A short history of amateur radio

Mark Pecen, VE3CPK/VE3QAM

Early wireless – the 1860's through early 1890's

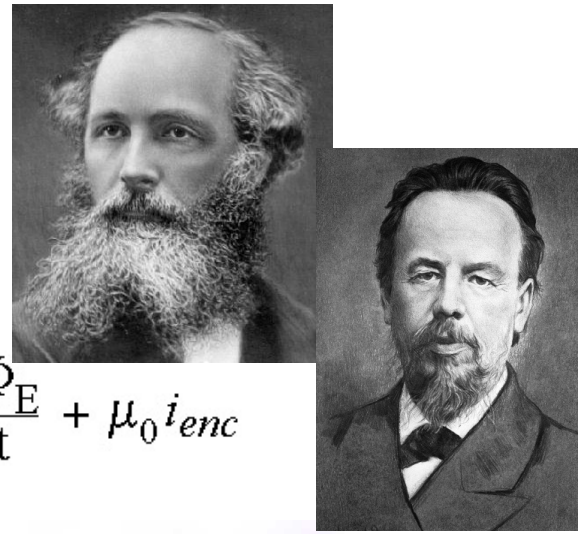
- By the year 1850, most electrical phenomenon had been investigated by academic researchers
- James Clerk Maxwell (1831-1879), Professor of Experimental Physics at Cambridge introduced a new model for examining both electrical and magnetic phenomena in around 1861
- His new mathematical model, today referred to as Maxwell's equations, predicted that there might be the existence of electromagnetic waves
- Later in 1891, Heinrich Hertz in Germany and Alexander Popov in Russia both gave a practical proofs of concept, demonstrating Maxwell's theory – sending electromagnetic waves across a distance of about 1 metre
- Operating frequencies during this period in history were around 100 MHz, due to the small size and value of resonant components

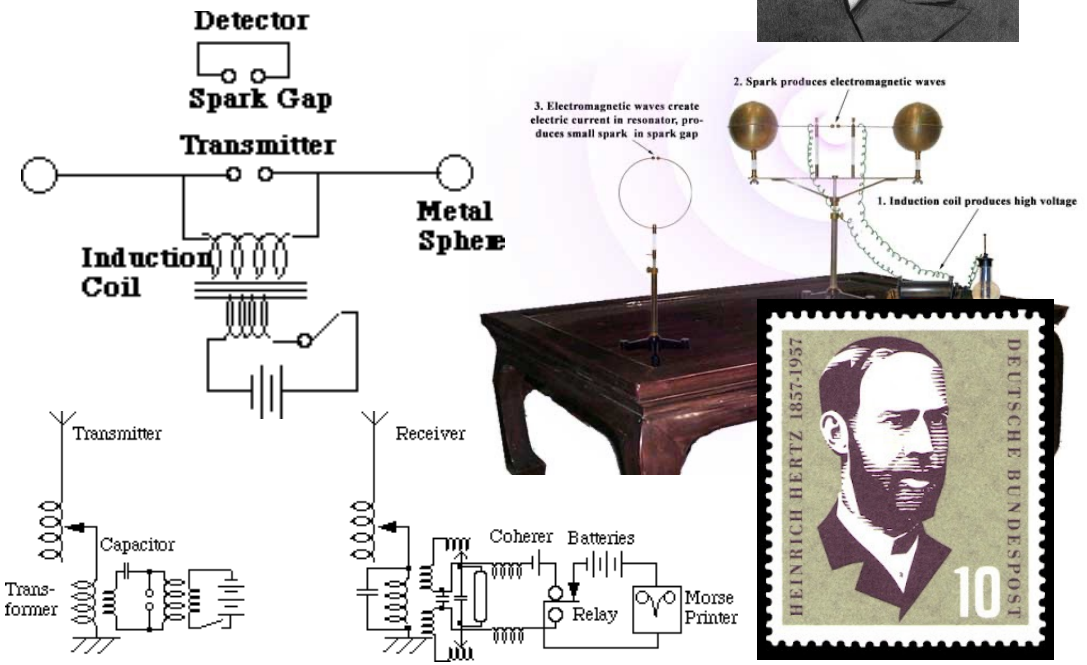
$$\oint \mathbf{E} \cdot d\mathbf{A} = \frac{q_{enc}}{\varepsilon_0}$$

$$\oint \mathbf{B} \cdot d\mathbf{A} = 0$$

$$\oint \mathbf{E} \cdot d\mathbf{s} = -\frac{d\Phi_B}{dt}$$

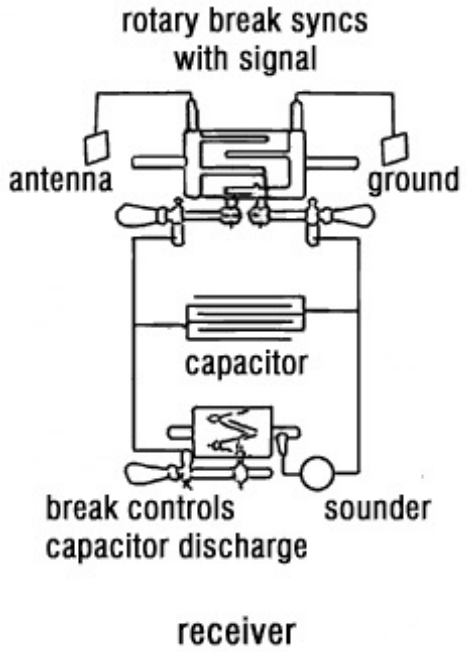
$$\oint \mathbf{B} \cdot d\mathbf{s} = \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt} + \mu_0 i_{enc}$$

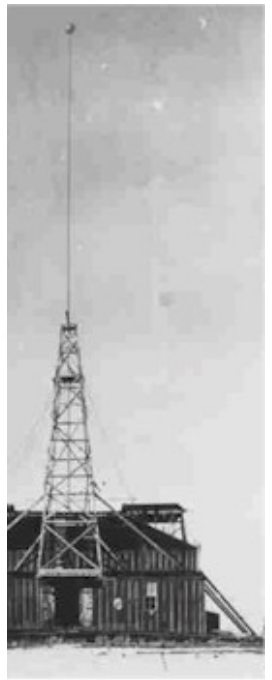


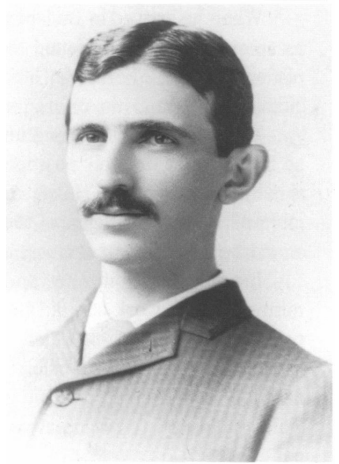


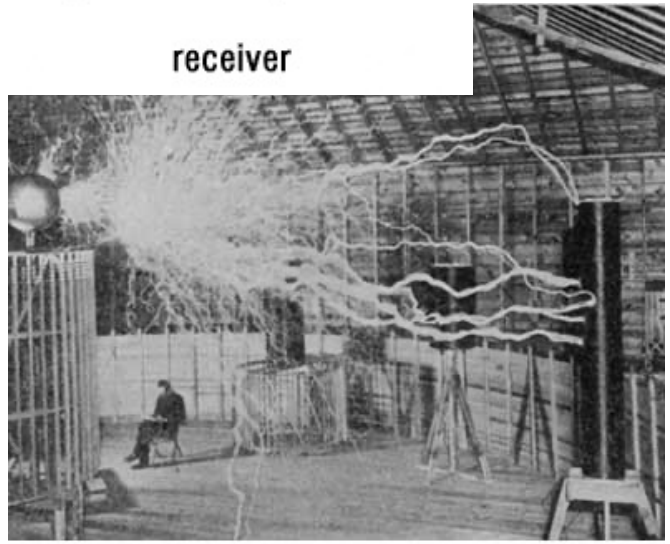
1892 – Nikola Tesla files the first wireless patents

- High frequency generators for producing continuous waves
- Coupled and tuned circuits, today a version of his “Tesla coil” still exists
- Rotary and series spark gaps
- Oil-insulated transformers and condensers.
- Mica capacitors impregnated with wax under vacuum
- Stranded conductors ("Litzendraht”)
- Aerial and ground connection
- Selective tuning by beat waves or heterodyning
- Arcs for producing continuous waves
- "Ticker" for receiving continuous waves.





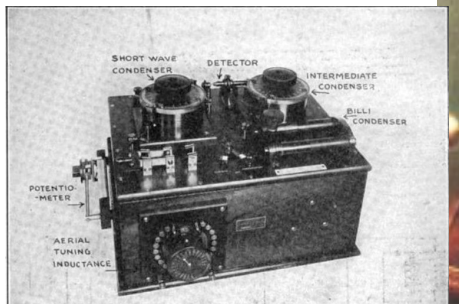


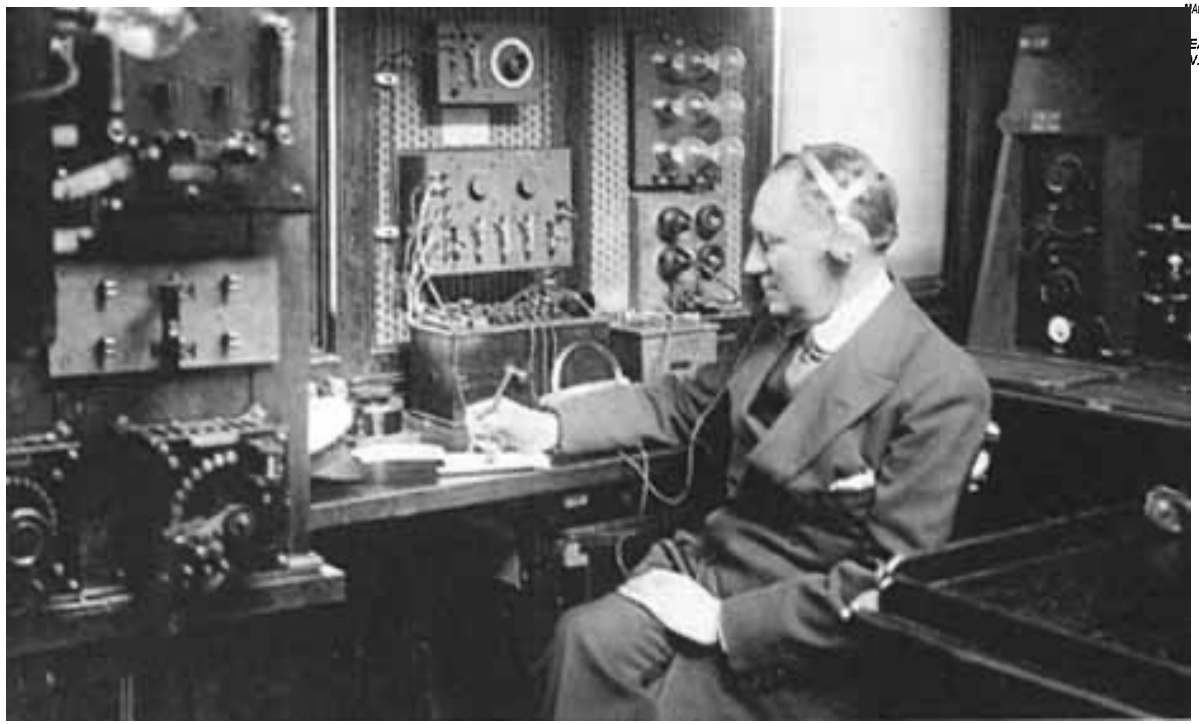


Tesla's Colorado Springs Laboratory in 1899.

1896 – First practical wireless system

- First practical wireless demonstrated by Marconi, 'Hertzian Waves' over two miles!
- When Marconi learned about the experiments of Heinrich Hertz and Popov's, he saw the possibility of using these waves for maritime communication
- (below Later in life on his yacht, Elettra)





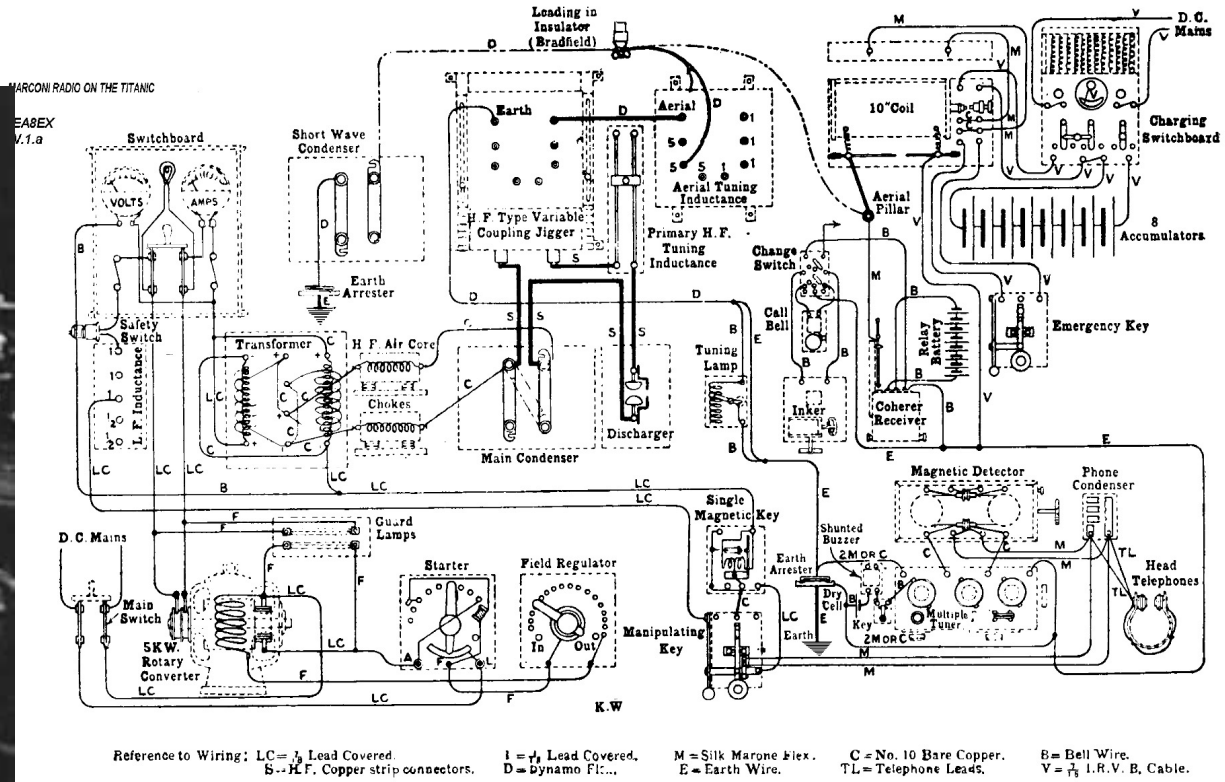


Fig. Connections of 1½/5-kw. Marconi Converter Set.

1898 – U.S. Navy establishes first coastal station

- Not difficult to see the military importance of this new communication technology!

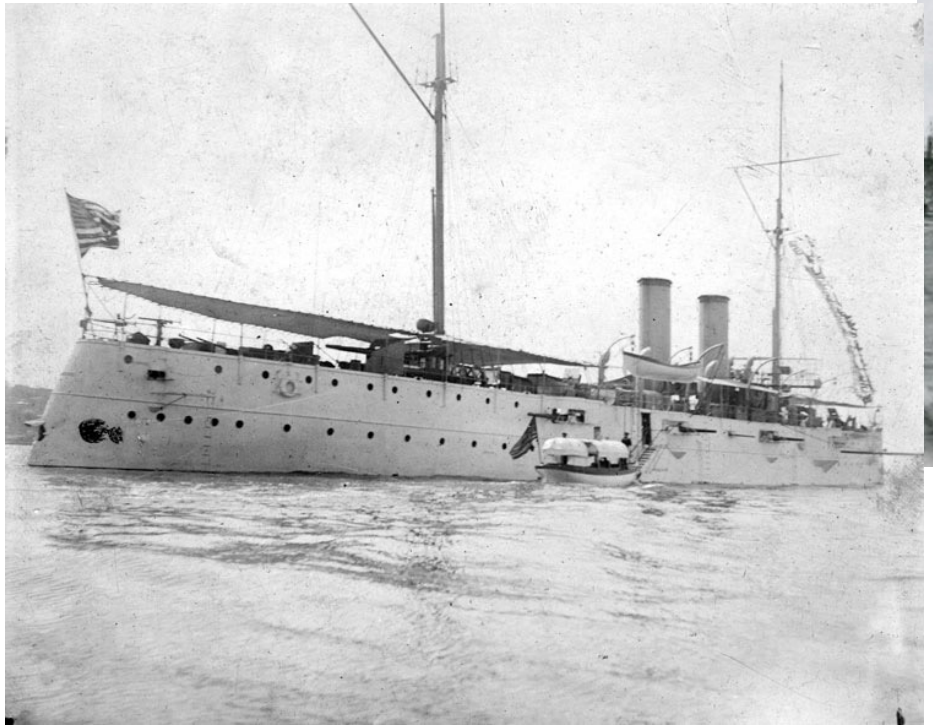
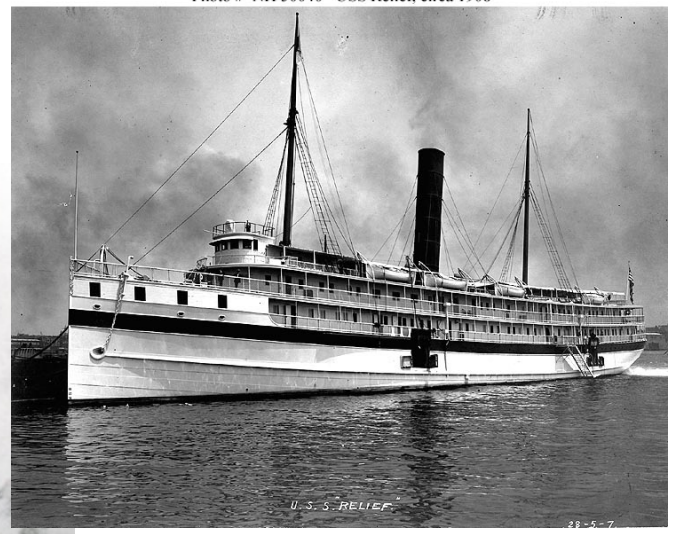


Photo # NH 50040 USS Relief, circa 1908

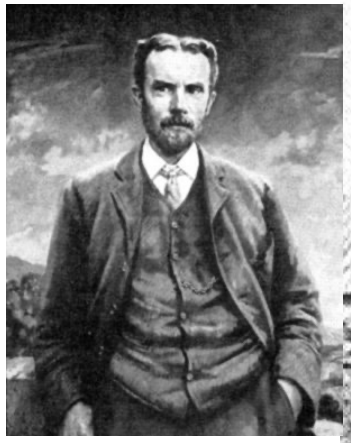


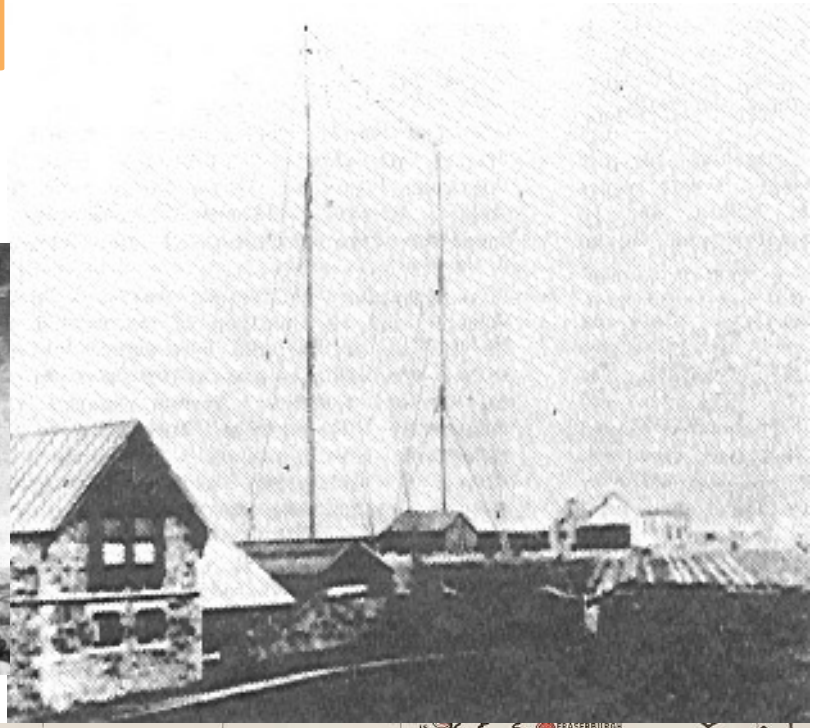
1899 – First commercial use of wireless!

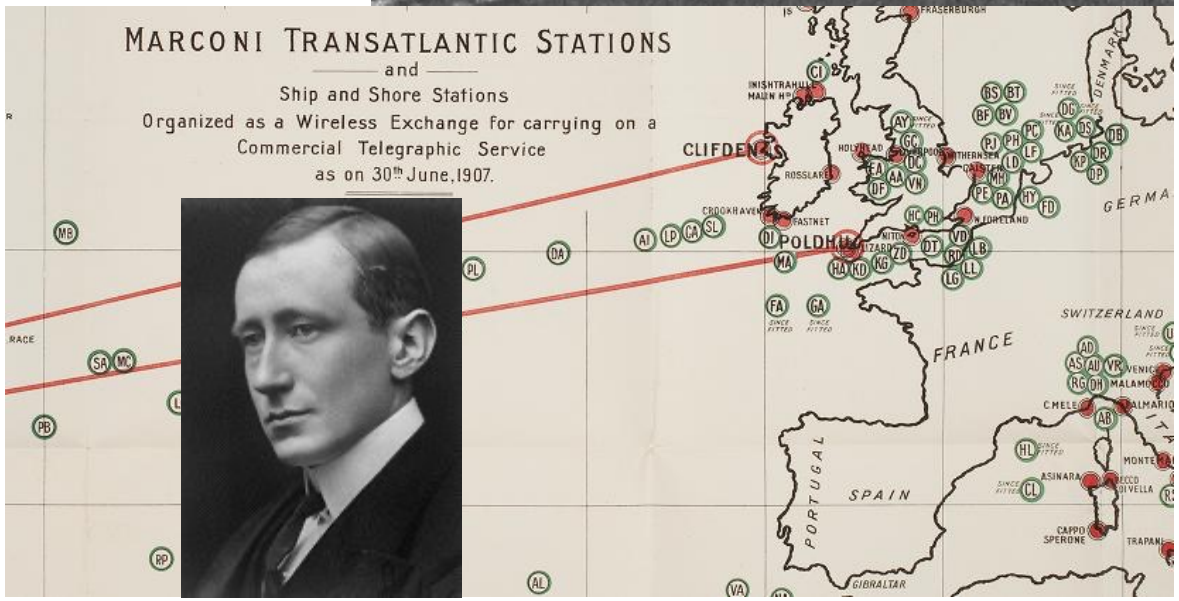
- The first broad-based commercial use of wireless communication was for reporting on yacht races in New York Harbour
- The race occurred over a two-week period
- Yacht positions were reported each day in the newspapers
- Prior to this innovation, the race would have been reported on by newspapers after the fact

1899 – Long distance demonstrated

- The first radio amateurs began their quest for long distance wireless communications
- Long distance, now called “DX”, was considered anything over 10 miles between 1899 and 1912
- 1899, Marconi sends a signal over the English Channel - 32 miles
- 1901, Marconi makes the first trans-Atlantic contact via spark-generated wireless telegraphy
- 1902, Oliver Heaviside predicted that there was an conducting layer in the upper atmosphere which allowed radio waves to follow the Earth's curvature
- The Heaviside layer was proven in 1923 when radio pulses were transmitted vertically upward and the returning pulses from the reflecting layer were received

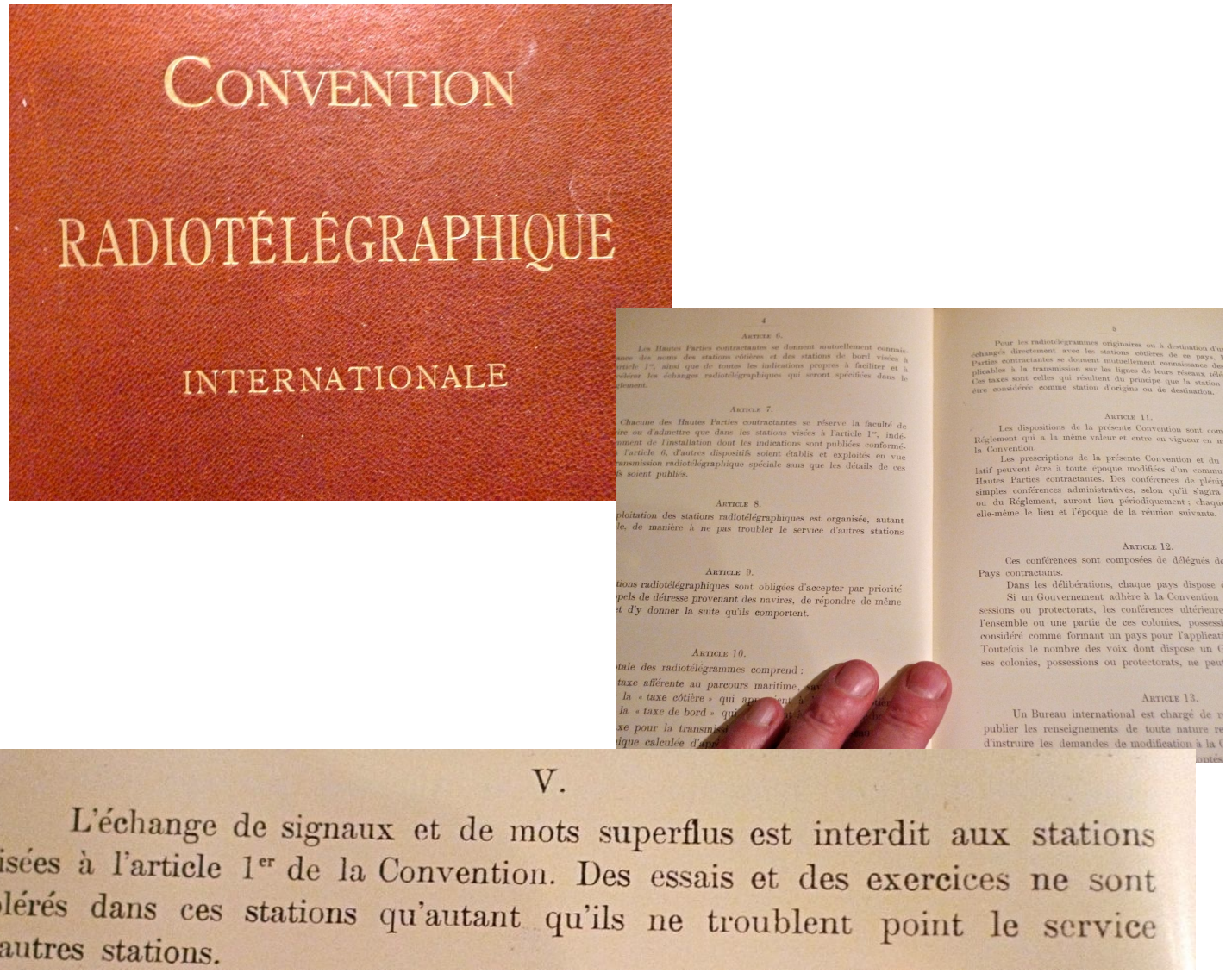






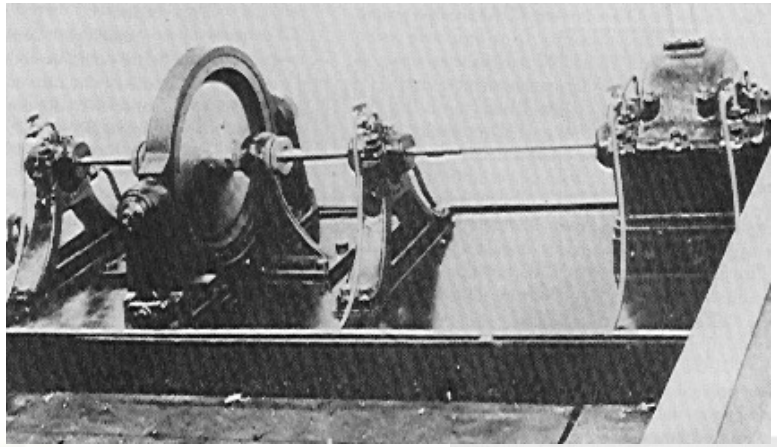
1905 – First wireless telegraph regulations

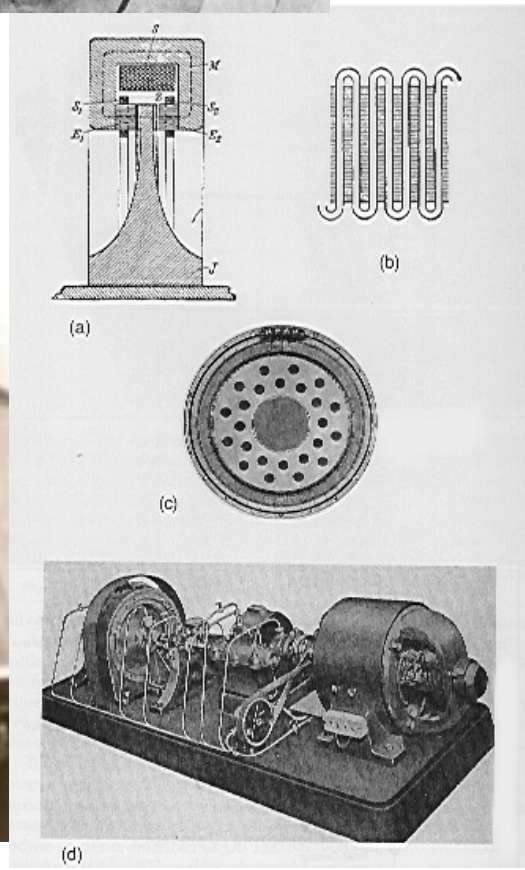
- The Union, forerunner of the International Telecommunications Union (ITU) established the first regulations for wireless telegraphic communication
- “Convention Radiotelegraphique” was drafted in 1905 by participating Union member countries
- The ITU is now an agency of the United Nations (UN) and is the principal organisation that sets global direction for the use of wireless spectrum today
- The decisions by the ITU member counties are treaty binding among member countries



1906 – first wireless speech

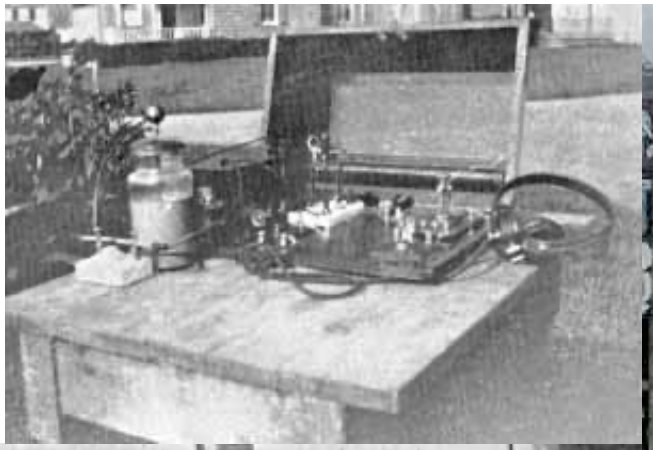
- 1906, Canadian engineer Alexander Fessenden demonstrated voice modulation using a two kilowatt 100 kHz alternator producing a spark modulated by an alcohol flame
- Also in 1906, the "Berlin International Wireless Telegraph Convention" defined call letters and operating procedures for wireless stations, and **standardised the name "radio" for the wireless technology**
- Again in 1906, Lee De Forest invented the "triode" or "audion" tube that could both rectify and amplify paving the way for narrower-band CW and voice communication

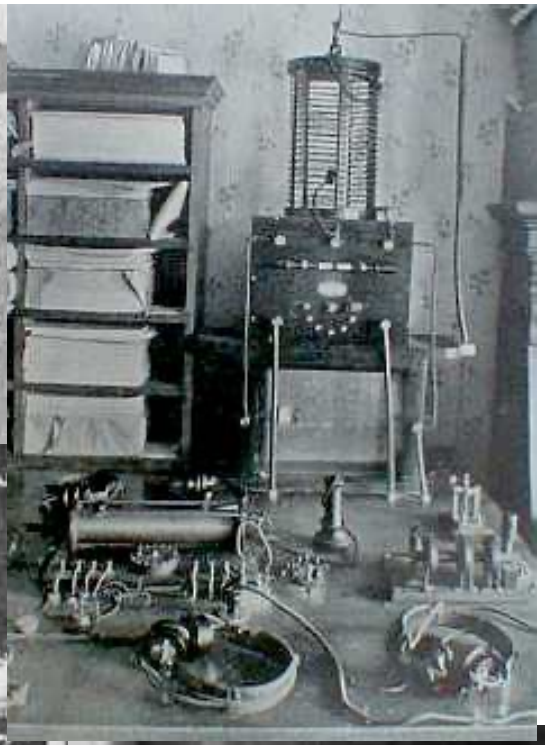


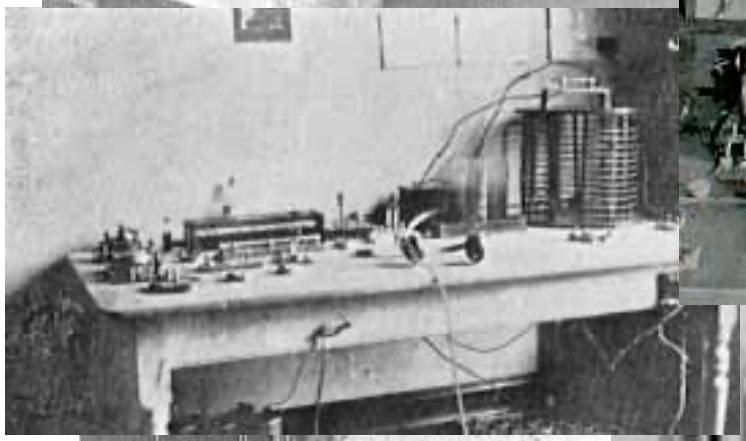


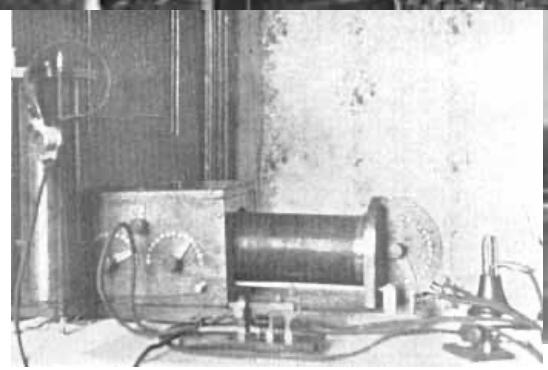
1908 – Beginning of the age of Amateur Radio

- 1908, Hugo Gernsback published his first magazine, Modern Electrics which helped to popularize Amateur Radio
- 1909, the first known amateur radio club was formed: the Junior Wireless Club, in New York City
- Young radio amateurs built receivers with whatever parts are available, including some earphone elements removed from telephone booths
- Don Wallace was an early amateur 1909 with a self-assigned call and communicating with his buddy a block away with a spark coil from a Ford
- Also in 1909, the Callbook was issued - The Wireless Blue Book
- 1910 Oct 5. The first Cat's Whisker Detector invented by B. F. Miessner – his patent was sold for $200



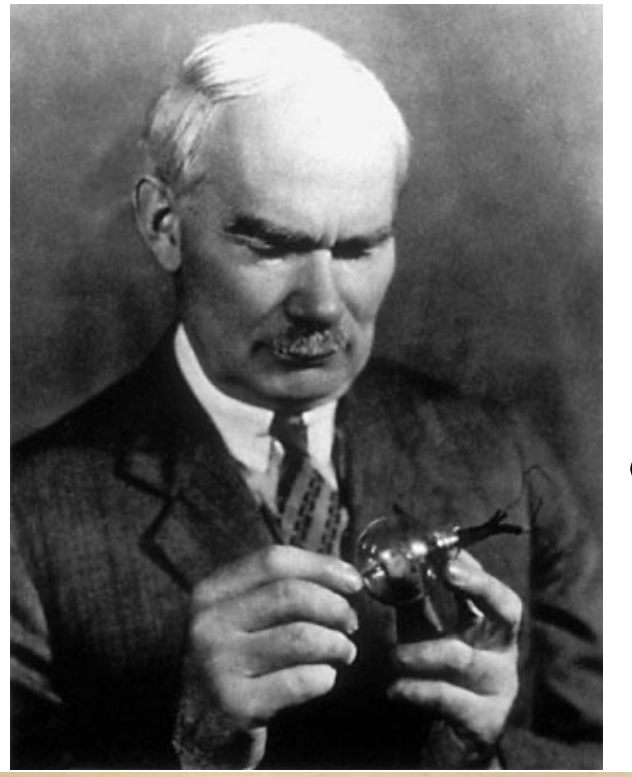


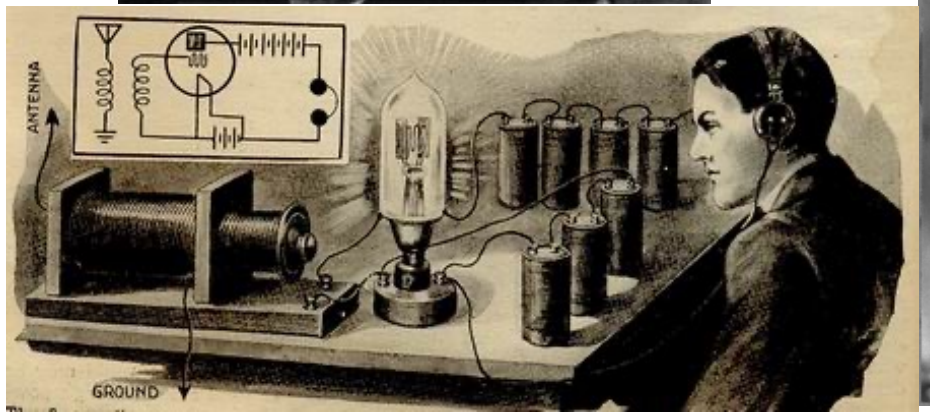


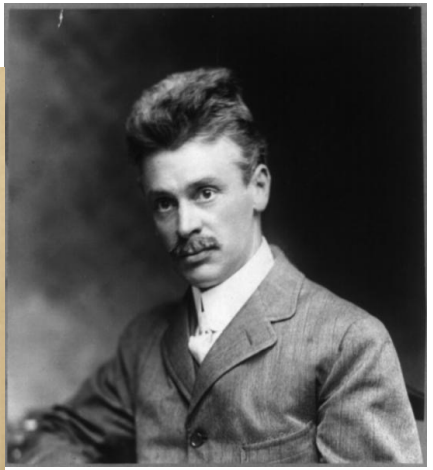


1912 – Formal regulations for amateur

- The Radio Act of 1912 created the first Amateur Radio License in the United States – Germany and other European countries enacted similar regulation
- Amateurs were allocated frequency bands of 200 metres and down but soon discovered that these “high-frequencies” could provide communication over long distances – 200 mtrs = 1.5 MHz
- 1913 Amateurs using Audion tubes in their receivers discovered that distances of up to 350 miles were now possible on 200 metres.
- 1914 - The ARRL is organized by Hiram Percy Maxim to help relay messages, typical ranges were 25 miles
- QST magazine appears in 1915, which still exists today





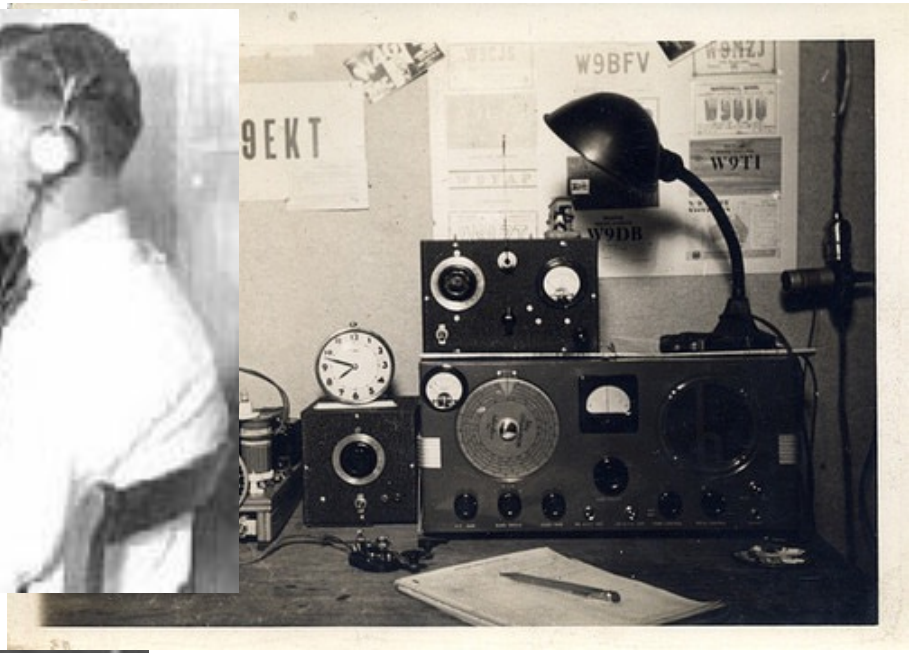


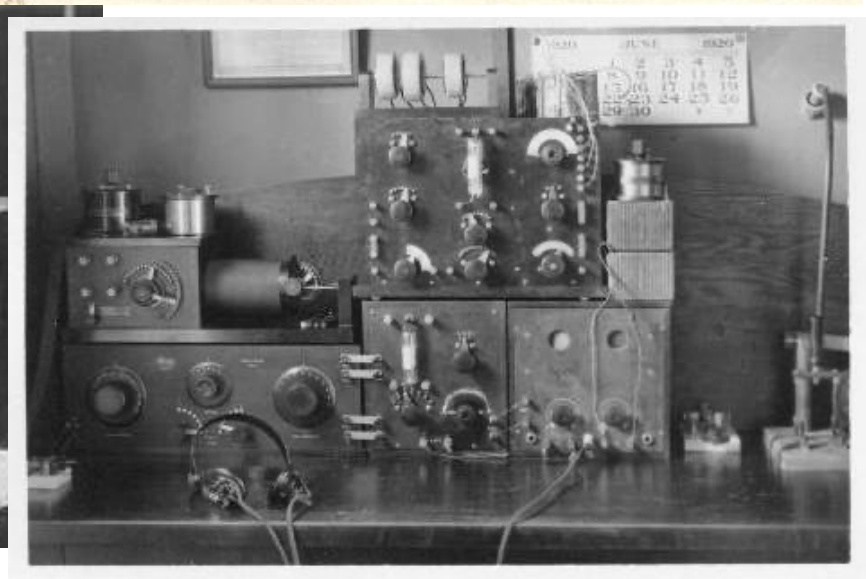
1915 – 1920 – Most stations still home made

- 1915 Ray Kellogg invents the The electric loudspeaker
- 1915 John R. Carson applied for a patent to suppress the carrier and one sideband of an AM signal
- 1916 Amateur Station 2IB works 8AEZ Lima Ohio - 750 miles across the USA
- 1916 Amateur station 2PM succeeded in breaking all records by sending the first transcontinental relay message from New York to California
- 1917 - There were about 6,000 Amateurs licenced in the U.S.A.
- 1917, Amateur radio was shut down during the remainder of WWI in most countries until 1919 when most countries began gradually to licence amateurs again
- 1918 - The superheterodyne-principle is discovered by Armstrong

1920 – 1926 – Commercial amateur gear arrives

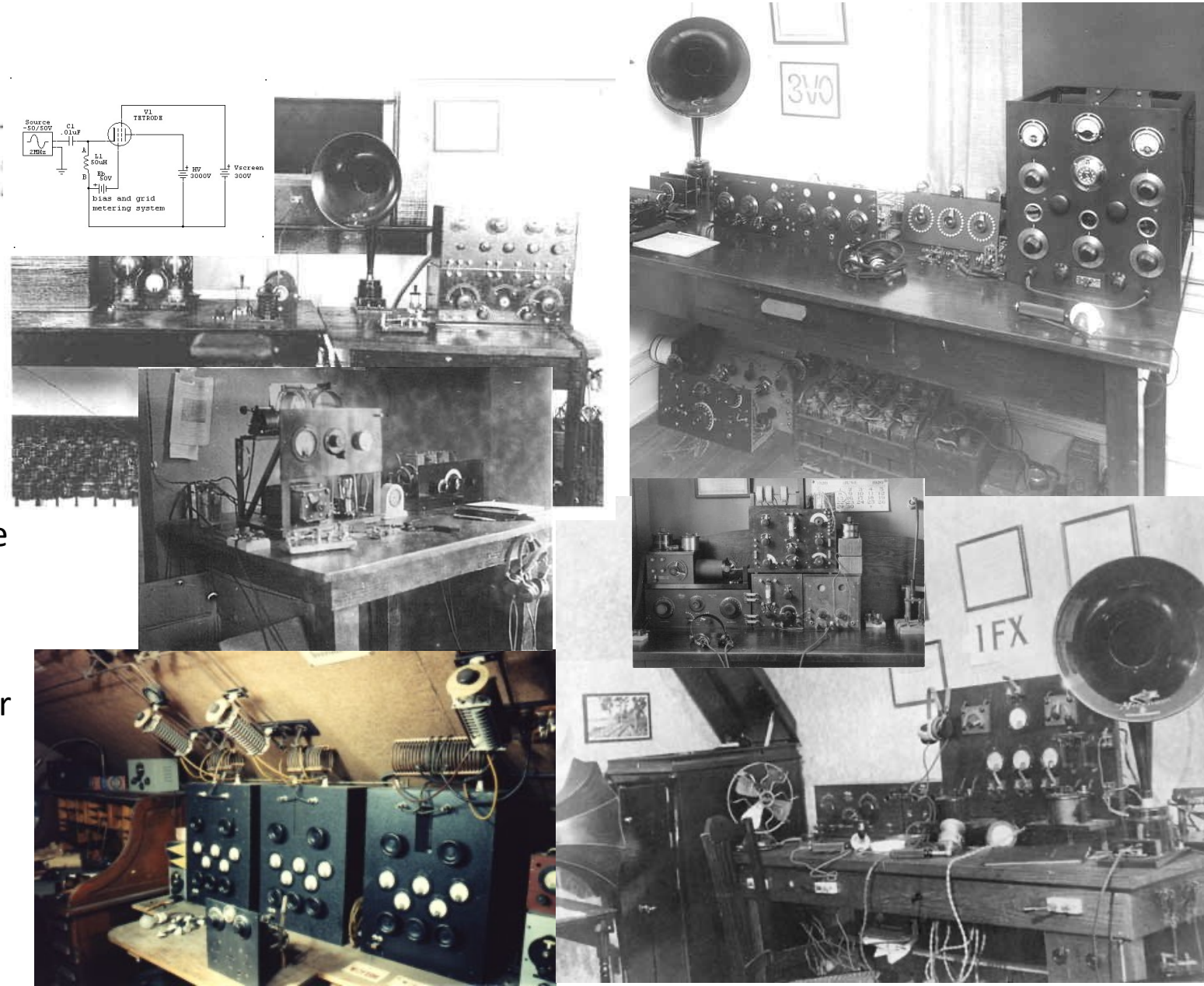
- 1920 Commercial amateur equipment gradually comes onto the scene in many countries
- 1922 Carson describes FM
- 1923 - Patent granted for SSB
- 1924, H.S. Shaw introduces the amateur radio community to quartz crystal oscillators
- In 1924, Amateurs received new bands at 80, 40, 20, and 5 meters
  - Spark transmission was prohibited on the new bands
- 1925 - International Amateur Radio Union (IARU) is founded to further the interests of amateurs
- 1926, Spark transmission was prohibited for use by Amateurs
- 1926, Hidetsugu Yagi and Shintaro Uda invent the "beam" antenna array





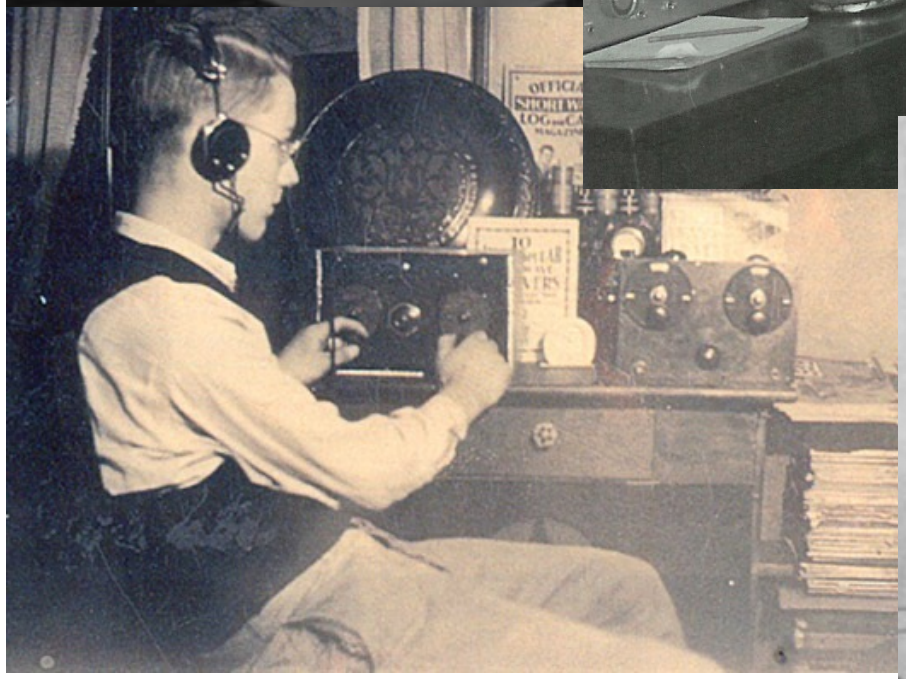
1927 – 1930 – Global call sign prefixes appear

- The 10 meter band is opened to Amateurs
- 1927 - the Convention Radiotelegraphic allocated frequency bands to the various radio services, e.g. fixed, maritime, broadcasting, amateur and experimental to help ensure maximum spectral efficiency
- 1928 - As the transmitting range of amateur stations increased, Hams naturally worked DX and it became necessary to have international call signs international prefix structure is set by the International Radiotelegraph Conference of 1927-1928
- 1929 - **Screen grid introduced into the vacuum tube.** Pentodes came a year later
- January 1930, QST magazine announces Twenty-Meter Phone Authorization



1931 – 1939 – Broadcasters compete for spectrum

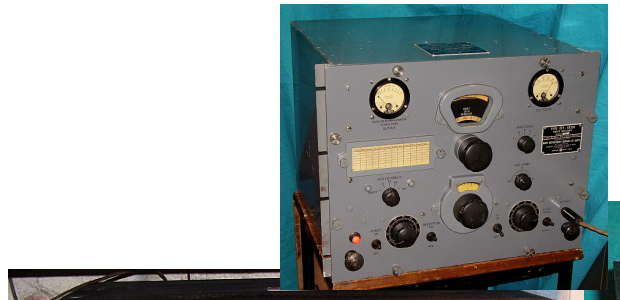
- 1932 – The Union decided to combine the International Telegraph Convention of 1865 and Convention Radiotelegraphique of 1905 to form the International Telecommunication convention, changing its name to International Telecommunications Union (ITU) in 1934
- **By 1933, there were at least 1,200 companies producing radios of some kind**
- The Communications Act of 1934 created the Federal Communications Commission - Amateur Licenses are reorganized into Class A, Class B, and Class C in the U.S.
- 1935 Russ Hall describes tropospheric refraction for the 5M band explaining why signals might exceed line-of-sight range
- 1936 Edwin H. Armstrong writes classic paper on Frequency Modulation
- In 1938, Amateurs lose the exclusive use of 40 meters, to be shared with SW Broadcasters



1940 – 1945 – WW II complicates amateur radio

- But WWII accelerated radio technology development!
- 1940, many countries prohibited amateur radio, including Canada, the U.K. and Australia
- June 1940, the US invoked the Telecommunications Convention prohibiting US amateurs from contacting hams elsewhere – portable operation prohibited
- 1941, tubes and other components were in short supply; each time the allied militaries asked hams to donate parts, they were flooded with whatever was needed
- December 7, 1941, the US entered the war; hams were immediately ordered to go QRT
- After VJ Day in 1945, hams were gradually given authorization to begin operating again across the globe



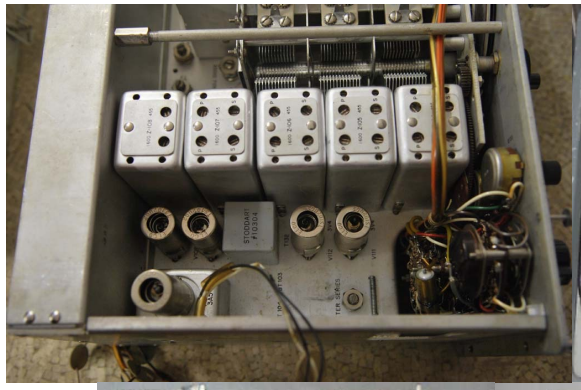







1945 – 1950 – Military surplus equipment!

- It was everywhere!
- 1945 onwards, Allied Radio, Lafayette, Burnstein- Applebee, Newark, World Radio Labs, Gotham Antennas, Fort Orange Radio, Radio Shack, Olson, Amateur Electronic Supply, Associated Radio, Digi-Key, Jameco, Poly-Paks, Fair Radio Sales, Dick Smith Electronics (Australian company), Heathkit, as well as Eitel-McCollough, Sylvania and RCA tube and design manuals began to serve the radio amateur
- Military surplus gear was freely available to the radio amateur – hams could easily adapt much of it to the amateur
- 1945, Coaxial cable in wide use by the radio amateur and war surplus cable was now available
- 1948 William Shockley invents the transistor. Within 10 to 20 years, the transition from tubes to solid state occurs



1950 – 1960 SSB becomes the desired mode

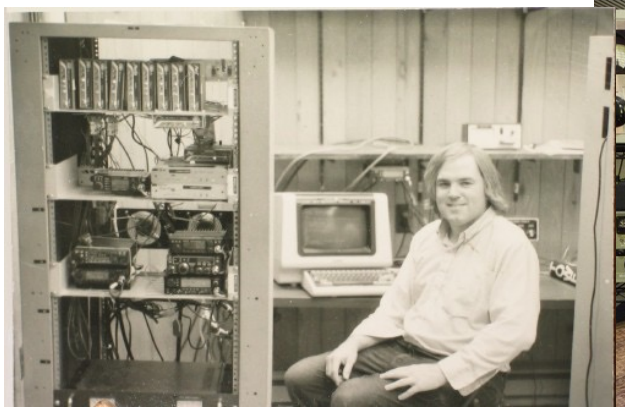
- The previously preferred voice mode was for the most part AM
- 1952 - 1956 SSB was making inroads on the ham bands
- Central Electronics, Hallicrafters and Collins all offered SSB amateur gear
- 1957 W6NLZ contacts KH6UK via tropospheric ducting and two years later, they achieve contact on 220Mhz between California and Hawaii
- 1958, the Class D Citizens is opened and Amateurs lost the shared use of 11 meters in many countries

1960 – 1970 – Space communication, solid-state

- 1960, first two-way moon bounce contact is made on 1296 MHz
- 1961, First amateur satellite, Oscar1, is shot into orbit
- 1962 June 2, OSCAR II was launched
- 1963 and beyond, many countries launch satellites having amateur radio transponder capabilities, including the former Soviet Union, U.K., Japan and the U.S.
- 1960's - 1970's, Lots of commercial amateur gear with many new transceivers having solid state receivers – transmitters for the most part remain with vacuum tubes in their final amplifiers
- Mid-to-late 1960's, the first amateur repeaters begin operations using modified commercial equipment
- Slow Scan Television begins appearing on amateur bands and in 1969, the first two-way amateur television contact between the U.S. and Europe

1970 – 1980 – FM repeaters everywhere!

- Countries use the metric system more and more and megacycles (mc) and kilocycles (kc) are gradually replaced with Hertz terms, MHz and kHz
- QRP low power enthusiasts challenge themselves with the furthest distance using the least amount of power
- FM amateur repeaters are deployed at amazing speeds across the world – most during this period were using used Motorola or GE equipment removed from police or taxicab service
- FM portables started appearing and became available to the radio amateur
- Late 1970s, Amateurs begin too use computers like the Amiga, Commodore, Apple, and TRS-80 to calculate various formulas and make CW and RTTY keyboards
- 1978 - Amateur packet radio began in Montréal, Quebec in Canada



1980 – 1990 – Digital, all solid-state, more bands

- ASCII computer code is authorized for amateur transmissions and personal computers are used to generate and receive standard Baudot RTTY code
- Two new digital data modes, AMTOR and packet become extremely popular
- 1981, regulators authorize spread spectrum on certain amateur frequencies
- Amateurs gained access to 10.100-10.109 and 10.115-10.150 MHz, the original 30 meter WARC band – amateurs also gained spectrum for 24 MHz (12m), 18.068 MHz (17m) and 902 MHz.
- 1988 – The GMDSS system was established by the International Marine Organization, a United Nations agency that oversees international shipping safety - this signals the end of Morse code usage by both commercial and the military

1990 – 2000 – Digital modes, DSP filtering

- DSP began to show up in amateur gear – next step to SDR
- 1993, The US Coast Guard discontinues monitoring 500 kHz CW as the International Distress Frequency, largely replaced by GMDSS
- 1999, Most commercial ship-to-shore CW stations close after decades of continuous service
- Throughout the 1990's, information theorists develop many interesting digital modulation and coding schemes for the radio amateur
- New digital modes include: PSK31 and derivatives, Contestia, DominoEX, MT-63, Olivia, JT-65, Thor, Throb and others
- By the year 2000, there were hardly any countries around the world that required morse code proficiency for an amateur licence

2000 – present: never before so many options!

- Digital modulation and coding schemes continue with greater sophistication, FT8 and others…
- Reverse beacons are developed, using the Internet to connect receiving stations – fairly complex propagation models are being studied that have never been possible before
- Software defined radio (SDR) comes to the radio amateur, enabled by high-speed DACs and ADCs plus fast computing for radio system control
- Digital audio makes its way to amateur radio – DSTAR, DMR and others, plus digital signalling systems

The future? Pretty much what you make of it…

- Higher integration continues to put more features in smaller packages with lower power consumption
- New digital technology continues to be incorporated into commercial amateur gear
- SDR has become super-available
- Amateur radio has become more of an experimental medium with many new hams
- Still a practical medium that allow theorists to become experimentalists at home – to try out and experience first hand the theory and practice of wireless communication

END

Mark Pecen

MARK PECEN is a senior technology executive in the wireless technology industry, currently serving as President of Quantum Valley Ideas Lab, a specialised advanced technology research centre, with a focus on quantum technologies in Waterloo, CANADA.

A pioneer in wireless technology, Pecen is an inventor on more than 100 fundamental patents in wireless communication, networking and computing, and is a graduate of the University of Pennsylvania, Wharton School of Business and the School of Engineering and Applied Sciences.

He served on over 20 advisory and governance boards for public and private companies and is an investor and advisor to several technology companies and advisor to the Canadian government and European Union in the areas of ICT research and technology standardization.

Pecen also served as chairman and founding member of the European Telecommunication Standards Institute (ETSI) Technical Committee Cyber working group for Quantum Safe Cryptography (Cyber QSC) in Sophia Antipolis, FRANCE.

Pecen is a retired senior executive at BlackBerry, Ltd. where he founded the Advanced Technology Research Centre. Previously with Motorola, he was awarded the title of Distinguished Innovator and Science Advisory Board member for his role in developing key technology and standards for wireless communication.