morse had adopted a series of uniform dots and dashes for his telegraph, representing the various letters and numbers. These assorted dots and dashes became the "Morse Code" (also known as the "Vail Code", after an assistant of Morse, Alfred Vail, simplified Morse's initial efforts). The dots and dashes of Morse's system were initially printed onto a paper tape. Within a short time however, code operators learned to directly listen to the clicking of the receiver to decipher the messages. Morse's patent was applied for in 1840. Morse successfully lobbied Congress over several years for the appropriations of $30,000 to construct the first wire telegraph line in the US. It was strung between Baltimore and Washington. On March 24, 1844, the first message on the line was from the Bible, *Numbers 23:23*: "What has God wrought!" [10] Construction of privately owned telegraph lines throughout the United States quickly ensued, and Morse's invention became the standard from of telegraphy throughout the world.

In 1843, Joseph Henry wrote on the possibility of electric oscillations, believing that the discharge of Leyden Jars could be oscillatory in nature.[11] He even noted that electromagnetic energy could be sent through space, and likely understood that a wave-type of action was at work. Fedderson then demonstrated the phenomenon when he photographed alternating spark discharges by using a rotating concave mirror. Faraday wrote that light and electricity might be different manifestations of the same force. By finding that discharges were oscillatory and that light and electricity were tightly interwoven, the work of these three individuals constituted significant advances towards the ultimate development of radio wave transmissions.

In 1850, James Clerk Maxwell, Professor of Physics at Cambridge made a huge theoretical contribution to the emerging theories of electrical phenomena. By mathematical computations, Maxwell demonstrated that electrical activity associated with electromagnets was likely the result of electromagnetic waves of radiation. He also concluded that light was basically electromagnetic in nature. Four small equations penned by Maxwell sets forth a unified theory of electrical and magnetic activity that had been previously examined in various fashions by Ampere, Faraday, Ohm, and others. Maxwell's equations were considered radical and highly controversial at the time, and some academics were quite skeptical of his thoughts. For example, Maxwell believed in an "ether" that filled empty space and could be used to transmit the electromagnetic waves. Subsequent work done by Lorentz of Germany showed that an elastic ether was not necessary in which to establish radiated waves, and only electric and magnetic fields in space would be needed. Even with this revision to Maxwell's thoughts, his basic belief in an electromagnetic wave to explain separate electrical and magnetic phenomenon remained intact. [12]

Meanwhile, the telegraph was rapidly spreading throughout America, Europe, and the rest of the world, and many advances were being made. Cook and Wheatstone reduced their telegraph to a single compass needle and formed the Electrical Telegraph Company. By 1852, 4,000 miles of telegraph line had been laid in England. Experiments started in the 1850's on duplex and multiplex telegraphy, both of which allowed for simultaneous transmission of signals on the same line. Cable lines laid in the Atlantic Ocean connected Europe to the U.S. on August 5, 1858.

The Morse Code was modified in 1851 for use in Europe, producing a simpler coded system. This version of Morse's code was known as the Continental Code, or the International Morse Code. Morse operators in America gradually adopted this version, and the International Morse Code was universally accepted by the early 1900's for all code applications.

Numerous scientific advances were also steadily occurring. German glass blower Heinrich Geissler developed a mercury pump in 1855 to produce tubes that held a good vacuum (many earlier efforts by other to hold a decent vacuum generally failed). A glowing pattern of light in Geissler's tube was created by the electrons moving about the tube. Physicists mathematically linked both static and current electricity to each other by a constant velocity "c". Hermann von Helmholtz used a tuning fork to vibrate and produce sound by switching an electromagnet on and off. This principle was the basis of the audio speaker, and was instrumental to later efforts by Alexander Graham Bell in inventing the telephone. Julius Plücker then showed that cathode rays bend when placed near a magnet, but the theoretical process was not yet understood. Alexandre Edmond Becquerel used a Geissler tube in 1859 to make the first fluorescent light. Frenchman Gaston Plante discovered the electric storage cell by making a battery using lead and acid. [13]

The US Army Signal Corp was formed in June, 1860. Initially using flags and torches as part of an optical system, the Corp quickly developed a portable magneto-electric communication device known as the "Flying Telegraph". This apparatus was hand operated, and could signal over several miles of insulated field wire laid on the ground or strung on poles.[14] Landline and portable telegraphs were used extensively during the American Civil War, and more than fifteen thousand miles of lines were laid exclusively for military purposes. Hiram Silby consolidated several private telegraph lines, and formed Western Union. The company connected the two coasts of America by telegraph lines in 1861. These lines were completed in spite of military hostilities between the Union Army, Indians in the Plains States, and Confederate soldiers. Signaling distances were improved by using electromagnetic receivers to supplement and amplify the line current with the use of local battery power, thereby "lengthening" the line. By 1866, Western Union had 2,250 offices and 70,000 miles of telegraph wires.

The first International Telegraph Convention was signed by twenty participating nations in 1865, and the International Telegraph Union (ITU) was established through this agreement. Around the same time, Charles Wheatstone invented the first automatic printing telegraph system. Messages were typed on an instrument, and then automatically coded and transmitted over the telegraph as a series of pulses. Thomas Alva Edison introduced Quadruplex telegraphy, which provided for the transmission of two messages simultaneously in both directions, in the 1870's. Another inventor introduced an early version of facsimiles built for telegraph purposes.

At the same time as large jumps were regularly occurring in the development of the telegraph, scientific advances concerning the properties of electricity continued unabated.

In 1861, German schoolteacher Johann Philipp Reis sent speech and music electronically through wires with a device he called “das Telephon”. Maxwell made another large theoretical advance when he postulated in 1864 that electrical activities should travel at the speed of light. His equations extended Faraday’s earlier theories on magnetic lines of force, and additional writings in 1873 by Maxwell provided more depth to his theories on electricity, magnetism, and radio waves.[15] Maxwell had now fully developed his theories, predicting the existence of electromagnetic wave radiation as well as believing that visible light was merely radio waves oscillating at high frequencies. Maxwell’s latest theories were brilliant as ever, but still highly controversial.[16]

French Chemist Georges LeClanche developed an early predecessor of the dry cell battery in the late 1860’s. Two English telegraph engineers, Joseph May and Willoughby Smith, discovered photoconductivity. In an important discovery that would set the stage for many future radio and electrical applications, Karl Ferdinand Braun in 1874 found that one-way rectification and conduction would occur when metal wires made contact with crystals. Irish physicist George Johnstone Stoney theorized the existence of electrons as “atoms of electricity” in the mid 1870’s. Around the same time, Werner Siemens demonstrated that electricity moves along a wire at approximately the speed of light.

By the 1870’s, amazing devices were being invented. Alexander Graham Bell invented the first practical telephone, and Thomas A. Edison recorded sound on cylinders. The first recording was Edison’s voice, reciting the first line of a children’s poem: “Mary had a little lamb”. Siemens and others independently invented a dynamic microphone, using electromagnetic induction. Alexander Graham Bell and his father-in-law, Gardiner Hubbard, founded Bell Telephone. Telephone switching exchanges quickly developed thereafter. An American, George Carey, sent pictures of wire bundles in 1879, arguably coming up with the first television-like device. In a great leap forward in the development of lighting apparatus, Thomas Edison on October 21, 1879 demonstrated the carbon filament light bulb. Edison used a carbon filament housed inside a vacuum bulb.[17] Within three years, the Pearl Street central power station in downtown New York City would be constructed. Edison also built several other DC power generating plants in the Niagara Falls area, and Edison was a strong proponent of DC electrical systems. Alexander Graham Bell and Sumner Tainter designed a telephone in 1880 that sent speech by light waves. Named a “photophone”, this device pre-dated today’s fiber optics by almost 100 years. French inventor Clément Ader built an ultra-sensitive microphone in 1881 to send sounds of the Paris Opera to listeners using two receivers, one for each ear. Dubbed a “Theatrephone” by Ader, the stereo effect was discovered in the process.

In 1883, Thomas Edison and a lab assistant accidentally discovered what has come to be known as the "Edison effect" while trying to keep the inside of his electric lights free of soot. Edison placed a metal plate in a vacuum bulb, connected a wire to it, but then noticed a curious one-way flow of electrical current from the light-emitting filament across the vacuum and onto the metal plate and wire. This was likely the first known observation of a vacuum diode. The Edison effect readily explains the operation of all vacuum tube devices, but Edison did not grasp at the time the implications of his find.

Instead, Edison was busy patenting the fuse and marketing early versions of his electric light bulbs.

German chemist Clemens Alexander Winkler discovered the chemical element germanium in the 1880's. The existence of germanium, named after Winkler's homeland of Germany, would be used extensively in future years in the manufacture of semiconductor materials and devices.

While Edison was developing DC power plants, Nikola Tesla was inventing induction motors for use with alternating current. Tesla teamed up with George Westinghouse, who invented a railway air brake, to build AC power plants for the Westinghouse train network and for industries around Buffalo, NY. In 1890, Tesla also invented a power step up device referred to as the "Tesla Coil" that raised voltages to the level of 300,000 volts.

From Wires to Wireless. Several efforts took place over the years to first reduce, and then ultimately eliminate, the wires necessary for the operation of a successful telegraph system. 35 wires were reduced to six wires. Morse reduced this to two wires, just enough to complete an electrical circuit for the induction of electromagnets. K.A. Steinheil eliminated the second "return" wire by using an earth ground at both ends of the telegraph lines. Efforts then concentrated on eliminating even the one remaining wire to the telegraph system. These activities centered on conductive and inductive methods, as well as electrostatic means. A true wireless transmission of radiating waves would take additional experimentation to achieve, however.

As far back as 1838, Samuel Morse used conduction methods via water to transmit telegraph messages. Within a few years, he had transmitted across (or through) an 80-foot canal. He connected a key to copper plates located along the shoreline, and a galvanometer to a pair of similar plates on the other shore. Morse later succeeded in sending signals nearly a mile through water. Others in England and elsewhere also experimented with water-borne conduction methods, notably, S.T. Sommering in 1811, James Lindsay in 1854, William Preece in 1872, Alexander Graham bell in 1878 (with telephone transmission across the Potomac River), and Willoughby Smith in 1893. [18]

The wireless sending of telegraphic code was not limited to water, either. Around 1880, John Trowbridge of Harvard University detected telegraph signals at considerable distances from overhead lines by simply using telephone receivers. Morse operators reported the same phenomenon as early as the 1840's – they would routinely hear key clicks in nearby telephone detectors whenever their telegraphs were in operation. Referred today as "crosstalk", most of these reports may have been due to induction from neighboring wire lines, although ground conduction may have also been possible in other cases. Trowbridge successfully carried out electromagnetic induction communications in ship to shore experiments around 1891.

Wireless experiments were also done in numerous tests involving wire aerials flown aloft by kites. In 1865, Mahlon Loomis flew two kites 18 miles apart, with each one carrying a wire reaching back to ground. Loomis described these kite wires as “aerials”. Loomis kept the two kites at the same approximate height, and placed a copper wire mesh on each kite. Today, such a set-up would be considered to be top-loaded vertical antennas in resonance with each other. A galvanometer connected to one kite wire measured a change of current when a galvanometer on the other kite wire was grounded to a coil of wire buried in the earth.[19] In 1870, Loomis successfully tested his ideas between two ships located two miles apart on the Chesapeake Bay. The U. S. Navy sponsored those experiments. In 1873, Loomis was granted a US patent for a wireless telegraph, but never obtained financial backing to more fully develop his ideas. Neither the patent application, nor any other available information on Loomis, has indicated that radiated transmissions were used instead of simple galvanometer deflections. [20]

In 1882, Physic professor Amos E. Dolbear of Tufts University received a US patent for a wireless telegraph after communicating over a distance of a quarter of a mile without wires. Dolbear used an electrostatic inductive system that initially used capacitors, microphones and telephone receivers. While not a true radiating wave in the scientific sense of the term, Dolbear’s transmissions probably involved the earliest wireless voice communications.[21] He even demonstrated an “electrostatic telephone” to a society of telegraph engineers in London in 1882 by having a cornet player send music over the device. At various times, he may have transmitted over 13 miles in distance. Dolbear’s patent prevented the Marconi Company from using an almost identical system in America until Marconi bought the patent rights from Dolbear. Edison also received a patent for a device similar to Dolbear’s, but then likewise sold it to Marconi.

Figure 1.1 – Dolbear’s Electrostatic Wireless. The following is the very simple, but effective, system employed by Professor Dolbear.[22]

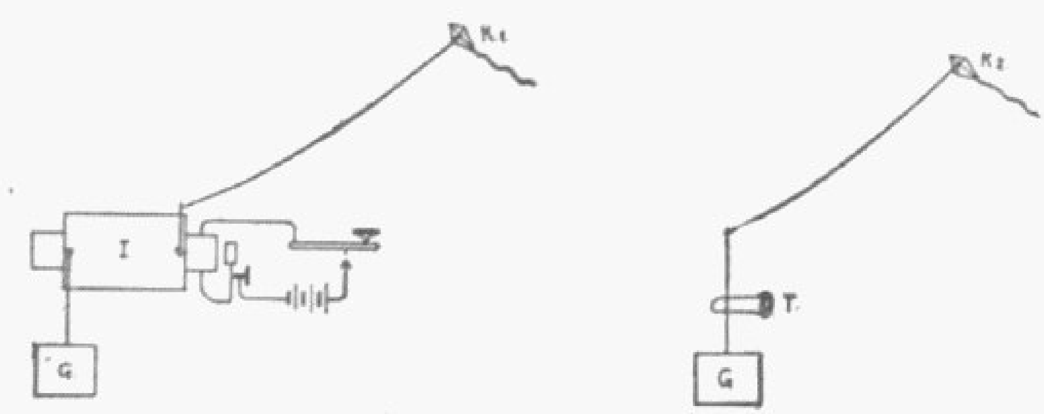

FIG. 63.— Dolbear's apparatus for electrostatic signaling. A kite K_1 at the sending station is charged by an induction coil I, and another kite K_2 at the receiving end is grounded through a telephone, T.

At the same time as Dolbear's efforts, Henry Preece of England perfected both conductive and inductive techniques to the point where wireless telegraphic systems were being used between the English coast and small offshore islands and isolated lighthouses. Distances involved were generally less than five miles, however.[23] His system was advanced enough to successfully handle all commercial traffic in 1895 between the Isle of Mull and mainland England after a cable line in the channel broke.

Figure 1.2 – Preece's Inductive System. The following diagram is the inductive part of Preece's system. He then used conduction through water to communicate with island and lighthouses.[24]

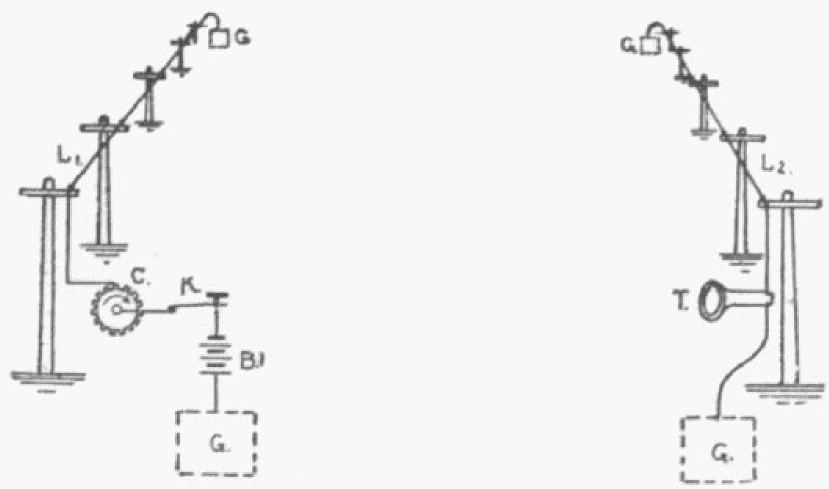

FIG. 59.—Preece's apparatus for signaling by electromagnetic induction. An intermittent current produced by the battery B and commutator C, and controlled by the key K, is sent through the line L_1 and returns through the earth. The receiver comprises a similar line, L_2, whose circuit includes a telephone receiver, T.

Wireless induction telegraphs for use in railway cars and stations were put in use in Europe and America in 1886. Both Phelps and Edison devised induction telegraphs for use around railway systems. Edison held a patent his system in 1891. Typically, a wire was laid between rails of the track, or by overhead means. A coil of wire was run around the railway car, and by induction techniques, telegraphy was possible between the rail cars and rail stations.[25]

Figure 2.3 – Railroad Induction Telegraphy. The following figure depicts a railroad inductive system for telegraphy between railway cars and the railway stations. Railroad cars parked on sidings some 60 feet or so away from the nearest inductive wire still could communicate to the station, in many cases.[26]

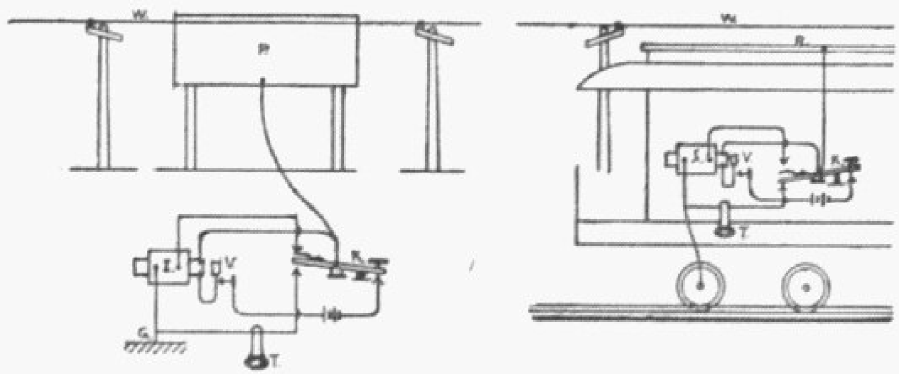

FIG. 64.—Electrostatic method of train telegraphy. At the land station (which is shown in sending position), the line wire W is excited by an elevated metallic plate P, charged by an induction coil I, operated by a key K and vibrator V. On the train a similar apparatus is connected to the metallic roof R of the car. Here the key is shown elevated, thus putting the telephone T in connection for receiving.

Another early experimenter was Nathan Stubblefield, a Kentucky farmer and part-time telephone repairman who may have tested a ground conduction system as early as 1885, although one source believes an inductive system was in use.[27] By 1892, his system may have involved telephony, and he achieved distances of over half a mile. In 1902, Stubblefield demonstrated a wireless telephone in downtown Murray, Kentucky. He received a patent in 1908 for an inductive system. Stubblefield gave few other public demonstrations, and his activities garnered little attention at the time.

Everything was now in place for the next big advance in electrical experimentation and invention: the transmission and reception of electromagnetic radiating waves.

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[1] Many of the items of this chapter have been referenced from various chronologies of technological progress. Very good compilations are: USA Amateur Radio History And Licensing, Compiled By AC6V, 1979-2000; http://www.ac6v.com/history.htm; Communication Systems and Technology, A Chronology of Communication Related Events, Part 1: 4004 BCE - 1899 AD, by R Victor Jones, http://people.deas.harvard.edu/%7Ejones/history/comm_chron1.html; The Dawn of Amateur Radio in the U.K. and Greece : a Personal View, by Norman F. Joly.

[2] A very nice summary of Thales is contained in: The Dawn of Amateur Radio in the U.K. and Greece: a Personal View, by Norman F. Joly, available on-line.

[3] Messages were sent through controlled fires set atop the signal mounds. Some of these historic mounds still exist today. At its zenith 1000 years ago, Cahokia was one of the most densely populated cities in the world, and used signal point mounds as a means of communications with several nearby Indian villages. Today, Cahokia Mounds is classified as a World Heritage Site.

[4] Gilbert published: *De Magnete, Magneticisque Corporibus, et de Magno Magnete Tellure* ("On the Magnet and Magnetic Bodies, and on That Great Magnet the Earth").

[5] Ewald Georg von Kleist, of Germany, and Pieter van Musschenbroek, a professor at the University of Leiden in the Netherlands, made the discovery independently.

[6] Gene Zimmerman, in his The World Above 50 MHz column, *QST*, Jan. 2005, at 85, has a nice presentation of Solar Cycle history and prediction methods.

[7] Communication Systems and Technology, A Chronology of Communication Related Events, Part 1: 4004 BCE - 1899 AD, by R Victor Jones.

[8] Oersted developed opinions on the relation between electricity and magnetism as early as 1807, but his electro-magnetic experiments in 1820 "caused unqualified astonishment throughout Europe", according to then contemporary writings. See, *Popular lectures on Science and Art,* Vol. II, Dionysius Lardner, 1848.

[9] Communication Systems and Technology, A Chronology of Communication Related Events, Part 1: 4004 BCE - 1899 AD, by R Victor Jones.

[10] From: USA Amateur Radio History And Licensing, Compiled By AC6V, 1979-2000. Morse sent the message form the chamber of the Supreme Court, then located in the basement of the US Capitol. His assistant, Albert Vail, received the message at the Mount Clair Depot in Baltimore. A young daughter of the Commissioner of Patents, Annie Ellsworth, brought the news of the Congressional appropriation to Morse. He was so happy at the news that he allowed her to choose the verse from the Bible. Being deeply religious, she decided upon Numbers 23:23. The paper strip containing the telegraphic characters of the historic message is housed at the Library of Congress.

[11] See, *Maxwell's Theory and Wireless Telegraphy*, H. Poincare & Frederick K. Vreeland, McGraw Publ. 1904, p. 22-23; 191-192.

[12] A very good summation on Maxwell's work, including his four equations, can be found in *VHF Handbook,* 1974 ed, Brier & Orr, Ch. 1, p.8-12.

[13] Communication Systems and technology, A Chronology of Communication Related Events, Part 1: 4004 BE - 1899 AD, by R Victor Jones.

[14] For an interesting historical review of the US Army Signal Corp, see "100 Years of Army Signals", Major Sidney S. Rexford, *QST,* June 1960, p.11-15.

[15] James C. Maxwell's paper was entitled "A Dynamic Theory of the Electromagnetic Field". Also see, *A Treatise on Electricity and Magnetism,* Oxford Clarendon Press, 1873.

[16] A very good turn of the century text explaining Maxwell's mathematical ideas is *Maxwell's Theory and Wireless Telegraphy*, H. Poincare & Frederick K. Vreeland, McGraw Publ. 1904.

[17]While Edison has been credited with the discovery of the electric light bulb, Sir Joseph Wilson Swan, a pioneering English chemist and physicist, made an incandescent lamp using a carbon filament 20 years before Edison's lamp. Edison and Swan teamed up to jointly market bayonet cap light bulbs. See, Communication Systems and Technology, A Chronology of Communication Related Events, Part 1: 4004 BE - 1899 AD, by R Victor Jones.

[18] The wireless transmission of signals through water had actually been practiced far before the efforts of Morse and others. In the 1740's and 1750's, Dr. Watson, Bishop of Llandaff sent electric shocks across the Thames in England; Benjamin Franklin made similar tests in Philadelphia; and De Luc did likewise across the Lake of Geneva. See, *Maver's Wireless Telegraphy,* William Maver, Jr, 1904.

[19] A classic book on early amateur radio activity, *"200 Meters and Down",* Clinton B. DeSoto, ARRL publ., 1936, 2001 ed, p.11, believes this was the first signal transmission through space. Today, many scholars feel that Loomis' experiments involved either electrostatic discharges or conduction of electricity, and not a true radio wave transmission. This is especially the case since clouds would be needed to charge the kite wires with static electricity before the system would work. Additionally, suspicion still swirls around many of Loomis' extravagant claims, although at least Loomis' kite experiment was repeated with success in 1909 at the London Telegraph Training College over a distance of three miles. QST, Jan. 1994, at 58.

[20] For small passages regarding Loomis, see: Communication Systems and Technology, A Chronology of Communication Related Events, Part 1: 4004 BCE - 1899 AD, by R Victor Jones; and USA Amateur Radio History And Licensing, Compiled By AC6V 1979-2000.

[21] See "Early Wireless: Marconi Was Not Alone", P. Kinzie, *Arizona Antique,* available on-line. A concise description of Dolbear's system is contained at 119-121, Maxwell's Theory and Wireless Telegraphy, Poincare & Vreeland, McGraw Publ. 1904.

[22] The diagram is from *Maxwell's Theory and Wireless Telegraphy*, H. Poincare & Frederick K. Vreeland, McGraw Publ. 1904, at 120.

[23] See "Early Wireless: Marconi Was Not Alone", P. Kinzie, *Arizona Antique,* p.8, available on-line.

[24] *Maxwell's Theory and Wireless Telegraphy*, H. Poincare & Frederick K. Vreeland, McGraw Publ. 1904, at 115.

[25] Both the Phelps and Edison induction systems are described by Maver, at 9-13.
[26] The diagram is from *Maxwell's Theory and Wireless Telegraphy*, H. Poincare & Frederick K. Vreeland, McGraw Publ. 1904, at 121.
[27] See, an article "Who's on First?" in the archives section of an on-line site, http://www.oldradio.com.

Chapter 2 – The Birth of Wireless

The Americans had been attempting to eliminate the wires of a telegraph system while several Europeans endeavored to explain Maxwell's wave theories. As we shall soon see, within the span of a few years of each other, Hughes, Hertz, and Lodge had all developed crude but functional equipment to generate and receive electromagnetic waves. Numerous others, including Branly, Popov, Marconi, Slaby, D'Arco, and Braun quickly improved upon the initial efforts at producing radiating waves.

Heinrich Hertz is widely credited for having developed the first electrical transmissions of a radiating nature. But David Edward Hughes, an English professor of natural philosophy and an early inventor of a type-printing telegraph widely used in Europe, probably generated the wireless transmission of radiating waves some eight years before Hertz. Staring in 1879 and continuing into 1880, Hughes transmitted and received radio signals from one part of a house to another. The instruments consisted of a spring wound device that sent out electric impulses at regular intervals, with a carbon microphone used by Hughes acting as the detector. The impulses were sparks generated from Leyden jar discharges, and Hughes discovered that these sparks produced sounds in carbon microphones even without wire connections. Henry had previously shown Leyden jar discharges to be oscillatory in nature. Hughes would start the spring on the transmitter and then walked slowly away from his lab with the receiver in his hand, noting how far the sounds could be detected. At times he was able to hear the sounds some 500 yards distant.

At one point, Hughes' transmissions were witnessed by several members of the British Royal Society, including William Preece (Hughes was also a member of the Society). The individuals in attendance incorrectly felt that Hughes had designed nothing but another induction device. Hughes was so discouraged by this that he never published his activities. He died in 1900 only a few months after he penned a short summary of his efforts for a book entitled *A History of Wireless Telegraphy*. In 1922, his original equipment was found in the storage area of a London tenement and put on display at a science museum in South Kensington. It indeed appeared to be capable of generating and receiving radiating waves.[1]

(Picture of Hughes' apparatus);

Because Hughes did not publicly circulate his experiments beyond that of the Royal Society, the credit for the first true wireless transmission goes to Heinrich Hertz. In astonishing series of experiments beginning as early as 1884, Hertz went about proving Maxwell's theories on radio waves. Since Henry had earlier shown that oscillations could be generated from a leyden jar, Hertz started there. He generated electromagnetic waves from a "sparking coil" that discharged a current across two wires attached to a leyden jar. The spark radiated out in all directions as a wave train. The wave traveled through space and jumped across a "detector" or "resonator", which was merely another closely spaced air gap between two wires or spheres. A small spark on the detector end indicated that the wave train had just passed through it.

(Picture of Hertz's coils from leyden jars in 1884?, and a description that this experiment predated the 1887-1888 classroom experiments?) vhf handbook, 1st ed, ch. 1))

Hertz's initial public demonstration took place in a classroom at Berlin's Karlsruhe Polytechnic in 1887. Sparks and electrical discharges were already a known phenomenon, but were thought to be the result of induction.[2] The brilliancy of Hertz's experiments was not in the spark transmissions and detections themselves, but in the confirmation by Hertz of Maxwell's wave theory. Hertz proved that the transmitting sparks radiated out from the origin point in a pattern identical to the physical properties of light, with the velocity of electromagnetic waves being equal to the velocity of light. The contribution of Hertz to radiating wave theory was so tremendous that early wave transmissions produced by sparks were commonly described as "Hertzian waves", and the measurement of frequency, (as in Kilohertz or Megahertz, etc), bears his name. The electromagnetic radiation of waves through space without the use of wires - "wireless" - was born. [3]

Figure 2.1 – Hertz's First Spark Gap Oscillators. Of particular interest to the VHF theme of this writing, radio transmissions by Hertz took place on frequencies of 50,000,000 "vibrations" per second and higher (In today's nomenclature, 50 MHz and higher). In the following figure, note the size of the radiating wires, spheres, and square plates of Hertz's first oscillators – they radiated somewhere in the ultra-high range. [4]

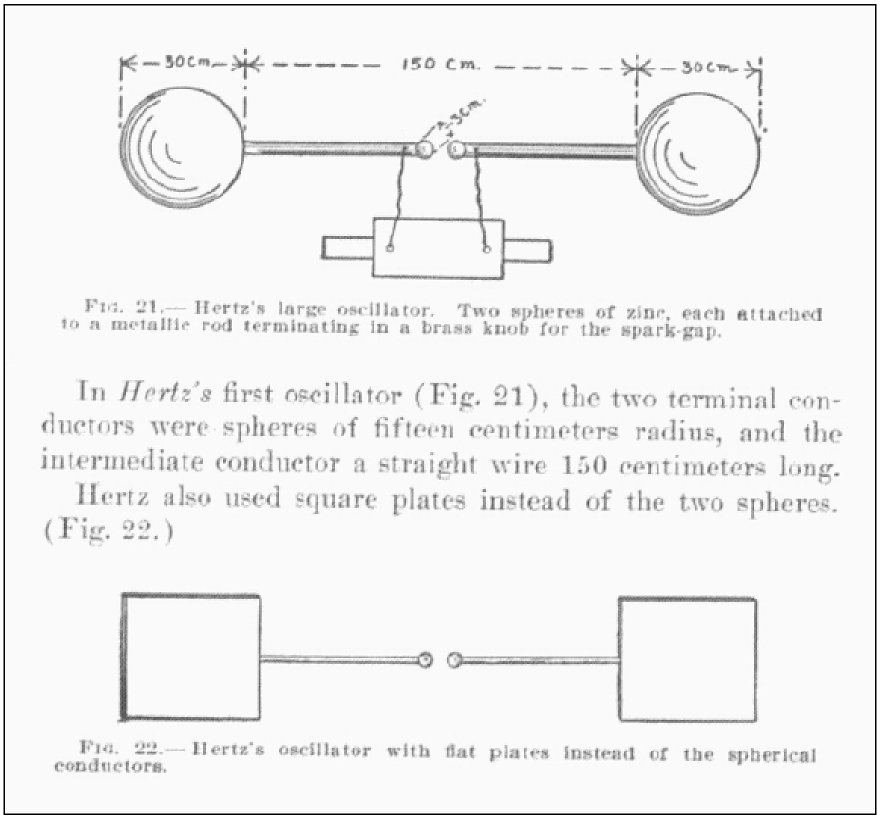

Fig. 21.— Hertz's large oscillator. Two spheres of zinc, each attached to a metallic rod terminating in a brass knob for the spark-gap.

In *Hertz's* first oscillator (Fig. 21), the two terminal conductors were spheres of fifteen centimeters radius, and the intermediate conductor a straight wire 150 centimeters long. Hertz also used square plates instead of the two spheres. (Fig. 22.)

Fig. 22.— Hertz's oscillator with flat plates instead of the spherical conductors.

Only a few items were needed to produce electromagnetic waves via spark: a battery, a spark induction coil, two metal spheres closely spaced, and larger spheres or metal plates attached by wires back to the air gap. When the energy built up to sufficiently large levels that the natural resistance of air was overcome, a spark would jump across the air gap, thereby generating the electromagnetic wave into open space.

Figure 2.2 – Hertz's Resonator. The receiving side of Hertz's devices was even simpler in design. The resonator, also sometimes referred to as a wave-detector, was merely a piece of wire bent into a circle, with a small air gap in it. The energy emanating from the radiating wave train collected on the resonator wire, and would jump across the air gap of the resonator without any further need of an energy source or other devices on the detection side of the system. The detection wire loop could be either open or closed. A closed resonator was useful for exact measurements of the air gap. The small size of the resonator closely resembles modern day TV receiving antennas at UHF frequencies.[5]

FIG. 27.— A closed resonator as used by Hertz. M is a micrometer screw for measuring the length of the induced spark.

Figure 2.3 – Hertz's Ultra-High Work and Early Parabola Antennas. At one point, Hertz even made a "small oscillator", which was merely composed of two spheres attached to very radiating small wires. It operated around 500,000,000 vibrations per second, somewhat above today's amateur 432 MHz band. Hertz then made a parabolic device that produced waves possibly as high as 500 Mc to 1 GHz. He used a parabolic mirror of zinc with the radiating wire and spark gap placed at the focal point. Described as a "parabolic projector or reflector", the arrangement was thought at the time to generate a parallel beam of electrical radiation similar to a luminous line of light.[6] This advancement on the basic spark gap generators and resonators demonstrated to Hertz that electromagnetic waves obeyed the laws of optics. In later experiments, Hertz would even show wave interference, reflection, and refraction.

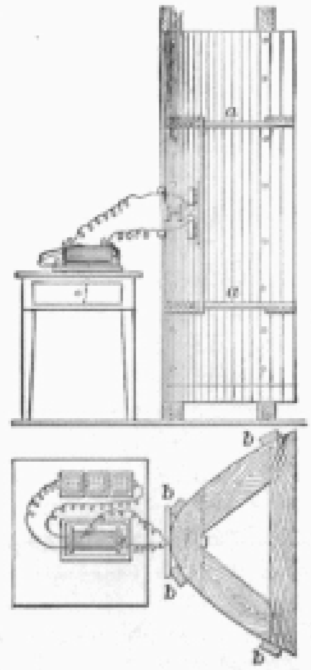

FIG. 44.— Hertz's apparatus for concentrating the radiations of an oscillator by means of a parabolic mirror of zinc. (From "Electric Waves," Eng. Trans.)

Subsequent to Hertz's experiments in the ultra-high range, other researchers generated spark transmissions at even higher frequencies. Professor Righi immersed a spark gap in oil to generate oscillations at 3,000,000,000 vibrations per second (3 GHz). He then decreased the size of the spheres, and obtained oscillations four times as rapid. Professor Jagadis Chunder Bose used three platinum spheres placed in a small box. Platinum was used instead of brass to prevent the spheres from quickly deteriorating. He produced spark radiations at an incredible wavelength of six millimeters (somewhere around today's 50 GHz). Bose commented that he was then within 13 octaves of visible light.[7]

After these early experiments, use of the ultra-highs generally receded into the background for many years while widespread radio experimentation and activity commenced in the neighborhood of 200 meters. The history of early radio is so fascinating, however, that a very short rendition of events up to 1924 is warranted here as a backdrop to VHF and UHF activities yet to come.

By late in the 19th century, wire telegraphy had been fully developed for railroad and general commercial communication use. But, non-induction types of telegraphy were still thought to be fanciful, especially since Hertz's apparatus was not capable of detecting or radiating waves over practical distances. Wireless was thus considered useful only for demonstration and experimental purposes. Many of these demonstration projects immeasurably advanced the knowledge of electromagnetic waves, however. For instance, in 1890, Edouard Branly developed a device called a coherer, composed of metal filings inserted into a glass tube.

Figure 2.4 – An Early Coherer. Branly attached a galvanometer in series between the coherer and a battery source to measure current flow through the coherer. Resistance of the circuit was lowered, and the current was increased, whenever the coherer was exposed to Hertzian waves, and this resulted in a greater deflection in the galvanometer. Far greater resonator sensitivity was achieved than through Hertz's resonator wire loop, but the coherer was often unreliable. [8]

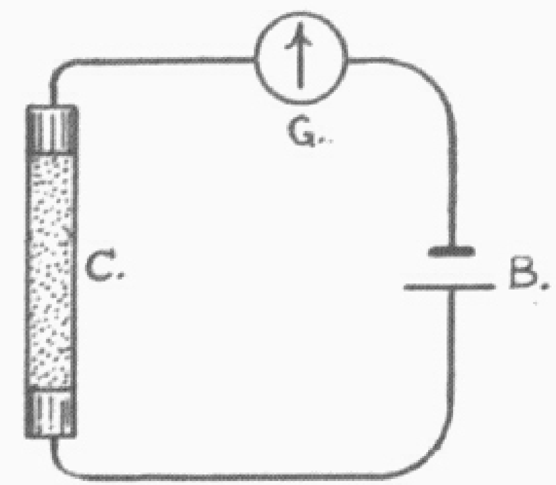

Fig. 33.—Early form of filings coherer, C, with galvanometer G and battery B.

In addition to Branly's coherer, other wireless experiments were proving equally fruitful. A British physicist,William Crookes may have been the first person to contemplate the usefulness of spark gaps, when he wrote in 1892 that electrical vibrations sent through the "ether" of space could deliver messages. Nikola Tesla in 1893 conducted possibly the first public demonstration of radiating wave transmissions using a spark transmitter and a tube detector.[9]

Sir Oliver Lodge independently determined the existence of electromagnetic waves at the same time as Hertz, but Lodge's efforts had not been finalized when Hertz published his findings. Lodge presented his own conclusions to the British Association in 1888. Lodge initially generated waves by direct discharges from leyden jars, instead of an induction coil attached to a leyden jar. He measured the radiating waves with a set of long wires, a precursor to today's open wire transmission line. The wires were almost 100 feet long, putting the transmissions at around 5 Mc. Lodge generated and detected the waves, but did not actually transmit them into space. Lodge then delivered a series of important lectures on Hertz and other early wireless pioneers. He popularized Branly's coherer, making several important improvements to it, and increasing its sensitivity. Lodge was the one who actually named the device a "coherer", because it made the wireless signals "coherent". By 1894, Lodge had extended the range of Hertz's experiments to around one hundred yards. Lodge received a British patent in 1897 and a US patent the following year for a wireless telegraphy system having more persistent oscillations.

At the University of Calcutta, J.C. Bose developed the wageguide horn antenna in 1897, using it at microwave wavelengths. William Conrad Roentgen, a professor of Physics at the University of Wurtzburg, discovered X rays while experimenting with vacuum tubes. Roentgen demonstrated that these rays passed though materials and set up florescence in certain crystals. The unit of measurement of exposure to X rays is today known as the "Roentgen".

Alexander Popov (also spelled Popoff), a Russian university professor, then adapted a coherer to detect distant lightning discharges. By 1896, Popov displayed a radiating and resonating wireless system before a meeting of the Russian Physical and Chemical Society gathered at St. Petersburg. He transmitted the message "Heinrich Hertz" a distance of 800 feet between two campus buildings. Of great importance in the development of wire antennas, Popov may have been the first person to take one end of the coherer to ground and the other end to a vertical wire.[10] The range of transmission was increased to 1,800 feet by Popov's activities. Soon thereafter, many experimenters were constructing huge receiving antennas.

The perception that wireless wasn't overly useful started to change when a young Italian student of Professor Augusto Righi, Guglielmo Marconi assembled together many pieces of various electromagnetic devices. Initially experimenting in 1895 at his father's estate in Pontecchio Bologna, Italy, he moved his equipment in 1896 to Salisbury Plain, England after failing to secure financial support from the Italian government. Along the way, Marconi made many strides in wireless communications. He improved the reliability of Branly's coherer, was one of the first to connect antenna wires and ground terminals to his sending devices, and may have been the first to attach a telegraph key to the sending side of the apparatus. In so doing, Marconi was able to extend the range of wireless messages over considerably longer distances.[11] Marconi received British patent no. 12039, on June 2, 1896 for a system of wireless telegraphy, and this was the first patent to issue by any government for a radiating wave wireless device. In 1897, Marconi founded the Wireless Telegraph and Signal Company.

In some of his earliest experiments while still in Italy, Marconi utilized the ultra-high frequencies. For oscillations, Marconi utilized a Righi oscillator, and like Hertz, placed the air gap into the focal line of a parabola reflector of zinc (or possibly copper). Within a short time, he had increased transmission and reception to over 2 miles, using very short wavelengths of only a foot or so. In 1897, Marconi sent and received modulated microwave signals over a 4 miles path, in a demonstration forth he British Post Office.

Marconi quickly experienced difficulties with interference from obstacles, however. "A few buildings and a small hill" were sufficient to cut-off the wave "quite effectively". In order to overcome this problem, Marconi began experimenting with larger capacity plates. He may not have realized initially that the larger plates were effectively increasing the wavelength of the devices. Later, Marconi added long vertical antenna wires and ground to the sender, which also was used to increase the wavelength. Thus, Marconi may have unwittingly moved to lower frequencies largely to avoid what today is known as microwave absorption characteristics. Marconi may have been one of the first, if not the first person, to have actually observed and experienced absorption tendencies at ultra-high frequencies.[12]

In 1898, Marconi came to the US, where he demonstrated for the US Navy telegraph links between Navy cruisers in New York and Massachusetts. In an early display of news and entertainment coverage, Marconi, John G. Pickard, and Lee de Forest, all separately covered the American Cup race in 1898 using wireless equipment. The next year, Marconi sent the first wireless telegraph message across the English Channel. Marconi's company name was changed in 1900 to the Marconi Wireless Telegraph Company. [13] On April 26, 1900, Marconi was granted US Patent No. 7777 for a tuned or synchronized system of wireless.

Professor Adolf Slaby of Germany observed Marconi's English Channel tests at Bristol in 1897, went home to Germany, and then promptly produced an improved method of coupling the transmitter to the antenna. Additionally, Slaby and Count Arco (or D'Arco) used capacitors for tuning both the transmitter and detector to a resonant length of antenna wire. Scientist Ferdinand Braun researched both conductive and radiating transmitting systems at the request of commercial interests looking into the feasibility of developing practical communication systems. From this research, Braun developed inductive coupling between a radiating transmitter and antenna. This was considered a major improvement over the common practice of connecting the antenna directly to the spark oscillator. Braun patented the coupler, which effectively eliminated the monopoly Marconi had achieved in transmitting circuitry.[14] Braun also invented the oscilloscope, constructed the first cathode ray tube, and invented several other wireless related items, including crystal rectification of electricity as far back as 1874, and rectification of radio signals by the late 1890's.

Around the same time, several other people improved upon the coherer by reducing its sluggishness of response. Dubbed auto-coherers or anti-coherers, the devices were often used in conjunction with telephone receivers to obtain better detector performance. In one ingenious experiment, a relay controlled by an auto-coherer operated a primary circuit of another spark oscillator, thereby automatically re-sending an incoming transmission to the coherer. This may have been the first wireless repeater ever established, having pre-dated VHF FM repeaters by some 70 years.[15] Other experiments eliminated the use of the coherer altogether for detection purposes – Marconi designed an inductively based magnetic detector, de Forest used an electrolytic responder, and a Canadian university professor, Reginald Fessenden developed liquid and hot-wire barraters. Fessenden tested many of these devices, and found them to have greater sensitivity than most coherers.[16] In particular, the barrater was used successfully in commercial services, and essentially was an electrolytic detector with a very fine platinum wire touching a diluted solution of acid. It gradually replaced the coherer in many receiving applications, since it could be up to 500 times as sensitive as a coherer as well as providing instantaneous action. Still other detectors were attempted: needles or fine wires placed across microphone elements, water placed between carbon surfaces, coal placed between brass plates, corroded steel being touched lightly by springs and wires, tantalum wires making contacts to mercury, and even flames used to heat closed spaced metal disks that were charged with electricity.[17]

In addition to Braun and several other notable researchers active in the field, J. J. Thomson, the head of the experimental physics program at Cambridge University, was involved in theoretical research of electricity. He discovered and identified units of electrical current, known as electrons, in cathode rays. Thomson believed that these units were a fundamental part of all matter. He formally suggested that the negatively charged subatomic particles, electrons, were embedded in a sphere of positive electricity, and that the two charges neutralized each other. Thomson's findings not only were critically important to electricity, they quickly revolutionized the entire field of physics. Thompson won the Nobel Prize in 1906. [18]

Numerous individuals became immensely curious about the scientific experiments then underway. Very simple receiving loops were set up in many residential neighborhoods along coastal areas of the US to listen in on wireless activities from military vessels. Merchant ship wireless sets and even some land-based commercial transmitters then appeared. Listening stations began to hear farther distances. Atmospheric noise and static crashes became a much talked about phenomenon. In January of 1898, British Leslie Miller published an article in the British hobby magazine "The Model Engineer and Amateur Electrician", encouraging experimenters in the new field of "Wireless". [19] The first US construction article of a wireless device appeared in the "American Electrician" magazine in July 1899, and this article was eagerly sought out by wireless experimenters starving for information on how to build a wireless. Other construction articles also appeared over the next few years.[20]

The feverish pace of wireless experimentation by academics and experimenters alike was not lost on the Navies of the world. Captain Henry Jackson of the British Royal Navy conducted wireless tests as early as 1895. Jackson and Marconi engaged in joint tests of wireless devices at sea, and Jackson had developed a practical wireless transmitter only a few months after Marconi. Following up on the earlier Marconi tests aboard military vessels, the US Navy in 1899 established coastal wireless stations and placed wireless equipment on it some of its ships. At the same time, Popov equipped the Russian navy cruiser Africa with his wireless communications apparatus for ship-to-shore communications, and the Russian battleship General-Admiral Apraksin was assisted in the Gulf of Finland by a distress call relayed by Popov's radio system.[21] Wireless telegraphy was employed by the US Army Signal Corps in 1898, and one of the first military wireless circuits was a 100 mile link across Norton Sound to Nome, Alaska. Commercial vessels started to adopt wireless practices, too. After being rammed by a freighter, the East Goodwin Sands Lightship sent on March 3rd, 1899 the first recorded maritime radio request for help. It was then quite common to use 500 kHz (at the bottom of the current AM broadcast band) as the international distress frequency, and many commercial and military interests routinely monitored this frequency.

A most amazing radio contact occurred on Dec. 12, 1901. On that date, Marconi bridged the Atlantic Ocean with a two thousand mile radio signal sent from Poldhu in Cornwall, England by John Ambrose Fleming and received in St. John's, Newfoundland by Marconi, himself. Marconi had received the letter "S" three times, possibly using an auto-coherer and telephone diaphragm acting as a receiving detector.[22] On the transmitting side of the exchange, a four tower circular array was used some 200 feet tall, with the spark transmitter having 18 kw of power and centered at 500 meters. Marconi's notes recorded the event simply as: "Sigs at 12.20, 1.10 & 2.20". The international press extensively covered and heralded the event, and the world was mesmerized by the feat.

As a result of Marconi's accomplishment, and the reaction of the popular press to it, individual "wireless" stations emerged throughout the world. Technically oriented individuals started to construct wireless transmitting devices. Hundreds of very small spark gap coils popped up, and neighborhood listening stations began transmitting. The era of radio "experimenters" had begun.[23]

In the US, individual usage and experimentation of wireless was quite common but was unregulated, while in the UK wireless telegraphy for experimental purposes was specifically provided for by law.[24] Notations of "amateur" radio however, would not be common until later in the decade. The first such reference to an "amateur" may have been in 1908 in a book entitled "Wireless Telegraphy for Amateurs".[25] And the term "wireless" was a natural extension of a telegraph without wires. "Radio", as a descriptive term, also did not come into common usage until later on. At the 1906 Berlin Convention, radio was thought to be more appropriate than "wireless", as radio was an abbreviation for "electromagnetic radiation".[26] The term may have also been derived however from the Latin word "radius", meaning ray or beam of light. The operating procedures and codes of early telegraph operators carried over to wireless transmissions. Indeed, many wireless operators came from the burgeoning telegraph industry. [27] Many people were operating their own private telegraph lines by this time, and they yearned to expand their operation without stringing new wires. Wireless telegraph provided a ready means of doing so.

Commercial interests flooded into the rapidly emerging wireless and telephone industries as well as the area electric power generation. Marconi's company was quickly developing or buying patents for numerous radio devices. Nikola Tesla formed an association with Westinghouse for the distribution of an alternating current (AC) electrical system. Edison favored his own direct current electrical system, and engaged in an intense rivalry with Tesla and his AC systems. Edison lost out to Tesla's group in a bid to supply Niagara Falls with hydroelectric power generation. Edison's company, General Electric, eventually moved to AC power distribution through a license with Tesla. GE then proceeded to build an AC distribution system between the Niagara Falls Powerhouse and Buffalo, NY. Meanwhile, Westinghouse went on to build seven more generating units within quick order, allowing it to establish a major position in the electrical generation industry. Alexander Graham Bell's companies, including Bell Telephone and American Telephone and Telegraph (AT&T), had a monopoly on many aspects of the telephone until his basic telephone patent expired in 1894. Even afterwards, Bell's companies controlled many aspects of telephone communications. Telefunken of Germany formed in 1903, utilizing various wireless patents of Braun, Slaby and Count D'Arco. It quickly built itself into a formidable presence in Europe and was considered to the primary worldwide competitor of the Marconi Company. In the US, Lee de Forest started his own wireless company, and was the first to use high AC voltages for spark discharges. In a few years, United Wireless would develop into the first "wireless trust". [28]

All of this commercial activity produced numerous patent infringement lawsuits. Virtually every company in the wireless field as well as many individual wireless inventors were embroiled in patent litigation. Tesla and Marconi were involved in one famous lawsuit that didn't end until a US Supreme Court ruling in 1943 invalidated one of Marconi's patents. Ironically, Marconi had died several years before, and Tesla died in the same year as the last ruling in the matter. Armstrong and de Forest were also extensively involved in litigation that went to the Supreme Court twice. The Court ruled against Armstrong on a regenerative patent, but subsequent to the ruling, many professional radio engineers and societies still credited Armstrong as being the inventor of the regenerative receiver. These decisions as well as several other patent cases financially exhausted Armstrong.[29] The patent wars were so involved that the Marconi and de Forest companies even ran competing ads in amateur publications in the 1920's, warning the readers of their claims to tube patents.[30]

Spark gap transmissions weren't the only means by which electromagnetic radiating waves could be generated. High-speed alternators producing radiating waves were proposed as early as 1891, and were in actual use by the late 1890's. Speech was transmitted via an early form of electric arc as far back as 1897.[31] In 1900 or 1901 (and possibly, as early as 1897), Fessenden attempted speech transmissions via spark between Cobb Island, Maryland and Arlington, Virginia in an experiment for the US Department of Agriculture. Fessenden's wife described the resulting transmission as "an extremely loud and disagreeable noise". He also sent music transmissions to pleasure boats on the St. Lawrence River. High-speed alternators were used to produce radiating waves of a continuous nature that then allowed for voice and music transmissions. These efforts by Fessenden were likely the first transmissions of continuous waves. The next year in 1902, Valdemar Poulsen developed a device known as an arc generator to also produce continuous waves.[32] Alternators were more refined in many ways than arc generators, but they could only be used for long wavelengths, whereas an arc could produce radiating waves into the short wavelengths. Alternators therefore supplemented spark gap in the longer wavelengths, and in future years, arc generators would be extensively used at both long and short wavelengths. It would only be with the advent of improved tube technology that high-speed alternators and arc generators were eclipsed. [33]

In 1902, Marconi observed that signals transmitted between two stations were much stronger at night than during the day. Many others were also aware by this time that transmissions could travel far beyond a straight-line path. Since Newton's *Optics* and then Thomas Young's wave theory of light, it had been widely accepted that light traveled in waves of straight lines, or as waves of concentric circles expanding outward in straight planes. Maxwell theorized, and Hertz then proved, that electromagnetic waves were identical to light waves. Scholars at the turn of the century were genuinely puzzled as to why radiating waves could obviously bend around the earth in some fashion and not be limited to straight-line wave paths, as was the case with light. No obvious explanation was readily apparent for the phenomenon being observed, but several theories were advanced. One of these theories concerned the possibility of atmospheric reflection of wireless transmissions. Arthur Edwin Kennelley (or Kennelly), a professor at Harvard University, and physicist Oliver Heaviside in England, separately identified the layer of the atmosphere known as the ionosphere. This layer of air was thought to impact the propagation of radiating waves, being something like a "mirror in the sky" that could reflect radio waves back to earth. Known for many years thereafter as the Kennelley-Heaviside layer, the discovery served as the foundation for future radio propagation studies. [34]

Transmitter sets were quickly established in many areas along the Atlantic seaboard. By Christmas, 1902, the US Navy had two land stations in operation, one at Annapolis and the other at the Washington Naval Yard. Lee de Forest installed both stations. Fessenden's company, National Electric Signalling, built three experimental land-based transmitting stations at Old Point Comfort, Cape Charles, and Ocean View in the Chesapeake Bay area. In 1903, the Navy installed a dozen German built Slaby-Arco sets for their Atlantic Fleet and established six more experimental stations on land. The Marconi South Wellfleet station at Cape Cod, Massachusetts was completed in January, 1903. Wireless sets were becoming more powerful, as evidenced by Marconi himself, when he sent a message from South Wellfleet, expecting have it relayed to England through a Marconi station at Glace Bay, Canada. Much to everyone' surprise, acknowledgement of the message came directly from Poldhu, England. Inspired by this event, further expansions of the Marconi wireless stations occurred along both the Atlantic and Pacific coasts. By 1904, the Navy has developed 20 shore stations, ten more under construction, and wanted 50 more. 24 battleships by then carried wireless sets, and plans called for 68 additional ships to be outfitted with transmitters. Fesseden built a new station in 1905 at Brant Rock, Massachussets with an innovative antenna design. In 1906, a station in Scotland with a similar antenna exchanged wireless signals with Brant Rock.

The earliest international conference on wireless telegraphy was the Berlin Conference, sponsored by Germany in 1903. The Conference produced a "Final Protocol" for governments of participating countries to review, but no concrete regulations aside from the international distress signal CQD emerged from the gathering. A matter left unresolved at the Conference was the extent and type of communication that could be developed between telegraphy stations of different commercial companies. In the US, President Theodore Roosevelt established a board to coordinate government radio activities. Up until that time, the Navy, the Army Signal Corps, and the Department of Agriculture all had wireless stations with little coordination between them. The Roosevelt Report in 1904 proposed oversight responsibilities for government wireless stations be vested with the Navy, and significant restrictions were recommended for commercial interests. Experimental stations were not extensively dealt with in the report.

Spark gap transmitters were the norm for the era. Many commercial and individual stations simply used untuned plain spark transmissions, and this produced a signal over considerable wavelengths. Some experimental wireless operators were using rotary gaps by this time, which was invented in 1905 by Fessenden. A rotary proved to be a big jump in transmitting ability, as it produced a clean high note that broke through static noise more effectively than a fixed spark gap. Additionally, transmissions could be tuned to some extent through variable inductance coils and loose inductive coupling to the antenna, thereby producing output generally at one wavelength. Later, synchronous rotary gaps, and quenched gap techniques came along to also improve wireless transmissions. Inexpensive wireless equipment and parts were becoming available to experimenters through catalogs, and some of the systems offered were surprisingly sophisticated for the time. [35]

Loose coupling greatly advanced the receiving side of a wireless set. Composed of two cylindrical coils with one being able to slide inside the other, loose couplers provided greater detection and tuning abilities than anything else devised to that time. Another receiving advance occurred when John Ambrose Fleming used the Edison effect to devise a two element "Fleming Valve". This device was the first vacuum tube diode detector, and was made out of an Edison light bulb with a metal plate inserted into it. Detector technology again advanced when Lee de Forest invented the audion, a three-element vacuum tube, in 1905, although it would take several years before these new tubes would be reliable enough for radio communications.

(a picture of a loose coupler?; how about the cover of the 25th anniversary QST?)

While vacuum tubes were slow in developing, crystals quickly became a standard means of detecting wireless signals. Braun previously realized that crystals generated one-way rectification and conduction of electricity. By the late 1890's, Braun had replaced a coherer with one of his crystals to see if one-way rectification would also work in wireless circuits. It did, and experimentation by many other researchers then commenced. By 1904, J.C. Bose had used a lead sulfide crystal for receiver detection. Shortly thereafter, additional crystal detectors were designed by Henry H.C. Dunwoody (carborundum) and by G.W. Pickard (silicon). In 1907, Pickard exhaustively studied the rectification abilities of over 30,000 materials, and found that many items, including galena, germanium, iron pyrite, and various lead and cadmium sulfides could be used for the detection of radiating waves. Crystal receivers were powered entirely by the radio waves emanating from the spark gap transmitter, and hence, no energy source was needed at the receiving end. Crystals proved to be very popular with experimenters, and inexpensive as well. Crystal receivers could readily discern telegraphy (which could not be done through telephone diaphragms alone), and many crystal detectors could easily separate numerous transmitters from each other. Crystals therefore represented a gigantic leap in receiving ability over all previous receiving methods, including galvanometer and ammeter readings, Hertz's spark gap receiving loops, Branly's and Lodge's coherers, telephone receiver diaphragms, electrolytic detectors, and even loose coupling. Crystal detectors were extensively used until after WWI when vacuum tubes became more reliable, as they allowed for a cheap and dependable means of detecting noth voice and code transmissions.

No radio law yet existed. The closest thing to regulation of the airwaves was the 1906 Berlin Convention, which principally dealt with unresolved issues left over from the 1903 Conference. Even though US representatives attended the Convention, the US Senate did not sign ratify the Convention's agreement until 1912, when the US enacted it's own radio law. The Berlin Conference is also noted for being the first international meeting that adopted the use of "radio" as the term to describe communication through space without the use of wires. Up until that time, and even for many years thereafter, "wireless" was commonly used to describe communication by electromagnetic means.

The US Navy issued "certificates of proficiency" to commercial and individual radio operators, but there was certainly no requirement to obtain one. The dominant belief then existing was that everyone had the right to use the airwaves. As a result, the Navy, commercial services, and private experimental stations regularly communicated with each other, and often caused interference to each when communicating to others. An estimated 150 wireless spark gap transmitters were in use by 1905, many of which were concentrated along the nation's northeastern seaboard.[36] Conflicts and interference became intolerable for all concerned, since spark gaps were, in effect, very crude 'all-wave' emitters of radio noise.[37]

On Christmas Eve, 1906, Reginald Fessenden demonstrated voice transmissions to astonished spark gap ship operators after he inserted a carbon telephone transmitter into the field windings of an Alexanderson alternator in a shore telegraph at Brant Rock, Mass. Military and commercial operators heard Fessenden's music and voice transmissions hundreds of miles at sea. Experimental stations on shore also heard the transmissions, and the event may have been the first voice communication received by non-commercial wireless experimenters.[38] Interestingly, Fessenden initially had intended to transmit the voice message to Scotland, but the receiving antennas there had been damaged by a storm. So, he improvised, and sent the voice and music transmissions to any ships who were within range. Just as important as the display of telephony was the relative ease in producing modulation (AM) and continuous wave transmissions.[39]

Other interesting activities in this time period included Marconi's discovery of directive properties in horizontal antennas, and the introduction of a wonderful device, the Vibroplex Keyer. On a startling note, a photo of King Edward VII was the first newspaper wire photo transmitted by wireless telegraph. It took 12 minutes to send from Paris, and was published in the London Daily Mirror. Wireless was making such a huge impact on people's everyday lives, and the technological advances were so astonishing in scope, that Marconi and Ferdinand Braun shared the Nobel Prize in Physics in 1909.

To many people within the federal government and among some commercial interests, individual wireless operators and experimenters were viewed as a problem and general nuisance. The government's problem was growing, too, as the number of wireless enthusiasts was rapidly increasing. In 1909, the first local amateur radio club was formed, as the Junior Wireless Club, Limited, of New York City. It was composed of five youths. The club later changed its name to the Radio Club of America, and ultimately became a very important place of experimentation and electronic research. By the next year, ninety amateur stations in 21 states were listed in the *Wireless Blue Book,* published by *Modern Electrics*. Wavelengths of operation varied between 32 to 950 meters.[40] Many large cities sported wireless clubs by 1910, and the number of amateur stations actually in operation may have been as high as 4,000 by 1910.[41] Chicago alone had an estimated 800 wireless amateur stations. The Wireless Association of America claimed at one point some 3,000 members. The explosion of radio clubs and associations led to a dominance of the airwaves by unregulated wireless experimenters: amateurs may have comprised 80% of all high-powered stations then on the air.

The amateur's knowledge of wireless technology was growing, too. In 1908, the first radio handbook was published, entitled *Wireless Telegraph Construction for Amateurs,* and other books were also appearing.[42] In addition to running a radio catalogue, Hugo Gernsback started three magazines having significant interest to radio experimenters, including *Modern Electrics* in 1908, *The Electrical Experimenter* in 1913, and *Radio Amateur News* in 1919. Armed with this sudden access to printed material on radios (as opposed to there being almost no available reading material just a few years earlier at the turn of the century), many amateurs built more powerful and better-equipped stations than either the Navy or commercial services, and amateurs were often more capable of radio operations.[43]

It was in this era that the term "ham" came into use. Possibly originated by commercial operators irritated at interference from some wireless experimenters, "ham" was initially meant as a derogatory reference to unskilled operators. Gradually, the reference lost its negative connotation, and became more accepted as a friendly description of amateur wireless hobbyists.[44] Radio clubs exploded in popularity by 1908, and experimenters had turned into amateur hobbyists, or "hams".

And the early usage of "cw" was meant as an abbreviation for "continuous waves", and not an abbreviation for telegraphic code transmissions. A continuous wave, or cw, was quite useful in those days for telephony experiments, while spark gaps generated most of the amateur radio telegraphic signals. As knowledge of vacuum tubes progressed, continuous waves would be used for both telegraphy and telephony. It would only be thereafter that "cw" would become a quick abbreviation for code transmissions, while "AM" or "telephony" would be refer to for phone work.

Technological advances were continuing to occur at a rapid pace. Fessenden invented the heterodyne radio receiver in 1905, in addition to continuing experiments with voice transmissions. The principle of heterodyning represented a fundamental advance in the development of radios, and "superhets" (an advanced version of the heterodyne invented by Armstrong in 1912) eventually would become the standard method of radio reception that is still in use today. De Forest conducted telephony experiments between buildings in New York in 1907, with a sizable amateur following listening in. He then installed wireless telephones aboard a private yacht in Lake Erie. The Navy was so impressed that it began putting de Forest equipment in its fleet. Thereupon, the US Fleet cruised around the world with 20 de Forest radio telephones aboard the ships. In 1908, de Forest, sent telephony messages from the Eiffel Tower to Marsailles, some 500 miles away. Three years later, he would broadcast a Met opera performance in NY.[45]

Starting in 1909, several unsuccessful attempts were made by some commercial interests (in particular, United Wireless) and the US Navy to prohibit amateur radio activities. For instance, a bill was introduced in the US Congress in 1910 that would have completely prohibited all amateur experimentation. After actually being passed by the Senate, the bill died in the House, through the active opposition from the Junior Wireless Club, other amateur groups, and even the Marconi Company, who was interested in furthering sales of radio equipment to amateurs. A bill was enacted into law in 1910 requiring certain commercial vessels to have wireless sets and operators on board. Voluminous Congressional testimony had been taken over the next two years concerning wireless transmissions, and a bills were pending on allowing the government to regulate the airwaves. By early 1912, it became evident that some type of national legislation on radio communication was going to be passed, as numerous commercial and military interests were pressing for varying and competing proposals.

On April 15, 1912, the wireless operators of the RMS Titanic telegraphed the following message to all vessels: “Ran into iceberg. Sinking fast”. The newly adopted Morse code abbreviation for an emergency, SOS, was used by two Marconi Company operators on the Titanic, but CQD (Come Quick Danger) also was used, owing to the fact that several versions of telegraphic code were then in common use.[46] Several ships changed course to come to the rescue, but were too far away. Other nearby vessels sailed past, oblivious to the situation. They had closed down their wireless rooms for the night after the operator went to bed. Within two hours, the Titanic had sunk in international waters. By morning, the Carpathia arrived on the scene and rescued the survivors in rafts. The body of Jack Phillips, the Titanic’s chief radio operator had been taken from one of the rafts to the Carpathia. He died after freezing waters swept him into the ocean as the Titanic was sinking beneath the waves.

David Sarnoff, then a 21 year old radio operator for Marconi, was in the wireless room at the Wanamaker store in New York when he heard the first faint messages about the disaster from the “Olympic”, the sister ship of the Titanic. For three straight days, he copied the reports and handled sea traffic, receiving every survivor’s name over the wireless. The White Star Line, owner of the Titanic, was insisting that everyone on the Titanic were safe. Meanwhile, Marconi himself ordered radio silence of all Marconi ship operators, since he had quickly arranged an agreement with the NY Times for an exclusive story. When reporters noted Sarnoff’s messages to the owners of the ship, they finally acknowledged the tragedy. Sarnoff became a local legend for his efforts. One of the final telegraph messages handled by several wireless operators read: “700 saved; 1500 lost”.

(picture of the memorial fountain at the end of Manhatten Island?)

The events surrounding the sinking of the Titanic demonstrated the need for national and international radio laws. Many calls went out to regulate and standardize radio transmissions and traffic handling, as the lack of radio coordination hampered efforts to rescue Titanic survivors. Some amateur operators in the New York area were also blamed for causing interference to the rescue efforts. Several years later however, this claim would be disputed in a book covering the Titanic disaster, where it was noted that amateurs strictly observed a radio silence to avoid interfering with the survivor lists being transmitted by other ships.[47] Some of the legislative proposals swirling about included severe restrictions or the complete elimination of amateur activities altogether.

The future of amateur radio hung in the balance.

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[1] An excellent review of Hughes' work, including circuit diagrams and photos of the original equipment is located on-line at: http://earlyradiohistory.us/index.html, United States Early Radio History, Thomas H. White, section 4. This on-line source also contains the 1899 letter written by Hughes shortly before his death that summarized his experiments.

[2] As early as 1843, Henry noted several instances of wave effects. Henry even magnetized a needle from a secondary current with a spark discharge and a primary current some 220 feet away. At the time, Henry's experiments were thought to be extraordinary examples of induction. See, Polytechnic Review, March 25, 1843; US Early Radio History, http://earlyradiohistory.us/1899fah.htm, reciting from: *The History of Wireless Telegraphy*, J.J. Fahie, 1899, Appendix D, n.3; Fahie also mentions other experimenters who observed similar effects: "Telegraphic Journal", 2-15-1876, p.61; and "Electrician", vol. Xliii, p.204. Henry and others clearly observed oscillatory waves, but Maxwell's theories were not yet in place to explain the significance of the observations. It would remain for Hertz to prove Maxwell right.

[3] Hertz never developed his early research experiments into more reliable communication devices. He even denied the practicality of such endeavors. It would take the efforts of many others, including Marconi, to do that. See: Communication Systems and Technology, A Chronology of Communication Related Events, Part 1: 4004 BCE - 1899 AD, by R Victor Jones, for references to Hertz.

[4] Figure 2.1 is taken from *Maxwell's Theory and Wireless Telegraphy*, H. Poincare & Frederick K. Vreeland, McGraw Publ. 1904, at 34. Other texts also note Hertz's UHF activities. "The Conference, in Relation to Amateur Activities", *QST,* Prof. A.E. Kennelley, Dec. 1924, p.18-19; "Radio Translated for the Experimenter", C. William Rados, *QST,* April 1927, p. 9-12; "Our Early Heritage – A History of VHF", by Bill Tynan, W3XO, Proceedings of the 28th Conference of the Central States VHF Society, 1994, at 66-69.

[5] The picture is from *Maxwell's Theory and Wireless Telegraphy*, H. Poincare & Frederick K. Vreeland, McGraw Publ. 1904, p. 39.

[6] The picture is shown at p.75 of *Maxwell's Theory and Wireless Telegraphy*, H. Poincare & Frederick K. Vreeland, McGraw Publ. 1904; the description of the parabola device is at 74-77. The reference to the "small oscillator" is at p.85.

[7] For references to Righi's and Bose's oscillators, see, Poincare and Vreeland, at 85-90.

[8] Branly's coherer is detailed at Poincare and Vreeland, at 45-47.

[9] Tesla demonstrated his "four tuned circuits" wireless in front of the National Electric Association in St. Louis. See, "Faux Wireless", on-line site maintained by R. Victor Jones, http://people.deas.harvard.edu/~jones.htm. In the same year, he tested a small radio controlled powered boat on a lake at New York's Madison Square Gardens to astonished crowds.

[10] Popov wrote of his lightning discharge resonator in *Journal of Russian Physico-Chemical Society,* v.28-29, p.896, 1895.

[11] A review of Marconi's early experiments can be found at Poincare and Vreeland, at 130-140, and following, as well as *Maver's Wireless Telegraphy,* 1904, at 53-65. While in Italy, Marconi initially used a Righi oscillator, which was simply composed of two metal balls, around four inches in diameter and immersed in oil, that were connected to an induction coil. Marconi quickly developed vertical wires and ground for the oscillator. The receiver used a coherer with a tapper, along with a vertical wire and ground.

[12] Poincare and Vreeland, at 132-135 notes that Marconi's first patent issued in 1896 by the British government was based on a Righi oscillator placed in the focal line of a parabolic reflector, but that he quickly developed larger capacity plates for his sender, partly to increase the wavelength and reduce the interference from obstacles, such as buildings and a small hill.

[13] The excerpts on Marconi come from: Communication Systems and Technology, A Chronology of Communication Related Events, Part 1: 4004 BCE - 1899 AD, by R Victor Jones.

[14] From "Early Wireless: Marconi Was Not Alone", P. Kinzie, p. 13, *Arizona Antique,* available on-line.

[15] Auto-coherers are detailed at p.68-70 of *Maver's Wireless Telegraphy,* William Maver, 1904. The relaying or repeating system of M. Guarini is noted at Maver, p.101-104. Guarini used a system practically identical to Morse's earlier wire-based automatic relay, except that a spark induction coil and auto-coherer were added to the circuitry. This first wireless relay station was set up midway between Brussels and Antwerp before 1904.

[16] For a description of these various devices, see *Maver's Wireless Telegraphy,* at 144-159; for more details on electrolytic detectors, see, CQ, 4-59, at 42-43. Electrolytic detectors were interesting devices, as they were self-restoring, not limited in its receiving speed, and could receive telephony, which was another favorite activity of Fessenden. Id, at 43.

[17] See, "In the Beginning, Part III, CQ, 4-59, at 43, 110, for a more complete description of these types of detectors.

[18] Communication Systems and Technology, A Chronology of Communication Related Events, Part 1: 4004 BCE - 1899 AD, by R Victor Jones. Not only did Thompson win a Nobel Prize, but seven of his research assistants and his own son would eventually win Nobel prizes, as well. Thompson was a pre-eminent leader in the field of subatomic particles throughout the early 20th century. *Id.*

[19] From: USA Amateur Radio History And Licensing, Compiled By AC6V 1979-2000, available on-line at AC6V's web-site.

[20] The Nov. 1901 issue of *Amateur Work* included an article, "Hertzian Waves", for the construction of equipment similar to what Heinrich Hertz had used. Another popular article was "How to construct an Efficient Wireless Telegraph Apparatus at Small Cost", by A. Frederick Collins, Feb. 15, 1902 *Scientific American Supplement.* These and several other early articles are available at: United States Early Radio History, Thomas H. White, http://earlyradiohistory.us/index.html, sec.12.

[21] The episode with the Russian ship occurred sometime between 1899 and 1901. See, Communication Systems and Technology, A Chronology of Communication Related Events, Part 2: 1900 to present.

[22] See, Poincare & Vreeland, at 182-184. The auto-coherer used by Marconi may have been a Solari or Italian Navy coherer, invented or further developed by Sig. Castelli. Mercury was placed inside the coherer, enabling it to quickly regain its sensitivity after the electrical waves ended. A telephone was also placed into the circuit to increase the sensitivity. *Id.,* at 183.

[23] DeSoto considered 1900 to be rough beginning point of experimental amateur radio, stating that during the "first twelve years of its existence amateur radio flourished without regulation". *Id.* at p.28. He further commented that the glowing press reports of Marconi's 1901 Atlantic tests aided in the development of existing "amateur radio experimenters". Another source, however, puts the date at 1908, when by that time, amateur wireless operators and experimenters were considered to be part of a recognized hobby. See, "The History of Amateur Radio", The Wayback Machine #10, Bill Continelli, http://www.ham-shack.com. Desoto acknowledged the 1908 date, considering it to be a demarcation between individual experimentation and amateur-type of wireless work. Desoto, at 23.

[24] In the UK, the Postmaster General was empowered to license wireless experimenters, pursuant to the 1904 Wireless Telegraphy Act. Only around 50 experimenters then existed in England, and they were assigned specific wavelengths to use. CQ, 3-59, at 39.

[25] The *book Wireless Telegraphy for Amateurs*, was written by R.P. Howgrave-Graham. See, The Dawn of Amateur Radio in the U.K. and Greece: a Personal View, by Norman F. Joly. In the US, a mechanical and electrical hobbyist magazine, *Amateur Work,* existed as early as 1901, but even articles there only noted the activities of wireless operators, and not "amateur radio" operators.

[26] Additionally, the term "radio shack" may have originated with wooden rooms or shacks that were commonly assembled on the bridge of ships to house the wireless sets. From, United States Early Radio History, Thomas H. White, sec. 12.

[27] USA Amateur Radio History And Licensing, Compiled By AC6V 1979-2000.

[28] Many of the commercial related references have been taken from: United States Early Radio History, Thomas H. White, sec.6 and 7.

[29] Armstrong was unsuccessful in most of his patent litigation, and his efforts at FM band allocations had been frustrated over the years by competing commercial radio and TV interests, especially from RCA and Sarnoff. Sadly, Armstrong's brilliance as an electrical engineer gave way to the frailty's of his own psyche, and he took his own life in January 1954.

[30] The March 1920 *QST*, at p.78-79, contained ads for Marconi and de Forest tubes on consecutive pages, and both ads prominently featured patent numbers for their own tubes.

[31] Simon experimented with a singing or speaking arc to transmit speech. See, *Maver's Wireless Telegraphy,* at 139-140. William D. Duddell also found that an electric arc could generate continuous frequency electric energy. The 10,000 cycle oscillations of the arc generated the nickname "singing arc". CQ, July, 1959, at 47.

[32] A good rendition of both high-speed alternators and arc generators is located at "United States Early Radio History", Thomas H. White, sec. 8 & 9. Poulsen's arc generator was able to produce voice transmissions over large distances as early as 1904. See, CQ, 6-59, at 48.

[33] As late as 1921, commercial installations were using Alexanderson alternators and the Poulson arc generators for high power, long distance radio transmissions. The Army Signal Corp then estimated that 80% of all energy radiated into space for radio purposes was being generated by arc generators, excluding amateur stations from the calculations. Large amounts of space in Army training manuals were devoted to both the high-speed alternators and the arc. See, *The Principles Underlying Radio Communication*, Pamphlet No. 40, US Army Signal Corp, 2nd ed. 1921, at p. 396-419.

[34] Kennelley published his beliefs in "On the Elevation of the Electrically-Conducting Strata of the Earth's Atmosphere", *Electrical World and Engineer*", March 15, 1902, p.473.

[35] As early as 1904, Hugo Gernsback formed the Electro Importing Company, and offered entire wireless systems under the name of Telimco Wireless Telegraph Outfits. The first national ad for Telimco systems possibly appeared in the *Scientific American* issue of Nov. 25, 1905. From, United States Early Radio History, Thomas H. White, sec. 12.

[36] DeSoto estimated the number of "worthwhile" amateur types of stations in 1905 to be around 150, and up to 500 or 600 by 1910. The number of small spark coils in use may have been "several times that number", *200 Meters and Down,* at p.24.

[37] Many of the references to the early years of radio have also been taken from the 50th Anniversary issues of *QST,* published throughout 1964. See for example, "The Birth of A.R.R.L.", January 1964, p.68-74, for the reference to a tuned versus 'all-wave' conflict within the Hartford Ct. Radio Club in 1914, at 70.

[38] The ARRL considers Fesseden's Christmas Eve transmissions to be the first radio broadcast by voice. In 2006, the League celebrated the 100 year anniversary of the event.

[39] See, "Broadcast History", p.4, available on-line at http://www.oldradio.com/current/bc_roots.htm. Imagine the surprise of ship operators listening for the buzzing noises of spark transmissions only to hear a high-pitched, whining noise that clearly had voice and music content to it. At various points in the Brant Rock experiment, poetry and bible passages were read, and Fessenden himself serenaded with a violin!

[40] DeSoto, at 25. The Blue Book was a publication of the Wireless Association of America, which was formed in association with an early publication, *Modern Electrics.* Many of he bigger stations congregated between 300 meters to 1000 meters. Ship, government, and much of the commercial activity took place at these very long wavelengths. *Id*., at 27.

[41] DeSoto, at 29, adds that 300 stations were registered just with the Harvard Wireless Club at Boston, and there were several hundred more amateur stations in the New York, Washington, and Baltimore areas.

[42] Early books on wireless included: *Maver's Wireless Telegraphy,* William Maver, Jr, 1904; and *Maxwell's Theory & Wireless Telegraphy,* H. Poincare, 1904;

[43] DeSoto, at 28, describes many commercial operators at the time as "hapless" and their equipment "inadequate". He even indicates that the Navy possessed almost no tuners at the time for any of their radio receiving equipment.

[44] One operator, Earl C. Hawkins of Minneapolis, was even listed in the May, 1909 Wireless Registry of *Modern Electrics* with the callsign HAM. An interesting history of the term "ham" is contained in: United States Early Radio History, Thomas H. White, section 12.

[45] References to Fessenden and de forest are taken from CQ, "In the Beginning, Part IV", 6-59, at 47.

[46] Of note, the radio signal "SOS" was first used in 1909 when the ocean liner Slavonia sent a distress signal out to nearby steamers. SOS was part of the International, or Continental, Morse Code popular in Europe, while CQD came from the American Morse Code. Eventually, the International version of code became universally adopted, and the older, American version dropped out of normal use. Still another version was the Phillips Code, used by many excellent operators. This too gradually gave way to the International Morse Code.

[47] See, *The Book of Radio*, Charles William Taussig, 1922.

Chapter 3 - The Law Arrives

Experimental wireless stations, also known by this time as amateur radio stations, were considered by many in the US military and by some commercial operators to be a general nuisance to their own activities. Many foreign governments weren't fond of amateurs either, contending that the airwaves should be controlled and parceled out according to governmental interests. In spite of such attitudes, wireless stations continued to appear around the world. Technology was already proving difficult to bottle up for long, especially when many thousands of highly active experimenters were actively pushing that technology along, through continual improvement and innovation on their own wireless sets, as well as developing more advanced operating skills.

An international conference on radiotelegraphy was held in London, England. Known as the London Convention of 1912, wireless rules were established for commercial and shipping concerns. Congress had grown weary of contending with the competing and jostling claims to the airwaves without any resolution, so finally a law was passed that officially ratified the 1906 Berlin Convention. Described as the Radio Act of 1912, the new law also incorporated many provisions of the London Convention. One very important clause was added to the new law however that was not part of either the London or Berlin Conventions: Regulation Fifteenth prohibited private, non-commercial stations from using wavelengths above 200 meters, except by special permission.[1] Amateur radio was thus given an official legislative birth in the United States.

The thought behind Regulation Fifteenth was that if amateur experimentation could not be legislatively prohibited, then it could at least be highly restricted. The then prevalent radio theory held that the effectiveness of radio signals increased in direct proportion to a signal's wavelength. By giving amateurs the shorter wavelengths of 200 meters and down, while awarding the longer wavelengths to government and commercial sectors, amateur radio could be relegated to radio wavelength oblivion. Eventually, interest in wireless at the individual level would wither away. [2]

But interest did not wither away. It blossomed, instead. By the end of the first fiscal year of enforcement under the new Radio Act, 5,000 amateur stations were licensed, and there may have been 10,000 stations with equipment capable of covering five miles.[3] And while the new law mandated activity below 200 meters, many licensed amateurs as well as unlicensed experimenters and other individuals continued to operate above 200 meters, and with more than one kilowatt of power. So long as some decency was shown toward government and commercial stations, other regulatory matters were not overly critical.

The Bureau of Navigation of the Department of Commerce initially was given jurisdiction by the Congress over the regulation of airwaves in the US. The Bureau authorized and licensed amateur radio operators, and initially restricted amateur transmissions to a maximum power input of one kilowatt, and all spark gap transmissions now had to possess a damped wave with a decrement of 2%.

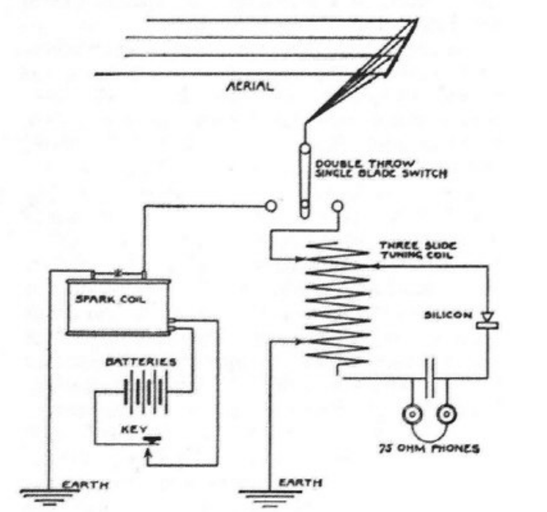
Before the Radio Act, amateurs simply made up their own calls. With the passage of the new law however, licenses and call signs were issued only after code requirements of 5 WPM and written exams were passed. [4] Skill Certificate #1 was awarded to a very interesting and well-known wireless operator, Irving Vermilya, who was given the call sign 1ZE. He operated into the 1950's, always with a very loud AM signal on the lower bands.

The commercial radio industry was then going through a severe shake-out. Many companies had been found to be either grossly inefficient or outright stock fraud schemes. For example, United Wireless, the first wireless "trust" possessing a near monopoly status, had been found guilty in 1912 of both massive stock fraud and large patent infringements. The American subsidiary of the Marconi Wireless Company then took over the assets of United Wireless, and with that, became the largest radio company in the US.

Radio advances were continually being made. The Audion tube had been improved upon by several engineers and scientists of the day, until it had achieved working practicality at reasonable cost - the original audion was both inherently unreliable and prohibitively expensive. In 1912 or 1913, Edwin H. Armstrong, while an undergraduate student at Columbia University, invented the regenerative receiver when he took an audion and used it to amplify a receiving signal through a tuned plate and grid circuit. Regeneration thereby transformed the audion from a simple detector into an amplifier of received signals, and this constituted a major advance in receiver technology. In 1914, a carrier wave had been combined with two sidebands to improve the quality of audio transmissions. Within a year, it was found that the carrier and one sideband could be suppressed without impairing the quality of the transmitted audio. The foundations of single sideband had thus been laid down by 1915. In the same year, American physicist Manson Benedicks realized that germanium crystals could convert alternating current into direct current. This discovery would lead to the development of the integrated circuit many years hence.

In an effort to aid the relaying of radio traffic among amateurs, the American Radio Relay League formed in May 1914 by Hiram Percy Maxim. In September 1914, the League published a map showing the location of 237 relay stations in 32 states and Canada. Over 400 stations were listed in the League's first List of Stations of October 1914. The second edition of the League's List of Stations, published in March 1915, contained 600 stations. The first issue of the *QST* began publication in December 1915. Other organizations were also promoting radio relays by this time. In 1915, Hugo Gernsback started the Radio League of America (RLA) in affiliation with *The Electrical Experimenter* magazine, and relays through this organization were scheduled soon thereafter.

Figure 3.1 - An Amateur Radio Station, circa 1914. This was a complete amateur radio station in 1914 – no tubes! Note the flat top aerial, the spark gap transmitter, and the silicon detector. Tubes were not overly common until after World War I. [5]



This a complete station diagram? Yes, indeed, in the era when the spark coil and crystal detector were supreme. From the *Wireless Age* of June, 1914.

War broke out in Europe in August 1914, and the operations of amateurs in England were prohibited through the Defence of the Realm Act of 1914. Canadian amateurs also went off the air in August 1914. In the US, amateur transmissions were halted by the US Navy in California, Utah, Arizona, Nevada, and Hawaii. The ARRL offered the services of more than 600 League members to the Secretaries of Navy and War. One amateur in the New York area, 2MN, meticulously tracked the transmissions of a broadcast station operated by Telefunken at Sayville, Long Island, and provided evidence that the station was sending coded messages to German submarines at sea concerning Allied shipping from New York Harbor. The government thereupon shut down the operation as a violation of the US's neutrality agreements in effect at the time.

With war looming on the horizon, the relaying of radio signals became vastly important to the both the amateur radio community and to national defense efforts. The League's President, Hiram Percy Maxim, was instrumental in securing from the Department of Commerce the 425-meter wavelength for use by specially authorized amateurs who relayed messages and other bona fide traffic through radio trunk lines. The RLA sponsored "rotary" messages in 1915 as well as a Washington's Birthday message that may have successfully been sent coast-to-coast on February 22, 1916. The ARRL attempted a national relay in 1916, and sent out its own Washington's Birthday message in 1917. Using an extensively developed relay trunk line, the League achieved a successful transcontinental relay on January 27, 1917. [6] A few days later on February 6, 1917, the same ARRL relay system accomplished the first intercontinental round trip message origination and answer in an astonishing time of one hour and twenty minutes. [7]

Figure 3.2 – A Radio Relay Trunk Line. The following map shows proposed relay trunk lines around 1916. Note the pattern of three north-south routes and three east-west routes terminating back into a connection along the West Coast. [8]

The success of the radio relay system was, in no small measure, due to advances in receiving capabilities. Armstrong publicly disclosed his regenerative receiver to the amateur and professional radio communities in 1915. Within a year, commercial and homemade versions of Armstrong's regenerative circuit were in use by amateurs. The reception of spark transmissions increased, in some instances, to over several hundred miles, as regenerative receivers had greater sensitivity than other types of detectors then in use. [9]

Figure 3.3 - The 1915 Armstrong Regenerative Receiver Circuit. The following schematic shows the first Armstrong regenerative receiver. This schematic was the basis for innumerable homemade amateur receivers.[10]

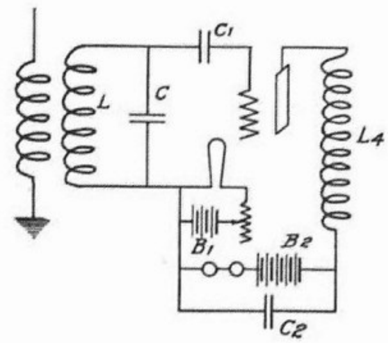


FIGURE 9

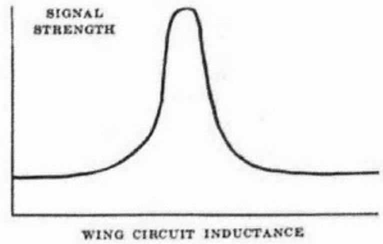


FIGURE 10

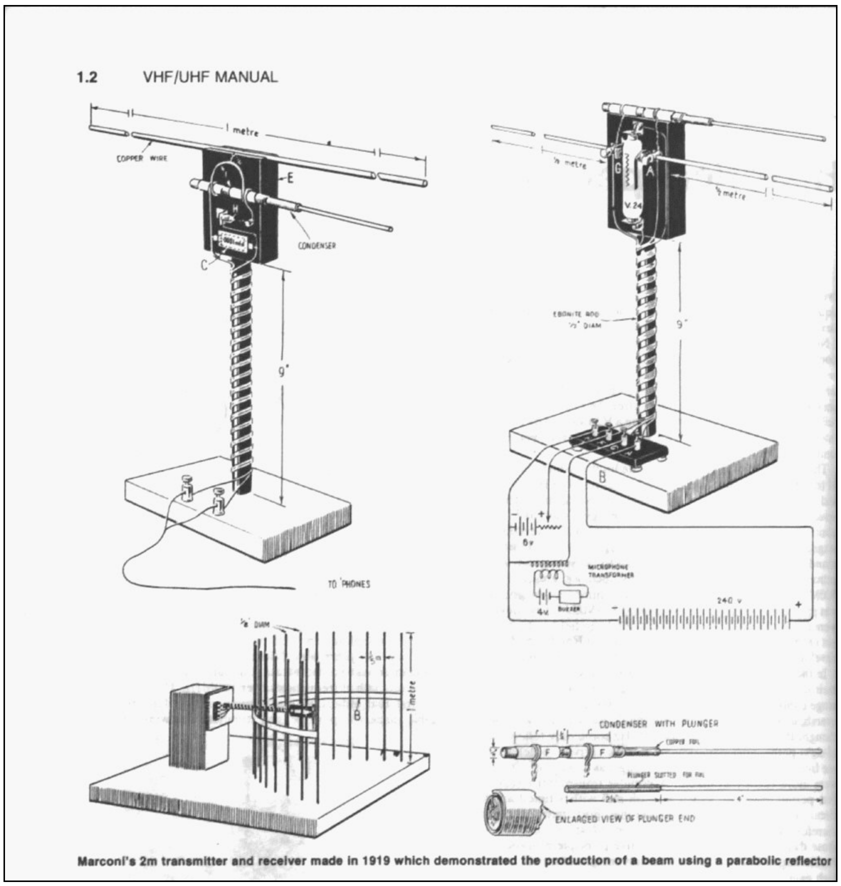
Early regenerative audion circuit and a graph showing the amplification achieved by varying the inductance in the plate circuit. This is the original "Armstrong"—tuned-plate, tuned-grid—circuit, taken from the first published paper on regenerative reception (*Proc. I.R.E.*, September, 1915).

On April 6, 1917, America entered the war, and all amateur radio stations were ordered to lower their antennas and render their radio equipment, including receivers, inoperative. The Navy asked the League to supply radio operators for the war. Within ten days, 500 amateurs had volunteered for service. Over the course of the war, between 3,500 and 4,000 amateurs joined the Army and Navy, most of whom went into the first wireless signal corps of the various services. In September 1917, *QST* stopped publishing, as its editor, Clarence D. Tuska, had also joined the war effort. [11] Tuska served in an important capacity with the Army radio corps, selecting and training recruits for radio related duties. Other amateurs also served with distinction – one notable case was that of Edwin H. Armstrong, who invented the superhetrodyne receiver while stationed at a Signal Corp lab in Paris, France.[12]

An armistice ending WWI was signed on November 11, 1918. The League reformed in February 1919, and *QST* began publishing again in June 1919. Meanwhile, on April 12, 1919, amateur receiving privileges were restored. Canadian amateurs went back on the airwaves on May 1, 1919, after a five-year hiatus. There were several unsuccessful attempts in Congressional Committees, both during and after the war, to give the Secretary of Navy permanent control of all radio in the US. Amateur radio was once again in serious threat of extinction. In an early and effective display of lobbying, The League sponsored a "blue card appeal", and thousands of cards were sent in to Congressional members from amateurs and their relatives. Hiram Percy Maxim personally lobbied Congress for restoration of amateur radio privileges. Support in Congress swung towards amateurs, and a joint resolution was introduced in the US Congress calling on the Navy to release its hold on radio frequencies. The Navy finally consented, and amateur transmitting privileges were authorized in the US at 200 meters in October 1919.

Even while amateur radio activity was just starting up again in the US, experimental work at UHF frequencies was being conducted in Europe by Marconi. In 1919, Marconi was using dipoles and parabolic reflectors on frequencies near what is today 2 meters. He even built a 150 Mc AM transmitter using a using a V24 triode valve. The receiver used a diode crystal detector. Other experimenters in Europe were also active on the UHF frequencies. Triodes were adapted to work at 900 mc, and the forerunner of magnetrons, diode valves with a split cylindrical anodes, were under development as early as 1920. [13]

Figure 3.4 – Marconi 2 Meter Antennas. The following diagram shows interesting dipoles and parabolic reflectors made by Marconi for 2 Meter work, circa 1919. [14]



Marconi's 2m transmitter and receiver made in 1919 which demonstrated the production of a beam using a parabolic reflector

In addition to previously discovering that vacuum tubes could amplify signals in receivers, Armstrong also realized as early as 1912 that audions could be made to oscillate at radio frequencies. These oscillations produced a continuous wave, or c.w. Sparks and cw and were both used by the military during WWI. After the war, spark gap transmissions still dominated the amateur airwaves even though sparks created tremendous interference. For instance, a spark signal centered on 200 meters could generate noise of varying amplitude from 150 to 250 meters, even with the 2% decrement as required by regulations. The adoption of cw as well as the use of vacuum tubes was slow in coming, however, and this was largely due to the lack of affordable and dependable equipment. This state of affairs changed in 1920, when the Radio Corporation of America introduced a very popular five-watt tube, the UV-202, for only $8. More powerful tubes quickly developed from there.

(picture of a 202?) ,

Although there is some dispute as to who issued the first QSL card, by 1919 ARRL members were circulating cards for reporting the reception of amateur transmissions. Within a short time, the famous Flying Horse Radio Amateurs Callbook was published, and that aided in the mailing of QSL cards throughout both the country and internationally.[15]

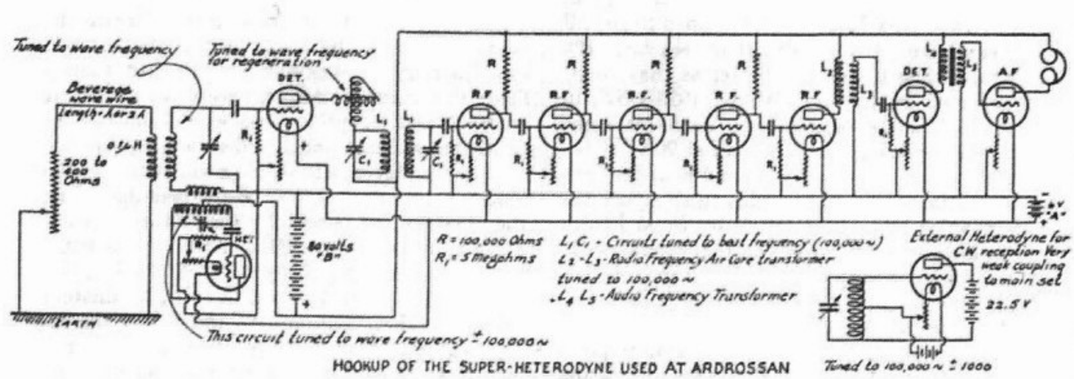
Radio technology had been advanced in the war effort. Vacuum tubes, continuous waves, and many other innovations had been utilized by the military powers in WWI, and certain civilian interests and sectors were beginning to show interest in these developments after the war. In the aftermath of WWI, nationalism was evident in the policy of many governments, and the US government became concerned that radio technology was moving out of American control. This led to the creation of the Radio Corporation of America (RCA). Initially formed as a competitor to British Marconi, RCA took over the American subsidiary of Marconi, and General Electric became the parent company of RCA. Recognizing that military communication needed to remain within US control, the US Navy had a representative on the RCA Board of Directors. Within a short time, AT&T, Westinghouse, and United Fruit developed alliances with RCA, thereby pooling some 2,000 radio and electronic patents. Even though the federal government encouraged the formation of RCA through GE, federal anti-trust action then split the two companies apart. From that point on, RCA was able to grow on its own into a dominant company in the radio industry. [16] Meanwhile, Westinghouse separately bought patents from Edwin Armstrong and Lee de Forest, to continue their presence in the electronics fields.

Radio receivers were now rapidly advancing in their sophistication. A neutrodyne circuit was invented by L.A. Hazeltine that achieved greater stability in the circuits. Also, the superhetrodyne receiver became more widely available. It was more sensitive to weaker transmissions, and that allowed for better reception of individual stations. The “Reinartz tuner” also had very good performance, being a regenerative receiver with a fiexed feedback coil. These circuitry improvements aided in receiver capabilities. Reception of real DX transmissions was becoming more a possibility.

With 10,809 amateurs licensed by June 1921, the combination of spark gap interference coupled with only a loose compliance of wavelength and power restrictions led to the Department of Commerce issuing informal but rather direct notes to amateur radio enthusiasts. The League commenced a campaign aimed at the adoption of cw for all amateur use, and developed a strong belief in the self-policing of the federal amateur regulations. Dozens of articles appeared in *QST* on good operating practices, with regular admonishments from none other than Hiram Percy Maxim, the co-founder and President of the League, to improve both operating skills and the technical proficiencies. Amateur operator compliance with all regulations became a top priority with the ARRL. [17]

In December 1921, ARRL radio tests were conducted between the US and Scotland, with several ARRL and Radio Club of America members, including Edwin Armstrong, transmitting and America's Paul F. Godley, 2ZE, listening in Glasgow, Scotland. These "Transatlantics" showed that the transmission of continuous waves was vastly more efficient than spark.[18] It soon became clear that a 5 watt transmitting tube costing as little as $8, when made into a single tube CW transmitter, could outperform a very large spark coil.

Figure 3.5 - 1921 Godley Receiver Used in Trans Atlantic Tests. Paul Godley was the nation's foremost receiving expert when he built a receiver based on the following schematic. It was the most advanced receiver built up to that time. Note the amazing differences from the equipment of only seven years before, in Figure 3.1 above.[19]



The receiver circuit used by Godley in the successful transatlantic tests of December 1921. With a regenerative first detector and a regenerative i.f. amplifier, this could have been the first amateur receiver to approach single-signal c.w. performance. The detector tubes were UV-200s; the others, A-P amplifiers of the "hard" variety.

Crystal-controlled transmitters began appearing regularly on the bands, and these radios immeasurably improved the stability and overall quality of amateur transmissions. *QST* even ran several pioneering articles on quartz crystals, including how to grind and adapt them for amateur use.[20] At the same time that CW and crystals were improving the transmission of signals, the reception of radio waves advanced on several fronts, too: Godley's receiver in the transatlantic tests used 10 tubes that may have approached single-signal cw capabilities. Armstrong disclosed another of his inventions, the super-regenerative receiver, in 1922. [21] The super-regenerative would be greatly used a decade later on the ultra-high frequencies where it broad-banded nature could receive modulated signals. Crystal detectors were also being widely used in receivers by this time, and one article even suggested that wireless operators in the Montclair, NJ area experimented with a junction-type of circuit for the crystals, coming remarkably close to a crude form of transistor some 20 plus years before Bell labs invented the device.[22] Advances in radio technology ended the era of the spark coil. By 1922, amateurs were quickly moving to cw, relegating spark transmissions to the status of an antique.

(picture of 8-22 QST cover and article?)

"Low loss" receiving tuners were developed in 1923 and 1924. Frequency Modulation techniques were more fully developed by Armstrong and others, in an effort to reduce radio static and background noise. The new FM methods necessitated the use of frequencies above 30 Mc where space was available for wide bandwidth transmissions.

Amateurs were having great adventures. The ARRL selected a great operator, Don Mix, to accompany the McMillian Artic Expedition. Mix took along a 200-meter station, and using the call WNP, made hundreds of contacts on the way back and forth to the Artic. [23] Use of amateur radio on the Expedition was so successful that dozens of other Expeditions, including those by Admiral Byrd, used amateur radio on their own missions.

During this era of amateur innovation, broadcasting was exploding across the nation and abroad. Amateurs were then allowed to broadcast music, news, and other items of interest, and hundreds of them did so by modulating their CW transmitters. For several years, a Westinghouse engineer, Frank Conrad, 8XK experimented with what became the first commercial radio station. He played music and broadcasted form his garage in Philadelphia. In September, 1920, Conrad was mentioned in an ad for radio receivers by a local department store. The receivers quickly sold out! A vice-president at Westinghouse, Harry P. Davis, realized that idle plants of Westinghouse could be put to good use building receivers, and Davis proposed to build a station at the Westinghouse facilities. KDKA in Pittsburg went on the air on November 2, 1920 using the 360-meter wavelength and having 100 watts of power.[24] Thereafter, Westinghouse quickly established WJZ, KYW, and WBZ at its plants in Newark, New Jersey, Chicago, and Springfield, Massachusetts.

Technology had advanced to the point where commercial broadcasts of information was technically practical and economically feasible. In 1922 alone, almost 500 new broadcasting stations were licensed in the US, versus a total of only eight in operation just a year before. All transmissions were on the same wavelength. Additionally, 1,200 amateurs had made at least one broadcast by 1921, and some had developed their broadcasts into regular programming. In Britain, the British Broadcasting Company (BBC) was formed and began a rich heritage of sending out broadcasts of a non-commercial nature. With the creation of the BBC, control of the British airwaves by British Marconi abruptly ended. The massive surge in broadcasting affected amateur radio organizations. *QST* briefly used a "Citizens Radio" motif before returning to its banner of being "devoted entirely to Amateur Radio", while Gernsback lost interest in his magazine sponsored RLA, and wandered off towards coverage of broadcasting information.

Interference problems quickly surfaced. Between amateur sparks, radiating regenerative broadcast receivers, wireless stations at sea, and overlapping broadcast stations, complaints arose within short order. Non-selective broadcast receivers contributed greatly to the problem. To deal with the matter, Herbert Hoover, then Secretary of Commerce, assigned separate frequencies to broadcast stations, and required the stations to be licensed. Further, Hoover prohibited broadcasting among the amateur population. Quiet hours were imposed on amateur stations in evening hours. Hoover had probably exceeded his authority in making these decisions, but immediately after the regulations went into effect, broadcasting by amateurs quickly dropped off as a favorite pastime. The ARRL referred to The department of Commerce's regulations as "gentleman's agreements", with which there was a general compliance with by amateur radio operators.

So much activity relating to radio transmission was taking place that the government began to adopt standard and uniform practices and measurements of the radio waves. The Navy commissioned a great experimental station, NAA, at Arlington, Virginia in 1910. The station began regular broadcasting of time signals in 1913, and also conducted twice-a-day weather reports. The three masts at the location were so tall – between 450 and 600 feet – that transmissions at the Eiffel Tower in Paris could be heard from NAA. Within a few years, NAA engaged in transatlantic radio communication with the Eiffel, and in 1916, worked Honolulu on phone. Other governmental tests and activities were also occurring. The Bureau of Standards and the ARRL conducted joint fading tests in 1920's, and the Bureau put the now famous WWV station on the air in May 1920 in Washington, D.C. Regular schedules of standard frequency signals occurred by May 1923 on assigned frequencies between 75 to 2000 kHz.[25] During this time, the Bureau of Standards recommended the use of frequency designations instead of more traditional wavelength measurements.

With amateur activity occurring on 200 Meters, many hams and non-hams alike generally believed that wavelengths below 200 meters were useless for radio work. The Allied and Axis powers during WWI had both experimented with shorter wavelengths. After the war, some amateurs were beginning to report very good conditions whenever they tried out the shorter wavelengths, or "short waves". Concerted efforts were made to use these short waves for radio communications. Several amateurs were testing and planning for both Atlantic and Pacific Ocean contacts, using better equipment and pre-arranged schedules. Then, a two-way transpacific contact was made on November 25, 1923 through the course of routine operating between Charles York, U7HG, of Tacoma, Washington, and an American operator in Tokio, Japan using the call JUPU.[26]

After much work to improve operating skills and equipment, several attempts were made at a direct contact to the European continent. On November 27, 1923, a transatlantic two-way contact was accomplished on 110 meters between France's Leon Deloy, 8AB, and two of the most experienced American relay managers and equipment experimenters of the day, Fred H. Schnell, 1MO, and John L. Reinartz, 1QP-1XAM. Dozens, if not hundreds, of hams listened in on this historic exchange between the continents. The signals were booming at each end of the path! The Atlantic had been successfully crossed, and with great style.[27]

With 15,000 amateurs then being licensed in the US alone, great operating activities were regularly occurring. Over the next few months, dozens of other US amateur stations had two-way contacts with several other countries on wavelengths between 108 and 118 meters.[28] The distance barrier was being broken at home, too. Many amateurs were having regularly nighttime two-way contact coast-to-coast by 1923. Attempts were then made at daylight "transcons", by connecting with a west coast station before sunrise there, and then working as far into daylight on the east coast as possible. On January 12, 1924, 6XAD of Catalina, California, and 2ADM of Schenectady, NY, completed the first transcon under daylight conditions on both sides of the contact.[29] Daylight transcons became regular events by the summer of 1924. By the fall, an English station worked to New Zealand, a distance of 12,000 miles.

For many years, the propagation of radio waves remained a general mystery. The amazing long distance work being done by amateurs became more readily understood when an English physicist, Edward Appleton in 1924 confirmed the existence of the Heaviside - Kennelley layer that was first proposed in 1902. Appleton transmitted radio pulses vertically upward, and then analyzed the pulses as they returned from the reflecting ionospheric layer.

The rush was now on to the higher frequencies. On July 24, 1924, the Commissioner of Navigation authorized additional amateur radio wavelengths at 80, 40, 20, and 5 meters.[30] While amateurs were authorized to use portions of their existing wavelengths for telephony, all of the new wavelengths, including 5 Meters, were initially limited to CW operation.[31] Additionally, spark transmissions became restricted for use on only 150 to 200 meters, and special amateur stations above 200 meters were no longer allowed. Operating practices among amateur wireless stations increasingly moved away from an early "anything-goes" attitude, too: direct communication with commercial and military services was eventually banned, and other eccentricities of the era, including the playing of music and the sending of sporting and news reports over the air, were frowned upon and ultimately restricted to only commercial operations. [32]

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[1] Interestingly, the term "amateur" was not used in the Act. Instead, the regulation applied to stations "not engaged in the transaction of *bona fide* commercial business by radio communication or experimentation…". A definition of 'amateur" would come for the first time, many years later, in the First National Radio Conference of 1922.

[2] One writer believes however that a supposed intent to do away with amateurs by the 200 meters allocation was a bit overdrawn, and became a common belief among amateurs in the early 1920's. See, United States Early Radio History, Thomas H. White, sec.12. Another on-line author, William Continelli, felt that the 200 meter restriction was a reaction to amateur interference over the years, and especially to amateur activity during the Titanic disaster when the Carpathia was within range. See, The History of Amateur Radio, The Wayback Machine #2, Ham-Shack.com.

[3] DeSoto, at 35.

[4] Initially, amateur call signs were issued by a number, indicating the radio district that the amateur lived in (1 through 9) followed by two letters between A and W - for example, 1AW. X calls signs were issued for special experimental stations (ex: 1XE); Y for School licenses (9YY); and Z for Special Amateur licenses (8ZZ). 1x3 calls (1AAA) were issued beginning in 1914. W and K prefixes were not assigned to Amateurs until Oct. 1, 1928, and N prefixes were not common until at least the 1970's. See, USA Amateur Radio History and Licensing, Compiled By AC6V 1979 – 2000, for this and more information on call signs.

[5] The diagram, including the text box, was taken from "Fifty Years of A.R.R.L.", ARRL pub. 1964, p.19.

[6] Gernsback's magazine sponsored RLA and Maxim's fledgling ARRL and *QST* had an on-going rivalry until WWI, when amateur radio was shut down by the war. For a nice review of this rivalry along with notations of competing relays and running commentary from their two respective magazines, see: United States Early Radio History, Thomas H. White, sec. 12.
[7] Both of these League sponsored relays are vividly recounted by DeSoto, at 49.
[8] This map was taken from "Fifty Years of A.R.R.L", p.15.
[9] "ARRL: The Early Years", *QST,* Feb. 1964, at 71-74, contains a very nice description of Armstrong's circuit and its impact on amateur radio reception abilities.
[10] The schematic, including the text box, was taken from "Fifty Years of A.R.R.L", p.20.
[11] An interesting perspective of WWI and the early days of ham radio is presented in "Twenty Years of Amateur Radio", *QST,* May 1934, p.20-26. See also "ARRL: Amateurs Serve Their Country", *QST,* March 1964, p.66-76. DeSoto states that the number of Navy radio men increased from 979 in 1917 to 6,700 at the time of the Armistice, and that a "considerable proportion of these, especially in the higher brackets, were amateurs". DeSoto, at 52.
[12] Armstrong developed the superhet in an effort to detect German submarine signals around the lower wavelengths of 80 meters. The signals were heterodyned to lower frequencies where vacuum tubes could boost the signal strength. See, Bill Tynan, "Our Early Heritage"', Proceedings of the 28th Conference, Central States VHF Society, 1994, at 66. Armstrong publicly disclosed his invention in "A New Method of receiving Weak Signals for Short Waves", Proceedings of the Radio Club of America, Dec. 1919.
[13] See, *VHF/UHF Manual*, RSGB publ., 4th ed., 1991, at p. 1.1-1.2.
[14] The diagram is taken from *The VHF / UHF Manual,* G.R. Jessop, G6JP, 4th ed. 1991, RSGB publ, p.1.2.
[15] One claim was that C.D. Hoffman, 8UX issued the first QSL card, while another claimed the first European QSL card came from W.E. "Bill" Corsham, 2UV, of Willesden, London. A post card with the call 8ML was reproduced in "Wireless World" in May 1923. See, USA Amateur Radio History and Licensing, Compiled by AC6V, 1979-2000.
[16] Communication Systems and Technology, A Chronology of Communication Related Events, Part 2: 1900 to present, contains a good summary on the relationships of the government, RCA, and GE.
[17] The Department of Commerce's informal demand at self-policing is noted at DeSoto, p.68. From the inception of the League, compliance with the regulations was a must: official relay stations of the League could be de-listed if skill levels and equipment were not kept up to date. By publication of the 1925 Annual QST Index, for instance, over 20 articles were published in just that one year on "good operating practices".
[18] The cover of the January 1922 *QST,* and the accompanying story, noted the Transatlantic test in great detail. Godley not only used one of the most sophisticated receivers of the era, but his antenna was a beverage. This was likely the first beverage ever used in the UK. For an interesting English perspective of the tests, see: The Dawn of Amateur Radio in the U.K. and Greece: a Personal View, by Norman F. Joly, who notes that eight British amateurs had also copied the message correctly, with one of them using only a simple three valve receiver and an inverted L wire antenna.
[19] The Godley schematic, including text box, was taken from "Fifty Years of A.R.R.L", p.46.
[20] The first article to appear on the use of crystals was "Oscillating Crystals", H.S. Shaw, *QST,* July 1924, p.30-33. Other articles included: Sept. 1924, p.XVI; Jan. 1925, p.35; Dec. 1925, p.62; Nov. 1925, p.41; Aug. 1925, p.35. Crystal grinding and mounting was described at May 1928, p.24; and Feb.1928, p. 27.
[21] Armstrong disclosed this receiver in "A Super-regenerative Circuit", Proceedings of the Radio Club of America, June, 1922. He then wrote about the receiver in "A New Method for the Reception of Weak Signals at Short Wave Lengths", *QST,* Feb. 1920, p.5.
[22] "Transistors in 1923?", Ronald L. Ives, Jan. 1959, CQ, at 35+ provides for very interesting reading. A large number of wireless experimenters in the NJ area attached a phonograph needle to a silicon crystal mounted in soft solder and then carefully split so that the crystal was supported by two "blobs of solder". Bias of either polarity was applied across the two solder mountings. Performance on occasion "was rather remarkable". These experiments ceased in 1924 when telephone repeater tubes found their way into amateur "blooper" regenerative receivers.
[23] *QST's* in 1923 were filled with news of the Expedition, and a sketch of the McMillian's ship, the Bowdoin, graced the cover of the October, 1923 issue. The Expedition was featured in that issue at p.10-12, "White Silence of Artic Broken". President Coolidge even sent a Christmas greeting to McMillian at the North Pole.

[24] KDKA was initially owned by Westinghouse. During the first night's broadcast between 8:00PM and midnight, Conrad and an assistant, Donald Little, announced Warren Harding's Presidential election victory. One thousand listeners may have heard this first broadcast. The event was given wide coverage in the print media. The station was featured on the cover of the May 1928 *QST*.

[25] The history pages of the WWV web-site contains interesting information on WWV, WWVH, and WWVB. See, http://www.boulder.nist.gov.htm. The original transmitter in 1920 was a 2 kW spark gap. Output power by 1923 was 1 kW, and the accuracy of the transmitted frequency was quoted at "better than three-tenths of one per cent". Quartz oscillators installed in 1927 dramatically improved frequency accuracy.

[26] DeSoto, at 85, states that this contact was accepted as valid within amateur radio circles, but that little was known of the Japanese station or its American operator, and that the authenticity of the contact had never been "completely established". The contact was described in and was factually accepted as being a non-scheduled contact in "Direct Contact with Japan", *QST,* Feb. 1924, p.14. The contact was on 200 meters. The city of Tokyo was spelled at the time as "Tokio".

[27] In preparation for the attempt at an intercontinental contact, Deloy visited the US to study American radio techniques, Schnell secured permission to use the 100 meter wavelength; and Reinartz designed the transmitter in use by all three stations making the attempt. DeSoto, at 85-87, has a very nice description of the historic exchange. "Fifty Years of A.R.R.L.", 1964 ARRL publ., at 35-39, has an extensive discussion of the matter, as well. *QST* heralded the event in "Transatlantic Amateur Communication Accomplished!" Jan. 1924, at 9-12; "1XAM's Transmitter", Jan. 1924, at 26-26.

[28] Several notable contacts with foreign countries were described in "The Progress of Transatlantic Amateur Communication", *QST,* Feb. 1924, at 15-18.

[29] "Daylight Transcon at Last", May 1924, *QST,* p.41-42. No one knew that the contact was finishing in the daylight on the west coast until reference was made a few weeks later to an almanac, which listed sunrise in California on that day at 6:29AM. The contact ended at 6:36:30 AM pacific time.

[30] The initial regulations did not specify the exact frequencies or wavelengths of use, only "75 to 80 meters, 40 to 43 meters, 20 to 22 meters, 4 to 5 meters…"; See, "The New Short Waves", *QST,* Sept. 1924, p.8-9. The regulations further noted that the new band allocations were "necessarily tentative because of the rapid development taking place in radio communication".

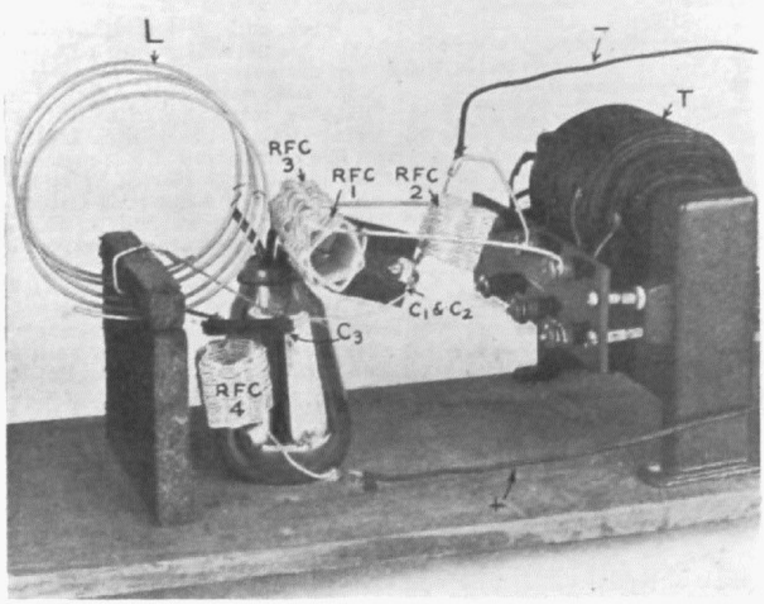
[31] "Twenty Years of Amateur Radio", *QST,* May 1934, at 23-25. Telephony activity in a section of one of the newer frequencies, 3500 to 3600 kc, was authorized in early 1926. See, "New Phone Band Authorized", *QST,* Feb. 1926, p.8, although many hams and amateur organizations, including some within the ARRL, believed that phone techniques had not yet advanced far enough to ensure quality levels of communication at short wave lengths.

[32] Amateurs were prohibited from generally communicating with commercial and government stations in the October, 1927 regulations issued by the FRC. The playing of "music, lectures, sermons, or any other form of entertainment" was also banned. "Changes in Amateur Regulations", *QST,* Dec. 1927, p.24.

Chapter 4 - The Beginnings of U.H.F.

Prior to July 1924, virtually no amateur activity existed on very short wavelengths. In fact, at the First National Radio Conference in 1922, amateur radio short-wave frequencies weren't even discussed, let alone any ultra high activity being mentioned. At the Second National Radio Conference held in March 1923, all frequencies below 130 meters were specifically reserved and available for use only by special licensing of the Department of Commerce.[1] About the only written reference made to UHF in amateur circles was a small query in an ARRL Editorial concerning short wave experimentation: "Wouldn't it be fascinating to have an amateur band from 40 to 50 meters or even from 4 to 5 meters, where we'd have to develop totally new methods and brand new apparatus to make them work?" [2] The reference by the League to 40 and 5 meters was not merely random thinking. On the contrary, it was quite deliberate in nature, as the ARRL had been negotiating for a year with the Department of Commerce for additional frequencies, including the ultra-high region.[3] The 1924 allocation of a 5-meter amateur wavelength therefore marked the very beginning of the ultra-high era in amateur radio.

Figure 4.1 – The Original 5-Meter Oscillator. The following picture is the first 5-Meter oscillator ever described in an amateur radio publication. Note that all of the parts, except the transformer core, are handmade. [4]



DETAIL OF THE OSCILLATOR, SHOWING CHOKES AND CONDENSERS.
See Fig. 2 for meaning of the lettering.
The mica condensers are not satisfactory at 5 meters and should be replaced by air condensers such as those shown in Fig. 8.
Notice the short leads especially.

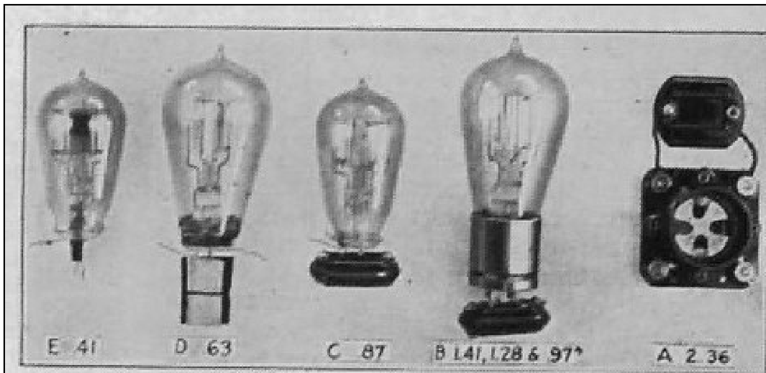
5-meters was initially viewed as a short wavelength. For instance, as late as 1927, construction articles were treating 5-Meters as a "short-wave". [5] It became quickly apparent however that the frequency allocation might be radically different from 110, 80, or even 20 meters. Articles began to note 5-meters as an "Ultra-High Frequency", abbreviated as "U.H.F.", and 10 meters was also commonly treated as an ultra-high frequency. It wasn't until 1930, however, that radio magazine indexes even referred to 5-meters or 10 meters as ultra-high frequencies. [6] The term "Very High Frequency", describing the radio space between 50 and 400 Mc or so, first came into widespread use in WWII. What we commonly think of today as being the UHF spectrum and the "microwave frequencies" came into use even later. [7]

Additionally, early references to amateur allocations were invariably in "wavelengths" with the basic measurement being in "meters" (for example: 200 meters). This designation was only occasionally translated into a frequency measurement, normally expressed in kilocycles. It took much encouragement before frequency designations were regularly used.[8] In the ultra high ranges, even when frequency measurements were used, "kilocycles" and not "megacycles" were often employed. The term megacycle, or mc, was advocated in the late 1920's, but gradually developed only thereafter.[9] Indications of frequency in Megahertz instead of megacycle were even longer in the making. References to "bands" (as in the 80 meter band, etc) did not come into regular usage until separate tuning ranges or bands developed on amateur receivers, although many early references to 5 meters and ¾ meters did mention "band" activity. During the early years of equipment development, a simple tuning knob moved a receiver through the entire radio spectrum, often in a single rotation. Any references to "bands" were more illustrative than real.

By the mid 1920's, a few hams had begun experimenting on 5-meters. The original 1924 5-meter allocation was actually between 4 to 5 meters, or 60,000 to 75,000 kilocycles, but was loosely characterized as being "5-Meters".[10] In October 1924, the Third National Radio Conference changed slightly the amateur wavelength boundaries assigned a few months before in July, 1924 by the US Navy in order to establish more precise harmonic relationships, and thereby reduce interference to broadcast stations. At that time, the 5-meter wavelength was changed somewhat to 5.3 to 4.7 meters (56,000 to 64,000 kc). By the next year, the 5-meter allocation was more precisely defined as being between 4.69 to 5.35 meters, but still at 56,000 to 64,000 kilocycles in frequency.[11]

On March 17, 1925, the Department of Commerce allocated frequencies at ¾ meters (400,000 kc to 401,000 kc) for amateur use. In announcing the new wavelength, the League indicated that the Bureau of Navigation acted at the request of the ARRL Board of Directors. [12] Supposedly, 400 Mc was developed for "beam experiments", as this was the resonant frequency of popular bowl-shaped electric heaters which could be pressed into service as a dish antenna. [13] Little activity initially occurred on this ultra high frequency however, and one writer believed that "this band is of interest only in that it demonstrated the confidence built up in the Department concerning the experimental ability and value of amateur radio". [14] Several article appeared on construction techniques for the new band, but almost all parts, including the tubes, had to be modified. [15] The new frequencies were posing severe challenges to even the most experienced of amateurs.

Figure 4.2 – Tubes for ¾ Meters. The following picture shows various tubes being reworked and physically altered for use at ¾ meters.[16]



GROUP OF SHORT-WAVE ULTRAUDION OSCILLATORS SHOWING CONSTRUCTION NEEDED WHEN OPERATING AT ¾ M. DIRECTLY AND ADVANTAGE OF WORKING IN MANNER SUGGESTED. THIS IS THE GROUP MENTIONED BEFORE AS USED BY PHELPS AT 2EB.

A technical editor at the ARRL, Robert S. Kruse, made huge contributions to the early usage and development of 5 and ¾ meters when he wrote numerous articles in *QST* on equipment at UHF frequencies. He also wrote or co-wrote a monthly *QST* column entitled “Experimenter's Section Report”, (which many amateurs referred to as the “X Report”, for short), and was the author of several articles on the Fading tests jointly sponsored by eth Bureau of Standards and the ARRL in 1920.[17] Other writers also made early and important contributions to the understanding of UHF activities. [18]

Figure 4.3 – UHF Schematics. The following diagram of various transmitter circuits was taken from one of Robert Kruse’s articles. [19]

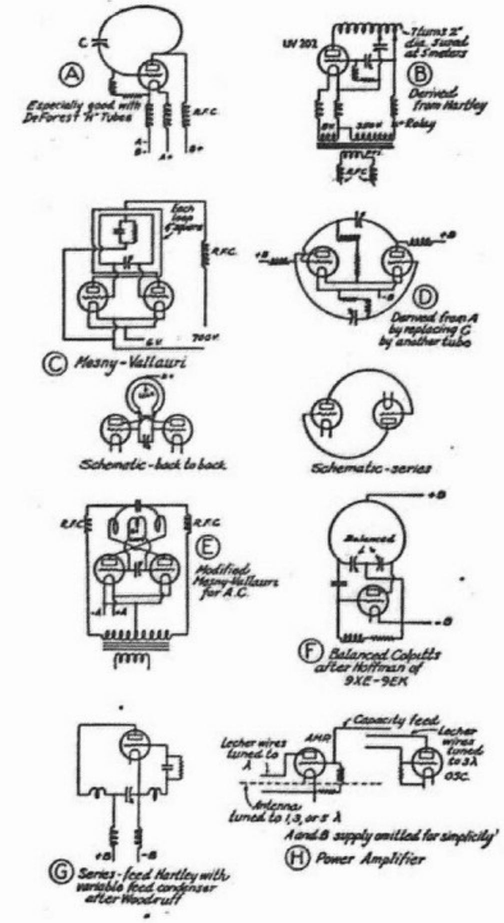


FIGURE 1 SENDING CIRCUITS

In general the condensers are chosen for low minimum capacity and special construction for this purpose is an advantage as the maximum capacity wanted is not much over 15 micromicrofarads. Inductance turns are usually about 3 inches in diameter. Above all they must be solid so as to avoid vibration.

With the advent of short wave and ultra high frequencies available to the amateur, the radiation and reflection of radio waves became oft-discussed subjects. Robert S. Kruse engaged in ground-breaking work in the early 1920's with the joint Bureau of Standards – ARRL fading tests. Other writers also made important contributions to radio propagation theory at short wavelengths.[20] Amateurs also wrote of their efforts at horizontal wave reflections and polarization attempts.[21] Still others were commenting on the effect of Auroras on radio signals.[22] U.H.F. activity reports were being analyzed in the context of the various propagation concepts and beliefs floating about. International 5-meter tests occurred in July through September of 1926, resulting in the 5-meter reception in Tripoli of an Italian transmission.[23] Domestic long distance reception reports and records were also being noted and closely reviewed.[24]

With amateur radio contact becoming more common internationally, it was felt that an amateur organization was needed to foster the hobby throughout the world. The ARRL took the lead in forming the International Amateur Radio Union (IARU) in 1925, and League officials, including Hiram Percy Maxim and K.B. Warner, became the initial officers of the new international body.[25] An organization dedicated to international radio pursuits quite progressive for the time, since no governmental treaty, including any signed by the US, then recognized amateur radio at the international level. Indeed, many governments were very leery of any private, non-governmental activity involving the usage of the airwaves. Of great relevance to the general theme of this text, the IARU would go on in future years to advocate the development of the ultra-high frequency ranges, and UHF activity ultimately became quite common throughout Europe.

Back in the United States, broadcasting interests began to coalesce and merge into powerful networks. In 1926, Westinghouse, General Electric and RCA formed the National Broadcasting Company, or NBC. Founded by David Sarnoff, manager of RCA, many patent disputes between RCA, GE, Westinghouse, United Fruit and AT&T were resolved with the creation of the new company. RCA, GE, and Westinghouse initially owned NBC in a joint arrangement. The following year, a competing radio network, CBC was founded and quickly purchased the financially troubled United Independent Broadcasters (UIB), a 16-station radio network. The merged network, now renamed Columbia Broadcasting System, or CBS, also had financial difficulties until William S. Paley, a cigar company manager who was convinced of the power of advertising, invested $500,000 in the network. Within a short time, Paley was President of the company, and ultimately would lead CBS into a major broadcaster of both radio and television.[26]

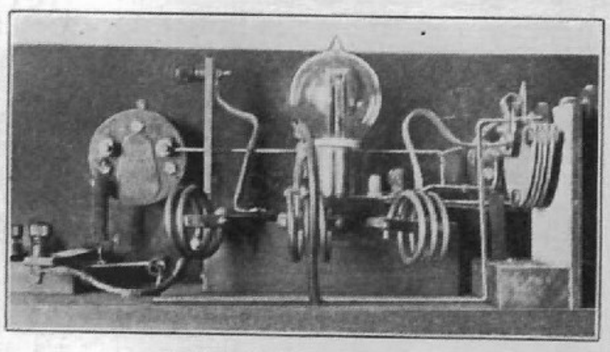
In addition to the broadcasters beginning to take seriously the transmission of pictures over radio, amateurs were also developing their own equipment for the transmittal of facsimiles and pictures. One of the earliest articles describing amateur radio facsimile and picture transmissions was written in May 1925, and in the same month, amateurs were allowed the use of any amateur frequency for the transmission of pictures and facsimiles.[27] Several experimenters wrote of their pioneering efforts to generate moving and still pictures over the radio.[28]

The Fourth Annual Radio Conference held by the Department of Commerce on Nov. 9-11, 1926 preserved the amateur waves at 5-meters and “75 cms”, despite efforts by the US Navy to reserve all frequencies below 16.6 meters for experimental purposes.[29] Much of the discussion at the Conference centered on broadcaster related problems, especially the interference and congestion between broadcast stations. The recommendations from the various Radio Conferences had essentially been “gentleman’s agreements” between the all parties involved, but by 1926, some commercial interests were challenging the arrangement. There was a general recognition that many of the recommendations of the Fourth Conference probably exceeded the statutory authority of the Radio Act of 1912. It was felt that new legislation would have to be quickly developed to correct that difficulty. The governance of the radio spectrum through the Radio Conference system quickly broke down when a Federal District Court case and a subsequent 1926 US Attorney General ruling held that the 1912 Radio Act did not provide express authority to administrative agencies for the regulation of the airwaves.

These legal decisions set off a stampede by broadcasters to change their frequencies and operating practices in what came to be known as the “Summer of Anarchy”. Most amateurs continued to observe their current practices, however. [30]

Legislation did indeed move quickly. A few months later in February 1927, a newly created agency, the Federal Radio Commission, was given jurisdiction over the regulation of the airwaves through Congressional amendments to the 1912 Radio Act. The amendments were largely aimed at thwarting the recently developed broadcasting monopolies and bringing some order to the rapidly ensuing chaos on the broadcast frequencies. The new law contained no technical specifications, however, and authority was generally granted to the FRC to adopt more extensive regulations.[31] In its first meeting held on March 15, 1927, the Commission extended all amateur licenses and all amateur radio operating privileges (including amateur activity on 5 and ¾ meters), until “further notice”, but then added code and written exam requirements for new amateur licensees.[32]

Figure 4.4 – Transmitter No. 1. The following picture is of an experimental, but complete, one-tube 5-Meter transmitter, circa 1925 to 1927. The tube was a Westinghouse 216A. The transmitter was “put on the air with no results.” [33]



5-METER TRANSMITTER NO. 1

In the photo may be seen the following:

Milliameter—0-50

Antenna coupling coil consisting of 2 turns of No. 4 bare copper wire.

Plate coil consisting of 3 turns of No. 4 bare copper wire with movable tap.

Grid coil consisting of 3 turns of No. 4 bare copper wire.

V.T. is a W.E. No. 216-A.

Plate stopping condenser is a 3-plate variable condenser.

Radio frequency chokes are wound on a ½-inch diameter and have 20 turns. They are put in all filament and plate leads.

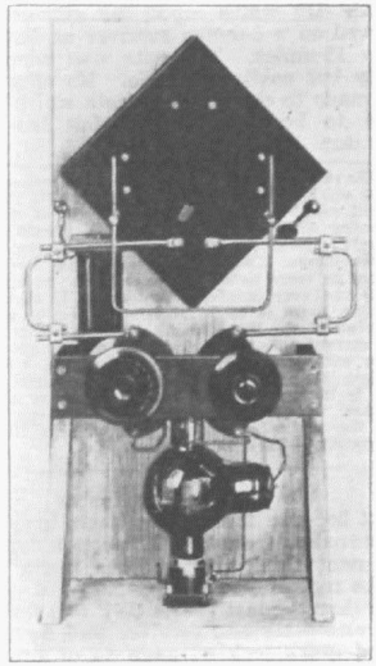
Plate source was from about 200 volts of Burgess “B's”. Tuning was done by changing number of turns on plate and grid coil. Antenna current was about .4 amp. This set was the result of the “hay-wire” laboratory set.

The circuit was a series fed Hartley.

The first amateur experiments on 5 meters occurred shortly after the band was authorized. Using debased UV-202 tubes, 9APW conducted tests with 1FG. Experiments continued, and by March 1927, regular two-way contact on 5 Meters was occurring between a few stations located in close proximity to each other. For instance, repeated communication between 2EB in New York City and 2NZ in New Jersey some 15 miles away was considered worthy of note.[34] Several one-way signal receptions of far greater distances were also being reported. By May and June of 1927, came confirmed reports of 1000-mile signal reception of 9EHT, although no relays or two-way contacts could be established. Monthly 5-Meter tests occurred in 1927, led by announcements contained in the Experimenters' Section Report of QST. Many hams hoped that 5 Meters would become quite useful in extending long distance communication abilities of the lower bands. Recent papers and amateur radio articles suggested that ionization of air might be responsible for the generally good operating conditions on the shorter waves.[35] There was therefore great hope that the reflection of radio waves off of ionized layers of air might even be better when transmissions moved to the higher frequencies of 5 Meters. Real excitement existed among UHF devotees that "skip" might be used for long distance work.

With this enthusiasm in mind, the ARRL sponsored a 5 Meter CQ Party on June 11-12, and June 18-19, 1927, following a CQ Party format previously held on 100 meters in 1923. This 5 Meter event may have thus been the first organized gathering of hams on a UHF wavelength. Prizes were given out for being the "best" in various activities, but this CQ Party was not described as a radio contest. Instead, it was more of an activity time with some "rules of the game". With the recent activity reports of long distance reception, the CQ Party drew lots of attention and interested parties.[36] A 5-meter crystal controlled transmitter was even transported to the top of a mountain.[37] Propagation turned out to be very puzzling however, as hams were unable to contact anyone but the most local of stations. To sort out the propagation characteristics of the band, another 5-Meter CQ Party was scheduled for November 12-13, 1927. [38]

Figure 4.5 – A Laboratory Transmitter. The following picture is of a 5-Meter Transmitter made in the ARRL Lab around the time of the first 5-Meter CQ Party in June 1927. Note that all the parts are mounted on a wood base, a common practice for the time. The transmitter used one tube – a UX-852 Radiotron. It generated 300 watts input, and its signal was heard 15 miles away. [39]



FRONT VIEW OF TRANSMITTER
At the top is the fixed feed condenser with the U-shaped antenna coupling coil mounted on it, and the two halves of the main inductance going off to either side. To the left of, and a bit below the feed condenser are the tubular resistors. Directly under the feed condenser is the mounting for the two tuning condensers and under that the UX-852 tube in its socket.

On October 27, 1927, the Federal Radio Commission affirmed amateur wavelength allocations set forth in the Fourth National Radio Conference, which specifically allotted 5 meters and ¾ meters to amateur use. Significantly, the FRC added telephony privileges to 5 meters and 20 meters, and extended telephony at 150-200 meters. Phone privileges on 80 meters were rescinded however, due to severe interference to amateur 80 meter cw transmissions. Spark transmitters were completely prohibited, after having been restricted to 200 meters in the Fourth National Radio Conference in 1927. [40]

Further administrative changes were afoot, as well. An international radiotelegraph convention in Washington, D.C. in late 1927 gave international recognition to amateur radio for the first time, and approved international amateur frequencies on 160, 80, 40, 20, 10, and 5 meters (although the international 5 Meter authorization was more limited than in the US).[41] Many US amateurs were disappointed at the outcome of the Washington Conference, since almost half of all amateur frequencies had been lost in the process. Some amateurs even actively opposed ratification of the Washington Treaty. However, amateurs throughout the world were provided international protection, in spite of open hostility from many governments unreceptive to the entire concept of private individuals owning and operating radio equipment and installations.

In all, the Washington Treaty ensured the existence of a world wide amateur radio hobby. The loss of domestic frequencies had the primary effects of pushing US amateurs towards a greater efficiency in operating abilities and providing the impetus for improving one's own equipment. Signatory nations were required to implement provisions of the Treaty by January 1, 1929. Even as Congress was debating the Treaty in early 1928, the League quickly funded a technical development program, with articles on "1929" amateur transmitters, receivers, voltage supplies, tuners, and antennas. The program was a serious effort at bringing the amateur's equipment up to date with the technical requirements of the 1927 Treaty. [42]

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[1] The First National Radio Conference was mentioned in DeSoto, at 77. No mention was made of UHF activities at Second Radio Conference, either, as the discussion revolved around accommodating amateur interests in the higher wavelengths at and above 200 meters with similar interests of the broadcasters. See, "The Second National Radio Conference", *QST,* May, 1923, p.12-15. *QST* itself carried no technical articles on the ultra highs until after the July 1924 allocation of 5-meters.

[2] The comment occurred in the Editorial of the March 1924 *QST*, p.7-8, in a discussion on "The Short Waves". This may have been the first reference in a radio publication to any kind of ultra-high amateur radio activity, and certainly to a 4-5 meter band. The 5–meter allocation occurred a few months later on July 24, 1924.

[3] DeSoto, at 93, indicates that the League was actively involved in negotiations with the Commissioner of Navigation to obtain wavelengths below 200 meters.

[4] The picture is taken from "Working at 5 Meters", S. Kruse, *QST,* Oct. 1924, p.13-19.

[5] "New Short-Wave Receivers", *QST,* June 1927, p.9-17, was filled with construction ideas on 5 meter receivers.

[6] The 1924 *QST* Annual Index placed three articles on 5-meters under the heading "Short Waves". The 1925 Index had 5-meters articles under Transmitters and Receiver headings, and then as separate headings for either "5-Meters", "5 Meters and Below", or "Ten and Five Meters" between 1926 through 1929. The 1930 *QST* Annual Index first used "Ultra-High Frequencies" for 5 and 10 meters.

[7] Tynan makes this point as to the early use of "U.H.F." versus the more recent nomenclature of "VHF" and "UHF", in his 1994 Central States Conference paper, "Our Early Heritage", at 66. The 1943 *QST* Annual Index first used a "Very High Frequency" Heading, and the 1947 Annual Index was the first to mention "VHF and Microwaves".

[8] In "We Ought to Talk Frequency", *QST,* K.B. Warner, Sept. 1928, p.19-23, it was highly suggested that the time had come to speak in terms of kilocycles and not wavelength or meters.

[9] Usage of "megacycles" to express a frequency measurement was suggested in the Experimenters' Section Report, *QST,* June 1927, p.42, stating that "megacycle stays good for the 5-meter and .77-meter bands where kilocycle becomes preposterous".

[10] See, DeSoto, at 93, and the July 24,1924 regulations themselves for the "4 to 5 meter" language. It was generally thought at the time that the allocation did indeed cover the entire 15,000 kilocycles of radio space between 4 and 5 meters. The regulations are contained at "The New Short Waves", *QST,* Sept. 1924, p.7-8.

[11] The results of the Third Conference, listing 4.7 to 5.3 meters for amateur use, are noted at "The Third National Radio Conference", *QST,* Dec. 1924, p.16-17. The allocations were to be revisited after one year. Radio regulations in effect Jan. 5, 1925, added precision to 5-meter wavelength designations, but kept virtually the same frequencies of 56,000 to 64,000 kc. See, "New Regulations for Transmitting Stations", *QST,* March 1925, p.29.

[12] See, "A New Amateur Band at ¾ Meters", May 1925, p.36. The authorization came from General Letter No. 269, Bureau of Navigation of the Department of Commerce, March 17, 1925. The General Letter defined the space as being between .7486 and .7477 meters. This new allocation of frequencies was then commonly referred to as "¾ Meters". Today, we refer to the current allocation as being at "70 cm".

[13] See, "1927: The Year of Living Dangerously", Bill Orr, CQ, May, 1994, at 140.

[14] DeSoto, at 102. As late as 1936, DeSoto wrote that the "band has seldom been used except for an occasional stunt". There was almost no activity initially, and a full two years after 400,000 kc was

authorized, it was noted in the Experimenters' Section Report of *QST* that there were "signs that the .77-meter band will come alive soon"; *QST,* June 1927, at 41.

[15] "Getting Down Below 5 Meters", Harry Lyman, 6CNC, *QST,* January 1926, p.28, may have been the first article discussing ¾ meter activity. Other early articles on 400 Mc include: "Landmarks in the ½ to 5-Meter Region", *QST,* Robert S. Kruse, June 1927, p. 27-30; and "Progress and Plans at 5 Meters – and Below", *QST,* July 1927, p.34-37. A 400 Mc demonstration station set up at the 1927 ARRL Hudson Division Convention was noted at: "The ¾ Meter Band Officially Opened", *QST,* August 1927, p. 9-14.

[16] "The ¾-Meter Band Officially Opened", Boyd Phelps and R.S.Kruse, *QST,* August 1927, p. 9-14, at 13.

[17] Kruse wrote the some of the earliest technical articles on 5 meter equipment. His article, "Working at 5 Meters", *QST,* Oct. 1924, p.13-19, was likely the first amateur writing on 5 meters. Kruse also penned other early VHF articles. See, *QST,* July 1926, p.34-37; Jan. 1927, p.36-39; June 1927, 27-30.

[18] Some of the very early writers include W.H. Hoffman, 9EK, April 1925, p.19-20, and June 1927, p.33-34; A.H. Turner, *QST,* June 1927, p.24-26; E.M. Guyer and O.C. Austin, July 1927, p.29-30. The better equipped 5 meter stations were also noted. 9APW's 5 meter station was profiled in successive articles: *QST,* Dec. 1924, p.40, and January 1925, p.28. 6CNC's station was discussed at *QST,* March 1925, p.50-51, and at Jan. 1926, p.28. A 1 Kw 5 meter "set" of 9ZT was reviewed at *QST,* May 1925, p.43-44.

[19] "Progress and Plans at 5 Meters – and Below", Robert S. Kruse, *QST*, July 1926, p.34-38, at 34.

[20] Two articles on the Fading tests are contained at "Final report on the Fading Tests", August 1923, p.29; Sept. 1923, p.23; Other articles include: "The Navy's Work on Short Waves", (Dr. A. Hoyt Taylor), *QST,* May 1924, p.9-14; "The Conference, in Relation to Amateur Activities, (Prof. A.E. Kennelley), *QST,* Dec. 1924, p.18-19; "The Reflection of Short Waves", (John L. Reinartz), *QST,* April 1925, p.9-12.

[21] Dr. G.W. Pickard's pioneering studies on horizontal polarization were written about by Robert Kruse in "Horizontal Reception", *QST,* Feb. 1926, p.9-17. John M. Hollywood also wrote an important article on the topic in "Horizontal Wave Experiments at 2AER", *QST,* Nov. 1926, p. 32-33, and concluded that stations, at times, should use "the same type of transmission and reception, either vertical or horizontal". GE conducted some famous tests, with the assistance of the League and many individual amateurs. "General Electric Short-Wave Test Results", M.L. Prescott, *QST,* Nov. 1926, p.9-13.

[22] In one of the earliest amateur radio articles on aurora, W.M. Sutton commented on several aurora events in 1926, observing that auroras "deadens" signals from 35 to 500 meters, but also provided evidence that, in some instances, signals might actually become stronger. "Aurora and Its Effects Upon Radio Signals", *QST,* Oct. 1926, p.23-24. Charles C. Henry then added to Sutton's comments by providing detailed observations of several auroras in 1926 that severely disturbed Western Union telegraph lines. "Aurora Investigation", *QST,* Dec. 1926, p.62.

[23] The tests were first proposed in an article by Robert S. Kruse, "Progress and Plans at 5 Meters - and Below", *QST,* July, 1926, p.34-38. Schedules were set up in "Experimenters' Section Report", *QST,* August 1926, p.41, and were again noted in *QST,* Sept. 1926, p.44. The Tripoli – Italian report was highlighted in "Experimenters' Section Report", *QST,* Dec. 1926, p.44; and noted at *QST,* Nov. 1926, p.13. A picture and schematic of the transmitter was presented in *QST,* Jan 1927, at 32-33.

[24] "Experimenters' Section Report", *QST,* Oct. 1926, p.27-28, commented that 2AUZ has been heard in Hammond, Indiana. The reception report was also noted at p.13, Nov. 1926. The 2AUZ station was presented in great detail in "Experimenters' Section Report", Dec. 1926, p.44-45. The transmitter used a single UX-210 tube.

[25] An interesting write-up on the formation of the IARU is contained in: "International Amateur Radio Union formed1", *QST,* June 1925, p.9-16.

[26] References to NBC, CBS, UIB, Sarnoff and Paley are taken from Communication Systems and Technology, A Chronology of Communication Related Events, Part I1: by R Victor Jones.

[27] The initial article on point was "Visible Radio Communication"", Wilkerson, *QST,* May 1925, p.15-18. Permission by the Bureau of Navigation, Department of Commerce to use TV was noted in *QST,* July 1925, p.38. A few years later in August 1928, the FRC authorized the use of amateur television and picture transmissions on only two bands: 150-175 meters (1715 to 2000 kc) and 5-meters (56,000 to 60,000 kc). See, "Amateur Television Waves", *QST,* Oct. 1928, p.8.

[28] "Television Arrives", G.L.Bidwell, *QST,* July 1925, p.9-15; "Amateur Television", Paul Thomsen, *QST,* Sept. 1928, p.17.

[29] "The Fourth National Radio Conference", *QST,* Jan. 1926, p.33-36. The allocation table listed 5.35-4.69 meters, 56,000-64,000 kcs, and 0.7496-0.7477, 400,000-401,000 kcs for amateur use. On an interesting

note of the usage of "kc" versus "cm", this cited *QST* article itself referred to "75 cms" as the ¾ meter wavelength allocation.

[30] See, "Editorials", *QST,* May, 1927, p.7-8, where it was felt that amateurs theoretically could operate on any wavelength below 200 meters. In the Editorial, the League heavily encouraged all radio stations to stay within their allotted wavelengths until new regulations could take effect. Most amateurs did so even while the broadcast frequencies broke down into utter chaos.

[31] "The New Radio Law", *QST,* April 1927, p. 39-44, contains a reprint of the entire 1927 Radio Act. The new Act codified the word "amateur" for the first time. At the time, the amateur community doubted that an administrative agency could adequately deal with technical details and rights of amateurs. See "Editorials", *QST,* April 1927, p.7-8. The Editorial expressed its hesitation with the matter when it concluded "We shall very soon see".

[32] "Radio Regulation Returns", *QST,* May 1, 1927, p.15-17. No examinations were required for current licensees, as existing licenses were merely extended from before the Act.

[33] The picture of "Transmitter No. 1" and the "no results" reference was taken from "An Investigation of the 5-Meter Band", E.M. Guyer and O.C. Austin, *QST,* July, 1927, p. 29-30, at 29.

[34] The 2EB and 2NZ route was noted in: "Flash! 5 Meter Results", *QST,* March 1927, p.55. The activities of 2EB were also mentioned in *QST,* March 1927, p.44-45.

[35] Ionization was theorized as far back as 1902, and was referred to as the "Kennelley-Heaviside layer". Dr. A Hoyt Taylor suggested reflection of radio waves could occur from ionization in: "The Navy's Work on Short Waves", *QST,* May, 1924, p.9-14; Prof. Kennelley himself briefly commented on ionization in "The Conference, in Relation to Amateur Activities", *QST,* Dec. 1924, p.18-19; and John L. Reinartz discussed radio reflections from ionized air in: "The Reflection of Short Waves", *QST,* April 1925, p.9-12.

[36] The event was announced in "Another CQ Party-This Time on 5 Meters", *QST,* May 1927, p.44. Activity levels for the event were high. 5 kw and 15 kw sets were on for the test, as were several International stations. *QST,* June 1927, p.42.

[37] The expedition was done by 2XM, and the farthest contact made from the mountain was 120 miles. See, "ARRL: The Boom Years", *QST,* June 1964, p.78-79. 2XM and F.G. Paterson conducted several mountain-top forays earlier in April, 1927 with confirmed contacts at 150 miles. See, "5-Meter Work at 2XM With Crystal Control", A.K. Turner, *QST,* June 1927, p.24-26. These activities may be the earliest reported portable and mountain-top UHF work.

[38] Initial results of the Party were in "The 5 Meter CQ Party", *QST,* August 1927, p.47. More results were contained in "The 5 Meter CQ Party Produces a Puzzle", *QST,* Sept. 1927, p.41-42, along with comments on a 120 mile contact between 10A and 2EB. A second event was announced for Nov. 19-20, 1927 at "Another International 5 Meter CQ Party", Sept. 1927, p.24; and at "The November Tests", *QST,* Nov. 1927, p.37-40.

[39] The picture and transmitter description is taken from "A 5-Meter Transmitter", *QST,* W.H. Hoffman, June, 1927, p.33-34, at 33.

[40] "Changes in Amateur Regulations", *QST,* Dec. 1927, p.24+. The UHF allocations were 64,000 to 56,000 kilocycles, or 4.69 to 5.35 meters; and 401,000 to 400,000 kilocycles, or 0.7577 to 0.7496 meters. Phone privileges were granted to the entire 5 meter band. The League was happy with the new regs, stating that "the new license is a close approach to the ideal we have had in mind for years…It looks good to us". *Id.,* at 30.

[41] The 1927 Washington Conference was extensively described at "The Amateur and the International Radiotelegraph Conference", *QST,* Jan. 1928, p.15-22; and "Extracts from the Washington Convention", Feb. 1928, p.28-29. The Conference's 5 meter allocation was restricted to 56,000 to 60,000 kc, while a UHF type of band was opened at 28,000 to 30,000 kc. Both 10 and 5 meters were for amateur and experimental purposes.

[42] The first of many articles in *QST* on updating equipment for compliance with the 1927 Treaty was: "Overhauling the Transmitter for 1929", Ross A. Hull, *QST,* Aug. 1928, p.9-19. Further articles on the subject are at: Sept. 1928, p.9-14; Sept. 1928, p.25-30; Oct. 1928, p.9-19; Nov. 1928, p.9-17; and Dec. 1928, p.13-16.

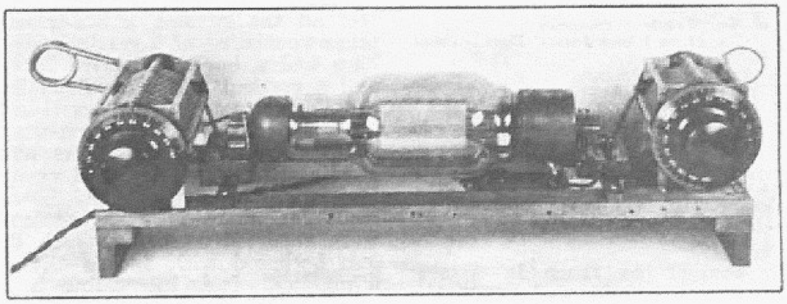
Chapter 5 - Three New Bands

5 Meters was developing a reputation for being rather quirky and unpredictable, and there was a general disappointment that the band seemingly did not support long distance traffic typical of the short wavelengths.[1] Further, virtually all of the equipment was home made and was difficult to work with even under the best of circumstances. To keep problems to a minimum, many UHF receivers employed super-regenerative circuits having a simple design while still possessing good gain. Feedback problems and self-oscillations were notoriously common however with "super-genny's". Most transmitters were extraordinarily unstable and exhibited severe drifting. It was quite normal for listening operators to follow meandering transmissions up and down the UHF wavelengths. Some transmitters even utilized broadly resonant, untuned grid circuits. In England for instance, a TNT transmitter circuit was regularly used. This circuit had two valves arranged in a push-pull pattern with broad resonance.[2] In the US, 852 tubes came into common use by 1928, and these tubes were ideal for UHF work.

In early 1928, the US Senate debated the Washington Conference Treaty, ratifying it on March 21, 1928. [3] Amateurs were eager to explore the new wavelengths authorized by the Treaty. At the urging of the League, the Federal Radio Commission on March 6, 1928 opened 10 meters for amateur use ahead of both the Treaty's ratification date and effective date.[4] Between the difficulties being experienced at UHF as well as experimentation occurring on short wavelengths, 5-meter activity had already dropped off before 10 meters was authorized. With the arrival of the newest UHF band, many more amateurs simply moved to 10 meters.[5] There was great interest initially in 10 meters, and early radio articles described the activity with the same unabashed enthusiasm as had been the case with 5-meters just a few years before.[6] In an effort to try out the band, a Ten Meter DX Party took place in late May 1928. [7] Other 10-Meter tests both in the US and Australia occurred in August 1928.[8] In a rush to get onto 10-meters, many amateurs actually transmitted on 14 mc and then deliberately radiated a second harmonic onto 28 mc! In commenting on almost two dozen calls being heard by W6DZL, the Communications Department of the League wondered: "If a small amount of 'harmonic' energy was responsible for some of these signals, what might a real bunch of 28 mc. transmitters do?" [9]

The new band proved to be no panacea, however. Far from it, many hams experienced the same frustrations as they did on 5 meters. Some amazing distances could be traversed upon occasion.[10] But overall, the wavelength was far less supportive of consistent DX work than was 20 meters.

Figure 5.1 – A 28,000 Kc Transmitter. The following design was from one of the earliest construction articles on 10-Meter equipment. With the early start-up of 10-Meters, many 10-Meter articles quickly appeared. [11]



THE 28,000 KC. TRANSMITTER AT 1SZ

A 204-A is used in an Armstrong circuit. The plate coil and condenser are at the left and the grid tuning circuit at the right. The blocking condensers, by-pass condensers and grid leak are located behind and under the tube. The antenna was a Zepp employing a half wave vertical radiator, 16 feet long. The two feeders were each 8 feet in length. The receiver was described in the article "A Portable Receiver" appearing in the April, 1928, issue of QST. No contacts were established with the equipment.

People generally referred to as "bootleggers" and "would be" hams were still populating the ham bands (and 5 meters in particular), as there had been a history of casual experimentation of individual and commercial transmissions from the earliest days of radio.[12] Indeed, when the FRC allocated 10 meters in 1928, the Commission also provided a US regulatory definition for the first time of who constituted an "amateur" radio operator, in an effort to stamp out the unauthorized use of all ham bands.[13]

Early amateur radio definitions relied upon the experimental, non-commercial nature of wireless activities by individuals, as the term "amateur" did not come into common usage until 1908, or thereabouts. Even after 'amateur' radio became more accepted as a distinct hobby, the critical test of what constituted an amateur radio station continued to be the non-pecuniary and experimental nature of the communications. England authorized wireless telegraphy "for experimental purposes" in the 1904 Wireless Telegraphy Act. In the US, the Radio Act of 1912, Regulation Fifteenth allowed the usage of airwaves below 200 meters to stations "not engaged in the transaction of *bona fide* commercial business by radio communication or experimentation". The term "amateur" was likely defined for the first time in the Final Report of the First National Radio Conference of 1922, to wit:

> "An amateur is one who operates a radio station, transmitting or receiving, or both without pay or commercial gain, merely for the personal interest or in connection with an organization of like interest."

The Radio Conference did not carry the weight of federal law however, so this definition was more descriptive in nature than legally binding. The 1927 Washington Treaty, General Regulations, Article 1, gave international protection to "private experimental stations" that satisfied the following conditions:

> "1. A private station intended for experiments with a view to the development of radio technique or radio art;

2. A station used by an "amateur," i.e., by a duly authorized person interested in radio technique solely with a personal aim and without pecuniary interest".

FRC General Order No. 24, dated March 7, 1928, adopted the following language as the amateur radio definition:

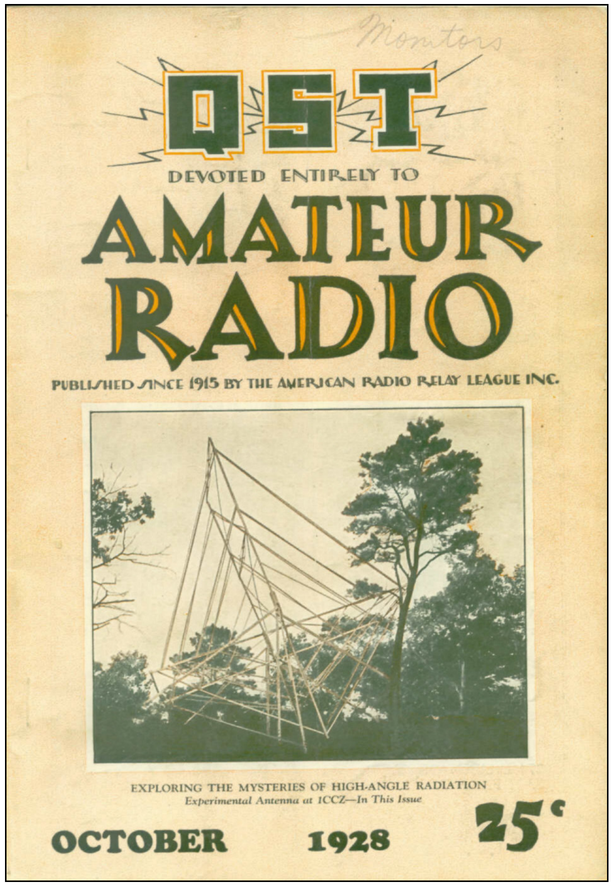
> "An amateur station is a station operated by a person interested in radio technique solely with a personal aim and without pecuniary interest. Amateur licenses will not be issued to stations of other classes."

With the implementation in the US of the 1927 Washington Conference, 5-meter activity then became limited on January 1, 1929 to the internationally recognized frequencies of 56,000 to 60,000 kc.

It was during this time frame that a revolution in antenna design occurred: In 1927 and 1928, Hidetsugu Yagi and Shintaro Uda invented the beam antenna.[14] The design had roots in directivity experiments conducted by many others, including both Hertz and Marconi, but the innovation was in the addition of both reflectors and directors in front of and behind the driven element. The earliest "Yagi-Udi's", as they were then commonly known, were just wires spaced apart on large, bulky wood frames, many of which could not be rotated. It took many more years of experimentation before the designs developed into the sleek shapes of modern looking metal and tubular yagi antennas.

Early UHF antennas were merely vertical or L type wires resonating at an ultra-high frequency. Yagi and Udi experimented with their antennas on frequencies as high as 6 gHz, obtaining telephony contacts as far as 10-30 kilometers.[15] Others quickly began experimenting with beam antennas on 10 and 11 meters, where the physical size of the arrays was more manageable.[16] In the years ahead, UHF frequencies would prove to be ideal for these new types of antenna arrays, owing to the relatively small size of antennas at UHF frequencies.

Figure 5.2 – A 10 Meter Beam Antenna. The following picture graced the cover of the October, 1928 *QST*. The antenna closely followed Yagi and Udi's specifications, and was possibly first experimental beam meant for amateur use.[17]



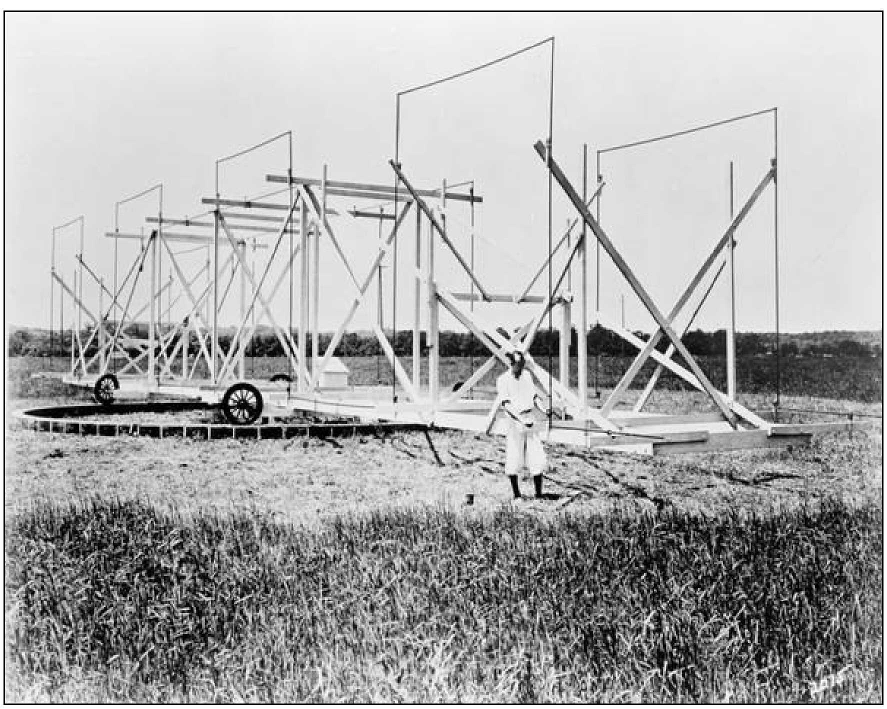
With the general disappointment of the 1927 5-Meter Tests, interest shifted to 28 Mc. Reports continued into 1928 and 1929 of great international activity in far-away stretches of the world, but propagation remained a mystery. There was also a lack of predictability to the wavelength, and interest in 56 Mc (especially) and to some extent, 28 Mc waned from 1928 into the early 1930's. Activity reports of 56 Mc evaporated. Indeed, the only ultra-high reports noted in 1929 QST's in either the Experimenters Section or in the Communications Department involved 28 Mc. Not a single report was made of 56 Mc activity during the entire year!

Military and commercial interests began to upgrade their communication equipment in the late 1920's, as European patents had become available in the US by then, and there was a general desire to improve the quality of and standardize electrical component manufacture. AC radios were supplanting old battery receivers in broadcasting, and amateurs quickly made use of the newer receivers. The ARRL embarked on an equipment improvement program of its own by 1928 and 1929, and many amateurs upgraded their equipment on the lower frequencies to "1929 standards", some with crystal control. [18] Within a few years, commercially made receivers designed for the amateur market arrived on the scene, including the National SW-3.

On April 5, 1930, the FRC issued new regulations under the 1927 US Radio Act. The regulations changed 10 meters and 5 meters from a shared experimental basis to an allocation reserved exclusively for amateur use. The regulations also reserved 400,000 to 401,000 kc for amateur stations, thus providing authorization under US law to continue amateur operations on ¾ meters.[19] Phone, television, facsimile, and picture transmissions continued to be allowed on 5 meters.[20]

A radio engineer for AT&T Bell Labs in New Jersey, Karl Jansky, in 1931 was given the assignment of finding various sources of shortwave noise. Working with a large antenna at 22 MHz, he found that most of the noise was related to thunderstorms and other earth-bound reasons. He found that one source of noise could not be readily explained, however – it methodically appeared in the skies four minutes earlier each day. Jansky was convinced that the radio static emanated from beyond the earth. After further study, he realized that he was listening to the background noise from the center of our own Milky Way. Jansky described his efforts as listening to "star noise", as "radio astronomy" would not be commonly used until after WWII. Jansky's findings were publicly disclosed in a page one story in the New York Times in May, 1933. Virtually all the professional astronomers of the era ignored Jansky's discovery, keeping their attention focused on their own optical observations. It took many more years before others would further advance Jansky's efforts.[21]

Figure 5.3 – Jansky and his Antenna. The world's first radio astronomy antenna was mounted on a square wooden structure that could be rotated for added directivity. After tracking down the sources of radio static, Bell Labs was satisfied that the noise would interference with their electrical designs, and assigned Jansky to other projects. He never conducted further radio astronomy observations, directing his studies instead towards radar in WWII and microwave repeater technology after the war. [22]



Microwave experimentation occurred in 1931 when Andre Clavier of Paris made the first trans-English Channel microwave contact on 1.7 GHz using a 3 meter parabolic dish antenna. A decade later, Clavier would go on to test tropospheric scatter at 3 GHz. The magnetron was also developed in this same time period. British Admiralty enlisted the University of Birmingham, England in efforts to produce a microwave generator for the "microray" wavelengths.

In 1932, all remaining radio related functions in the Department of Commerce was transferred to the Federal Radio Commission. On October 1, 1933, FRC regulations pertaining to amateur radio were extensively revised. Telephone sub-bands were more fully authorized and expanded, new amateur license classes were instituted, and power supply filtering requirements were required on the lower bands.

An International Telecommunication Convention was held in Madrid in 1932. Amateurs were accepted at the Convention as having an important role in the radio world, instead of being viewed with suspicion by many countries, as was the case in the 1927 Washington Conference. In the end, no major changes were made at the conference to international amateur radio frequencies. The Madrid Convention was ratified by the US Congress on June 12, 1934.

A few days before that, the Communications Act of 1934 was enacted on June 9, 1934. The Act replaced the FRC with a new body, the Federal Communication Commission, effective July 1, 1934. The new body took over all functions of the FRC. The overall scope of the new Commission was expanded somewhat by the 1934 Act, but no substantial changes that adversely impacted amateur radio activities.[23]

On June 22, 1934, amateurs were authorized the non-exclusive right to operate at all frequencies above 110 mc, on an experimental basis. In addition, general mobile work was authorized above 56 mc. Both of these actions were taken at the League's request. [24]

The League quickly moved towards developing activity on two UHF bands that were harmonically related to 56 mc – 112 to 120 mc (2 ½ meters) and 224 to 240 mc (one ¼ meters), as well as proposing activities on other UHF frequencies.[25] Some experimentation was also occurring by this time on 400 Mc and higher, although most of the activity was still on 5 meters. A few years before in 1932, Marconi conducted his now famous experiments off the Italian coast at frequencies near 500 Mc. He was able to achieve consistent transmission paths over 150 km (90 miles). [26]

Thus, within 10 years of the initial 1924 authorization of the first experimental UHF frequency allotment at 56 mc, five separate wavelengths existed for amateur radio activity on the ultra-highs: 28-30 mc, 56-60 mc, 112-120 mc, 224-240 mc, and 400-401 mc. The framework of what we consider today as the four lower VHF bands was firmly established by the Depression. While the exact location of the VHF bands have moved around over the years, and with the fifth set of frequencies – that of 10 meters – being viewed today as the highest HF band instead of the lowest UHF wavelength, it is amazing to realize that the basic framework for amateur VHF activity was solidly in place over three generations ago. VHF has deep historical roots.

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[1] The 20 year history article, at "Twenty Years of Amateur Radio", *QST,* May 1934, p.20-26, succinctly summarized the feeling at the time: "A few experimenters struggled diligently with 5 meters, but achieved no satisfying results". The disappointment of the early 5-Meter experimenters is also evident in an excellent technical article, "Developments in Ultra High Frequency Oscillators", *QST,* July 1931, p.9-20, at p.9, in which it was commonly felt that 5-meters was "not so good for DX…(and) no good at all".

[2] See, VHF/UHF Manual, 4th ed. 1991, RSGB publ., at p.1.1.

[3] See, "Recent Changes in Radio Law and Regulations", *QST,* May 1928, p.14-15.

[4] *QST,* May 1928, at p.14-15. Authorized 10-meter frequencies were 28,000 to 30,000 kc. The same regulations continued to authorize 400 Mc and 5-meters, with the full 5-meter frequencies of 56,000 to 64,000 kc being maintained for the moment, instead of the Treaty's more limited 56,000 to 60,000 kc allocation.

[5] Bill Tynan in "Our Early Heritage", Proceedings of the 28th Conference, Central States VHF Society, 1994, at p.67, discusses the initial hopes of 5 Meter enthusiasts being dashed by 5 Meter conditions, with activity then shifting to 10 Meters.

[6] In "Ten-Meter Results!", *QST,* May 1928, p.46, initial reports were quite encouraging. The first reported 10-meter contacts occurred on April 1, 1928 between 6UF in Knowles, Cal.; 8EX in Cleveland, Ohio; 6DBO, Raymond, Cal.; and 8ALY in Rochester, NY. *Id.*

[7] The DX Party was mentioned in "Ten-Meter DX Party Coming", *QST,* May 1928, p.46-47. One point was awarded for reception of 10-meter signals, and 5 points for a complete contact. The results of the Test were announced at *QST,* July 1928, p.49-50. The highest score was of 2TP, Leonia, NJ, with all of 36 points.

[8] The second US Test scheduled for August 1928 was announced in *QST,* July 1928, p.50, and *QST,* Aug. 1928, p.51. Australian tests between August and December, 1298 were noted in *QST,* Sept. 1928, at I, and results of both Au and US tests were contained in "About 28-mc Work", *QST,* Oct. 1928, at I-II, where a 1500 mile Australian contact was mentioned.

[9] "About 28-mc. Work", *QST,* Nov. 1928, at IV-V. Using 2nd and even 4th harmonics (from a 7,000 kc transmitter) on 28 mc was discussed in *QST,* Oct. 1928, at I-II. Harmonics were also mentioned at *QST,* July 1928, p.49-50.

[10] The first "truly" transcontinental contact on 10 meters may have occurred the month before the DX Test on April 29 between 6ANN and 2JN. *QST,* July 1928, at 50. The earliest transpacific reported contact might have been Oh6CFQ, Honolulu, who worked nu6BOE before the DX Tests. "Ten Meters," *QST,* June 1928, at 44. G2OD, Middlesex, England, and W1AQD of Maine made contact on Oct, 21, 1928, and W6UF had a two hour contact with ZL2AC, New Zealand, on Nov. 8. *QST,* Dec. 1928, p.I-II.

[11] The picture is from "28,000 Kilocycles – and How!" Harold P. Westman, QST, Aug. 1928, p.37-42, at 37. The article contains nice reviews of several pioneering 10-meter stations. The first articles on 10-meter equipment were "A Portable receiver", James J. Lamb, *QST,* April 1928, p.41-42; "Getting Started at 30 Megacycles", Robert S. Kruse, *QST,* May, 1928, 9-10; and "Ten Meters and the Ultraudion", J.T. McCormick, *QST,* May, 1928, p.11-13. A more refined transmitter was discussed in "28-Megacycle Crystal-Controlled Transmitter", Howard Allan Chinn, *QST,* Nov. 1928, p.29-32.

[12] Bill Tynan, in "Our Early Heritage", Proceedings of the 28th Conference, Central States Society, 1994, at 67, noted the problem with bootleggers as well as unauthorized but historically important commercial and private experiments on the ultra high frequencies.

[13] The 1928 FRC regulations, and the amateur definition in the new regs, were extensively reviewed in "Recent Changes in Radio Law and Regulations", *QST,* May 1928, p.14-15. Robert S. Kruse commented one month after the 10-meter band opened that "the main effect of the announcement so far appears to have been a complete collapse of the bootleg activity on 30 Mc.–the attraction probably went out when it became legal", in "Getting Started at 30 Megacycles", *QST,* May 1928, p.9.

[14] S. Uda wrote his ground-breaking paper in May, 1927 in "High Angle Radiation of Short Electric Waves", Proceedings of the Institute of Radio Engineers; H. Yagi's famous work is "Beam Transmission of Ultra Short Waves", in Proceedings of the Institute of Radio Engineers, June, 1928.

[15] See, VHF/UHF Manual, 4th ed. 1991, RSGB publ., at p.1.1.

[16] A. Meissner wrote on beam antennas for 27,250 kc in "Directional Radiation with Horizontal Antennas", Proceedings of the I.R.E., Nov. 1927; The watershed article among amateurs was "High Angle Radiation", Paul S. Hendricks, *QST,* Oct. 1928, p.31-32.

[17] See, *QST,* Oct. 1928, at 31-32. The antenna was built at the summer home of 1CCZ on Cape Cod, and was aligned towards eastern Australia, given the activity occurring there at the time. The beam employed two directors, the driven element, and three reflectors arranged in a parabolic fashion around the driven element. The resonant frequency was 28,846 kc.

[18] "1929" equipment articles included: "A 1929 Receiver (Hendricks), *QST,* Feb. 1929, at 29; "Another 1929 Receiver (Hendricks), may, 1929, at 15; 'Modern Practice in High-Frequency Radiotelephony" (Hull), April, 1929, at 8.

[19] The Washington Treaty did not reserve any frequencies above 60,000 kc for any types of services or interests. Presumably, treaty nations could continue allocating frequencies above 60,000 kc as they saw fit.

[20] "Our Regulations Are Revised", *QST,* May 1930, p.16-20. The same month that the new regulations were published in *QST,* the magazine's editorial page noted that facsimile had been previously authorized on 1715-2000 kc and the 56 mc band, but that the editor had not heard of much amateur experimentation with the mode at 5 meters. The editorial went on to discuss some technical aspects of facsimile. *QST,* May 1930, p.7-8.

[21] From the NRAO web-site, Ham Radio Connection sub-page located at: http://www.nrao.edu/

[22] The picture is from the Bell Labs web-site, at: http://www.bell-labs.com/news/1998/june/4/jansky2.jpeg.

[23] "The New Law", *QST,* August, 1934, p.34.

[24] *QST,* "What the League is Doing", August, 1934, p.32. Up until these rules changes, only aircraft was considered to be "mobile", and then only on the 56 meter band. Transmissions in automobiles could only occur after the auto was stopped.

[25] "The Editor's Mill, *QST,* June, 1934, p.7-8, discussed moving onto frequencies at 120, 240, 480, and 960 mc. The first article on 2 ½ and 1 ¼ meter equipment appeared very quickly, *QST,* "Firing Up on the Newly-Opened Ultra-High Frequencies", Ross A Hull, Sept. 1934, p. 13-17. Another nice article on tubes and directive antennas appeared in "Practical Communication on the 224-Mc. Band", Ross A. Hull, *QST,* Nov. 1934, p.8-11. Another good piece was "Notes on the Ultra-High-Frequency DX Work", Ross A. Hull, *QST,* Dec. 1934, p.8-9.

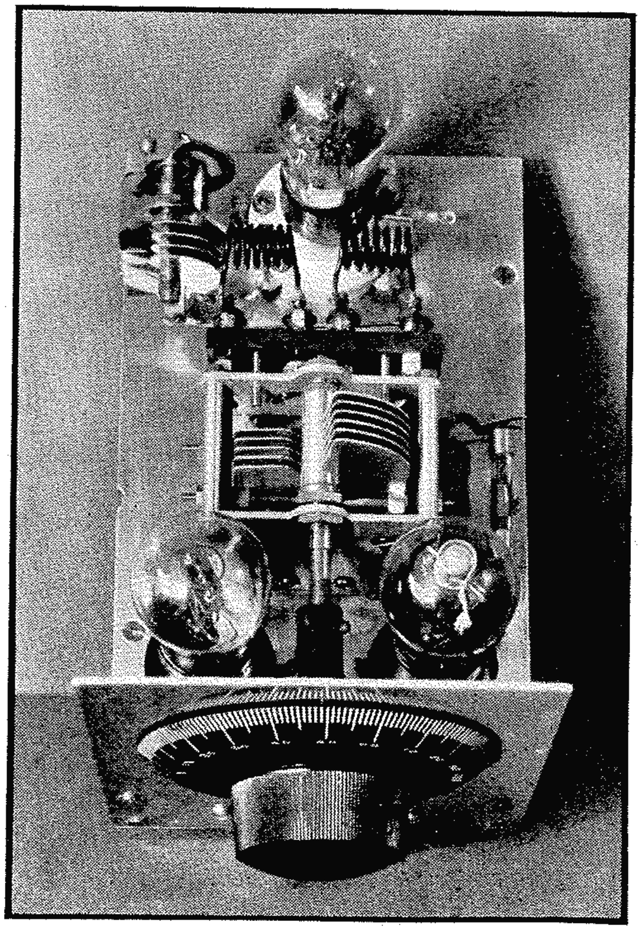
[26] Marconi's tests were noted in Tynan, p.68, and in the *VHF / UHF Manual,* 4th ed. 1991, RSGB publ., at p.1.1-1.2. The VHF/UHF Manual believed that these tests were "perhaps the first real indication that communication far beyond the visible range was possible".

Chapter 6 – Exploration of UHF Propagation

By the early 1930's, amateurs were beginning to modulate their oscillations. The unstable voice signals could not be received properly by selective receivers being used by that time on 40 and 20 meters, but sounded much better on super-regenerative and broadly tuned "rush boxes". Plenty of room existed on 5 meters for these wide signals, and modulated oscillators and super-genny's made for ideal short-range equipment. So long as the two stations were transmitting on somewhat different frequencies on the 5 meter band, duplex phone operation could result. This was an entirely new concept in radio, and was an instant hit on the amateur bands, as it allowed for telephone-like conversations.

The equipment was rather easy and cheap to build by this time, with tubes from household broadcast sets being pressed into service as transmitting tubes for a 5 meter rig. As Ed Tilton commented "these were the magnets that drew countless newcomers, including the author of these lines, into amateur radio in the early Thirties". [1]

Ross Hull had been working at ARRL Headquarters as a technical editor. Hull and other pioneering experimenters wrote a series of popular articles detailing portable 5-meter equipment. This sparked tremendous interest on 5-meters.[2] The following picture is a receiver based on one of the articles.



A PLAN VIEW OF THE SUPER-REGENERATIVE *56 mc. receiver, the chief features of which are extremely high sensitivity, simplicity of tuning control, and an ability to operate reliably in a moving automobile.*

After building the equipment from the construction articles in the 1931 *QST* issues, the Bloomfield Radio Club in New Jersey held an event on Washington's Birthday, 1932. A record 56 Mc distance may have been established in that event when W2AFP worked W2TP over 48 miles using "buzzer" modulation. High Point, NJ served as the western end of the contact.[3] 56 Mc QSO Parties were also held in early 1932 in New Jersey, Massachusetts, and Connecticut. 13 stations were worked and 18 messages handled from W1AWW.[4]

Numerous 5-meter airplane and glider tests were also conducted in 1932 and 1933, generating further activity.[5] Within a short time, hundreds of 5-meter stations populated the airwaves in the New York, Boston, and Philadelphia areas.

Most UHF communication at the time involved only local distances. Still, questions persisted regarding UHF propagation characteristics. While it was becoming increasingly clear that reflection or refraction of radio waves off of different layers of air was responsible for the DX characteristics of the short waves, 5-meter propagation remained one, deep, unending mystery. Engineers and physicists generally believed that ionospheric refraction could be used for extended communications only up to around 12 or 13 meters, and possibly up to 10 meters during great solar conditions. [6] Yet, scattered reports and rumors continued to circulate of transcontinental and transatlantic reception of UHF signals.

Around this time, Ross Hull erected a directive antenna at Seldon Hill in West Hartford, Ct, where many League staffers then lived. He immediately made contact with Boston area hams, some 100 miles distant. Over the next few weeks, it became obvious to Hull and other ARRL staff members that routine contacts on 5 meters were possible far beyond the line of sight. Hull wrote of his experiments in *QST,* and his activities on VHF were widely followed. [7] By showing the effectiveness of directive wire arrays, Hull's VHF propagation articles quickly became classical reading material for both 56 Mc work as well as for the entire antenna design field.

Amateurs were astounded in 1935 when W2DEE was heard in Michigan on 56 mc. On June 22, 1935, W1CBJ worked W8CYE on 56 mc in a two way contact over 900 miles. Over the next year, sufficient long distance contacts occurred to formulate a belief that sporadic communication could be supported beyond those normally reflected beyond the ionosphere.[8]

In an effort to sort of propagation abilities on the ultra-highs, 28 Mc year-long contests were conducted in 1934-1935, and 1936. One point was awarded for each completed contact at a distance of 100 miles or more, with same station contacts only being allowed once a month. Equipment design and development was also credited, as was turning in weekly reports to the League. Herbert Wareing, W9NY, of Milwaukee, Wisconsin, won the 1934-1935 contest by making 256 contacts on 28 Mc with 128 different stations. He worked six countries on four continents, worked all US radio districts except for W7, keyed the transmitter manually at all times, and never exceeded 200 watts of power.[9] Six individuals submitted formal entries, and another dozen or more amateurs submitted regular reports, but did not submit a tabulation of DX scores, experimental data, and apparatus description. "Hundreds" were then engaged in 28 Mc work, and presumably made one or more contacts in the contest. Thus began the proud tradition of not submitting a contest log!

John J. Michaels, W3FAR, of North Wales, Pa, won the 1936 28 Mc contest. Rules were similar to the previous year's contest, and the winner used horizontal doublets, with five-wavelength (167 foot) long flat top horizontal wires spaced exactly 33 feet off the ground. W3FAR kept his power under 50 watts during the entire 12 months, and at 5 watts during the month of March, 1936. He submitted a 45 page log to the ARRL, which was considered a "valuable treatise on 28-Mc communication". Honorable mention was given to OE1FH, who would have placed third in the competition had entries outside of W/VE been accepted (this started another long tradition of not accepting international entries in domestic ARRL contests!). He made 360 contacts to North America in 1936. 77 individuals submitted at least one weekly report but then did not enter formal summaries for further consideration. No mention was made of the exact number of amateurs who submitted all of the required paperwork necessary for “consideration”.[10] Incidentally, W3FAR achieved the first WAC award on 10 meters the year before the 1936 contest, on October 12, 1935.[11]

This enthusiasm for the ultra-highs carried over into contests conducted on the lower frequencies. While focusing on short-wave lengths, early Field Day exercises allowed UHF activity. Every FD from the 2nd annual event in 1934 through the last pre-war exercise in 1941 contained references in the contest write-ups or soapboxes to the use of 56 Mc. Indeed, much of the pioneering work on UHF in the 1930’s grew out of these early Field Days. Ed Tilton, W1HDQ, achieved early fame and recognition by being the high-scorer on the 56 Mc band during the 1934, 1934, and 1936 Field Days.

By the thirties, Edwin Armstrong had made numerous breakthroughs with frequency modulation (FM) systems. He had been experimenting with the concept since 1925, and several years later in 1933, Armstrong was awarded circuit patents for FM. On June 9, 1934, Armstrong demonstrated the superior noise reduction characteristics of FM by broadcasting an organ recital in both AM and FM. With this demonstration, he showed that FM was a practical, wideband, noiseless system. In 1936, Armstrong wrote a very important paper on FM, and his analysis of a noise-free high fidelity system became the basis of FM broadcast activities. Soon thereafter, the FCC allocated 42-50 mc to FM broadcasting. W2XMN in Alpine, NJ was initially set up by Armstrong in this first FM band. It was eventually moved to 108 Mc and operated there until the late 1950’s. On an interesting historical item, Armstrong’s original tower in New Jersey was used by the media after 9-11-01 attacks, since a major TV and radio mast atop the World Trade Center had been destroyed.

In 1936, G5BY was the first European to span the Atlantic on 56 MHz when his signals were heard by W2HXD. In the same year, the League and the Milwaukee Radio Amateur’s Club, co-sponsored a 12-month competition on 56 Mc. Paralleling in some respects the 28 Mc contest occurring during the same year, a trophy was to be awarded to the winner of the all-year event. The event did not develop the number of reports and points for contacts as was hoped. The affair was deemed to be “no competition” in view of the “circumstances that the entries are insufficient in number and quality to make an award justified”.[12] Instead, the trophy would be awarded to the first person to make a confirmed 56 Mc. two-way contact between two continents. It would be another 11 years before the trophy was claimed. The first 50 Mc-only inter-continental contact occurred on March 23, 1947 when W4IUJ, West Palm Peach, Fla worked OA4AE, Lima, Peru.[13]

By 1937, the 5 meter band had been reduced to a 4 mc bandwidth between 56 band 60 mc. The band also had become over-populated by very unstable oscillator rigs. At the request of the ARRL, the FCC in 1938 imposed stabilization and power supply filtering requirements on 5 meters similar to that required on the low bands. This initially reduced activity on 5 meters but also indirectly led to experimentation on even higher frequencies, as hams simply moved their unstable equipment from 5 meters to 2 ½ meters. The year before, the FCC reserved 112 to 118 Mc and 224 mc as future amateur bands. By 1938, amateurs were expressly granted amateur privileges on 112 and 224 Mc. Many hams moved to these higher frequencies to avoid the new regulations. Ironically, this would prove to be a boon in activity on these newer frequencies.

With better stability of signals, 5-meters ops after 1938 did not have to contend with excessive QRM, and thus could concentrate on improving equipment, antennas and equipment. Eventually, crystal controlled transmissions and super-heterodyne receivers with relatively narrow IF's were developed for 5-meters, and that led to regular communications occurring over distances of 250 miles or more, especially on CW. With the longer distances that were now possible, more instances of e-skip on 5-meters were noted.

Field Days in the late 1930's continued with efforts on 56 Mc. In the 1937 FD, W2DKJ used 56 Mc exclusively, making 74 contacts. This was quite extraordinary for the time, as all equipment was transported to the tower at 40 Wall Street, NYC! High Point Park in New Jersey was used by another group solely on 56 Mc, the Tri-State Radio Club, W3GKI. 62 contacts were made with only 15 to 18 watts of power. In a very early reference to another great VHF location, Mt. Greylock was used in this Field Day, with W1EFN making 33 QSO's. Five other stations were also noted as working only on 56 Mc that year.[14] In the 1938 Field Day, W2AJW made 73 of their 165 contacts on 56 Mc. A 60 foot fire tower in New Jersey on top of a hill 250 feet above sea level was used in the effort.[15] The leading Field Day crew in the 1939 FD, the Egyptian Radio Club of Alton, Illinois (W9AIU) made contacts on both 56 and 28 Mc, as well as 14, 7, and 1.75 Mc.[16] In the 1940 FD, a 112 Mc distance record was set at 206 miles, only eight months after the frequency was first used in a UHF contest.

In 1938, the Varian brothers developed the Klystron tube capable of microwave output of significant amounts. In England, a resonant cavity was also developed. That same year, the distance record for 56MHz was shattered when W1EYM made contact with W6DNS over a 2500 mile contact on July 22, 1938. W1EYM used a rhombic antenna for receiving, with 240 feet on a leg.

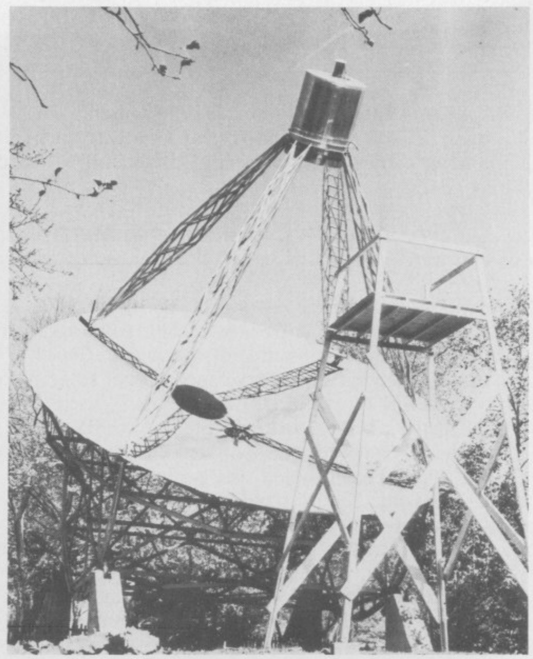
The first "true" ultra-high contest that was actually completed was an international one. In 1938, the Radio Society of Great Britain sponsored a 56 Mc International Contest. This was also a year-long event, with distance points awarded and monthly reports sent to RSGB. Any station in the world could enter. It was strictly a CW event – all types of modulated carriers and telephony were prohibited. This was possibly due to some countries only having cw authorization on 56 mc. The same station could only be worked once every seven days, and all stations had to be from a fixed location (unlike many domestic UHF events, including the UHF Relays, Marathons, and especially FD). There was also a companion 56 Mc reception reporting contest, for those areas of the world not yet authorized for transmissions on 5 Meters.[17] A number of US amateurs participated, and W9NY of Milwaukee, Wisconsin led the contest with over 100 contacts. He was on the air 338 days during 1938, running 300 watts input to a two-element co-linear in-phase antenna. Only 42 contacts made by W9NY were over 200 miles in distance, and 73 contacts were less than 200 miles.[18] Many years later in 1967, the League commented that "this very first v.h.f. contest was way ahead of its time".[19]

UHF activity in general was becoming so recognized by the late 1930's that in December, 1939, the League started a column in *QST* exclusively devoted to the higher bands. Ed Tilton, W1HDQ, was the column's first editor, or "conductor". Originally entitled "On the Ultra Highs", this column contributed greatly to knowledge of VHF activities in the early days of amateur radio. For a few months in 1942, the column's title was "Off the Ultra Highs", in a not so subtle reference to delays in developing a civilian wartime amateur radio service. The column's title was updated to "On the Very Highs" in May, 1943, and was again changed to "The World Above 50 Mc" in December, 1945. Metric notation was adopted in January, 1976, and the column became known as "The World Above 50 MHz". Other than a brief interlude between August, 1944 through September, 1945 (Tilton was then assigned to the Pacific with the US Navy), the column has run continuously to the present day, and has been a focal point for the entire VHF community.

Early ham-related ultra high transmissions showed evidence of tropospheric propagation, along with many instances of sporadic E and aurora propagation. For example, Vice Dawson, W9ZJB, of Kansas City, Mo in 1939 made the first 56 Mc "grand slam", having worked all 9 US area call areas, with several contacts being made by sporadic E. This accomplishment was considered so monumental at the time that it was noted in Tilton's very first *QST* column in December, 1939. Amateurs were making these types of contacts at a time when some professional engineers still doubted that atmospheric conditions could even be used for radio communications.

A radio engineer, amateur radio operator, and avid DX and VHF enthusiast, Grote Reber, read about Karl Jansky's radio astronomy experiments. Starting in 1936 from his home in Wheaton, Illinois, Reber built a 32-foot diameter dish antenna in his backyard to listen to radio emissions from the skies. He also built most of his radio equipment, and some of his VHF / UHF receivers were on the cutting edge of technological design for the time. Reber conducted many of his experiments at VHF/UHF frequencies, having attempted radio observations first on 3300 Mc and then on 900 Mc. In 1939, Reber confirmed Jansky's earlier discovery by listening for radio signals at 160 Mc, slightly above our present day 2-meter band. By methodically mapping all the radio sources he could detect, Reber by 1941 had completed the world's first radio sky survey. For almost a ten year period before and during WWII, he was the only radio astronomer in the world. It was only many years later that both Jansky's and Reber's early and groundbreaking work became widely recognized and honored. Reber's results were eventually published in many scientific journals, and his Sky Surveys became the standard reference manual for all radio astronomers for many years. Today, his contributions to radio astronomy are considered so important that his original parabolic antenna (as well as a replica of Jansky's original antenna) is on permanent display at the National Radio Astronomy Observatory (NRAO) site at Green bank, West Virginia. Reber's amateur radio callsign, W9GFZ, is now in use by the NRAO amateur radio club.[20]

The original radio astronomy parabolic dish antenna of Grote Reber drew so much interest in his hometown that it became a minor tourist attraction. The dish antenna was custom designed by Reber at a time in which television antennas only existed in a few experimental research laboratories around the country. The picture was taken in Reber's backyard in Wheaton sometime after 1936. The wooden platform in front of the antenna was used for servicing the focal point apparatus.[21]



Listening for the ultimate DX: Radio astronomy got its start with this dish, designed by Grote Reber. Grote built the dish, which is 10 meters in diameter, in 1936. For the story on the first radio astronomer and his continuing work, see the story on page 58 of this issue. *(photo courtesy National Radio Astronomy Observatory)*

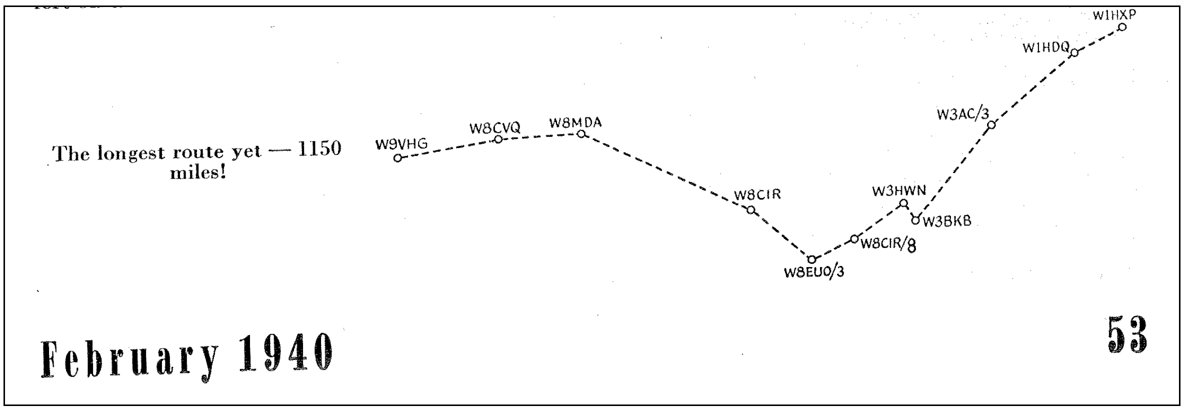
In many ways, the ARRL UHF Relays and Marathons were the predecessors to our present-day VHF contests. Perhaps most importantly, these events developed into serious efforts at exploring propagation and developing communication abilities at ultra-high frequencies. The first "U.H.F. Field Day and Relay" occurred on September 9-10, 1939. Drawing upon UHF tests and relay methods developed earlier in the decade as well as in the successful FD operations on 56 Mc, any amateur was invited to participate, whether fixed, portable, or mobile. The contest announcement even noted: "get set for a second F.D. dedicated to the ultra highs!"[22] Distance points were given for the contacts as well as points for message origination and relays. The objective was to relay messages "away from their starting points by town-to-town hops".

Some stations set up at high points and mobiles at half-way places, and were thus in a position to bridge gaps in relay traffic routes. The longest relay route went from the east coast to Chicago, for a total distance of 1000 miles, involving 11 stations. The fastest route went from W1HDQ in Massachusetts to W3DBC in Washington, DC, covering 325 airline miles. The message was sent and returned in 8 hours 22 minutes. Detailed descriptions of numerous routes were contained in the contest write-up.[23] 28 stations submitted a report, although it was obvious from the results that many more participated. All activity was on 56 Mc. The leading scorer was Goyn Reinhardt, W3AC/3, who operated from High Point, New Jersey. Strapping a four half-wave collinear array to the side of a patio, Goyn operated portable from his Plymouth Coupe (see below picture). The antenna was an adaptation of a design by Ross Hull. The transmitter was a self-controlled oscillator running 45 watts to a pair of 807's. 308 points was amassed by Reinhardt. [24]

W3AC/3, leading station in the Relay operating from his Plymouth coupe at High Point Park, N. J. (alt. 1800 ft.).

In recent years, this UHF Relay has been commented upon several times. In a 30 year retrospective of VHF contesting, it was noted that: "This affair was the first ARRL sponsored v.h.f. contest and it turned out to be the grandfather of our present V.h.f. SS and QSO Party systems." [25] In another wonderful retrospective article, two mountain-top vhf operators were operating from High Point State Park, NJ in the 1994 September VHF QSO Party, the very same spot as the first UHF Relay. They asked a local visitor for help in locating extra VHF radios for use in the operation. He soon came back with a friend – it was none other than Goyn Reinhardt, who lived nearby! By that time being 87 years old and having the call W2AF, Goyn carried along his original transmitter from 1939 and an extensive scrap-book of pictures and mementos! Contest activities came to a quick halt as the two operators recognized the historical significance of the occasion. [26]

Back to the early years of contesting, the UHF Relay format was so successful that "UHF Relay Number 2" was held in November, 1939. A much greater volume of traffic was handled than in the 1st relay, and over 94 stations submitted logs. Skip occurred during the event, allowing a "surprising" number of messages to reach their destinations. The longest route, from Boston, Massachusetts to Chicago, ran 1150 miles, and involved 11 operators (see the route, below, described in the Feb. 1940 *QST*). W3AC/3 was again the leading scorer, with 40 contacts and 408 points. For the first time in any UHF organized event, 112 Mc was used for several of the relays. [27]



The relays settled into a quarterly pace from there. A large turn-out occurred for the Third UHF Relay, held in February, 1940. W3AC/3 continued his leading scores, again from High Point, NJ, working 32 stations and scoring 370 points. A large percentage of relays were delivered, and many made a complete return route as well. 112 Mc was again used for some of the relays, and for the first time in a Relay event, messages were sent on 224 Mc. [28] The fourth Relay held in May, 1940 had 500 to 1000 miles skip contacts, allowing for an amazing 1800 mile relay route between Tucson, Arizona and Orlando, Florida. For the fourth time in a row, W3AC/3 took high honors, with 34 contacts and 384 points.[29] The fifth UHF Contest took place in September, 1940, but had an absence of "DX-skip" communication. 112 Mc was used to a greater extent than before. W2DKJ/2 took the top place with 50 contacts on 56 Mc and 112 Mc, and 858 points. Relays were developing into a "practical and efficient system". In the sixth UHF Contest held in December, 1940, states worked were also noted in the reports. W3HOH led the event with 53 contacts on 56 Mc and 112 mc, 6 states worked, and 4164 points. An extra multiplier was given for cw, and many of the stations primarily relied upon code for the relays, as a result of the multiplier. Several of the relays were accomplished only because of the use of cw, given the marginal band conditions.

The seventh UHF Relay had no contest write-up on it, and the eighth Relay only had a small box score, without any extensive discussion. W2BZB led with 75 contacts on 56 Mc and 112 Mc, with a total score of 256 points. The ninth UHF was described as a

“Round-Up” and was held on Nov 1-2, 1941. It also did not have any contest write-ups on it that could be located.

“UHF Marathons” were also sponsored by the League in 1940 and 1941. The then four VHF bands of 56, 112, 224, and 400 MHz were included in some of these contests, although most of the contacts took place on the lower two bands. The Marathons ran for an entire year, with monthly awards for high point scorer on the month, and then a cumulative award for high scorer on each band. QSO points were provided for various distances and bands. A separate award was given for working the most states throughout the year on each band. While Marathon contestants were automatically entered in the worked all states competition, an operator did not have to compete in a Marathon to qualify for the states award. Contacts achieved in a UHF relay would also count towards that year’s Marathon.[30] The last pre WWII Marathon was actually stopped by US entry into the war on December 8, 1941 after attracting around 80 entrants from all over the country.

Several achievements occurred in the 1940 Marathon. The first 224 Mc contact in any contest occurred in the first month’s Marathon, in January, 1940. In that event, W1AIY made one QSO on 224 Mc, one month ahead of the frequency initially being used in the UHF Relay. W1HDF set a distance record on 224 Mc in May, 1940 (13 miles), while another participant in the Marathon, W6IOJ began a series of distance records on 224 and 400 Mc, with a 135 mile contact on 224 Mc in August, 1940 and an 11 mile QSO on 440 Mc in September, 1940. Ten different ops won the 12 monthly certificates (W3HOH won 3 times). The national high score was established on 56 Mc by W5AJG with an incredible 166 contacts. The high score on 112 Mc was set by W6RVL, at an even greater 191 contacts, and the 224 Mc high score was made by W6IOJ, with 4 QSO’s. The states awards went to W9ZJB, 27 states on 56 Mc; W2DZA, 5 states on 112 Mc; and 3 amateurs on 224 Mc with 2 states, W1AIY, W1HDF, and W1KLJ. [31]

In 1940, foreign amateur contacts were banned, as the war in Europe expanded. Portable and mobile operations below 56 mc were also prohibited, although an exception was allowed for Field Day exercises. The US government assigned Raytheon to work with MIT in developing microwave type tubes. The US Army Signal Corp had conducted secret radar experiments since 1930 at Ft. Monmouth, NJ, even having an army colonel hold the basic patent for radar in the US. The Army Signal Corp also encouraged Armstrong’s FM system, which assisted army mobile communications.

In 1941, Clavier used 3,000 Mc for tests on tropospheric scatter. US amateurs did not being work on the 3300 Mc band for an additional 14 years, until after WWII.

The 1941 Marathon added multipliers for FM and above 400 Mc work, as well as providing monthly credit for minimum regular activity. The most states award was also maintained.[32] W6IOJ and W6LFN made the first contest QSO on 400 Mc in the January, 1941 UHF Marathon, over a distance of 20 miles.[33] It was a DX record on the band at the time. W6IOJ continued breaking records during the year, with a 60 mile contact on 400 Mc in September, 1941. There were 8 monthly winners with 3 amateur winning 2 or more months in 1942. The national high score was achieved on 56 Mc by W8CIR, with 131 QSO's and 2,416 points. The high score on 112 Mc went to W3HOH, amassing 425 contacts on that one band. The high score on 224 Mc was achieved by W2DZA, with 5 contacts. W6IOJ took top honors on 400 Mc, with 2 contacts, both of which were DX records at the time! Most states worked in 1941 on 56 Mc went to W2BYM, at 30; on 112 Mc, 5 stations at 7 states each; on 224 mc, W2DZA, with 2 states.[34]

As of December, 1941, UHF distance records were 2,500 miles on 56 Mc; 335 miles on 112 Mc; 135 miles on 224; and 60 miles on 400 Mc. Both the 224 and 400 Mc records were set by mountain top stations in California, where much experimentation on the ultra-high frequencies was then underway.

That's where amateur DX ultra-high records stood in late November, 1941 when a SCR-270-B Army Corps radar unit operating on 106 Mc had just been installed at the Opana Radar Station, Oahu (in the Hawaiian Islands). Two weeks later on December 7, 1941, two army air corps privates using the radar device detected a huge movement of airplanes some 130 miles away. This was the first wartime use of radar by the United States military. But given the newness of the installation and the equipment, the radar was thought to be either faulty or possibly tracking B-17's that were due from California air bases. Fifty minutes later, the first Japanese bombs fell on Pearl Harbor.[35] Only after the initial attack did anyone realize that the radar unit worked successfully and had actually spotted the first wave of Japanese attack airplanes. The episode is one of the great "what ifs" of military history.

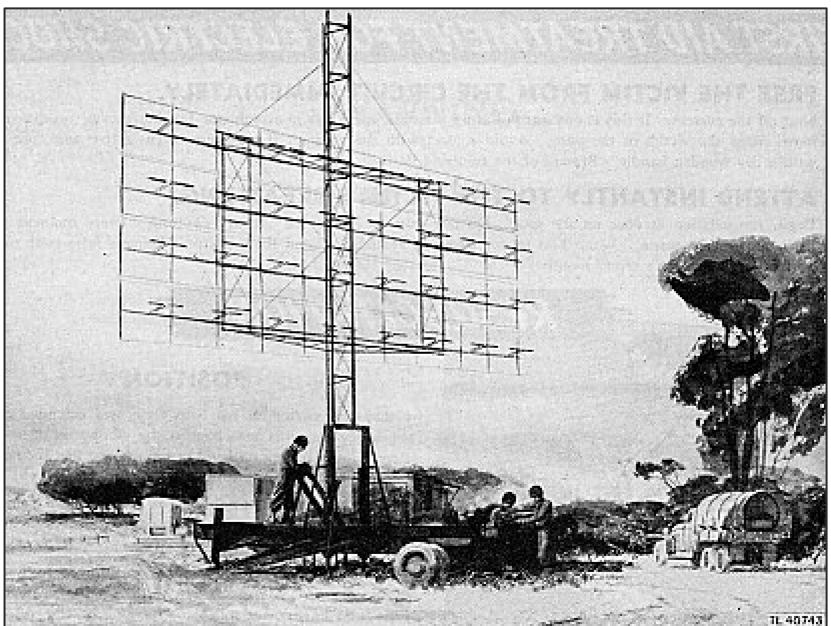


Figure 1. Radio Set SCR-270-DA.

The US declared war the next day. Amateur radio stations immediately went off the air. Massive support for the war came from the amateur community. Of the 60,000 amateurs licensed in 1945, 25,000 served in the armed forces during the war, and another 25,000 served in critical war industries or as instructors in military schools. Amateurs also used their skills at home in the War Emergency Radio Service (WERS) with 112 Mc activity dedicated to the war effort. [36]

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[1] VHF Manual, 1965 ed., ed Tilton, editor, p.8.
[2] See, *QST,* 7-31, at 9-20; *QST,* 7-31, at 21-25; 8-31, at 9-13. The pictures is at: "Five Meter Receiver Progress", Ross Hull, *QST,* July 1931, at 21.
[3] *QST,* 5-32, at 22-24.
[4] *QST*, 7-32, at 34.
[5] *QST,* 5-32, at 34-36; 6-32, at 20-23; 9-32, at 29; 10-32, at 32-33.
[6] Using a pulse method of ionosphere sounding, physicists started to connect propagation to the sunspot cycle. In 1927, Pickard demonstrated a correlation between the solar cycle and radio propagation. Under favorable sunspot conditions, the upper limit of ionospeheric propagation was believed to be around 30 Mc. "ARRL: The Boom Years", *QST,* June 1964, p.78-79.
[7] "Extending the Range of Ultra-High Frequency Amateur Stations", *QST,* Oct. 1934, p. 10-13+. A small follow-up occurred the next month, "Five Meter Performance Hits New Levels", *QST,* Nov. 1934, p.9. Hulls' UHF operating activities were considered remarkable at the time. See, "The Editor's Mill", *QST*, Oct. 1934, p.9.
[8] From, Orr, VHF Handbook.
[9] *QST*, 1-36, at 19-20.
[10] *QST*, 7-37, at 29-30.
[11] *QST*, 12-1935, at 11.
[12] *QST,* 7-37, at 35.
[13] *QST*, 5-47, at 61.
[14] *QST*, 11-37, at 12-13.
[15] *QST*, 12-38, at 28.
[16] *QST*, 12-39, at 35.
[17] *QST,* 12-37, at 53; 1-38, at 62.
[18] *QST*, 9-39, at 58.
[19] *QST,* 6-67, at 66.
[20] Most of the information on Reber has been taken from the NRAO web-site, Ham Radio Connection sub-page located at: http://www.nrao.edu/.
[21] The picture is from *QST,* __________.
[22] *QST,* 9-39, at 33.
[23] *QST,* 11-39, at 26-27+.
[24] *QST,* 11-39, at 26-27;6-67, at 66. The picture is at *QST,* 11-39, at 27.
[25] *QST,* 6-67, at 66.
[26] "Echoes of the Past", *QST,* June, 1995, at 48-49.
[27] *QST,* 2-40, at 52-54. The picture of the route is at p. 53.
[28] *QST,* 6-40, at 44-45.
[29] *QST,* 9-40, at 32.
[30] Rules at *QST,* 1-40, at 26-27.
[31] *QST,* 3-41, at 53.
[32] Rules at *QST,* 1-41, at 24-25.
[33] *QST*, 4-41, at 53.
[34] *QST,* 2-42, at 40.
[35] The sketch of the radar device used at Pearl is taken from: http://www.infoage.org/pearl.html
[36] *QST*, 1-2000, at 31.

Amateurs in WWII

To do ---
(emphasize amateur contributions in the emerging VHF and microwave areas; review the British books on war-related radio)

Post WWII Amateur Activity & The Cold War

Rest of document: Keep converting from an outline to regular text; put in pictures, footnotes, etc. Emphasize more of the history of VHF and technology and less of VHF contesting;

- Following WWII, hams received temporary privileges initially on 235 Mc, and then on 112 Mc on August 21, 1945. Various VHF contests were thereafter intermittently conducted. The first post WWII VHF event was the Connecticut 112 Mc QSO Party held in September 1945. It attracted 132 entries. The high scorer completed 50 contacts in 37 towns from a portable location in Prospect, Ct.

- In November 1945, the FCC moved the 56 Mc band to 50 Mc, and the 6 meter band was born. This was done to provide frequency allocation to TV channel 2, and the new 6 meter band was allocated space directly below that frequency (immediately touching off a never ending dispute between 6 meter hams and adjacent property owners with channel 2 TV set's!). In March 1946, the 112 Mc band shifted to 144 Mc, starting the era of 2 meters. There was much discontent among the ham community concerning both band moves, as almost all equipment and antennas had to then be rebuilt by hand. Additionally, many hams were concerned that the roominess of UHF activities in pre-WWII was being replaced by a general encroachment from the commercial interests (this concern is even greater today, with numerous threats to amateur frequency allocation occurring on a regular basis).

- Pre WWII Marathons and most states awards were reinitiated to encourage the use of these new frequencies. Distance and frequency points were awarded for the 4 VHF bands of 50, 144, 235, and 400 Mc. Extra points were given for the use FM. The first VHF Marathon was held between May and December, 1946. Six stations worked between 24 to 27 states on 6 meters, seven stations worked over 100 QSO's on 6, and six stations contacted over 200 QSO's on 144 Mc. Today, all of these various contest events and activity weekends both before and after WWII are seen as predecessors to the modern day VHF contests.

- Several microwave bands were opened in November, 1945 (See, Early Contacts article, for more details).

- In January, 1946, a US Signal Corp lab used a 4000 watt 111 MHz transmitter to bounce signals off of the moon. Station engineers for this historic event included amateur radio operators. *(This is from Pocock's book, and he has more details on these events, with citations to QST's). (Also describe Project Diana).*

- Radio amateurs studied and utilized meteor reflected propagation as early as 1946 (? On date; see Tilton's columns in 1953; Pocock, at 12, also has the 1946 date with references to a 1-46 QST issue). Propagation enhanced VHF communications extended distance records on 6 meters by 1947 to over 10,000 miles, and over 660 miles on 2 meters. (KCK Note: detailed comments on early meteor scatter and aurora are in my "Early Contacts" outline).

- Over the years, certain technical achievements have had tremendous impacts upon amateur radio and radio contesting. One of the biggest such achievements initially occurred in 1948, when three Bell Telephone Laboratory engineers invented the transistor. This one little device revolutionized and forever changed all of electronics and communication. The invention led to the miniaturization of electronic components and ever more sophisticated communication equipment. The three engineers received the Nobel Prize in Physics in 1956 for their efforts.

- On another interesting note, the 1946 FD marked the beginning of a VHF only entry, with some groups operating 50, 144, and even 420 Mc; QST, Feb. 1947, at 47-48; one group even made the first QSO in a contest on 2400 Mc!. The VHF only category was used again in 1947 (also, note that that Ed Tilton, W1HDQ, was the 56 Mc leader in the first FDs in 1934, 1935, and 1936, and citations on that are in the "Early Contacts" article).

- In 1947, a VHF Relay and QSO Party was run in May. This event was similar to the UHF Relays and Contests of pre-war days, but also had some similarities to the modern day VHF QSO Parties (rules are at QST, May, 1947, at 70; note similarity with UHF Relays rules, as well as having contacts in the May contest count towards standings in the 1947 UHF Marathon). Thus, this one event served as a bridge between the UHF events of pre-WWII with the more modern types of contests to come.

- The development and popularity of the "big three" contests occurred within a very short time frame in the late 1940's. The weekend contest format was utilized. In 1948, the 1st Annual January VHF Sweepstakes debuted. The January VHF SS was designed to be the VHF counterpart of the HF Sweepstakes contests, complete with a club competition.

- A May VHF QSO Party occurred in 1948. The September VHF QSO Party started in 1948. The June VHF QSO Party then began in 1949, with the dates shifting one month from May to June to take advantage of better band conditions. The 1947 May event was styled as more of a “relay” while the May 1948 contest was more of a QSO Party in focus. The 1948 May contest may have therefore be seen at the time as the same affair as the 1949 June contest, only one month different in the date.

- The January VHF SS scoring system was initially based on contacts with no QSO Points given out for different bands, just additional contacts for each band. 1 point was given for receiving a transmission from another station, and 2 QSO Points were given if both sides acknowledged the exchange of information. ARRL sections only counted one time, with no additional sections being counted per band. The exchange followed the ARRL message relaying methods: QSO number, call sign, RST signal report, ARRL section, time and date.

- The QSO Party format was significantly different. Between 1948 and 1952, 1 QSO point was given for 6 and 2 meters, and 5 QSO Points were granted for contacts on 220 and above. Sections counted per band. The exchange for the QSO Parties was much simpler than the January VHF SS: only exchange the call sign and ARRL section. Signal reports were optional.

- With both types of contests, the contacts or QSO Points were then multiplied by the number of ARRL sections worked plus 10 (for the January VHF SS) or worked per band (for the QSO Parties) to arrive at the final score. All foreign stations counted for one additional multiplier (one added section for the January VHF SS, and one section per band for the QSO Parties), with all foreign contacts being grouped together as one section.

- Initially, time was kept in local standard time for all VHF contests, with stations on both sides of the contact having to be within local time frames of the contest for the contact to be counted.

- The first January VHF SS in 1948 attracted 347 log entries from 40 sections. W3DFV in New Jersey won the event, with 117 QSO’s in 7 sections, operating only on 2 meters. All contestants used 2 meters, some were on 6 meters, and only 3 operated on 235 Mc (which was then moved back to 220 MHz in April, 1948). The club competition took place only in the January VHF SS, but was part of that contest from the start. This first club event was won by the Frankford Radio Club of Philadelphia, and the competition attracted 17 clubs. All clubs competed against each other. The subdivision of the club competition into three tiers would not even be contemplated for many years to come.

- In the 1948 January VHF SS, the only category was single-op. A multi-op was noted in the 1949 September QSO party, but with indications that the stations were not eligible for an award. Multis were listed as separate entries in the line scores only starting with the 1950 January VHF SS, but only single-ops were given section awards.

- The May VHF QSO Party of 1948 produced 162 entries from at least 34 sections. The highest recorded contact was made on 220 Mc, even though 420 Mc, 1215 Mc and even higher frequencies were in use by that time. The high scorer of this first post WWII QSO Party was W1CTW of Ct, with 126 contacts in 15 sections. The 1948 September QSO Party generated 98 logs from 29 sections. 220 Mc was again the highest recorded band used in any of the logs submitted. The winner was W1FZ, operating from Blue Job Mountain in NH, working 130 contacts in 15 sections on 5, 2, and 220 Mc.

- Initially, ARRL staff was ineligible for contest awards in the contests. This continued until the late 1970's, when League staff were initially allowed to operate at non-home stations of staff members, and then finally in 1978, when asterisks referring to "Hq. Staff, ineligible for award" were discontinued without much public acknowledgement that the long standing practice of ineligibility had come to an end.

- Portable and mobile activity was always popular, especially in the June VHF QSO Party. *QST*'s as far back as the late 1940's contain pictures and write-ups of both portable and mobile operations. In fact, in many June contests in the 1950's, one third of all stations were portable, as high ground gave operators a great advantage. With the advent of more sophisticated equipment and antennas in the 1960's, many fixed stations were able to compete effectively against the "mountain tops", but portable activity remained popular. Initially, however, the contests had all types of entries (fixed, portable, and mobiles) placed together. Competition occurred only by ARRL sections (there were 71 sections at the time). VE8 / Yukon was treated and counted as an ARRL section though, for purposes of the VHF contests.

- During the winter of 1950-1951, W2NLY and W3QKI worked each other regularly on 144 Mc. over a 350 mile path, becoming some of the earliest users of tropospheric scatter.

- By the early 1950's, crystal controlled equipment was becoming universally accepted, and contributed greatly towards the enhancement of VHF equipment frequency stability. WWII surplus AM radio aircraft equipment was becoming a mainstay on 2 meters, and commercial equipment such as the early Gonset 6 and 2 meter communicators were being developed for and used by VHF oriented amateurs.

- The first 50 Mc WAS award was completed by _____ in the late 40's or early 1950's (exact info is in Tilton's column). It included only the 48 contiguous states, as at that time, neither Hawaii nor Alaska were States of the Union (they were then considered to be US Territories). *[KCK note: 48 states on 50 mc was achieved in the summer of 1948; see Tilton's column] Vince Dawson in 1948!*

- W1PNB conducted the 1st experiments on 6 meter SSB in 1951, and also made the 1st 50 Mc SSB on aurora in 1952 (5-52 QST, at 61). W2JJC, New Market, NJ made the 1st 2 meter sideband QSO on the 27th of March, 1954 with W3HWN, Mechanicsburg, Pa (12-54, Tilton, at 69; another note on W2JJC on 2 meters SSB in Tilton, 4-55, at 62; also see 5-56, at 59).

- The first amateur transmission using transistors was made in late 1952 or early 1953 when K2AH, using a one transistor transmitter, worked W2UK on 2 meters some 25 miles away. The power output was 50 microwatts. The power supply was a single 22 ½ volt hearing aid battery, dropped to 8 volts (2-53 QST, at 65; there is a nice picture of the transmitter, as well as a cover picture of K2AH keying the transmitter, which is sitting on a tripod in front of several large racks). (There is also an article written by K2AH in 3-53 QST on the transmitter). Some three years later in 1956, the cover of *QST* contained a picture of the world's first all transistor amateur radio receiver (May, 1956, QST, article at 11).

- The first successful amateur reception of moonbounce echos occurred January 27, 1953 between W4AO and W3GKP. (Article in 3-53 QST and also, Tilton, 4-53 on Project Moonbounce). The effort was so technically difficult at the time that it would take several more years before a successful QSO was made.

- A great controversy ensued throughout the 1950's concerning the use of horizontal versus vertical polarized antennas. Many hams used vertically aligned antennas, in keeping with the traditions of broadcasting and mobile commercial services. Others felt that horizontally polarized antennas performed better. Many emotional and non-technical reasons also were evident. The controversy continued with many of the more experienced operators using CW moving towards horizontal arrays, while many others still favored vertical alignment. The lack of consensus as to polarization evolved somewhat in future years into a SSB versus FM argument, with weak signal enthusiasts using newer yagi type of horizontally polarized antennas and better equipment, while many other hams relied upon FM simplex (and by the 1970's, FM repeaters) having vertical polarization for their VHF activities.

- Beginning in June 1953, the QSO Party format was revised to count 1 QSO Point for contacts on 6 and 2 meters, 2 QSO Points for 220 and 420 MC, and 3 points for contacts made above 420. During this time period, most of the contest contacts were still occurring on 6 and 2 meters, but activity was gradually increasing on 220 and 420 Mc.

- Meteor scatter work on 2 meters was pioneered in the early 1950's by Paul Wilson, W4HHK, of Coulterville, Tennessee, and Ralph Thomas, W2UK, New Brunswick, NJ. (nice note on the early days of meteor scatter and suggested protocol, in Tilton's column, 10-54, at 61-63; also note in one of Tilton's column in 1955 on W2UK taking down his station; and then the 10-55 Tilton column on a 2 yr retrospective of MS work). The two operators had been attempting a tropospheric contact when they noticed short bursts of audio. After many months of experiments, regular communication became possible through a coordinated method of transmissions being reflected or scattered off of the ionized trail of meteors passing through the upper atmosphere. The first exchanges accepted by the League as a valid contact occurred on Oct. 22, 1953 (CQ, Nov. 1993, at 96). A meteor contact was considered such a breakthrough in radio communication that audio tapes of the meteor scatter contacts between these two amateurs were played at a meeting of propagation physicists of the International Scientific Union in 1954. Wilson and Thomas won the 1955 ARRL Merit Award for their success with meteor scatter communications on 2 meters (nice article on the merit award, with pictures, 10-56, at 62). (EIMAC ad from QST in the late 1980's gives 1946 as the year that radio amateurs first studied and utilized VHF meteor scatter propagation, but no citations to specifics).

- In 1951, Novices were granted operating privileges on 2 meters. Technicians received privileges on 6 meters in 1955, and then on 2 meters in 1959. The popularity of Heath Tower's and Sixer's led to tremendous amounts of lower VHF band activity. Weekly AM check-in and RACES nets of 30 or more hams were common throughout the metropolitan areas of the US. All of this activity led to a veritable explosion of VHF contesting activity, and contest log entries of over 1000 per January VHF SS occurred between 1957 and 1967. 1500 entries were received in the 3 years between 1961 and 1963. A similar peaking in log submissions occurred for the QSO Parties. This time period has been referred to as the "baby boom" of VHF contesting.

- Beginning with the 1954 January VHF SS and both QSO Parties in 1954, certificates were given to Novices and Technicians having the highest score in any section where significant competition existed (which was defined as there being at least three Novice or Technician entries in any section).

- For the QSO Parties, section awards were given to multi-op entries beginning in the 1954 June VHF QSO Party. Multi's had become popular by then, especially in portable hilltop locations in the June contest.

From Sputnik to the Early 1980's

- The Soviets launched the world's first satellite on October 4, 1957. Named Sputnik I, it operated on a 20 MHz frequency, but could only send a continuous beep. The space race was on! Four months later, on January 31, 1958, The United States launched Explorer I, packed with scientific instruments. This first US satellite was instrumental in discovering radiation belts that would later be named after the scientist who was responsible for the experiments, Dr. Van Allen.

- Contesting activity produced a milestone in the 1958 June QSO Party when W4GJO in Florida worked 346 stations and 35 sections on only one band, that of 6 meters. This was the highest scoring, single-band entry to date for any of the three VHF contests. Meanwhile, the January VHF SS had over 800 entries.

- While VHF was once thought to be the province of only line of sight modes, by 1958 atmospheric reflected types of communication were becoming increasing common on 6 meters. It was evident that "ionospheric" propagation could be quite useful for practical communication on the VHF frequencies.

- *CQ* magazine also sponsored VHF contests (normally twice per year) between 1956 and 1966. These contests used counties as multipliers instead of ARRL sections and VE provinces. *CQ* VHF contests had developed a "county equivalent" for international areas outside of the US. The use of county multipliers was almost prophetic in nature, having pre-dated the development of the grid squares by some 30 years!

- Moon echos had been heard in various experiments as early as 1948, but the echos usually had usually been received at the point of origin. A lunar reflection of radio signals between two separate stations was first accomplished in February, 1951 when the National Bureau of Standards and the Collins Radio Company experimented on 418 Mc. A 20 kw transmitter was used at Cedar Rapid, Iowa. The transmission antenna was a fixed array consisting of a chicken wire horn antenna supported by telephone poles. The receiving antenna was a half wave dipole mounted at the focal point of a 31 foot diameter paraboloid. The cw transmission was the historic message "What hath God wrought!" (CQ, 5-52, at 88).

- The US Navy had been experimenting since 1951 with moonbounce relays, and had accomplished two-way communications by sometime in the 1950's. Exact details have always been murky, due to the security nature of the work. The relay system was publicly disclosed by the Navy in 1960, when it was revealed that the Navy was using a 100 KW transmitter to feed a 84 foot diameter steerable dish antenna for the relays. Information was exchanged on frequencies between 425 to 435 Mc, and the transmission sites were around Hawaii and Washington, DC. (CQ, 4-60, at 78).

- With the advancement of electronic equipment, specialty activities previously considered impossible or exceedingly rare had arrived on the VHF scene. 144 Mc EME had been tried as early as 1953 by W6DNG and others, and partial callsigns were actually exchanged. But activity generally shifted to 1296 Mc, where antenna sizing and other factors were more manageable. (9-60, 10-60, QST's). The first amateur radio EME contact occurred between the EIMAC Radio Club, W6HB, and the Rhododendron Swamp VHF Society, W1BU, on 1296 MC on July 21, 1960 (or possibly, July 17, 1960). Sam Harris, W1FZJ, led efforts on the East Coast end (CQ, 9-60, at 78). With the exception of the US Navy and possibly some affiliated commercial efforts, these two amateur stations were then the only installations in the world possessing EME capabilities.

- 2 meter moonbounce signals were again attempted by K1HMU and W6DNG in August and September, 1962. The efforts were so technically challenging that Sam Harris felt "maybe" a QSO had been completed. (QST, 11-62, at 72-73). A definite QSO on 2 meters was finally achieved on April 11, 1964, between W6DNG and OH1NL (June, 1964 QST, at 95-96). 420 efforts at EME began in earnest once power levels were increased in January, 1963, and W5DSA engaged in moonbounce work shortly thereafter. The first actual QSO on 432 occurred May 20, 1964 between W1BU and KP4BPZ, operating from the Aricebo radio telescope in Puerto Rico (7-64 QST, at 105; 8-64, QST, at 92-93).

- Amateur radio activity on meteor scatter and aurora was becoming increasingly common, as well.

- John Chambers, W6NLZ, and Ralph Thomas, KH6UK (who also pioneered meteor scatter work as W2UK) made the first transpacific 2 meter and 220 MC contacts. They also heard each other on 420 Mc (lead articles in QST in 1961). For their endeavors, they won the 1961 Edison Award and 1960 ARRL Merit Award.

- The increase in the ranks of hams from the above noted regulatory changes coupled with advances in VHF equipment capabilities led to a high of 1561 logs (or 1563 logs, depending on source) being submitted for the January VHF SS in 1961. Club participation increased as well, with the number of clubs entering the VHF SS going up from 30 in 1995 to 69 clubs by 1962 and 1963.The 1961 June VHF QSO party also reached a high water mark of 558 submitted logs.

- In December 1961, the first amateur radio satellite was launched. Named Oscar I, the satellite contained a 140 milliwatt beacon at 145 MHz that transmitted a simple, repetitive CW message. It circled the Earth for 22 days. Within only a few years after the launching of the first Soviet and US satellites, the era of amateur radio satellites had begun. Oscar I was a remarkable achievement for amateur radio. (cover picture, 1-62 QST; cover story, 2-62, at 9; 11-24, several articles).

- Bell Labs built a giant cat's ear microwave Holmdel antenna in the early 1960's as part of a very early satellite reflecting system called Echo. The antenna quickly became obsolete with the launching of the Telstar satellite in 1962. Two Bell Lab researchers, Arno Penzias and Robert Wilson, were then able to use the Holmdel antenna for radio astronomy experiments at microwave frequencies. They kept coming up with a background noise in the antenna system. They tried everything they could think of to eliminate the annoying noise from their receiving system - including removing several pigeons roosting in the antenna. After four seasons of putting up with this noise, they sought out theoreticians to explain the noise. Robert Dicke of Princeton University showed that the noise was really microwave remnants of background radiation emanating from the big bang. Penzias and Wilson had quite literally stumbled upon one of the greatest scientific discoveries of all time – proof of the big bang! For their efforts, Penzias and Wilson shared the Nobel Prize in Physics in 1978.

- 1st amateur two way QSO via an amateur satellite may have occurred on the 13th orbit of OSCAR III, between K2IEJ, Oceanside, NY and K9AAJ of Quincy, Illinois. The QSO occurred at 11:50 AM Eastern time, March 9, 1965 while the satellite was passing over Nebraska. (CQ, May, 1965, at 56-57).

- In 1967, the League celebrated 30 years of VHF contesting in its June edition of *QST* (at p.66-67) by referencing the initial contests in Great Britain and the US (as noted above).

- After 30 years of VHF contesting, the use of local standard time was changed in the 1967 June and September VHF QSO Parties to Greenwich Mean Time (GMT), thereby eliminating the confusion that had always existed over the start and end time of a contest on both ends of the contact. The January VHF SS was not finally changed to GMT until some 13 years later in 1979!

- In 1968, Novices lost phone privileges on 2 meters, and lost all 2 meter privileges in 1972.

- The 1969 September VHF QSO Party changed participation time from 28 hours to any two 14 hour consecutive periods out of a 35 hour contest period. The June VHF QSO Party rules changed to two 14 hour consecutive periods in 1973. The rules were changed back starting in the 1974 June VHF QSO Party, with the two 14 hour consecutive periods being eliminated in favor of 28 non-consecutive hours in a 35 hour contest. Off times had to be at least 30 minutes in duration.

- Several hams in the US and around the world listened in on Apollo astronaut transmissions as they circled the moon in the late 1960's. Many of these transmissions occurred on 2.2 GHz. A short time later in 1969, Neil Armstrong became the first person to step on the moon. At the time, landing on the moon was considered a great American achievement. Today, while the Apollo program is still viewed as a significant accomplishment for America, the entire space program of the 1960's culminating in Apollo and a manned moon landing is now being viewed as a technological milestone for the entire human civilization.

- The first 50 MHz EME contact was made in 1972 between W5SXD and K5WVX (W3ZZ, 9-2004, at 77; notes on 6 meter EME).

- Even though HF operating activities were generally adopting the use of SSB over AM, VHF activities were much slower to utilize the newer form of phonic communication. It wasn't until 1970 that SSB was firmly established on the VHF bands, even though it was clearly superior in terms of bandwidth usage. With so much AM VHF equipment now becoming outmoded and even scorned by some VHF enthusiasts, a difficult period developed on the VHF bands. While beginners were still having great adventures with their Towers, more serious operators were becoming exclusively based on CW and SSB. Participation rates in the VHF contests of the late 1960's and early 1970's suffered as a result of Novices losing all 2 meter privileges in 1972. By 1967, the number of acceptable logs for the January VHF SS had dropped to 1123. By 1975, only 600 or so log entries were received for the event. Club participation declined to a total of 21 clubs in the 1975 and 1976 January VHF SS.

- Starting with the 1974 January VHF SS, the exchange was modified to align with the streamlining of the exchange that occurred in the 1971 HF SS, with the contact number, a power precedence, the call sign, check, and section information being exchanged. Meanwhile, the exchange for the QSO Parties was much simpler: call sign and section.

- The administration for the ARRL sponsored contests generally followed the practice of an informal idea or formal proposal being sent to the Contest Advisory Committee, which was composed of both HF and VHF contest operators appointed by the League. The CAC would then consider the matter, and if it approved of the item, would send it on to the League's Awards Committee. This Committee was in turn composed of ARRL staff members would then consider and ultimately act on the CAC's recommendation. If approved by the Awards Committee, the proposal would subsequently be approved as a rules change for future contests. The item could also be sent back to the CAC for further study. The Awards Committee was also in charge of the League's Award program, and hence its name.

- Long standing oral traditions in the club competition of the January VHF SS were expressly stated in 1974 when the CAC declared in writing that three club entrants were necessary for a club to enter the club competition; two-thirds of club participants in a multi-op must be members of the club, four club meetings a year must take place, and club members must live within 175 miles of the club to be eligible as a club entry.

- Beginning in the mid-1970's, specialty contests were being conceptually developed. Events focusing on Moon Bounce, the 10 GHz band, and the UHF bands were under active consideration. Numerous ideas were also being entertained for revisions to the existing contests.

- The January 1976 edition of *QST* marked a momentous occasion: this was the first issue with the wider paper format. The original size of 6 ½ by 9 ½ inches was chosen simply because that was the size that the local printer used in 1915. The smaller size was still commonly available for many years thereafter. As new printing presses were put into service however, larger page sizes were used, and over one inch of paper had to be trimmed from each *QST* to fit into the smaller size. When the price of paper skyrocketed in the mid-1970's, the League finally made the decision to move to larger size print.

- Because of conversion by the League to the new page size, publication of the rules for the 1976 January VHF SS was completely left out of both the December 1975 and January 1976 editions of *QST* ! In spite of this oversight, numerous VHF clubs got the word out, and the contest went on. The VHF community was only slightly ruffled by the experience, but none the worse for the effort. Overall, the experience just reinforced the importance of the VHF clubs in VHF contests.

- Put into effect for the first time in June 1976, codes were developed for 2304 MHz (f); 3300 MHz (g); 5600 MHz (h); and 10,000 MHz (i). The 3 QSO point rule above 420 MHz was still in effect, however for the VHF QSO Parties, while no extra QSO points were awarded in the January VHF SS for any bands (just extra contacts for each band).

- With the publication of technical notes on VHF yagi designs in 1976 by the National Bureau of Standards (NBS), yagi antennas became increasingly common among amateurs. Considered an innovation at the time, NBS styled antennas for amateur work generally replaced the bulky collinear arrays that had been commonly used throughout the post WWII period. For years after the publication of the NBS notes, amateurs took great pride in finely crafting "hand rolled" NBS types of VHF yagis.

- FM rules caused consternation throughout the 1970's and early 1980's much as the rover rules continue to cause controversy today. FM simplex rules were put into effect experimentally beginning in the 1976 June VHF QSO Party, but caused problems for many years thereafter. FM repeater contacts were prohibited in 1976, and this rule was warmly received. The 1977 June QSO Party prohibited the use of the 2 meter FM national calling frequency, 146.52 MHz, as well as adjacent guard channels. A few months later in the 1977 September VHF QSO Party however, the use of the FM simplex calling frequency was allowed by any station for no more than 4 hours in the contest, but the prohibition on the guard channels remained in effect. The 1978 January VHF SS also provided for a 4 hour usage of 146.52, but by the 1978 June QSO Party, the 4 hour rule was modified to allow usage of the frequency in no more than 1 hour increments. The 1st August UHF Contest in 1978 effectively prohibited any FM contacts (see below). Starting in the 1979 January VHF SS, the 4 hour rule was also applied to 223.50 MHz. In June 1982, the use of 146.52 was completely prohibited. But the 4 hour rule on 223.50 was at the same time completely lifted so that simplex contacts on the 222 FM simplex call frequency could be allowed throughout the contests.

- The exchange was again simplified for the January VHF SS format starting in 1977: The serial number; call sign; signal report; and section. Gone were the power precedence and check.

- The Big ear radio astronomy antenna at Ohio State University recorded a one minute anomaly on August 15, 1977. Nicknamed the "Wow" signal (Dr. Jerry Ehman circled the data on a computer print-out, and in the margin wrote "Wow!"), it is even today the single most likely candidate of a SETI signal being received on Earth. Due to its lack of predictability, the Wow signal remains unconfirmed, but has certainly achieved legendary status.[1]

- A major change occurred with the 1978 January VHF SS. QSO points were added for the first time, and were much more generous than in the VHF QSO Parties. 2 points were awarded for 6 and 2 meter contacts; 4 points for 220 and 432; 8 points for 1215 MHz; and 16 points for 2300 MHz and higher. As a result, station scores that used microwaves dramatically increased.

- Another change took place with the adoption of DXCC countries as additional multipliers, beginning in June 1978. The change was in effect for both the January VHF SS and the QSO Parties. Each DXCC country that was not an ARRL section counted as a separate multiplier for each band worked (in addition to each ARRL section worked for the January VHF SS or worked per band for the QSO Parties).

- Throughout much of this era in VHF activities, the Mt. Airy VHF Radio Club (nicknamed the "Pack Rats"), completely dominated the club competition of the January VHF SS. Having won the club competition 29 years in a row (and starting with their club win in 1961), the Pack Rats of the day set a standard for operating excellence that has never quite been matched by anyone else in the entire history of ham related VHF activities. For instance, in 1976, the club led an expedition to Barranquilla, Columbia so that K2UYH could become the first amateur to work all continents on 432 MHz. They made the contact off the moon to do it, and may have thus been the first EME station and EME contact in South America. An incredible feat both at that time, and to this day!

- The greatness of the Mt. Airy Club was made possible, in no small measure, by an intense rivalry with another great club, the Rochester NY VHF Group. The Rochester club challenged the Pack Rats throughout much of the 1970's and into the 1980's, only to see their efforts continually place second. This pattern continued even after the development of the three-tier club rule (see below), with both Mt. Airy and Rochester being the only groups at times to enter the Unlimited. Mt. Airy's continuous reign as club champion came to end only when the Rochester group took

[1] "Dr. SETI's Starship", Dr. Paul Shuch, *CQ VHF,* Fall 2003, p. 84-82.

the Unlimited gavel in 1990, due to the Pack Rats only fielding 49 entries (the Pack Rats still had more points than Rochester, but were now put into the Medium club category, which they won, of course).

- A second major boom in VHF contesting took place in the late 1970's, and this was largely due to mass usage of Japanese manufactured multimode rigs. Log entries in the January VHF SS again climbed upward, peaking at 987 in 1980 after having declined to around 500 in the mid 1970's. The June contests also were notable for their large participation rates on 6 meters during E skip openings. 60 section totals and 100 section all-band totals were becoming common in almost all ARRL Divisions. All band QSO's in the June Party broke the 1000 contact threshold in the multi-op category during this time frame, and approached 800 or more contacts with several Single-Op entries.

- The first August UHF Contest took place in August 1978. Initially, a 1 x 1 degree square was used as a multiplier, with latitude and longitude headings, signal reports, and call signs being used as the exchange. 3 QSO Points were given for a contact on 220 and 430; 6 points for 1296; and 12 points for 2304 MHz or higher. Stations could be worked once per band, although if mobile, the station would not count for another contact but would then count as another 1 x 1 square if the station moved to another 1 x 1 square. Multipliers were the number of different 1 x 1 latitude / longitude squares worked per band. The use of 434-435 MHz was prohibited (this was intended to effectively prohibit FM contacts for this contest). Single and multi-ops could enter. The first UHF contest in 1978 thus saw the first use of a latitude / longitude type of square.

- In order to encourage smaller clubs to compete in both the HF contests and the January VHF SS, effective for the 1978 HF SS and the 1979 January VHF SS, the club competition was split into three groupings: Unlimited, Medium, and Small. Each group would only compete directly against each other. The unlimited category was for those clubs with 51 or more entries, while Medium club were for entries between 11 and 50. Small clubs had 10 or fewer entries. Club radius and meeting requirements also varied for the three groupings: the unlimited and medium clubs had a 175 mile radius while local clubs had a 20 mile radius. Four club meetings were required per year. For members of the larger clubs living more than 50 miles away from the club center, 50% or more of the meetings must be attended, while no attendance rules were in effect of for the local clubs. SO and Multi's counted towards the club scores, but 66% of a multi's operators had to be club members, and both the guest and station licensee were to be club members for the guest SO's.

- The first EME Competition was held in 1978. The event was held over two weekends in the spring. The EME had competition by SO-single band; SO-multi-band; multi-op-single band; and Multi-op, multi-band. Use of non-amateur commercial equipment (i.e. radio telescopes) was listed separately. Each contact was given 100 points, and the multipliers were the DXCC countries plus the US and Canadian call sign districts worked on each band.

- Rules regarding multi-op operation were also reviewed in the late 1970's. Effective for the 1979 January VHF SS, multis could elect to give out consecutive serial numbers per band rather than one set of serial numbers for all bands. By the 1980 September VHF QSO Party, the multis could no longer make contacts with their own operators except on 2.3 GHz and higher. Further, in a prohibition primarily aimed at multi's using FM and SSB simultaneously, multiple transmitters could not be used on the same band at the same time. In 1983, a requirement of three multi entries per section before multi awards could be issued was dropped, and only the demonstration of a significant ability was thereafter required for the issuance of multi-op awards.

- By the early 1980's, contacts on successively higher microwave bands were being reported. The June 1981 QSO Party noted line scores with 24 GHz contacts (J). Laser rules were adopted by June 1981, providing for the use of coherent radiation on transmission and at least one stage of electronic detection on receive. One contact was reported on 48 GHZ (with a K designation) and light (300 GHz, with an L designation) in June 1982.

- In May, 1981, an ad hoc committee on VHF contesting had been established by the League and the CAC to study contest format changes.

- In 1982, the EME Competition was changed to two weekends in the fall, so that antenna work in preparation for the contest could be done in better weather. Thus, 1982 was the only year in which there were two separate EME contests: the 5th EME in April and May, and the 6th EME Competition a few months later in October and November.

- In June 1982, solo band activity was started for single-ops. The intent was to encourage the development of smaller stations into a competitive class. These SO entries could work more than one band, but then only report for the one band that they wanted to enter in the contest.

- Distance points based upon differences in lat / long of the stations were added to the UHF in 1982 (for only this one contest, it turned out). Referred to as RANGE, the concept was initially developed by the Ramapo Mountain ARC in their Spring VHF Party held in March, 1981.

- For the January VHF SS format, the exchange was shortened in 1983 by dropping the consecutive serial number requirement. The exchange simply became the call sign, signal report and section. The exchange for the QSO Party format remained the same: just the call and section, with the signal report continuing to be optional.

- The June 1983 VHF shortened the duration of the contest to 33 hours, and then dropped the off time requirement. Thus, contesters could operate all or any parts of the event. This was done to encourage the use of time consuming activities such as meteor scatter and EME.

- Also tried out for the 1983 June VHF QSO Party, the multiplier was changed so that VE provinces were added as separate multipliers instead of using ARRL sections in Canada. Additionally, the West Indies, Hawaii, and the US controlled Pacific areas were considered to be separate DXCC countries, instead of merely treating them as ARRL sections.

The Era of the Grid Squares

- Collecting states and countries was a traditional activity for VHF operators to engage in. The VHF community felt the need for a smaller, more uniform and more geographic based multiplier, however. Europe had been using such a system with much success for a number of years, and by the early 1980's, the search was on for a similar system in North America. Distance points were tried out in the 1982 August UHF, but were awkward to calculate manually.

- The Central States VHF Society was instrumental in the development of the grid square concept. It experimented in the early 1980's with 1 x 1 squares similar to what was being used in Europe, and then gave out awards, referred to as WHG awards (for worked one hundred grids), to encourage the usage of these grids.

- The League quickly added to the mix, and within short order, the Maidenhead 2 x 1 grid squares were introduced in 1983. On an interesting note, Curt Roseman, K9AKS, authored the ARRL grid map in 1983, and Urbana, Illinois still has a prominent place on official grid maps, as that was where the grid square map was actually developed! Widespread usage of grid squares occurred very rapidly both in the United States and internationally. As one contester (KA1ECL) put it at the time: "The grid system is the greatest thing that has happened to VHF since the Twoer".

- In 1983, the League developed the VUCC program (VHF / UHF Century Club), and it was a huge success from the start. The VUCC award was designed to be the VHF equivalent of the DXCC on HF. Awards were given for working and confirming 100 grids on 50 or 144 MHz; 50 grids for 220 or 432; and 25 grids for 1296. Endorsements for all bands were also provided for.

- The first VHF contest to use grid squares was the 1st VHF Sprint Sprints in 1983. The Sprints began as a way to encourage widespread usage of grid squares, and to also coordinate with VHF activity nights on the East Coast. These contests were four hour in length, single band events scheduled weekly between April to early May. (In 1983 only, the Spring Sprints were six hours long, and a second set of Sprints occurred in the fall as well, with those being four hours in duration). A new VHF/UHF band was worked each week and was considered to be a separate contest. The only category was Single-Op. The Sprints initially were held on the four VHF bands and 1296 MHz.

- The first existing VHF contest to use the grid squares was the 1983 August UHF. Distance points were abandoned, and a grid square designation for each band became the multiplier, instead. The following month in the 1983 September VHF, grid squares were first used in the VHF QSO Party format. In 1985, grid squares per band were used as multipliers for both the January VHF SS and the June VHF QSO Party. Grid square multipliers have been integral to the scoring system of all ARRL VHF contests (except for the 10 Gig and the EME) ever since. The adoption of grid squares was a spectacular event for all of VHF operating, and constituted a fundamental change in the scoring methodology used in the VHF contests.

- The 1983 August UHF eliminated the prohibition on FM usage in the 434-435 MHz band segment.

- The 1983 September VHF also revised the scoring rules slightly: 1 QSO point would still be given for 6 and 2; 2 points for 220 and 432; 3 points for 1296; but then 2.3 GHz and higher was awarded 4 QSO Points. This same QSO point system was implemented in the 1985 June VHF QSO Party, but the January VHF SS retained 1 to 16 QSO points for contacts across the various bands.

- Between 1983 to 1987, 10 operators achieved WAS on 222 through a series of portable EME capable Dxpeditions to states inactive on the band. Since that time, no other WAS certificates have been issued for 220 MHz, in spite of great advances in EME oriented technologies.

- Commencing with the 1985 January VHF SS, the exchanges was again shortened, this time to just the exchange of grid squares. Dropped from the exchange was the signal report.

- Also in 1985, the League expanded the VUCC program to include additional microwave bands beyond 1296 MHz. 10 grids would be needed for a VUCC award on 2.3 GHz; and 5 grids for 3.4 GHz, 5.7 GHz, and 10 GHz. Later in the development of the program, the VUCC award was made available for all bands higher than 10 GHz, with 5 grids being required for any band.

- In commenting on the numerous rule changes occurring at the time to the August UHF, the League stated: "The contest exchange / scoring format has undergone more changes recently than a chameleon in a kaleidoscope". Much the same could be said for all the rules changes being made during that era, regardless of VHF contest!

- With grid square related changes, came uniformity across contests. Aside from the differences between the QSO point calculation, the big three contests were now virtually identical in objective and scoring methods utilized. This was far different than when these contests first started in 1948. The January VHF SS and the VHF QSO Parties then had different scoring techniques, exchanges, and purposes to the contests.

- Amateurs were allocated a new band, 902 MHz, in 1986. All contests quickly included this new band in their scoring formats. Typically, 902 was given the same number of QSO points as was 1296. The VUCC program also adjusted for the new band, by giving a VUCC award for 25 grids confirmed on 902 MHz.

- The 1986 January VHF SS had the QSO Points lowered somewhat, to 1 point for 6 and 2; 2 points for 220 or 432; 4 points for 902 or 1296; and 8 points for 2.3 GHz or higher. The QSO points were lowered in order to adjust for the increased points in the SS coming from per band multipliers that were changed the year before.

- Use of non-amateur communication during a contest (i.e the telephone) to solicit a contact was always considered bad form. The Rules for the 1986 June VHF QSO Party for the first time indicated that such communication was inconsistent with the spirit and intent of the contest rules. The rule was initially widely misinterpreted as preventing scheduling in advance of a contest. In the write-up on the Results of the 1986 June VHF, the League's staff noted that only schedules done over non-amateur communication during a contest was prohibited.

- In 1986, the 10 GHz Cumulative was introduced. The scoring system was decidedly different than all other contests: Distance points plus QSO points equaled the total score. No multipliers were used. This type of scoring method encouraged working stations more than once, and sharpening operating skills to achieve ever further distance points. The distance scoring method for the 10 Gig thus borrowed from the tradition of the early, pre-WWII UHF Relays. The first Cumulative occurred over two weekends in September and October. Virtually everyone staked out high ground and was portable. Contestants participated as one class.

- The QRP Portable category started in the September VHF QSO Party of 1986. QRP Portable was added to the June VHF QSO Party in 1987, and to the January VHF SS in 1989. Entries had to run 10 W PEP or less from a portable power source and with portable equipment and antennas.

- E skip conditions on 6 meters were so astounding in the 1987 June VHF QSO Party that many operators felt that propagation was the best ever experienced.

- The Second Annual 10 GHz Cumulative in 1987 (and thereafter) was moved to two weekends in August and September.

- In 1987, the Spring Sprints added 902 MHz as a sixth single band contest, and 2304 MHz was added in 1988. Through 1987, the Sprint results were printed in QST. Starting the following year however in 1998, the posting of the results was transferred to the *National Contest Journal.* Log submissions plummeted, but activity generally remained high.

- In the 1980's, *CQ* resurrected their VHF contest. By 1987, The *CQ* WW VHF WPX had activity for 6 through 1296. Categories included SO, Multi-op high and low power, and portable. 1 QSO points was given for contacts on 50, 70, and 144 MHz; 2 point for 220 and 432; and 4 points for 902 and 1296. Multipliers were prefixes.

- The Club rules were amended slightly in 1988 to require all members of unlimited and medium clubs attend at least 2 meetings a year, instead of the previous rule that required only that people living 50 miles away from the club center to attend 50% of the meetings of the club per year.

- By the early 1990's, numerous hams had achieved WAC and WAS on several of the VHF bands through the use of EME (including 220 in the late 1980's). But DXCC eluded everyone. Finally, just past the peak of solar cycle 22, several stations confirmed 100 countries on 6 meters. By the fall of 1991, over 20 amateurs had achieved the 6 meter award. All eyes then turned to 2 meters. A great moon-bouncer, Dave Blaschke, W5UN, seemed the odds-on favorite to be the first person to achieve 2 meter DXCC. But disaster struck on March 19, 1990, when his "Mighty Big Array", or MBA as it came to be known, was destroyed by a nearby tornado. His DXCC count stood at 97 at the time. After clearing away twisted metal for a month, he slowly rebuilt his antennas through the summer of 1990. On October 28, 1990, W5UN passed the 100 country milestone by working a 2 meter contact with VS6BI. Shortly thereafter, W5UN was awarded the first DXCC on 2 meters. Both the 6 and 2 meters DXCC was all but impossible a few short years before. Through dogged and relentless persistence as well as technological improvements to radios and equipment, DXCC on the VHF bands was now a reality.

- In 1991, after several years of debate at the regulatory level, the bottom 2 MHz of the 220 band was awarded to commercial services. There were numerous sign-off parties around the nation as the transfer date of August 27, 1991 approached. Amateur activity continued to go on between 222 and 225 MHz, and weak signal work shifted to 222.100 MHz +-. [2]

- Starting in February 1991, Morse code requirements were eliminated for Technicians operating above 30 MHz. This move was highly controversial at the time, and it started the trend that ultimately led to Morse requirements being relaxed on the HF bands, as well. The new "Tech-Plus" designation quickly blossomed the amateur radio ranks, and would have a major impact on VHF operating and contesting for years to come, as new hams would now start on the VHF bands, instead of the Novice HF sub-bands. [3]

- The development of computerized antenna modeling programs in the early 1990's led to increasing sophistication of antenna design. The venerable NBS yagi design gave way to a complex design in VHF yagi's that improved receive and transmit capabilities of amateur radio operators enormously.

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[2] There was even some discussion on the bands of protesting the transfer by continuing rogue operations on 222, to which the League admonished readers when it stated "We can imagine nothing more destructive of our interests than for interference in the 220-222 MHz band to be traced to our doorstep." *QST,* "220-222 MHz" editorial by David Sumner, K1ZZ, August 1991, p.9. Ultimately, no rogue activity was ultimately reported or engaged in, to anyone's knowledge.

[3] Entire VHF columns were devoted to the new licensing regime. See, "Newcomers to the World Above 50 MHz – Let's Welcome Them", Bill Tynan, W3XO, *QST,* June 1991 (?), p.76-77. Tynan noted (The Commission's) "Decision is certain to have profound consequences for the world above 50 MHz.".

- Throughout the 1990's, amateur radio communication to the Space Shuttles was being routinely scheduled on a secondary basis, as numerous Shuttle astronauts also held ham radio licenses. QSL card confirmations of contacts with Shuttles have become prized possessions within the amateur community. (By 2003, old QSL confirmations with any STS flight of the ill-fated Challenger or Columbia shuttles have become even more prized).

- The addition of the participation pins to many of the ARRL VHF contests beginning in the early 1990's proved to be very popular among contestants. The plaque program for the top national scores has also proved popular.

- While the Pack Rats dominated the January VHF SS Club Competition over the years, the multi-op category has been equally dominated by just a few groups. By the early 1990's, only a few groups were in real competition for the national top multi-op spot. In fact, only one multi stood out above everyone else. W2SZ, the Rensselaer Polytechnic Institute ARC operating from Mt. Greylock Massachusetts, had become the dominant operation in the multi category, with long-standing contesting records and scores in the June VHF QSO Party. More recently, the Grid Pirates, K8GP, have developed an intense rivalry with Rensselaer for the unlimited multi-op top spot. This rivalry is akin to the duel between the Pack rats and Rochester in the club competition. Another great multi-op effort is that of W3CCX, sponsored by the Pack Rats, operating in the June QSO Party.

The No-Code Tech Explosion

- *Expansion of the Categories.* Faced with the less than a competitive situation among the multi's, the Multi-op category in June 1991 was split into two separate categories, the Multi-Unlimited and Multi-Limited. The limited category competed on only four bands. These types of multis could operate on more than four bands, but then just submitted the best four bands for credit. All Multi-op records and high scores held prior to June 1991 were considered to be part of the Multi-Unlimited category.

- Many contesters felt that captive rovers of the big multi operations were also contributing to the problem. To deal with the matter, a separate rover category was added in June 1991. Prior to that date, rovers were considered to be either Single-Op or Multi-Ops entries, with the scores from each grid square visited by the rover being counted as separate entries. It was felt that a separate competition for the rovers would encourage operations independent of the big multi set-ups.

- The development of real time contest logging programs in the early 1990's revolutionized all of radio contesting, VHF included. Popular programs included CT, by K1EA, and NA, by K8CC, among others. Gone were paper logs and extensive manual dupe checking techniques. Computer duping, antenna steering, packet spotting, and other extensive accessories of modern day computer logging programs quickly became commonly accepted. (Editor's note: in 2003, K1EA moved his latest version of CT to shareware status, complete with easy downloading from his web-site, and was agreeable to providing continuing updates and technical support for the program!).

- By the early 1990's, another technical innovation had arrived. The commercial application of VHF power transistors at practical power levels was making a considerable change in commonly used VHF power amps. Power tubes for moderate power levels, along with the attendant risks of potentially lethal high voltage power supplies, were being replaced by 100 to 200 watt transistor power amps, all running on much safer 12 VDC power supplies.

- In 1992, the *CQ* WPX VHF included SO, Multi I and II categories, as well as SO portable and rovers. Multi II was limited to 4 bands. 2.3 GHz and higher was added to the mix, and was given 6 QSO points for each contact. An interesting incentive for CW was added to the contest, with one additional QSO point being given for any CW contact. The next year, the *CQ* WPX VHF changed the multiplier to include prefixes per band plus grid squares per band.

- In 1993, a long-time amateur radio operator who was a Professor at the University of Massachusetts and Princeton in Astronomy and Physics, Joe Taylor, K1JT, was awarded the Nobel Prize in Physics for the co-discovery of binary pulsars. He credited his early interest in ham radio in propelling him towards advanced degrees in science (In 1958, at the age of 17, Taylor wrote an article in *QST* on "ionospheric scatter", after he and his brother decimated the competition in a VHF competition).

Over the years, Taylor has maintained a continuing interest in VHF contesting. Most recently, he has developed a revolutionary software program for VHF scatter and moon-bounce (see note below). An amazing contribution to both science and hobby!

- In 1993, the VHF Spring Sprints retained 6 through 432 weekly contests between April and May. 902, 1296, and 2304 were merged into the same time period, with separate contests running simultaneously.

- Beginning in 1993, Field Day Rules provided for 100 bonus points and free station status for operations above 50 MHz. This bonus quickly became a favorite way for Field Day clubs to add extra points to their totals.

- By the early to mid 1990's, the regulatory granting of no-code technician licenses with VHF only operating privileges was making a dramatic impact upon the VHF community. Within the span of a few short years, the ham ranks went from virtually no newly licensed technicians to over one-third of all amateur radio licensees being VHF only technicians. Additionally, technical advances in phase lock loop technology and increased miniaturization of electronic components allowed for the introduction of 100 watts, multi-band, multi-mode VHF transceivers of a compact nature. For instance, the original ICOM 706 was considered a major breakthrough in HF and VHF equipment capability, and was extraordinarily popular among hams. The combined effect of the large increase in newly licensed VHF only hams coupled with technical innovations in radios produced an absolute explosion of VHF operating and contesting activities. This era can now be seen as being a third major boom in ham related VHF activities.

- The scoring system for the new rover class proved to be highly controversial, and rules changes occurred in June 1993. These changes also were controversial, and modifications to the scoring system once again occurred in January 1995. The rover rules are still causing controversy, and may be changed yet again!

- Starting in January 1995, five new bands above 47 GHz were added to the scoring system for all categories.

- In 1995, the Rover category was added to the August UHF Contest.

- By the mid-1990's, Internet access was becoming increasingly common. What had started out a generation before as an experimental way to establish communications and coordination between government, academic, and commercial scientific sectors, had evolved into a mode of communication with broad mass appeal to consumer and commercial interests alike. At first, the existence of non-ham types of entertainment and activities of a technical nature was seen as a threat to the continuing vitality of ham radio as a hobby. It became quickly evident however, that Internet capability could be complementary to the hobby. Indeed, by the late 1990's, internet access was increasingly being used as a way to enhance the amateur radio hobby, complete with personal and commercial ham radio related web-sites, reflector lists, and even a section on E-Bay and entire web-sites (E-Ham and others) being devoted to ham radios for direct sale by hams to other hams.

- In the mid-1990's, the Toronto VHF Society, using the call VE3ONT, used the giant Algonquin Radio Observatory to participate in several EME Competitions, much to the delight of EME enthusiasts. Tremendous signal reports were noted.

- Starting in 1996, the 10 GHz Cumulative Contest was changed to include a second category for stations operating on 10 GHz and above, and the contest's name was changed to the "10 GHz and Up Cumulative Contest".

- In 1996, the *CQ* WW WPX VHF dropped any use of prefixes as a multiplier, and adopted grid squares per band as the only form of multiplier. The name of the contest then dropped the "WPX" reference.

- *CQ* commenced National Foxhunting Weekends (NFW) in 1997. Foxhunting has been growing in popularity in recent years, and invariably the radio "fox" will be some simple and small transmitter operating at VHF frequencies. Participants come equipped with direction finding antennas and other assorted specialized equipment and antennas. The ARRL has Radio Direction Finding (RDF) Coordinators, and the League also sponsors national ARDF championships in the summer months.

- In contrast to the League's formalized rules procedures, the governance of *CQ's* rules structure was more direct: the editor of the VHF column for *CQ* magazine made the decision on any rules changes, after informal consultation with magazine staffers and members of the VHF community. (Editor's note: This was evidently the procedure in effect in the mid-1990's, when the editor of the "VHF Plus" column commented that after much thought on the subject, he was dropping altogether the use of prefixes as multipliers). More currently however, *CQ* VHF contest advisory committee exists.

- In 1998, some 11 years after hams reported great conditions in the VHF contests, tremendous bands openings occurred in both the June VHF QSO Parties and with the VHF bonus station in the Field Day exercises held some two weeks later. Numerous Division records in all categories were broken in the June QSO Party, and some stations reported almost constant activity on 6 meters throughout Field Day. (The Editor of these Notes vividly recalls working still having an open 6 meter band at day-break on Sunday morning!). Band openings were so strong throughout the summer E-skip and tropo season that they were dubbed the "openings of the decade".

- Band conditions were so strong in the June VHF QSO Party during this solar cycle that in 1996, 1998, and 2000, a total of eleven stations broke the 1000 QSO barrier on 50 MHz, with eight of them being from South Texas. Several stations in this time period also worked over 100 grids on 2 meters in a single contest in both the June and September VHF events.

- The radius for local clubs was expanded to 35 miles in 1998, but then briefly returned to 20 miles the next year. The mileage limit was again expanded to 35 miles in 2000.

- The club competition was expanded in 1999 to include the September VHF QSO Party.

- In 1999, separate VHF clubs became responsible for each band contest of the VHF Spring Sprints. This proved to be severely disjointed and confusing, so the next year in 2000, the responsibility for the VHF Sprints was transferred to the East Tennessee DX Association. Fixed and rover categories were provided for by 2002.

- Also in 1999, *CQ* magazine began sponsoring VHF activity weekends, once a month between May and June. Separate weekends are devoted to FM, weak-signal, and specialty modes. Categories include SO QRP, SO QRO, Multi QRP, Multi QRO, and Rover.

- The 2000 *CQ* WW VHF Contest revised its format to include only 6 and 2 meters. Over the years, the CQ VHF contest has usually been in July, and is an interesting event since it has been one of the few multi-band VHF contests not sponsored by the League. However, it has had varying degrees of success, has dramatically altered its structure several times, has been poorly publicized, and only enjoyed broad participation in its very early years in the 1950's and 1960's.

- Effective January 1, 2000, the Single-op category was split into high and low power classes, with all records and high scores prior to 2000 being considered part of the high power class. Low power was defined as 200 Watts PEP on 6 and 2; 100 W on 222 and 432; and 10 Watts on 902 and above. SO High Power was considered to be any power levels in excess of the limits imposed on the low power class, but the rules did not expressly define the maximum power level allowed in the SOHP category.

- The QRP Portable category had a name change effective September 2000 to "Single-Op Portable", with only slight clarifications occurring to the category definition. All records and scores pre-dating the name change were considered to be part of the SO Portable category. *(Note to KCK: More specific information on the clarifications can be found in my QRP article).*

- By 2002, a Fall Sprints reminiscent of the original Fall Sprint in the 1980's had been resurrected. Run by the Southeast VHF Society, separate band events existed for 6, 2, 222, 432, and microwave activity.

The Present and Future of VHF Activity

- There are now six categories of competition in many of the VHF contests in which to choose from: Single-op high power; single-op low power; single-op QRP portable; Multi-op unlimited; multi-op limited; and rover. In 1948, only single-op was available. What a difference eight decades of contesting makes! Discussions are currently underway to again expand or vary the categories in some manner.

- Club participation rules were dramatically relaxed in November 2002 for both HF and VHF contests. Canadian clubs affiliated with the RAC could now participate in any ARRL sponsored club competition. The territorial mileage for unlimited clubs was changed to either 175 miles from the club's center or an entire ARRL section (but not both), and the local club territory was maintained at 35 miles. In a controversial move designed to bolster club membership, the League dropped the two meeting per year requirement for individual club members. Additionally, only 50% of a multi-op's participants would have to be members of the club in order for the multi score to count as a club entry. Lastly, the station owner of a guest op run no longer had to be a club member so long as the guest op was a club member and the station was located within the club territory.

- At the start of 2003, the Contest Branch of the ARRL clarified existing rules, stating that use of BEACONet is allowable, as it is only an automated CQing system that uses existing VHF bands and modes that are within the letter and spirit of the rules. Use of digital modes (such as JT44) is evidently allowed so long as no lat / long indicator is used in the ID or CQ message. This would constitute a prohibited form of self-spotting, according to E-mail information received from the League.

- Digital modes became expressly allowed in the EME Competition in 2003.

- Effective for 2003, the high power entry for all ARRL contests was changed to a maximum of 1500 watts PEP or maximum allowable by the national licensing authority, whichever is lower.

- The ARRL Awards Committee decided in 2003 that the club competition would again be expanded to include the June VHF QSO Party, effective for the 2003 event.

- The "VHF/UHF Contesting!" column in the *National Contest Journal* has been instrumental in the development of both the Limited Multi and Rover categories. This column at one point even made formal proposals requesting the adoption of both Limited Multi and Rover categories. After extensive discussions by the Contest Advisory Committee, both categories were ultimately approved with some revisions. The column continues to be highly influential among the serious contest enthusiast, but its impact is tempered somewhat by the small subscription base of the *NCJ*.

- "The World Above 50 MHz" column in *QST* has also been instrumental in the development and encouragement of almost every VHF contest and VHF activity in the United States and beyond. This one column, with only six editors since 1939, has done more than any other single printed source in disseminating information relating to the VHF and UHF amateur radio spectrum. It continues to be a shining example of the long-standing support the League offers to the VHF community. Each of the editors of the column has been instrumental in VHF activities. They are as follows:

Ed Tilton, W1HDQ	1939-1960
Sam Harris, W1FZJ	1960-1967
Bill Smith, W5TVB	1967-1974
Bill Tynan, W3XO	1974-1992
Emil Pocock, W3EP	1992-2002
Gene Zimmerman, W3ZZ	2002-present

- The Central States VHF Society has been sponsoring a States above 50 MHz Award and contest since 1996. The contest is a year long event, and certificates are issued to any amateur who works at least 30 states on all VHF bands within the one year time period. Originally designed for both single and multi-ops, rovers were added in 2001 / 2002. Canadian provinces were added to state totals 2002 / 2003. Central States also sponsors a contiguous 48 state 50 MHz award, as well. Central States has been highly influential in the development of many items of interest to the VHF oriented amateur, with the most notable item being the development of the 1 x 1 squares that acted as a precursor to the ARRL grid squares. Its annual conferences provide a continuing treat to all VHF enthusiasts.

- The Six Meter International Radio Klub (SMIRK) has sponsored 6 meter only contests over the years. The format has varied little since the 1980's when grid squares became accepted: 2 QSO points for SMIRK members and 1 QSO Point for non-members. The multipliers are grid squares. Traditionally held the weekend between the June VHF QSO Party and Field Day weekend, the SMIRK contest has been a relaxed and enjoyable affair, attracting many weekend 6 meter enthusiasts at the height of the E skip season.

- Two other groups deserve mention. The San Bernardino Microwave Society recently celebrated their 40th anniversary as a group, and the North Texas Microwave Society is very active, as well. Both groups have immeasurably advanced the overall interests of amateur microwave activities, and have been heavily involved in many technological innovations of great importance. They provide a rich and continuing source of technical microwave knowledge.

- Recently, web based technology has dramatically changed the way in which contest reporting has taken place. Traditionally, contestant line scores were listed in *QST*'s, and that practice went back to the earliest VHF contests. ARRL web-based *QST* contest articles started becoming available in 1997. Interactive sorting capability of score related spreadsheets were available by 2002. The June 2002 VHF QSO Party

Results and the 2002 August UHF Contest Results, both of which were published in the January 2003 edition of *QST*, were the first contests to not contain the line scores from within the pages of *QST*. All line scores from these two contests forward would be listed exclusively within the pages of the ARRL web-site. The change represented the symbolic end of the print era for contesting, and many contesters are still wistful (and some are even resentful) over the line scores no longer being in print format.

- Additionally, the publication of contest rules for both HF and VHF contests have been moved from *QST* to an exclusively on-line availability. Only rules summaries are currently available in *QST*. This move has also proved to be highly controversial among serious HF and VHF contesters.

- Current usage of the VHF and UHF amateur radio spectrum includes many diverse activities. In addition to the "normal" types of amateur VHF / UHF activities of EME, microwave activity, E-skip, aurora, tropo ducting, and FAI, some other forms of radio communications include laser light activity, spread spectrum work, amateur satellites, ATV, 6 meter RC modeling, and RDF fox hunting.

- Today, technical frontiers by amateurs are being pushed as never before. For example, with the introduction of the WSJT and JT44 computer programs by K1JT, the new digital modes may propel weak signal work on EME and meteor scatter to a height never before even imagined. Computer software programs for high speed CW (HSCW) on meteor scatter and Digital Speech Processing are making large impacts upon operating abilities. Ham radio SETI experiments are other examples of innovative amateur radio activities occurring on VHF and UHF.

    - Note that Joe Taylor won a VHF contest with a brother when they were teenagers in the 1950's; he ran MS back in the 1950's; he went on to be a Nobel winning physicist as the co-discoverer of Pulsars; He retired from Princeton a few years ago; after he retired, he again returned to MS work, running a schedule in 2001 for the first time since the 1960's; he now has developed the JT digital modes for MS, terrestrial, and EME work.

- Discussions are now underway to again revise the contest rules and vary the format of the VHF contests. Numerous ideas are being circulated within the VHF community. For a summary of some of the thoughts being bandied about, please refer to The World Above 50 MHz column, *QST*, April, 2003, at page 86-88, "VHF Contests Reexamined: Changes in the Wind". Various VHF contest and operating reflectors also contain up to the minute discussions of possible VHF contest rules revisions.

- In 1992, K3HZO and WA3NZL made the frist Au contact on 902 MHz. (CQ, 6-93, at 97).

A Few Notes on International VHF Contests

- The ARRL contests have been mostly involved North American activity over the years. Some foreign entries run in the June VHF QSO Party when the chance of 6 meter skip is high, but otherwise, there have been few log submissions from outside of North America.

- *CQ* magazine does have more international support for their VHF contests. In the 1960's, *CQ* used county designations in the US and county equivalents internationally as a multiplier, and actively encouraged international competition. Contests have in the past expressly provided for credit on the International 70 MHz band, in addition to all US bands.

- The EME Competition sponsored by the League does enjoy significant international support, however. Around half of the entries may be from abroad in any one year. Indeed, the EME contest is the annual highpoint of activity for moon-bouncers around the world, and virtually everyone that is moon capable will run the EME competition. The better stations in the event have reached over 300 QSO's on 2 meters and over 100 QSO's on 432. Over 200 logs coming from all over the world have been submitted in recent years.

- Europeans have an incredible number and variety of VHF contests (of which little is known about by the Editor to these Notes, unfortunately). Europe had a strong VHF community throughout the post WWII period. They led the way, in fact, regarding the usage of latitude and longitudinal designations in their exchanges, and the Central States VHF Society and the ARRL both relied heavily upon their example in the development of the Maidenhead grid squares. We could learn much from their continuing activities. Anyone with knowledge concerning international VHF contest events should send comments to w9gka@arrl.net.