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Fall/Winter 2016

Journal of the CALIFORNIA HISTORICAL RADIO SOCIETY

CHRS Radio Day 2016

Master of Ceremonies
Stan Bunger

Auctioneers
Renee Richards, Peter Finch & Mike Adams

Radio Play - "The Maltese Falcon"

The Golden Gate Radio Orchestra

FOR THE RESTORATION AND PRESERVATION OF EARLY RADIO

FROM THE BIRTHPLACE OF BROADCASTING
CALIFORNIA HISTORICAL RADIO SOCIETY
HOME OF THE BAY AREA RADIO MUSEUM & HALL OF FAME

The California Historical Radio Society (CHRS), is a non-profit educational corporation chartered in the State of California. Formed in 1974, CHRS promotes the restoration and preservation of early radio and broadcasting. Our goal is to enable the exchange of information on the history of radio, particularly in the West, with emphasis on collecting, preserving, and displaying early equipment, literature, and programs. Yearly membership is $30 ($40 non-USA).

CHRS Museum in Alameda

CHRS has been fortunate to through the generosity of its donors to purchase a home for the CHRS museum and education center. It is located at 2152 Central Avenue. The building was built in 1900 as a telephone exchange.

CHRS volunteers are actively restoring the building to make it optimal for use. Our goal is to create an environment to share our knowledge and love of radio and enable us to create an appreciation and understanding for a new generation of antique radio collectors and historians.

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Contact us:
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Visit us at: www.CaliforniaHistoricalRadio.com

Contents of the Journal

Front & Rear Covers: Images of the CHRS July 2016 Radio Day auction, surplus clearance sale, plus the radio play, and orchestra performance.

From the Editor

This issue offers an emphasis on long wave communication that was very important in early radio and continues to play a unique role in contemporary communications. Once again I've had the pleasure of working with very generous and capable contributors. I want to thank Richard Quam of the Puget Sound Antique Radio Club, Bart Lee, John Staples, Gilles Vrignaud, Mike Adams, Walter Hayden, Scott Scheidt, and Steve Kushman.

I am always in need of quality content related to broadcast radio, ham radio, and television. If you have something to contribute, I urge you to let me know. I am especially interested in technical content. It can be of two types, a narrow topic in depth or a more broad topic with less depth.

Enjoy . . .

Richard Watts, jrchrs@comcast.net

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From The President

by Steve Kushman

Time is a funny thing. It helps us or hurts us depending how we use it. It makes events seem too long or too short, depending on how we feel about the activity. We always say, "There is plenty of time." But then wake up and say, "Where did the time go?" It's almost 2017! Time plays tricks on us. Let's take 20 years. A lot can happen in 20 years. It can seem like an eternity sometimes as the world goes by and we live our lives the best we can. But, passion changes it all. Here's where the time trick comes in. When you hear about a person doing the same job or activity for 20 years it sounds like such a long time. But as I reflect on my 20 years as President of CHRS, it seems like just the blink of an eye. But it was back in the last century, in 1996, when Dale Sanford asked me if I would like to succeed him. And during that blink a lot has happened to CHRS. We have evolved from a parking lot swap meet group into a true historical radio society that raised over $1Million and purchased an historical building as our forever home.

There are several more periods of time that are important to CHRS. The 10 years we spent at KRE was a transformational time when we started building and displaying our collection and library, developing methods of teaching radio repair and history, broadening our spectrum to include the Bay Area Radio Museum & Radio Hall Of Fame, the Society Of Wireless Pioneers, and learning to produce some really great and profitable fund raising events. Looking back, it's hard to believe we were at KRE for 10 years. It was challenging and fun and we learned a lot.

Being asked to leave KRE, with the opportunity to purchase the building and land no longer available was really a blow. It forced us to consider purchasing our own building. We had three-quarters of a million dollars in pledges to purchase KRE. We convinced the people with pledges to keep them with CHRS and direct them toward our possible purchase of a new building. We did and it led us to our next and current important period of time. It was 2 ½ years ago, on April 23rd of 2014, we took possession of 2152 Central Avenue. And this period of time is flying by. It's an exciting time as we progress with our efforts to build 'The West Coast Educational Center' for all things radio, broadcasting history and technology. Our tireless volunteers work three days a week transforming our 1900 telephone building into our 2016 homage to radio. The efforts of our volunteers plus the work being performed by our excellent outside contractors have produced great results.

These past two+ years have really been exciting. The time is flying by and there never seems to be enough time on our volunteer days. Time moves fast when you are having fun! When I see the terrific work and progress at Radio Central and realize that we, the members of CHRS, raised the money and bought this building and are updating it in the best way possible, it makes me very proud. We own it and no one can tell us to move. I hope all of our members feel as good as I do about owning this historic building.

Now its time to for the membership and community to finally be able to enjoy what has been accomplished. With the first phase building renovations soon to be completed, CHRS will once again offer an operating electrical and cabinet restoration shop, amateur radio station, the Jim Maxwell Library, kitchen, meeting places, and we will be restarting educational classes in electronics theory, radio restoration, amateur radio, and radio history. CHRS is one of a very few organizations in the world that offer specialized educational, restoration, and preservation programs for "everything radio." And there are only a few places in the country where can radio enthusiasts have access to such a center and to participate with others who share similar passions within only an hour or two drive.

Looking forward in time… As long as we continue to raise enough funds for the long run, CHRS will have a place to tell the stories of radio to the community and for enthusiasts to come together to educate, learn, collect, and restore in perpetuity. That's a lot of time.

A few words from my Thanksgiving message:

> We hope you all enjoyed the Holiday with family and friends and were able to reflect upon the things we are thankful for. We are thankful for the good fortunes of our favorite Historical Radio Society. These good fortunes

don't come without hard work and dedication. We are thankful to have a group of passionate volunteers, who are skilled and willing to give their time and talent to ensure the future of CHRS. We are thankful for the support we get in the form of monetary and equipment donations. We are thankful for being able to have the opportunity and facility to present the stories of radio and broadcasting. We are thankful to have members who generously pass on their knowledge and teach their skills to other members. We are thankful to have the support from the City of Alameda and the community. We are thankful to be able to foster friendships and camaraderie between our members by giving them a place to congregate, share ideas, work toward a common goal together and feel like part of a family.

And finally, I am very thankful and proud to be among such an outstanding group of dedicated and passionate collectors, historians, technicians, craftsmen, teachers and givers. Thank you all! You make CHRS the finest, most active, broadest based and most forward thinking historical radio organization… anywhere. Keep up the good work!

It's Steve under all that sawdust.

So, 20 years in the blink of an eye. It sure doesn't seem like that long. I still treasure being your President and being able to be part of this terrific organization filled with the finest people anywhere. Please take a moment to renew your membership and please donate generously to our 2017 construction campaign. I always want to hear from you with any questions, comments, and suggestions, please contact me at (415) 203-2747 or Steve@chrsradio.com

Wishing you a Happy Holiday Season and a Great 2017.

Best Regards, Steve

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CHRS Central Valley Chapter News

by Scott Scheidt

The Central Valley Chapter of CHRS held their 17th annual radio swap meet at the Stanislaus County Fairgrounds in Turlock, CA on Saturday, October 1st, 2016. This year, there were at least 20 vendors including one from Oregon with a good variety of radios and parts for sale. As always, coffee and donuts were on hand and the CVC had a nice collection of items in its raffle. Everyone had a great time and raffle sales were brisk. We are happy to report that this year was one of the most successful swap meets we have had in several years and are hoping this is the trend continuing into to the future, not only for our club, but for all the radio clubs in general.

CVC continues to offer the Radio Repair Clinic every Wednesday, 6 - 8 PM. Membership meetings are held on the 3rd Saturday every month at 10:30 AM. Our meeting are at the clubhouse at the corner of Bradbury and Commons just Southwest of Turlock.

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Radio Central Renovation Update

by Walter Hayden

Original circa 1900 exterior front elevation of 2152 Central Ave.

Seismic Upgrade: After long-awaited building permits were issued by City of Alameda, this substantial project could finally be done; Work was completed in July involving primarily the rear of the building's west and south walls. The construction contractor installed anchor bolts attaching exterior walls and floor to the building foundation, metal brackets attaching the roof structure to exterior walls, plywood shear wall on exterior walls, eight new replacement windows with improved double-paned thermal insulation and low-E glass, a new exterior door, and flooring to close openings used to access floor joists along exterior walls. The contractor also repaired dry rot resulting from previously poorly installed and maintained doors and windows. Unnecessary window and door openings were permanently closed.

Building Stucco: The stucco contractor has installed new stucco to repair or replace existing stucco as appropriate in building west wall and part of south wall. Final coat of stucco is colored so painting will not be required for many years.

Building Main Floor Rear Stairs: Rotten exterior stairway on building west wall was demolished. This stairway is being replaced with a metal and concrete stairway, which will be a very durable and will require little maintenance.

Archive Room: New interior wall was installed to create the archive room at the northwest corner of the building. A single panel glass door is installed in this wall. Archive room has one awning style window with Low E glass. This relatively small window was selected to reduce risk of sun damage to archive materials.

Restrooms: One of the upstairs restrooms has been remodeled to create a restroom meeting ADA requirements. The room has a toilet, lavatory, grab bars, and other accessories needed for a fully accessible restroom. Floor and lower portion of walls are covered with mosaic and subway tile. A new single panel door has been installed. In the downstairs bathroom, new cabinets, countertop, lavatory, deep sink, and toilet have been. A new awning style window and a single panel door has also been installed. The floor and lower portion of walls are covered with mosaic and subway tile.

Downstairs Hall: Damage to drywall ceiling in hallway adjacent to compact storage system has been repaired and painted. New light fixtures are being installed.

Electronics Shop: Drywall has been installed on shop exterior walls, other walls were repaired, and the brick chimney has been plastered. Trim has been installed on shop windows and doors. All shop walls have been painted.

Tube Room: Tube room walls were furred and drywall was installed on walls and ceiling. The brick chimney in tube room has been plastered. Walls and ceiling have been painted. A concrete contractor is being consulted about repair of damage in a small area of tube room floor. New awning style window has been installed.

Electrical Upgrade: Kevin Payne continues to improve building electrical system. He installed electrical receptacles in electronics shop walls, archive room walls, restrooms, downstairs tube room, and other areas. He has relocated fire alarm bell and pull switch at building rear. In the electronics shop he fabricated and installed an electrical support structure that fits between two of the workbenches. This structure provides the workbenches 120 volt and 240 volt power, Ethernet access to the internet, TV signals, telephone, FM signal, and a coaxial cable connection to the ham shack. A nearby Emergency Switch will shut off 120 volt and 240 volt power to workbenches. Provisions have been made for installation of light fixtures in downstairs tube room. Receptacles were installed on west wall of original brick building so equipment can be powered without use of extension cords. His work has been fully inspected.

Storage/Sales Shed: Construction is underway for a shed that will be used to store and market radios and electronic parts and equipment. This shed is located just inside the property line adjacent to building south wall.


Richard


Kevin


Steve


John and Keith

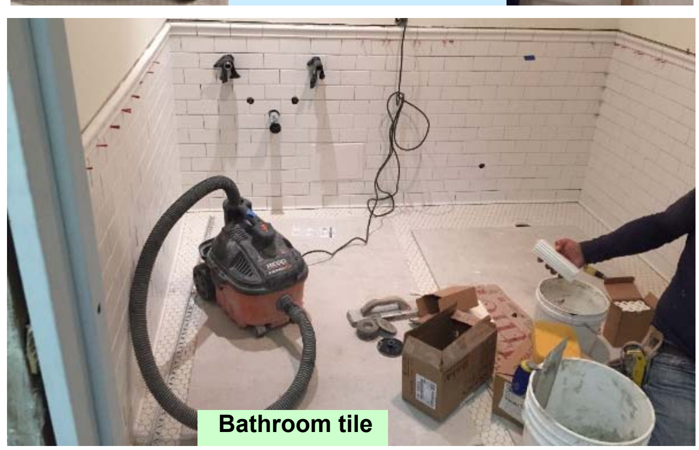

Robert and Cliff

It's really coming together


Shop almost finished — Keith, Jim, Kent, Earl


Earl, Kenneth, and Jim


Bathroom countertop


Bathroom tile

Listening to the Cradle of Radio: Long Wave Radio Then and Now

By Bart Lee, K6VK © 2016

I. Radio Came of Age a Century Ago, Growing Up in the Part of the Spectrum We Call the Long Waves — And CHRS Listens.

Guglielmo Marconi ("Bill" to his friends) transmitted across the Atlantic in December 1901 on a frequency of about 800 KHz, or a wavelength of about 400 meters. At the time he figured the longer the wave length, the longer the distance. The idea was that longer waves would sort of walk along the curvature of the earth. Most everyone agreed: *e.g.*, Reginald Fessenden and Karl Braun. So stations went to longer and longer wavelengths at lower and lower frequencies, as low as around 13 KHz, for commercial and naval long distance circuits. All of these required expensive, high power installations involving lots of wire for extensive antennas.

Noted radio authority Jack Belrose summarized:

> "Using 420-foot umbrella top loaded antennas … tuned to about 88 KHz, [Fessenden] successfully communicated two-ways across the Atlantic in January 1906, between Brant Rock, MA and Machrihamish, Scotland. Marconi in the meantime had not succeeded in transmitting a complete message, even one way across the Atlantic. Marconi was however building bigger antenna systems, and hence moving down in frequency. By 1904 his English antenna had become a pyramidal monopole with umbrella wire, and the frequency was 70 KHz. In 1905 his Canadian antenna, installed at Glace Bay, Nova Scotia was a capacitive top loaded structure, with 200 horizontal radial wires each 1000 feet long, at a height of 180 feet, and the frequency was 82 KHz." [1]

Signals of higher frequencies with shorter wavelengths that are today associated with radio came into play in the mid 1920s. Long wave radio then died — but it didn't really. The Cradle of Radio is rockin' today.

Radio in today's long wave bands presents, every night, historical resonances, ranging from Marconi to the hams. This history of long wave radio, and current uses, may provide some insight into these frequencies and these legacy bands. These bands are accessible on modern equipment with simple antennas. Amateur radio operators are now again welcome on the long waves.

From an historical point of view, one of the most interesting, albeit episodic, signals on long wave is station SAQ in Sweden on 17.2 KHz. It still fires-up its 1923 Alexanderson alternator a few times a year. The VLF Special Interest Group of the California Historical Radio Society, formed some years ago, continues to pursue this signal as the Holy Grail of long wave radio.

In the VLF group, John Staples, W6BM has focused on WWVB on 60 KHz as a beacon for experimentation, and research into small loop antennas, including the mathematics of loops and resonance (see article on page 22). John initially used a Collins R-389 long wave receiver of World War Two vintage, and SpectrumLab software to process and visualize the audio output. An image of his equipment appears in figure 1.

Fig. 1: John Staples' VLF receiving post at Paul Shinn's (a.k.a Mt Shinn) in 2012 with his R-389.

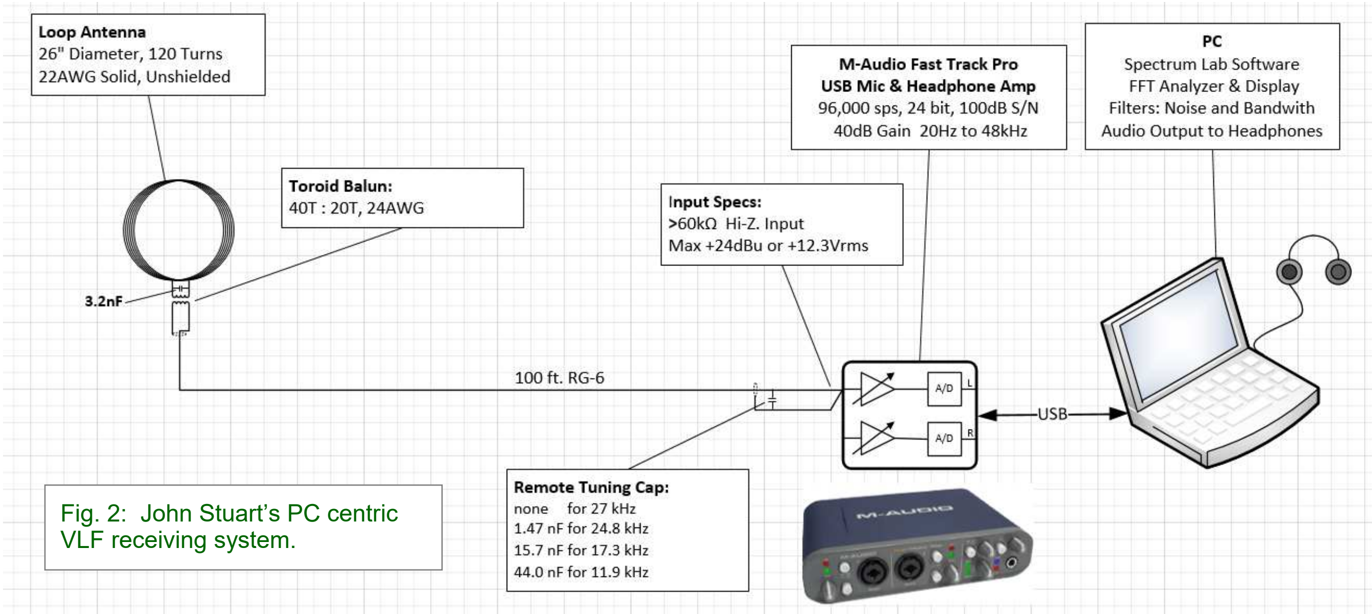


Fig. 2: John Stuart's PC centric VLF receiving system.

John Stuart, KM6QX implemented a soundcard, SpectrumLab software and PC receiver, making a bicycle-wheel diameter and quite effective loop on a stand. A diagram of his equipment appears in figure 2.

Denny Monticelli, AE6C, provided engineering assistance throughout. Scott Robinson put together one of the VLF Group's first working loop antennas. Paul Shinn hosted the 2012 Dxpedition to Mt. Shinn for the first try at SAQ. Paul had earlier received and verified SAQ. Gilles Vrignaud discovered long wave radio from Europe on the Internet, for some very interesting programming (see article on page 24).

Your author, Bart Lee, used the WinRadio G33 Software Defined Radio (SDR), and at first a Hustler 6BTV 33 foot vertical over an extensive ground system, then several iterations of a very large loop, two turns of shielded coax about 50 square meters in capture area, then two 50 foot tall vertical wire antennas with an impedance-improver circuit from W6BM. The WinRadio SDR provides extensive visualizations of received signals and spectra, by which the cryptic Russian Alpha stations on 11+, 12+ and 14+ KHz were first detected.

Thus, in several ways, long wave signals can be heard *and seen* with today's radios and / or computers using a simple loop or wire antenna — even the Russian "Alpha" stations. See figures 3 and 4.

These long wave signals communicate with submarines; they aid air and sea navigation; they supplement GPS, and they alert vessels to weather and dangers. A few long wave broadcasting stations also still vibrate the "ether" although they are hard to hear in California. Radio in today's long wave bands resonates still with historical uses. The long waves from

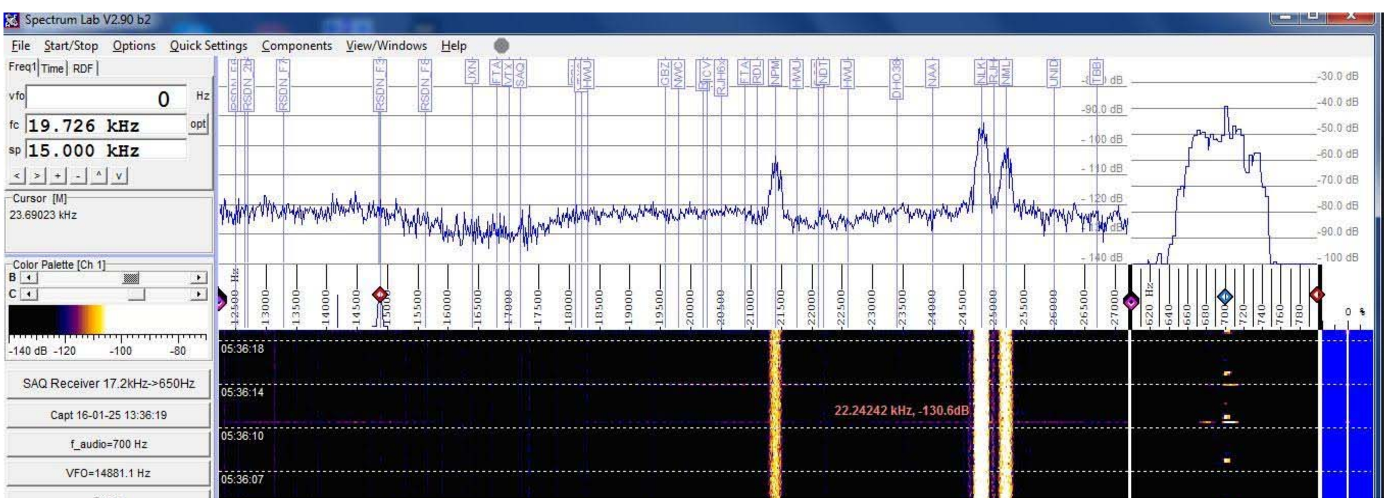


Fig. 3: Portion of a PC desktop visual display of John Stuart's reception of several VLF stations including a Russian Alpha, its audio on the right (SpectrumLab software).

around 10 KHz to 530 KHz continue to convey signals from around the world, and of local interest. The usual ionospheric propagation of the short waves matters little.

A 10 KHz signal has a very long wavelength indeed, some 30,000 meters, or 30 KM, or about 19 miles. That means that the signal moving at the speed of light is vibrating its electric and magnetic fields at such a rate that it has moved on 19 miles before it returns to the initial states of its electric and magnetic fields completing one cycle. By contrast, in the two-meter band popular with today's amateur radio operators, at about 146 MHz, the signal moves only two meters before it reaches its initial field values. In terms of photons, these energy bundles for low frequency radio each carry relatively little energy and hence "vibrate" slowly, at, say, 10 KHz. If a 10 KHz signal were audio, some (younger) people could actually hear it. Conversely, the two-meter band photons "vibrate" much faster because they carry more energy at 144 MHz. For further comparison, the photons of light "vibrate" at 400 to 800 Terahertz.

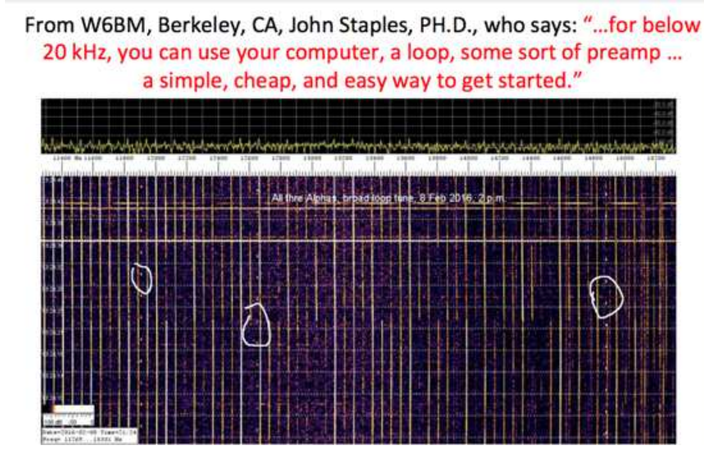


Fig. 4: John Staples' record of receiving three Russian Alpha stations — they appear on one screen (SpectrumLab software).

Despite the wavelength in kilometers, a low-cost up-converter permits a regular shortwave radio to hear these signals, usually at 4 MHz. An image of such a converter appears in figure 5. A loop antenna and soundcard connected to a PC provides both visual and aural reception, especially with audio visualization software such as SpectrumLab. Several Software Defined Radios work well as low as 12 KHz. Many short wave and amateur radio receivers are able to operate down to 100 KHz or even 30 KHz.

Fig. 5, A commercial VLF converter, up-converting to 4 MHz. Paul Shinn used such a converter to capture SAQ.

They early radio broadcasters on AM in the 1920s contested the maritime wavelengths, especially 300 meters and 600 meters (i.e. 1 MHz to 500 KHz). Maritime communications settled down to 600 meters, more or less, usually more, i.e., lower frequencies at 500 KHz and below. Maritime services first utilized what we call the long waves, the only wavelengths the equipment of the day could receive or transmit. Commercial interests went to longer and longer wavelengths for more and more distance. The U.S. government had banished the amateurs to shorter wavelengths, "200 meters and down" (i.e., 1500 KHz and up) in 1912.   They made the best of that challenge within a decade. They discovered that communications with wavelengths less than 200 meters, or frequencies above 1,500 KHz, could beat the long wave stations for distance and incur an order of magnitude less expense. The professionals had long despised the "hams" but the enthusiastic experimental amateurs had flat-footed the pros. This lead the way to commercial radio communication moving away from VLF and operating in higher and higher frequencies; So, today most of what we know as radio resonates at more than 500 KHz, up to 5 GHz and higher.

Looking back a hundred years, that now-ancient wireless telegraphy era from about 1912 to about 1922 that saw commercial companies, military, and naval forces adopt the nascent technology primarily in the long wave part of the radio spectrum. They drove the technology quickly into a worldwide industry of the time. Although the industry of international communications has flourished for a century, the long wave point-to-point technology died very quickly. The efficiency and lower cost of short wave radio put an end, for example, to most long wave commercial radio point-to-point communications circuits. RCA at "Radio Central" on Long Island, N.Y. dominated these circuits using alternators for European traffic. Only one, however, remains: station SAQ in Sweden. It operates as a museum station several times a year. Both Paul Shinn, of CHRS and Dennis Kidder, W6DQ have copied SAQ signals in California. In quest of this historical station SAQ, several CHRS members, as a CHRS program, have recently explored many aspects of long wave radio, as the VLF Special Interest Group — and all are welcome to join.

II. The Technologies of Early Long Wave Radio: Sparks, Arcs, Alternators, and then Vacuum Tubes.

(A) Sparking Away

In 1901 Marconi used his new Poldhu, Cornwall, UK, station as a pulse transmitter with a double spark circuit. As stations went up in wavelength and down in frequency, the spark employed to emit the radio frequency energy got longer and longer in time as well as higher in amperage. By about 1912 the Marconi stations used large rotary spark gaps to generate an almost (but not quite) continuous wave. A large telegraph key then interrupted this energy with Morse code. The Marconi rotary spark gap in Bolinas, California quickly got the nickname: "The Rock Crusher" for both the strength of its signal at more than 200 KW and the sound it generated, literally deafening.

Most wireless communications reached out locally and regionally at less power. A "quenched gap" spark system could produce 1 KW or much more. Standard receivers for long waves proliferated. Several companies such as United Wireless on the West Coast competed for marine and inland traffic, before and after World War One. The Marconi company dominated on the East Coast. An image of a spark station of the era appears in figure. 6.

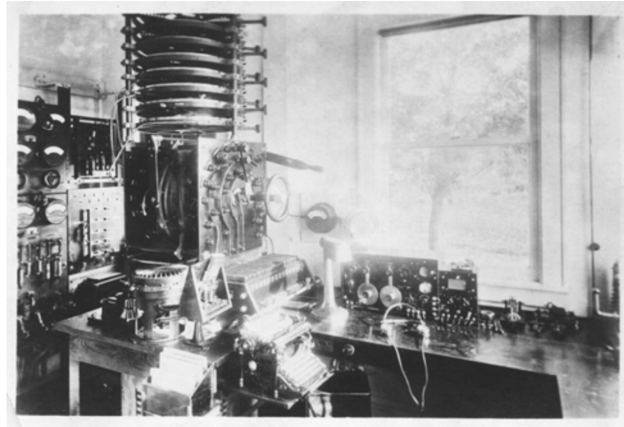


Fig. 6: A spark station, Navy or commercial dating from around World War One. This photo comes from John Staples' family, and is known as "Uncle Adrian's Radio Station."

(B) Whirling away

The only long wave station that has survived, SAQ in Sweden, still operates its 1922 Alexanderson alternator, on 17.2 KHz. An image appears in figure 7; the alternator idea originated with Fessenden. At the alternator's heart rotates a five-foot by three inch steel disk, spinning at 2000 rpm. Some 488 brass slots interrupt the magnetic fields around the wheel. These pulses generate the long wave radio frequency energy to be emitted. Alexanderson alternators could reach 100 KHz, but in service ranged around 20 KHz. Power ran upwards of 200 Kw. Other alternators operated in this frequency range as well. For example, in Bolinas, California, KET (known as "Bolinas High Power") operated at about 23 KHz. Ruins of this station may be seen at the KPH site in Bolinas maintained by the Maritime Radio Historical Society.

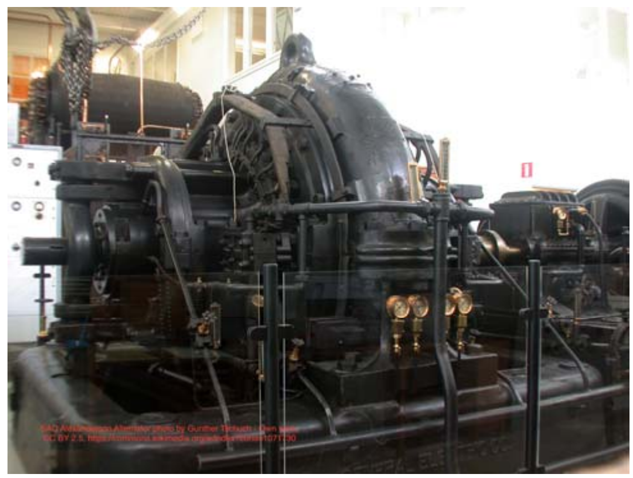


Fig. 7: The alternator at SAQ today (photo Gunther Tschuch).

The long wave alternator stations required vast antenna arrays to communicate reliably. Five or so radiating high tower vertical antennas had to point in the desired direction for each circuit to the several parts of the world. The Europe, Japan and South America circuits each required antenna arrays almost perpendicular to each other. RCA laid out its proposed 12 Radio Central arrays in a giant circle on a property of about ten square miles. A diagram of the proposal appears in figure 8.

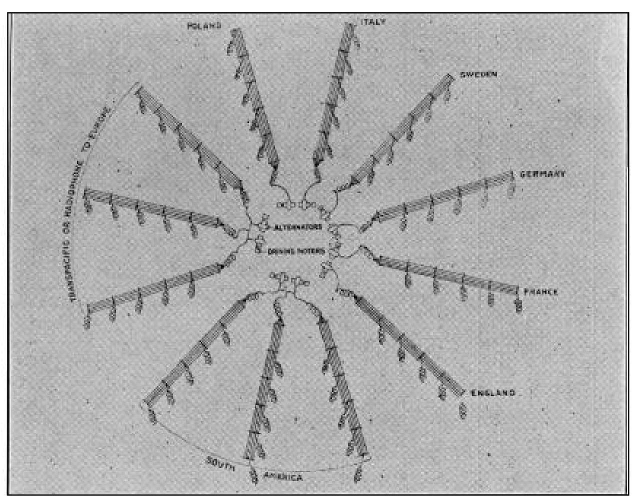


Fig. 8: The proposed antenna arrays for the alternators to be used by RCA for world wide VLF communications circuits.

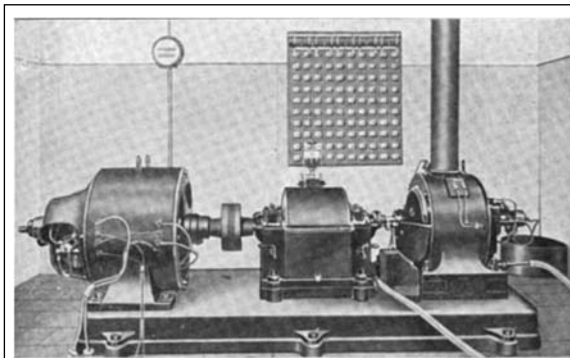
The German engineer Alfred Goldschmidt developed a similar alternator before World War One, although it operated at lower power. An image appears in figure 9. It worked with a frequency multiplier circuit, perhaps as high as 94 KHz.

The Germans put together a worldwide network including Eilvese in Germany, at least one station on the U.S. East Coast (Tuckerton, N.J.) and at Lome, in the African nation of Togo. Togo was then a German colony. Ruins of the Togo station survive, including what may well be the interior disks of a Tesla bladeless disk steam turbine. The British in World War One put a quick end to the German long wave (VLF) network.

(C) Arcing away

Around 1910, Federal Telephone and Telegraph of Palo Alto put the first commercial arc station on the air from San Francisco's Ocean Beach. Its logo appears in figure 10. Oscillations between the arc and the antenna by reason of the arc's negative resistance generated a continuous wave (albeit with lots of spurious emissions). This too created low frequency, long wave signals. The arc, however, did so with greater efficiency than spark. As early as 1915, the continuous wave arc had shown itself superior to the spark systems.

The arc technology lent itself to very high powers. By 1918, the U.S. Navy had contracted with Federal for two 500 KW arcs for station NSS at Annapolis for transatlantic service at below 17.5 KHz, and several other shore stations around the world. The Navy installed a one-megawatt Federal arc in France in 1918 for the other end of the transatlantic circuit. The Navy bought many Federal arcs, especially the 30 KW set for ships. History San Jose preserves most of a five-kilowatt arc inherited from Federal via the Perham Foundation. A schematic diagram and a drawing appear in figures 11 and 12.



12.5 kW Goldschmidt alternator installed in 1910 at a wireless station in Eberswald, Germany. It had an output power of 12.5 kW at a frequency of 30 kHz, or 8 to 10 kW at 60 kHz. It consists of a DC electric motor *(left)* driving the alternator *(right)* through a gearbox *(center)* which steps up the rotation speed.

Fig. 9: A Goldschmidt alternator in service.

Fig. 10: The logo of Federal Telephone and Telegraph, Palo Alto.

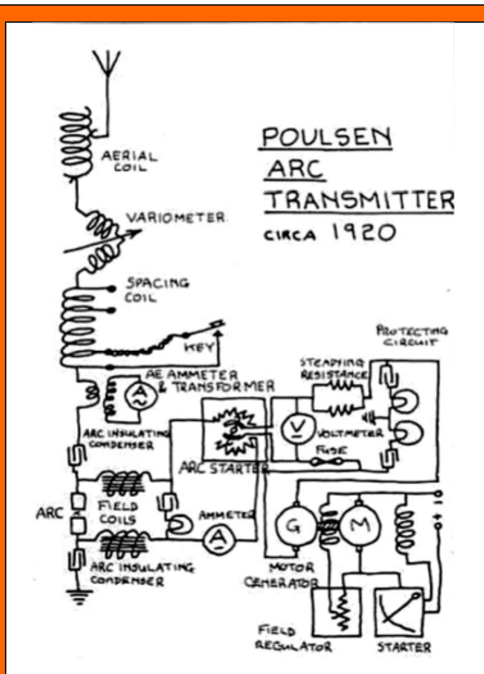


Fig 11: A schematic diagram of an arc transmitter (Royal Navy Amateur Radio Society, Spring 1994).

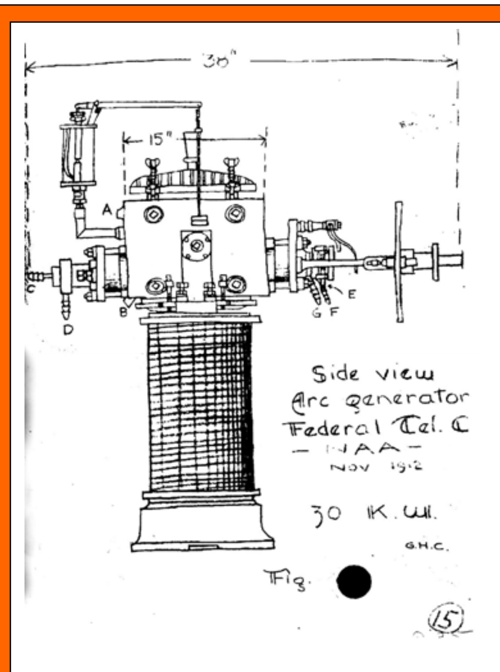


Fig. 12: A drawing by radio Historian George H. Clark of a Navy 30 KW arc as of 1912 (Smithsonian, Clark Collection).

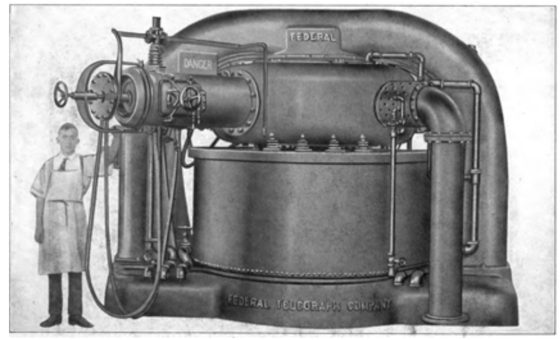


Fig. 13: The one megawatt Federal arc, circa 1918.

An eight-foot tall, 65 ton electromagnet made for a Federal high power arc transmitter sits outside the Lawrence Hall of Science in Berkeley. It once provided a strong magnetic field for Professor Ernest Lawrence's 27-inch cyclotron, as early as 1932. The high power arcs remained in Navy Service until about 1934. An image of a high power arc appears in figure 13. Thereafter the Navy used 500 KW vacuum tube transmitters.

(D) Tubes of Nothing

By 1913, Lee de Forest had gotten his little audion vacuum tube to oscillate at radio frequencies, on behalf of Federal Telephone and Telegraph in Palo Alto. Edwin Howard Armstrong had used the same sort of vacuum tube operation to create the regenerative receiver at about the same time. By 1916, the U.S. Navy used multiple paralleled vacuum tubes, producing a continuous wave that could be modulated by audio, for transoceanic tests of voice transmissions.

Radiomen heard these voice transmissions across the Atlantic in Paris, as intended — but also in Hawaii. The regenerative receiving circuit had made worldwide radio possible as of 1914. Vacuum tube transmitters soon replaced all other modes of generation of radio frequency energy, although it took a couple of decades to achieve high powered arcs.

III. The Evolution of Effective Techniques for Long Wave Communications

Long wave radio did work long distance. But any transmitter for these wavelengths required massive amounts of electrical power, long lengths of copper-bronze antenna wire in arrays, and an industrial-scale plant. Some of today's working long wave transmitters run as few as a couple of hundred watts (although amateurs are restricted to much lower powers). But to communicate with U.S. submarines, the Navy today operates a network of high power, giant "capacity-hat" antenna digital stations. These stations can range into the megawatts. Their long wave roots go back as far as 1912.

(A) Hearing Long Waves

The U.S. Navy between 1912 and the 1920s learned to use high power long wave radio-telegraph transmitters to reach ships at sea and other shore stations. Most early communications with its vessels took place between 175 to 550 KHz. U.S Navy shore stations used receivers spec'd down to 10 and 12 KHz. An image of a Navy long wave receiving installation, circa 1930s, appears in figure 14 .

Fig 14: The Navy long wave receiving station in the Washington, DC area, 1930s; Navy RE, RF & RG receivers.

Of the 36 U.S. Navy receivers listed by naval radio historian Captain L. Howeth [2] as normally used by naval ship and shore stations (excluding direction finder stations) during the period 1912 - 1928, 30 covered the long wave bands, nine of them down to 10 KHz. Two of the earliest were the models A and B, down to 60 KHz and 30 KHz respectively. Two of the latest of the period, the models RAA (for "general service") and the RCC (for "Shore stations") went down to 10 KHz and 12 KHz respectively. Long wave radio provided the Navy with reliable Fleet communications until well after World War Two. An image of a World War Two era Navy long wave receiver shown in figure 15.

Fig. 15: A Navy WW II long wave receiver; the RBA.

A great deal of the progress in the early radio art focused on improving antennas listening for hearing longer wavelengths. One example is Harold Beverage's "wave antenna" for receiving, now known as the "Beverage antenna." One long wire, of at least a wavelength, pointed at the signal source, can gather enough energy for the signal to be heard, while much diminishing all energy from other directions, especially noise, thus improving the signal-to-noise ratio.

Loop antennas, picking up the magnetic component of the radio wave, work in proportion to their electrical characteristics and their size — size matters, but not as much as one might expect. Quite small loops can capture VLF signals. On submarines, a loop antenna less than a meter or so wide seems to work just fine, even 15 meters undersea.

(B) Transmitting VLF

Early transmitters (after Marconi's wire arrays) took on a vertical aspect. Instead of horizontal arrays of great length, relatively short vertical elements got the signals out at very low frequencies and emitted very long waves. But they had to resonate at the intended frequency. A vertical antenna has a given inductance, which can be varied (usually at its base; Marconi's "jigger" coil did this). But capacitance to ground also controls resonance. The vertical long wave antennas, sometimes arrays of vertical elements, got to dress up in "capacity hats." These capacity hats put a lot of wire, sometimes like umbrellas, sometimes as horizontal arrays, above the antenna to form a capacitor to the ground. That added capacitance and lowered the antenna's inductance-controlled resonance. The length of the long waves translates to a need for very long antennas for these very long wavelengths, or some shorter antennas "loaded" with extra inductance and capacitance, to capture or emit the radio energy. Really long antennas cost a lot, are hard to maintain, and hard to site. Shorter antennas for lower frequencies, however, present challenges because they compromise performance in various ways. Much innovation went into compensation for these challenges.

As early as August 1899, in San Francisco, the experimenters put a Ruhmkorff coil into the Lightship 70 out in the fog. They wired a "capacity hat" — one of the first — at the top of their vertical wire antenna. Their signal, that the troopship "Sherman is sighted," got through to the Cliff House as the first radio traffic in America. Similarly, Doc Herrold in San Jose around 1916 put a massive capacity hat between buildings at the top if his antennas. He operated an arc transmitter at perhaps 40 KHz. So too, did young William Dubilier in Seattle put an enormous amount of wire atop his very tall antenna in 1909. The experimenters of the day thought that this wire topping did the radiating. Actually the vertical wire "lead" radiated at the lower frequency of resonance.

By 1918, the radio engineers had managed long wave radio, often using wire arrays above radiating vertical elements as capacity hats. This is still the design of most high power VLF stations. One history of Navy radio in the Pacific [3] reports:

> "The most important broadcast was the Primary Fleet (FOX) broadcast which was transmitted on the frequency of 26.1 KHz using the 500 KW VLF transmitter at Lualualei. Navy ships at sea and a majority of naval activities ashore copied the entire FOX broadcast. The Wailupe FOX was the most rapid way to get messages to ships."

The Lualualei transmitter, at 100 KW, came on the air in 1932. The alternator from Bolinas arrived for World War Two, so the Navy's earlier FOX broadcasts likely went out on Federal arc.

On the Atlantic side, Arlington (NAA) handled the fleet communications. The Navy first (in 1913) used a Fessenden 100 KW rotary spark, then a Federal 30 KW arc, then by 1925 a vacuum tube transmitter. [4]

(C) The Short Waves Cometh

World War One both advanced and retarded the development of the radio art. The need for high and reliable traffic volume across the Atlantic locked long wave technology into place, at least for a while. The hope for better radio: cheaper, faster, frequency agile, even portable, drove experimenters to the short waves at frequencies above 2 MHz and soon as high as 25 Mhz. These short wavelengths got out fine with way shorter antennas, even as dipole and other fractional wavelength configurations. Amazing (then and now) ionospheric propagation got signals to the antipodes. An early instance, Marconi's Beam Wireless Service, saw short wave signals get from Cornwall, UK to Australia, as early as 1927. The Beam Wireless signals, at about 9 MHz or 32 meters wavelength, radiated from large vertical parabolic arrays as antennas.

The great short wave revolution in communications drove long wave communications into the dustbin of history by the end of the 1920s. After 1919, the experimenters, amateurs and professionals like Marconi, even RCA, soon came to see advantages in the higher frequency ranges of what we now think of as the radio spectrum. RCA had planned for several alternators at VLF, with vertical antennas under wire-array capacity hats, to cover the world. But by 1923, RCA abandoned the long waves.

Nations soon broadcast directly to each other on shortwave radio, by the late 1920s. Armies and navies communicated among themselves and over long distances with relatively small short wave radio systems. Amateur radio operators talked across the Atlantic in 1923, and soon to the world on 40 meters and then on 20 meters. The then not-well-understood eleven-year sunspot cycle provided miraculous ionospheric worldwide propagation of radio signals every few years, well enough to maintain various enthusiasms.

Abandoned by RCA, abandoned by Marconi, Telefunken long out of the game, what was left of long wave? As it happens, quite a lot persisted, especially for naval communications, and then more came along.

IV. Long Wave Radio and Nuclear War (not to mention Maritime Convenience)

As early as the 1918, the U.S. Navy realized that long wave radio could reach its submarines without them having to surface. In World War Two, Japanese RADAR could spot a periscope, but not an underwater trailed antenna. In order to provide safe communications with U.S. submarines throughout the Pacific, the Navy turned to a high power long wave alternator. As its last use, one of the "Bolinas High Power" RCA Alexanderson alternators took up residence in the crater just north of Waikiki, on the Island of Oahu in Hawaii. From there it covered the Pacific theater of wartime operations.

The utility of very long waves, very low frequencies, for communicating with submarines became exponentially more important with the advent of the *Polaris* class nuclear submarines armed with nuclear weapons. [5] Both command and control as to launch, and fail-safe to prevent an erroneous launch, came to the fore. Only reliable communications could be trusted to authorize a launch and only reliable communications could prevent a bad launch, likely precipitating full-scale nuclear war by error.

The U.S put in place worldwide the 10 KHz OMEGA stations in the 1970s to provide a reliable fix of position almost anywhere in the world. So, too, the Soviet Russians created their own Omega-like system (known to us as the Alpha stations), for their own purposes. Both systems featured not direction finding, but "hyperbolic navigation." While this sound very mathematical (and it is), it's pretty simple at the receiving end. Two curves on the appropriate map intersect at two points, and other information eliminates one of the two. (That other information can be a third related signal). These now 50 year-old radio systems pioneered "Position, Navigation and Time" (PNT) services. The U.S turned off the Omega system in 1997 in favor of GPS, the multi-satellite Global Positioning System, for PNT.

Some of the U.S. Omega stations may have converted to submarine communications stations in the range of 15 KHz to 74 KHz. The U.S. Navy may well have built several of the others from Japan to Europe for this special purpose. At least seven such Navy VLF stations operate from Australia, Japan, Hawaii, the continental United States (3 stations) and Puerto Rico.

The question arises: If long waves don't bounce off the ionosphere as do short waves, and if ground wave propagation is so limited, how do the signals get around the world? The answer is surprising. The ionospheric D-layer is ionized at night, but of course, not by the Sun. These D-layer ions provide the reflective surface that send the long wave signals back down to earth, for the submarines and others. The full-sky energy that sufficiently ionizes the night-time D-layer for VLF comes from cosmic radiation. [6] Nearby appear two diagrams of the short day and long night range of the 60 KHz time signal of WWVB, from the National Institutes of Standards and Technology, figures 16 and 17. So, what may be resonances of the Big Bang may help to provide some important communications capabilities 14 billion years later.

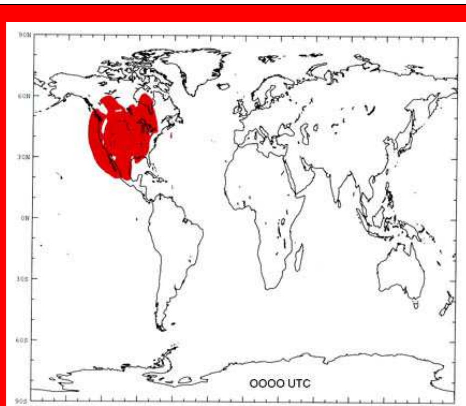


Fig. 16: Day range, WWVB, 60 KHz (NIST).

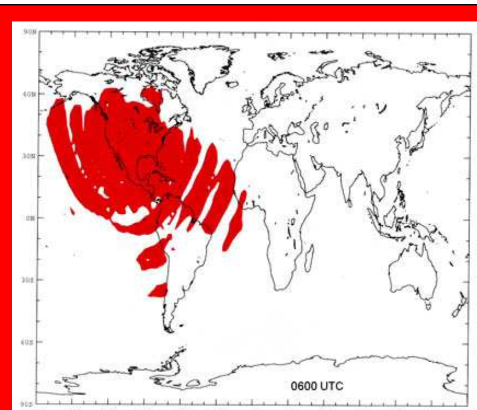


Fig. 17: Night range, WWVB, 60 KHz (NIST).

Navy VLF stations have used frequency shift radio-teletype (FSK) modulation since 1951, and traffic is also encrypted. In California, some of them are heard and seen all day: *e.g.*, North Dakota, NPL (ex-Omega); Washington State, NPG; Maine, NAA (honoring the Navy's most distinguished old callsign); and Hawaii, NPM. Nearby appears a screen capture of many of the VLF stations as received here, figure 18. Others in Australia (NWC) and Puerto Rico (NAU) are night-only catches. They each operate four channels with a total bandwidth of 200 KHz.

Japan, France and Germany operate VLF stations heard in California at night. A map of most known VLF stations appears in figure 19.

Russia operates its main worldwide communications network from Moscow as RDL on 21.1 KHz, often heard and seen at night. A screen capture of California reception of RDL appears in Fig. 20. The Russians also operate the frequently heard VLF "Beta" data stations and the "Alpha" navigation stations.

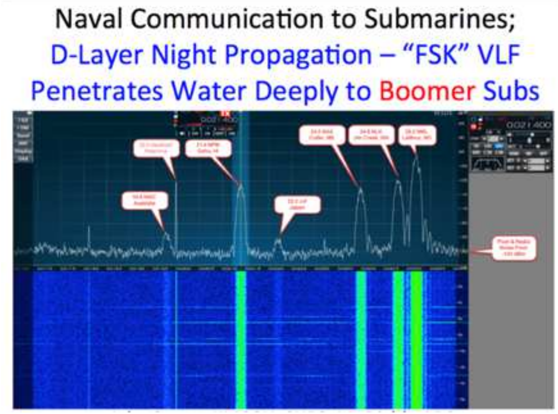


Fig. 18: Some of the more powerful VLF stations seen and heard in California (John Stuart). Scientists at Stanford graph these stations' reliable signals during the day to detect ionospheric anomalies, Sudden Ionospheric Disturbances (SIDs).

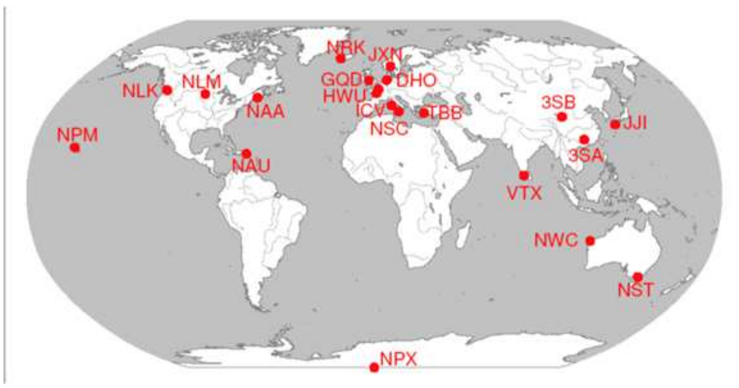


Fig. 19: Most of the VLF stations of the world appear on this map from Stanford; NPX in Antarctica is notional.

For a while the U.S. Navy operated a transmitter at 76 Hz (a wavelength of about 4,000 KM). At this frequency and wavelength, the sea-and-atmosphere interface is just a big waveguide. The capacity of the 76 Hz signal to convey information was limited by its frequency, efficiency, and narrow bandwidth. But that was not its purpose. It was a Fail-Safe. If, *but only if*, that transmitter went off the air could a submarine launch its ballistic missiles, no matter what other orders it had. Yet that extremely long wave radio system shut down about 1997 (as did Omega). The Soviets implemented a similar system at 82 Hz, now long gone also. The British Navy used a similar long wave fail-safe for its nuclear-armed submarines, using the presence of BBC Radio Four on 198 KHz.

The Navy has said that its network of VLF stations rendered the 76-Hertz fail-safe station obsolete. Presumably, in the event of war, someone, somewhere can pull the plug on these stations, just as would have been done on the 76 Hz station. The complexity of the network and its data would make a spoof impossible, so a false set of signals could not be substituted for the turned-off stations. Russia, on the other hand, seems only to have one 24/7 VLF system operating, the navigational (PNT) Alpha stations. Perhaps this is the Russian fail-safe system. Inasmuch as the hyperbolic nature of the positioning is reciprocal, this network cannot be spoofed either. This is so because a submarine navigator would know that the received spoofing signals do not emanate from Russia. Thus, these VLF signals, all of which can be heard and seen in California, may be keeping the world safe.

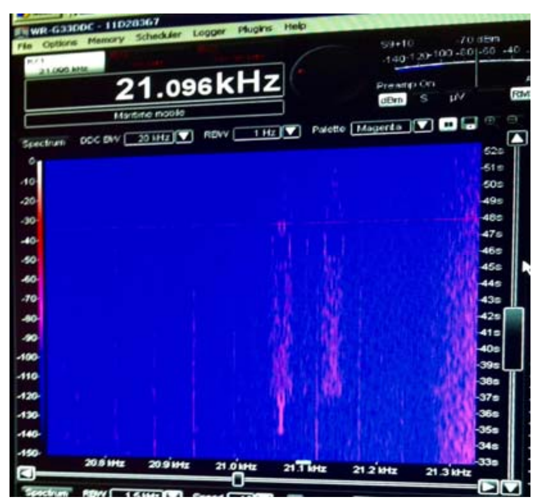


Fig. 20: The Russian world wide VLF station RDL on 21.1 KHz, a screen image from the WinRadio G33 at K6VK.

The Russians broadcast the "Alpha" signals from at least three sites. John Staples, as a principal of the VLF Special Interest group, put the sharp directional null of his home-made loop to work to determine the signals heard here come from the North-West. That means the Siberian station North of Beijing. A map appears in figure 21.

V. Air and Sea Navigation Aids

Navigation aids developed on long wave, again because of its stability. These 24/7 stations are the easiest to hear (and see). From about 200 KHz to over 520 KHz, these airport and shore-side navigational beacons throughout the world have for decades sent out two or three letter identifications (ID) signals, by which aircraft and ships can determine their positions. Only rarely if ever did ionospheric complications develop for these ground wave systems. Ships at sea could take bearings on shore stations and other ships. Aircraft could determine position by direction finding of airport beacons (as well as city broadcasting stations at considerable range). Coastal and inland stations have long announced themselves with simple Morse code identifiers, as they do to this day. In Northern California, a listener on a radio with a long wave band can hear several of these AM Morse code identified beacons, for example "CC" at Buchanan Field in Contra Costa County on 335 KHz. An image appears in figure 22.

In winter, stations from Canada to Mexico, and as far East as Montana, mostly in the 300 KHz range, beep away into California. The Canadian beacon stations cover considerable distance because they operate at higher power than the U.S. stations. They also send a distinctive "long-dash."

The government converted many of the existing or planned long wave transmitters (such as Omega and GWEN facilities) into very high power digital beacons in the range of 200 KHz to 400 KHz (but dropped their IDs). These beacons supplement the received digital GPS, the Global Positioning System signals from satellites. A fixed-position long wave beacon on the ground provides correctional data about GPS satellite signal discrepancies. (The satellite signals are subject to many propagational and other vagaries that limit precision). These ground beacons are operated by the Coast Guard (usually former coastwise beacon sites), the Department of Transportation (one or more of the GWEN sites among others) and in the Mississippi Valley, the U.S. Army Corps of Engineers. A map appears in figure 23. [7]

Many of the non-marine DGPS stations will close soon, because GPS-related FAA Wide Area Augmentation System (WAAS) provided by satellites will replace their functions.

After World War Two, utilities and governments otherwise continued with long wave radio services for special medium and long distance advantages. U.S. navigation at sea depended on the

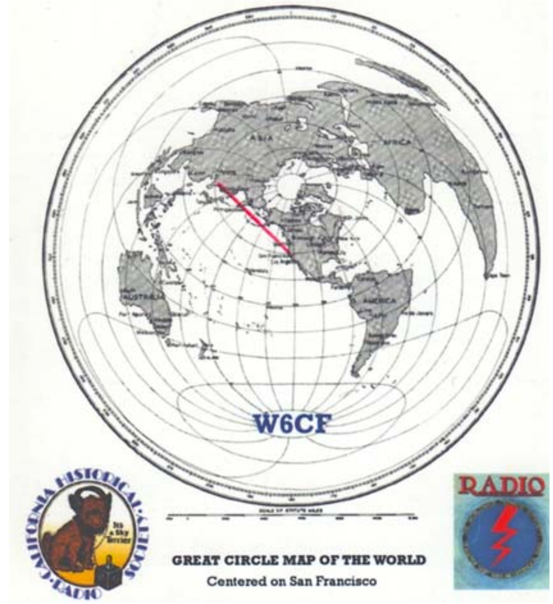


Fig. 21: John Staples' bearing for the Russian Alpha station in Siberia.

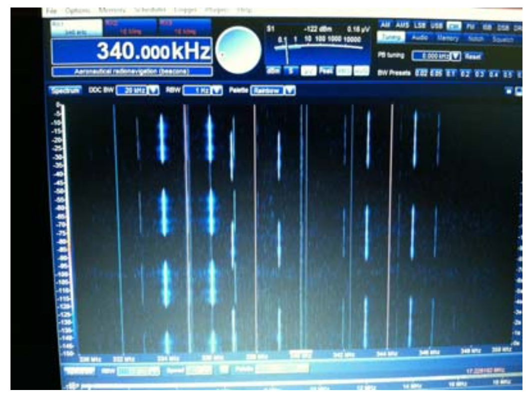


Fig. 22: Station CC in Contra Costa County, 335 KHz, a typical LF beacon for an airfield (K6VK)

Fig 23: A map of the U.S. DGPS high-powered stations.

Fig 24: Navy station NAA near Washington, DC on a 1920 postcard; the note says "These broadcast the Arlington time signals." (Author's collection).

Fig. 25: The Paris Eiffel Tower, used for radio since 1910, including time signals. (A reproduction in the author's collection).

powerful LORAN stations (LOng RAnge Navigation) operating at around 100 KHz or 3,000 meters. This too was a hyperbolic system. LORAN no longer operates but a new version, "E-LORAN" is in the works. E-LORAN may back-up the GPS system, which could be subject to many issues (*e.g.*, bad space weather). GPS is especially vulnerable in wartime to jamming and spoofing. Tests suggest that E-LORAN works well even deep inside steel and concrete in the big city, where GPS cannot reach. Its high power signals would be very hard to jam or spoof.

VI. Time Signals

Long wave provided reliable time broadcasts. The Navy station NAA, as well as the French Eiffel Tower station, sent out decades of time signals on long wave. Nearby appear two postcards celebrating these stations, figures 24 and 25.

Precise timing became a military, naval, scientific and commercial necessity, especially for longitudinal navigation. Today, several nations operate such time and frequency standard stations, such as WWVB in Colorado on 60 KHz, JJY in Japan on 40 KHz and 60 KHz, U.K. station MSF on 60 KHz, and China, station BPC, on 68.5 KHz. A screen capture of such stations regularly heard and seen in California appears in figure 26. (The Chinese BPC may well be a naval communications station as well, and perhaps a Fail-Safe station). Long wave time signals are more precise than the short wave ones (*e.g.*, WWV), because of less disturbance in the pathways.

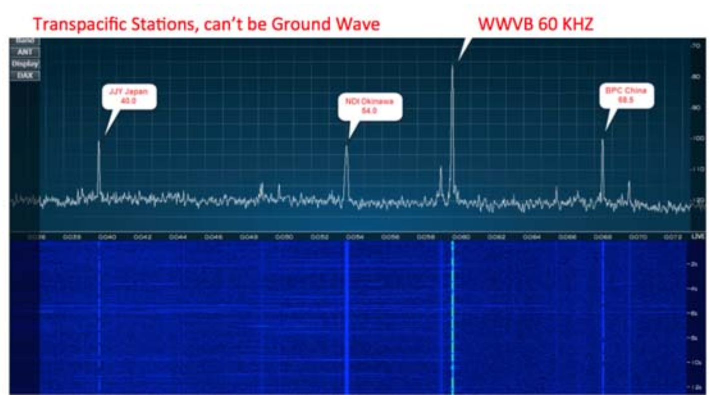


Fig 26: John Stuart's capture of Asian and US VLF time signals.

The ubiquitous "Atomic Clocks" re-set themselves by WWVB at night. SDRs and PC-enabled receivers can demodulate and record all of these stations just about every night, at least in winter. A small loop antenna or a longish vertical antenna suffices for WWVB and often for the other stations as well. John Staples has analyzed the WWVB signals in great depth.

VII. Marine Communications

Marine communications continued to use long waves for many decades. The calling frequency remained 500 KHz from the beginning. The frequency of 500 KHz, or 600 meters, involved short enough wavelengths so that ships could mount efficient antennas. An efficient antenna could make the difference between effective communications and noise, or in many case between life and death on the high seas. This frequency resonated just below the AM broadcast band, but it remained the private preserve of the marine shore stations and the ship at sea. These vessels ran relatively low power, other than the naval vessels. Moreover, 600 meters offered the reliability that short wave propagation conditions frequently compromised. Marine communications, however, have now transited through short wave radio and then to satellites.

Today, the only marine long wave signals come from the international NAVTEX stations, on 518 KHz. In the U.S., the Coast Guard sends out these regional FSK broadcasts about weather and safety at sea. A second frequency, 490 KHz is in the works and in use in Europe. NAVTEX from San Francisco and to the North is regularly heard (and demodulated) in Northern California. Many SDRs provide a NAVTEX software plug-in. An image of a NAVTEX reception appears in figure 27.

Fig 27: A NAVTEX reception in England.

VIII. National Broadcasting

Broadcasters in Europe from the 1930s and after continued to appreciate the stability of long wave signals for listeners, many of whom were too far away for regular AM broadcasting in the new internationally standardized band between 600 KHz and 1,500 KHz. The British BBC, the Irish, the Germans and the Russians have maintained AM broadcast facilities on long wave, between 150 KHz and 300 KHz. Some few are still broadcasting long wave to this day. Some commercial stations also appeared in the 1980s. A commercial logo appears in figure 28.

Fig. 28: The logo of the now-gone Long Wave broadcaster Atlantic 252; the 252 KHz frequency is still used for broadcasting.

These signals escaped ionospheric disturbance, and their listeners heard them by reliable ground-wave propagation. Sure, massive power was still required, often more than a megawatt. But the programs, usually government sponsored, got through to the people (for better or worse). Some such stations that have been heard in Manitoba, Canada [8] and hence that may sometimes be heard in California are:

KHz	Station	Location	Power
162	Radio France	Allouis, France	2000 KW
183	Europe 1	Felsberg, Germany	2000 KW
189	Rikisutvarpid	Gufuskalar, Iceland	300 KW
198	Radio 4 UK	Droitwich, England	500 KW

It would be a rare catch to hear one of these stations in California, and then it would only be possible at *O'Dark:30* around the winter solstice. Canadian and East Coast enthusiasts do log them however. Until 2013, Radio Rossi from Siberia reached California on 279 KHz under ideal conditions. Then it went out of business. A modern UK portable radio featuring the long wave band and the two stations most easily heard appears in figure 29.

Gilles Vrignaud of the VLF Special Interest group has discovered Internet long wave radio. With his smartphone, through Wi-Fi and the Internet, he can connect to dedicated SDR radios mostly in Europe. They tune in long wave (and other) broadcasting stations. They then make these signals available on the Internet (see article on page 24). [9]

Fig. 29: A modern English "Roberts" portable radio covering long wave as well as AM and FM. (Author's collection, from Alan Carter, BVWS).

In the United States, above the 100 KHz range, the Federal Emergency Management Agency (FEMA) predecessor set out to create in the 1970s a hardened emergency communications network known as GWEN.[10] That acronym came from Ground Wave Emergency Network. It ranged in frequency up to about 200 KHz. Only GWEN WGU-20 on 179 KHz in Maryland got on the air. It opened in 1973 and closed in 1990. Its QSL card appears in figure 30. Much of what the GWEN stations were supposed to do at long wave is now done by the NOAA stations on VHF. Today many cities benefit from local-only “emergency broadcast stations” on 530 KHz, just below the broadcast band.

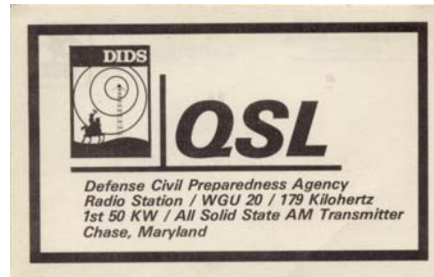
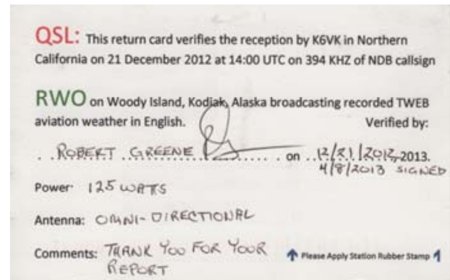


Fig 30: QSL card of the only GWEN station to operate, WGU 20, near Washington, DC.

IX. Air Traffic Management

Aviation took advantage of the stability and the (usually) limited range of low power long wave signals to manage air traffic. Each airport on its unique local frequency provided terminal weather and Notices to Airmen (NAMs) about runways, hazards and the like. In the San Francisco Bay Area, Oakland airport starting in 1929, provided reliable information to airmen, and continued well into the 1970s on 362 KHz. Some home radios, especially imports, also picked up some long wave in those days. So casual listeners, along with radio amateurs, tuned-in as well. Today, airports in Alaska still use long wave for voice Transcribed Weather Broadcasts (TWeB) from the airport beacon stations to report terminal aviation weather. It may be that auroral effects on other wavelengths and frequencies make long wave more reliable that far North. A QSL card for RWO in Alaska on 394 KHz appears in figure 31.


QSL: This return card verifies the reception by K6VK in Northern California on 21 December 2012 at 14:00 UTC on 394 KHZ of NDB callsign

RWO on Woody Island, Kodiak, Alaska broadcasting recorded TWEB aviation weather in English.

Verified by: ROBERT GREENE on 12/31/2012 2013. 4/8/2013 SIGNED

Power: 125 WATTS

Antenna: OMNI-DIRECTIONAL

Comments: THANK YOU FOR YOUR REPORT

Please Apply Station Rubber Stamp

Fig. 31: A (“prepared”) QSL verification of station RWO in Alaska transmitting recorded voice weather broadcasts, returned to K6VK. (Author’s collection)

X. Long Wave Amateur Radio

For many years, amateur experimenters have been authorized by the Federal Communications Commission (FCC) to transmit unlicensed in the 160 KHz to 190 KHz range, the 1750-meter band, at very low power, less than one watt. These “LowFers” also have occasionally been authorized at higher powers (five watts under Part 5 of the FCC regulations). At least one, WH2XVN, regularly operates in California on 183.5 KHz. See screen capture in figure 32.

At the other end of the power spectrum, the FCC has also authorized marine historical radio in Morse code on the old 600-meter marine frequencies from 425 KHz to 512 KHz. The Maritime Radio Historical Society (MRHS) with the sponsorship of the U.S. National Park Service, operates KPH / KSM in Bolinas California. MRHS has explored these frequencies for several years, with the help of WLO in New Orleans and regional U.S. Coast Guard stations. The Maritime Radio Historical Society reactivates marine frequencies between 425 KHz and 500 KHz several times a year. See screen captures in figure 33. These operations memorialize the great era of long wave marine communications. The operators hold the required commercial FCC First Class Radio-Telegraph licenses. They work their transmit and receive desks as true amateurs, for the love of radio. “Sparks” Richard Dillman, along with dedicated colleagues, revived this aspect of radio history (short wave as well as long wave).

Since 2006, the ARRL has operated a 600-meter experimental group as authorized by the FCC under the callsign WD2XSH. The ARRL notes over 200,000 hours of experimental communications of these frequencies. The 2016

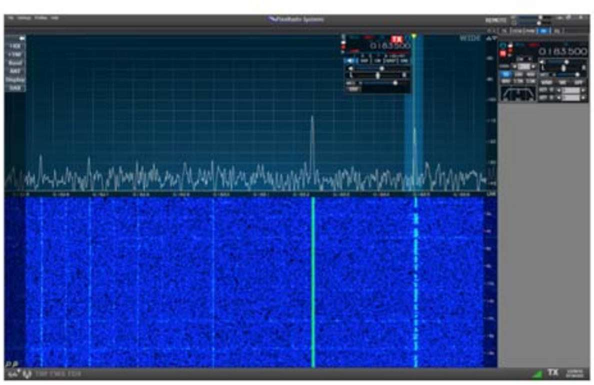


Fig. 32: A record of receiving WH2XVN on 183.5 KHz by John Stuart.

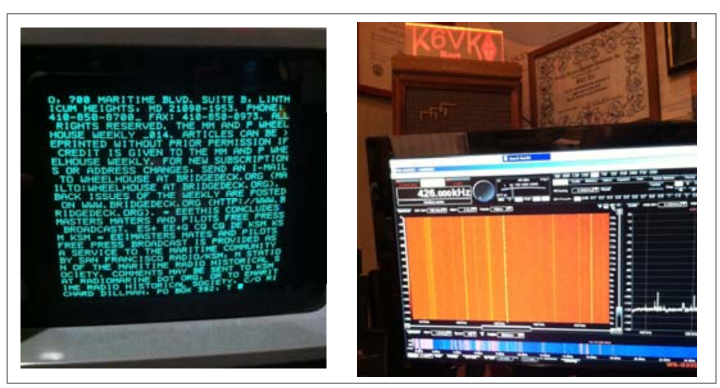


Fig. 33: Two screen captures of a transmission from the Maritime Historical Radio Society (KSM) on long wave marine frequencies. A Morse CW reader (left) displays text on the screen.

amateur radio Field Day in June featured operation of a number of long wave stations [11], including:

Callsign	Location	KHz	Mode	Power
WG2XIQ	Texas	474.5	CW	5-7 W
WG2XSV	Washington	475.5	CW	1 W
WH2XAR	Arizona	474.9	CW	1/2 W
WD2XSH	Washington	475.7	WSPR	
VE7CNF	British Columbia	477.5	CW	2 W
VO1MRC	Newfoundland	477.7	CW	2W [VO1NA]

The FCC is expected to authorize limited amateur radio activity on 139 KHz soon (the 2200 meter band) as well as on the 600 meter band (479 KHz). This 139 KHz or close frequencies are already in use in Europe and Canada. Joe Craig, VO1NA, got a 2200 meter signal across the pond to Europe some years ago. With his very long antenna, he acted as the Newfoundland receiving station for the 160 meter Poldhu beacon experiment of 2006.

XI. Conclusion: Do It!

Long wave radio is alive and well. All are welcome, as radio receiving stations and even as unlicensed transmitting stations — and, of course as licensed amateur radio operators. The Cradle of Radio still has much to offer the long wave enthusiast. The long Wave Club of America would be delighted for you to visit its website, and join up. Join the CHRS VLF Special Interest Group: we'll help you see and hear radio history and today's amazing variety of signals. A wire up a tree, a small home-brew loop antenna, a PC with a sound card is all it takes. Of course, other aspects of modern technology, such as the SDRs, can make this enthusiasm even more rewarding. (See figure 34, an Alpha station recorded and analyzed). Winter nights come every year, and the long wave stations flood the ether. Enjoy!

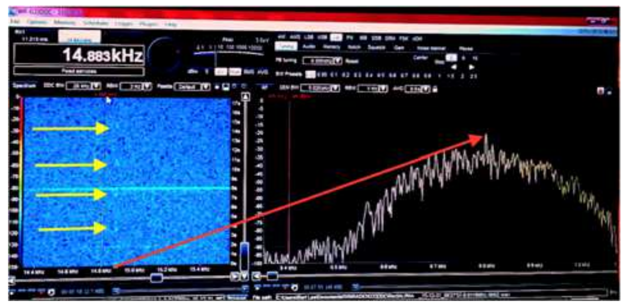


Fig 34: Audio analysis of a Russian Alpha station (on the right) and the RF waterfall of the stations "blips" - every 3.6 seconds, on the left (K6VK, Winradio G33, annotated).

For the history-minded, Wikipedia is a goldmine of useful information and interpretive analysis. It's usually accurate. Internet searches on topics of interest will yield enormous amounts of reproduced old time books, journals and magazines. Many websites will show and tell about long wave radio, including YouTube.

-- 73 de Bart, K6VK, e-mail: KV6LEE@gmail.com .

Notes:

1 Jack Belrose, Introduction "ELF/VLF/LF Radio Propagation [etc.]," p. I-3 (NATO, 1993); http://www.dtic.mil/dtic/tr/fulltext/u2/a267991.pdf
2 History of Communications-Electronics in the United States Navy, Captain Linwood S. Howeth, USN (Retired), 1963 (Table); http://earlyradiohistory.us/1963hwm.htm
3 Brief summary of the Wailupe Hawaii Naval Radio Station in the 1920's at http://www.navy-radio.com/commsta/wailupe.htm
4 NAA Arlington, Sparks Journal, Volume 3 No. 3, 1980, Society of Wireless Pioneers; http://www.navy-radio.com/commsta/arlington/NAA-Pages%20from%20Vol3No3-2.pdf
5 See generally: L.A. Gebhard, Evolution of Naval Radio-Electronics and Contributions of the Naval Research Laboratories (1979), especially Ch 3 on VLF. www.dtic.mil/dtic/tr/fulltext/u2/a084225.pdf
6 J. A. Adcock, VK3ACA, "Propagation of Long Radio Waves," *Amateur Radio* [Australia], June to Sept. 1991, as cited in Q*EX.*
7 See: http://www.navcen.uscg.gov/images/Plots/Site_Map_No_CHinch_Lg.jpg .
8 See: http://www.angelfire.com/mb/amandx/longwave.html
9 See *e.g.*, http://radiomap.eu/links/
10 Larry Waldbillig: http://historysdumpster.blogspot.com /2014/11/the-long-wave-radio-band.html, with a recording of its program of ID and weather.
11 http://njdtechnologies.net >> 2016 Field Day

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Measuring Absolute VLF Signal Intensity with Tuned B-Field Loop Antennas

By John Staples, W6BM

In this article, John sets out a rigorous way to make some determinations about radio signals in the Very Low Frequency (VLF) range. Several CHRS members have been exploring this historical legacy set of bands, from 11.9 KHz up 530 KHz. Historical though they may be, these frequencies are still in world-wide use, by navies for submarines around 20 KHz, by aviation and the Coast Guard, and now by amateur radio hobbyists. (The hams have two new bands at 139 KHz and 472 KHz). The interest of CHRS has focused on the historical Swedish mechanical alternator station, SAQ on 17.2 KHz. This station utilizes the only remaining operational Alexanderson alternator for generating RF signal. The alternator was installed in 1924 and was in service until 1996. SAQ now brings the alternator up to power and broadcasts briefly only twice a year at the end of June and on Christmas Eve. It is very difficult to receive this signal in California but it has been done.

John shows how to find exactly how strong a signal is, on any given antenna at any given location. This means that VLF enthusiasts can now compare receiving conditions in various places. Is the top of Mt Diablo better for SAQ than, say, the hills of Berkeley? John has also found that the enthusiast can optimize small loop antennas, often the most practical. He shows how to determine with simple instruments a loop's resonance, at which and below which it is most sensitive.

For the technically inclined, a definition may be helpful:

> "The strength of an electromagnetic wave is … measured in terms of the intensity of the electric field; this is expressed in … microvolts per meter…. This …[is] the number of [micro]volts which would be induced in a piece of wire one meter long placed in the field parallel to the electric lines of force … " (B. W. Griffith, Radio- Electronic Transmission Fundamentals (1962))

Editor's Note by Bart Lee

Here is a step-by-step procedure that can be used to measure the absolute field intensity of a plane propagating wave with a B-field tuned loop antenna. You can use the procedure presented here to set up a spreadsheet to calculate the absolute signal intensity if you can measure the amplitude of the signal out of the loop or through an amplifier between the loop and a calibrated receiver.

The formula relating the signal strength E (microvolts per meter) to the open-circuit voltage V (microvolts) induced across the loop terminals, when the plane of the loop is in the direction of the received signal, is

$$\frac{E(\text{microvolts/meter})}{V_{loop}(\text{microvolts})} = \frac{Z_0}{2\pi\mu_0 f N A} = \frac{47.7x10^3}{f(\text{kHz}) N A(\text{m}^2)}$$

at frequency f (kHz) where N is the number of turns of a loop with cross-sectional area A in square meters. The voltage from the loop is measured with a high-impedance device, such as an oscilloscope, an AC voltmeter or through a high input impedance amplifier. Computer microphone inputs or 50 ohm receiver antenna inputs do not have a sufficiently high input impedance when used directly, and they will load the loop, lowering its output voltage.

The sensitivity of the loop is proportional to the frequency f if the loop is ideal, that is, without resonances. Inter-winding capacitances in the loop and additional capacitance across the terminals of the loop will cause the loop to resonate at a frequency given by the parallel resonance of the loop inductance L and the total equivalent capacitance C present within and across the windings.

If the loop is used at a factor or 3 or so lower than its resonance the above equation applies with reasonable accuracy. At resonance, the voltage output is larger than the equation indicates, which can be used to advantage, with the resonating capacitor is across the loop terminals. At resonance, the ratio of the resonant to non-resonant signal strength is the resonance gain, G_{res}.

The loop resonance frequency can be measured by placing high input impedance voltage measurement device across the loop terminals, and then exciting the loop by a small loop placed near the receiving loop driven by a signal generator..

An amplifier following the loop will provide additional voltage gain, G_{amp}. The amplifier should have a high input impedance and low output impedance to drive a receiver with a low input impedance. A simple amplifier, such as an emitter or source follower, will have a voltage gain slightly lower than unity. A transformer may be used between the loop to increase the output voltage into a high input impedance amplifier, and also to convert a loop configuration balanced to ground to an unbalanced transmission line.

As an example, a 24 inch diameter loop of 90 turns has a radius of 12 inches, or 0.3048 meters. Its area A is πr^2, or 0.292 m^2. For a frequency of 24.8 kHz, well below the measured resonance, the calculated loop sensitivity constant is 73.2 microvolts/meter per microvolt. This says that if the loop puts out 1 microvolt at 24.8 kHz, that the E-field intensity of the received signal is 73.2 microvolts/meter.

The gains due to the amplifier G_{amp} and the resonant gain G_{res} of the loop must be taken into account. In this example, the measured signal strength from the output of the preamplifier at resonance is 3300 microvolts, and 360 microvolt at the same frequency with the resonating capacitor removed. This gives a resonance gain of 3300/360 = 9.17, or 19.2 dB. In addition, the separately measured gain of the preamp itself is 26 dB.

If the measured voltage from the amplifier is 3300 microvolts with a total (preamp + resonance) gain of 45.2 dB, then the voltage from the loop operating in the non-resonance mode would be 45.2 dB less than 3300 microvolt, or 18.1 microvolts.

Since the voltage from the unresonated loop before the amplifier is calculated to be 18.1 microvolts, then the absolute value of the 24.8 kHz signal electric vector is 1325 microvolts/meter.

$$E = 73.2 \text{ volts/meter per volt} \times 18.1 \text{ microvolts} = 1325 \text{ microvolts/meter}$$

John Staples has long been FCC-licensed as W6BM, is the Trustee of the CHRS Amateur Radio station W6CF, and is a Fellow of the California Historical Radio Society.

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Listening to Long Wave Broadcasts With Someone Else's Equipment

By Gilles Vrignaud

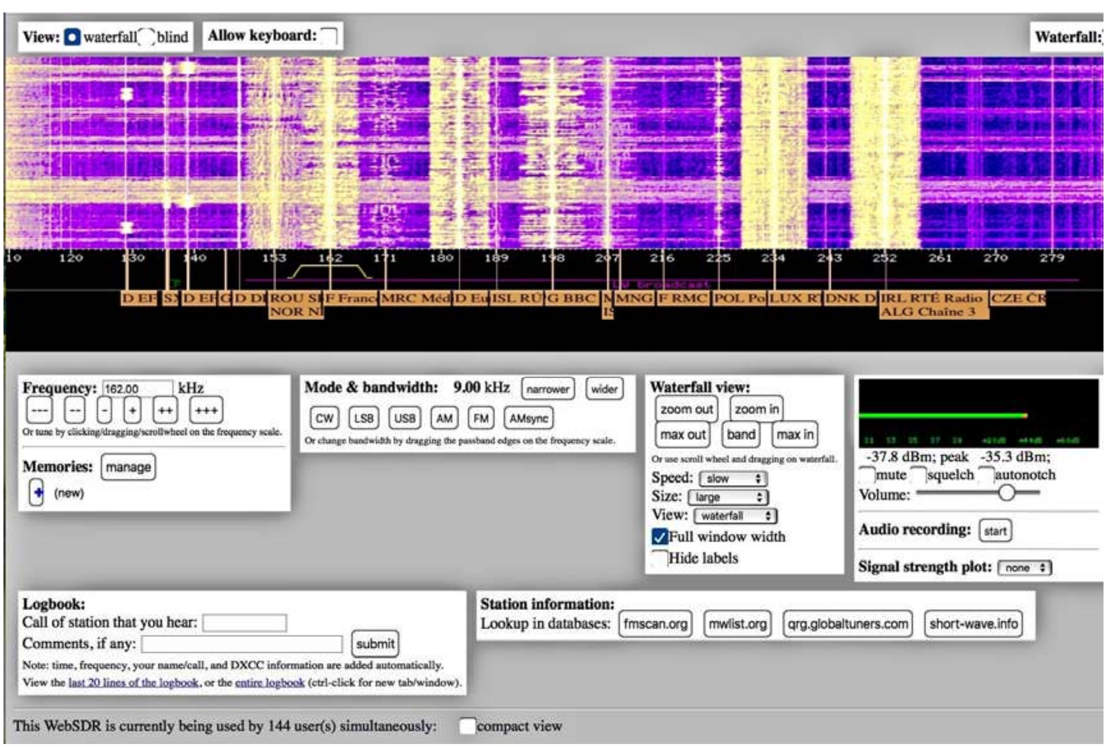
I have always enjoyed listening to Shortwave Broadcasts from many countries. Unfortunately, this is becoming increasingly difficult because many governments have abandoned their short wave and long wave broadcasts in favor of new "improved" digital technology. You can still listen to many short wave and long wave broadcasts by virtually relocating your antenna and borrowing time on a state of the art receiver from a generous soul who is willing to share.

The development of Software Defined Radio (SDR) has opened up many exciting opportunities for listening. SDRs can outperform many of the finest receivers by using the power of Digital Signal Processing (DSP) to perform even the most sophisticated functions of signal selection, bandwidth control; and demodulation modes to name a few. SDRs have been around for several years, but they were expensive and required a computer interface and a lot of fiddling. If you cannot afford a dedicated SDR system, the technology is now readily available for all to share on the web. All you need is a web browser.

One of the pioneers who made this technology accessible to all is the University of Tente (at Enschede in the Netherlands). The Faculty for Electrical Engineering and the Radio Club ETGT created a standardized web interface for SDRs, available to any serious amateur willing to share a listening station. This web interface makes it easy for anyone with Internet access to choose a receiver and location combination and piggy back on the SDR for some serious listening.

A list of the available web sites with accessible SDRs can be found here: http://www.websdr.org/

As I write this, I have been listening to *Radio France Internationale* (Long Wave) on 162 KHz from the university's system in Enschede. This is an impossible endeavor from my West Coast location. This screen shot give an idea of the flexibility of the controls available to the web visitor. The display combines a spectral view in the frequency domain (many with actual station annotations), with a waterfall depicting the modulation content in the time domain. It is even more remarkable to note that I am sharing this SDR with 144 other users!



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A 30-Line Mechanical Television Reproducer

By John Staples, W6BM

> John presented an experimental mechanical television he built to television enthusiasts at a meeting in May 2016. This fascinating and relatively simple construction demonstrates the principles of one form of early television from the 1920s. John's approach provides an excellent example of an experiment one can build to demonstrate for themselves the magic of mechanical television.
>
> Editor

As television technology first developed in the 1920s, low-resolution scanning systems based on spinning wheels or mirrors, coupled with narrow-bandwidth radio transmission systems, produced images with 30-60 lines of resolution at frame rates of 12-15 frames per second. The amateur builder could construct simple image reproducers comprising a rotating wheel with a spiral of holes, backed by a large-area neon lamp connected to the output stage of a modified AM radio receiver. A scanner at the sender generates an analog video signal that when received illuminates a light source behind a synchronized scanning wheel, producing an image. The image is reproduced one pixel at a time, and the eye integrates the flashes of light to produce a full image.

One of the prominent pioneers of mechanical television was the Englishman John Logie Baird, who in the late 20s was using a 30 line resolution at 12.5 frames per second. By the middle 30s, the resolution had increased to 240 lines at 25 frames per second, when fully electronic television superseded his mechanical system.

Synchronization was often non-existent: the viewer usually had to manually adjust the wheel speed to match the speed at the transmitter. When used, synchronous motors would achieve synchronism if the transmitter and receiver were on the same power grid, but since the transmissions were in or just above the broadcast band, they could be received at far distances, without guarantee of power line sync.

As the video spectrum produced at the low scanning rate of the first experiments was confined to the audio range, some acoustical recordings were made of the video signal. Several of these recordings have survived and have been recovered by Englishman D. F. McLean who published a few frames of the images on the Web. I constructed a mechanical playback reproducer to reproduce some of these image sequences.

The Player

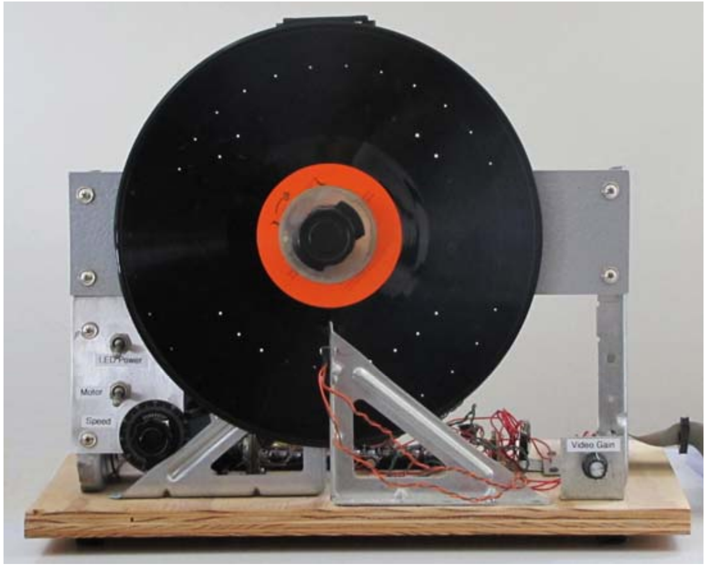
My mechanical reproducer comprises the following parts: a 12 inch wheel with a spiral of 30 holes, a light source that is modulated by the video signal, a motor that drives the wheel, and a source of video to modulate the light source.

Modern technology was used to implement the player, including a computer to generate a video stream synchronized to the rotation of the scanning wheel. Most of the components came out of the junk box or from the hardware store.

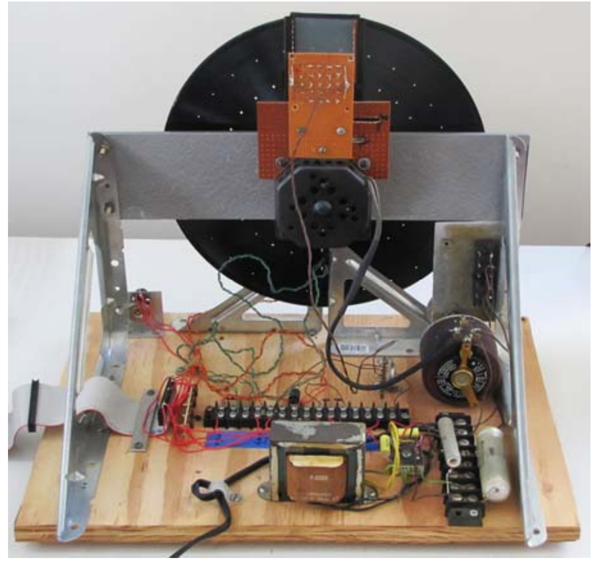
A key element of the reproducer is a scanning wheel containing a spiral sequence holes that form the line scanning. The accuracy of the image depends on the precision of the location of each hole in the scanning disc. My scanner uses a modified 12 inch long-playing record as the disc, with the holes drilled using a computer-generated template. The size of the reproduced image is about an inch square for a 12 inch diameter disc, and each of the 30 holes must be located with a precision better than 0.003 inch.

A small induction motor spins the disc at speeds up to 1200 RPM, adjustable with a Variac, corresponding to 20 frames per second.

A 5 x 5 array of 25 white LEDs is positioned behind the wheel. They illuminate a ground-glass diffusing screen that gives a uniform illumination behind the scanning wheel. The image is very bright, clearly visible in brightly lit rooms, as each of the 25 LEDS is pulsed up to 80 mA by the video signal.



Front view — 12 inch disk (an old LP) with a spiral pattern of 30 holes with a modulated light source behind that spins at 1200 RPM.



Rear view — In the center is the induction motor with the LED light source mounted above. A small Variac on the right side controls motor speed.

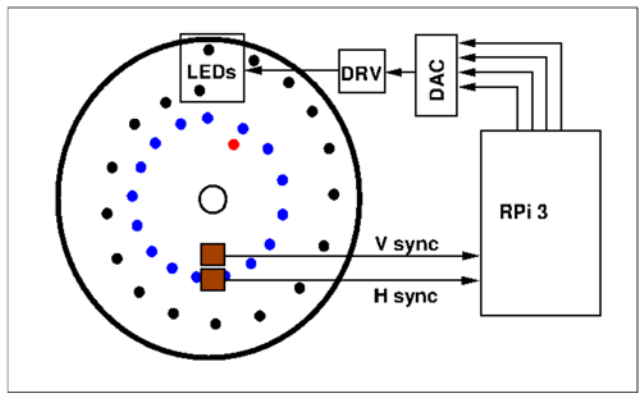
The synchronization of the wheel with the video signal is simplified by generating the synchronism pulses by the wheel itself; the computer then sends the generated video signal back to the LED array. The horizontal sync signal is generated by 30 equally spaced holes observed by a phototransistor, and an additional hole at a smaller radius generates the vertical sync pulse, one pulse for each revolution of the wheel.

A RaspBerry Pi 3 (RPi 3) microcomputer accepts the two sync pulses and generates a video stream. Using synchronization pulses from the wheel allows the wheel to display a stable image at any rotational speed.

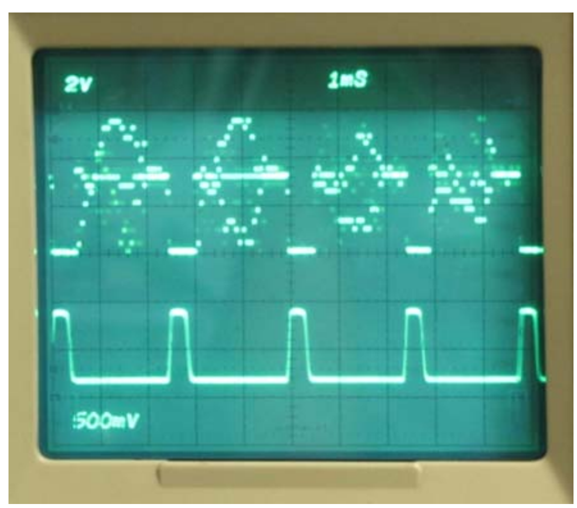
The microcomputer senses the sync pulses and calculates the speed of the wheel and the duration of each pixel of the image to be displayed. The computer outputs a data stream from a 30 x 30 look-up table for each frame of the image sequence. The 4-bit digital video signal is converted to a 16-level analog signal by a DAC that drives the LED array. The figure (center right) shows the 4-bit video signal going to the DAC along with the horizontal and vertical sync signals generated by the sync holes in the wheel (blue and red holes) going back to the microcomputer. The pixel rate is calculated at the end of each frame, so the image is always in sync with the wheel.

The figure (lower right) shows the 16-level analog signal that drives the LED array, along with the horizontal sync pulse sensed by a phototransistor at the wheel.

The lookup tables for several programs are provided: several static test images and two moving sequences generated from the original Baird acoustical recordings recovered by McLean.



The outer pattern of holes (black) form the scan lines of the image. An inner pattern of holes (blue) provides horizontal sync pulses to the RPi 3. The hole in red provides the vertical sync pulse.



The upper trace is of the 16-level analog signal of the image that drives the LED. The lower trace is the horizontal sync.

The figure below shows images generated by some of the test signals.   In each of these examples, the light source is allowed to illuminate a wider area producing not only the primary image in the image center, but also adjacent partial images on either side. In fact, if the entire wheel were illuminated, 30 images would be displayed, each offset by one horizontal line from the next.

Examples where adjacent images become visible when the light source is allowed to illuminate a wider area.

The figures below show detail that can be displayed in a 30-line static image is very limited: however, motion adds a lot to the perception of more detail in the image.   In addition, since the image is highly pixelated (30 x 30), at large size, the image may be unrecognizable, but at small size, the pixelation will be less noticeable, and the image may be recognized. Here is the same 30 x 30 image at two magnifications, along with the 16-level digital representation of one frame.

The 30-line image is highly pixelated (left), but it is not as apparent when viewed as a smaller image (above) especially when in motion.

```
static char  image[][30][30] = {
"DDDDDDDDDDDCCC9788989988766565",
"DDDDDDDDDDDDB97777677877665555",
"DDDDCCDDDDDDB999A9776665555555",
"DDDDBCDDDDDCBBCBCCB97555655565",
"EDCCABCD99BCCCDDDCBBA864655555",
"DDDCBABC9ACDDDDDDCCCCA75555545",
"DDDCCABA9CDDDDDDDDDCCB96554545",
"DDDDDBB9BDDDEEEEEEDDCCB7444445",
"DDDDABBACCDDDEEEEDEDCCCA444444",
"DDDDCCBBBBCDDEEEEDDDCCCB444434",
"DEDDCCBCBBCDDDEEEEDCCBCB443333",
"EDDCCBAABBCCDDDEDDCCBBCB543333",
"DDEDCAAA9ACDDEEDEDDDBAAA543334",
"EDDDDCB99ACCCCDDDCCCBAAA543344",
"DEEDDDCBAA9989BB9999AA99533344",
"DEDDEDCBA987669B45558989433343",
"EEDEDB87BBCCBBCCBBCDB99B543434",
"CCCBB866BACDDCCBBDDCA9AB444434",
"888887569ABCBACCBCCCB9AA444433",
"6676655579AA99BB88AB9885555444",
"566656656A88A9659A889865554454",
"6666665559AA888889A98555444454",
"6666665547ABAA9989AA9654444444",
"66766774469ACBBBAABA8444444444",
"55559984437ACBA9ABB95345875454",
"433379855348CCCCCB973347886445",
"3333699552358ACCB9742348886344",
"333236873322468875433347885344",
"433323695322222222223357884344",
"433332378533321112233578884444"};
~
```

The image is encoded in16 gray scale levels. Above is its pixel-by-pixel representation in hexadecimal. Each row is a scan line.

The computer used is a RaspBerry Pi 3 (right), using a four-core 1.2 GHz ARM processor running Ubuntu 16.04 Linux, and the application code is written in C.   The sync pulses are sensed by phototransistors mounted near the wheel which trigger the video output stream generated from the image lookup tables.   A real-time display on the controlling computer screen shows a number of running parameters including wheel rotation speed, pixel clock rate and horizontal and vertical sweep speeds.

The RaspBerry PI 3.

In the next issue John plans to present his project of successfully building a TV camera with a 70-year-old iconoscope. Iconoscopes are fairly rare and attempts to make them operational have been seldom attempted. ◊

Tom Swift and His Photo Telephone

By Mike Adams

First was the smoke signal and the drum. Then came the telegraph, dot and dash communication using wires. Then the wire was waterproofed and placed underwater for the Trans-Atlantic Cable. Then there was the wired telephone, and the ability to communicate distances using the human voice. In all of these devices wires were the problem. High winds would blow them down, hackers would cut wires and intercept secret communication, and continuous maintenance was needed for every mile of the circuit. As the 20th century unfolded it was Marconi and others who modified the telegraph and the telephone to be "wireless." This would bring a new era of communication, unlimited by weather and distance, it would save ships at sea and bring advantages in fighting the Great War. But there would still be a place for wired technologies. Before the Cable TV and the Internet there was the Photo Telephone.

Cover, Tom Swift and his Photo Telephone, or the Picture that *Saved a Fortune*, by Victor Appleton (Stratemeyer Syndicate house name), Grossett and Dunlap, 1914.

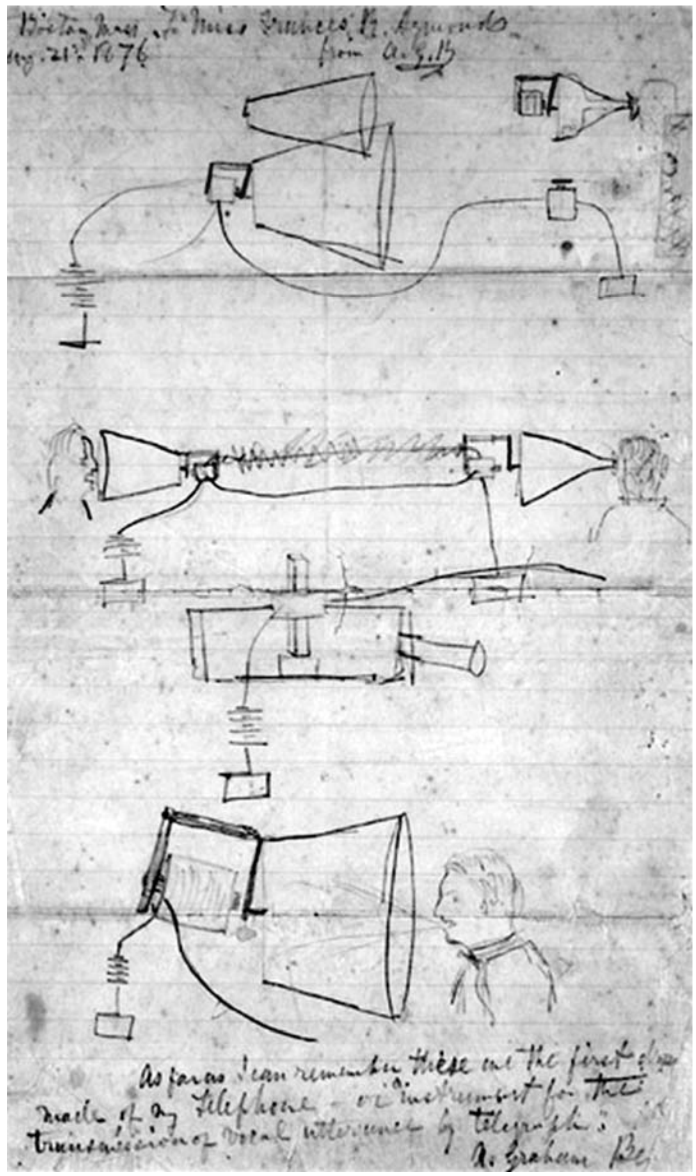
In 2015 I wrote a book called *Radio Boys and Girls: Radio, Telegraph, Telephone and Wireless Adventures for Juvenile Readers, 1890-1945.* It was published by McFarland Press and it examined electricity, wired telegraph and telephone, wireless and broadcasting through the stories in the juvenile fiction series genre. I originally had included *Tom Swift and his Photo Telephone* as part of a larger chapter on visual communications, including the motion picture camera. Along with the cinema girls and boys this 1914 story of wired communications ended up on the cutting room floor. It has been resurrected for this CHRS Journal article. It features odd hybrid technology - part wired telephone, part Bell's 1880 Photophone, part 1950s Picturephone, and a bit of science fantasy - all used in the service of adventure.

The Tom Swift series consists of 40 books issued between 1910 and 1941. As juvenile science fiction for young readers it is one of the best-selling series ever written. It was the creation of Edward Stratemeyer who outlined the stories and characters and hired contract writers to do each book under the nom de plume of Victor Appleton. It enjoyed enough popularity with the generation of kids that grew up reading it in the first half of the twentieth century that it was revitalized in the 1950s as Tom Swift Jr. What did the Swift series have that the others lacked? First, gadgets. Tom Swift invented dozens of new, mostly improbable communications and radio-TV-film-themed devices, often before they were ever invented for real. He also invented or modified in his pages every new land, air, and water means of transportation. He made submarines go deeper, aircraft higher, autos and motorcycles faster. Granted, many of what Tom 'invented" was first speculated upon in the popular press of the day, and often his inventions had already happened, like talking pictures and wireless. But by adding adventure, life or death thrills, and a rescue or two, it didn't matter, because Tom Swift was the kind of young man you wanted to be, a sort of the STEM (university curriculum emphasizing Science, Technology, Electronics and Math) model, but 100 years earlier.

It's the usual cast of Tom Swift characters: Tom of course, his dad the once famous inventor Barton Swift, his best friend Ned, an older gentleman named Mr. Damon, a giant named Koku, and his all-around handyman Eradicate. There was also his girl Mary. An interesting thing about this story is that right in the beginning they establish his dad as an old man:

"The elderly gentleman, his hair was quite white now . . ." (Page 1) Why is this significant? It is because Tom, like other Stratemeyer Syndicate heroes, never aged throughout the three-decade series and was never described physically in an age -descriptive way. But here was the author in this early 1914 volume describing the elder Swift as old and feeble. Still, he challenges his son on the possibilities of a Photo Telephone: "It can't be done! I admit that you've made a lot of wonderful things, things I never dreamed about, but this is too much. To transmit pictures over a telephone wire, so that persons cannot only see to whom they are talking, as well as hear them - well, to be frank with you Tom, I should be sorry to see you waste your time trying to invent such a thing!" (Page 1) So in the opening paragraphs of this story we are given the setup, the invention, the premise of this story, and the opinion of the doubting Swift patriarch. Can Tom do it?

Tom moves into his professor mode and begins to explain to dad that people laughed at Bell, Morse and Edison when they were developing their telephone, telegraph, and light bulb. He tells us that folks laughed at the Wright Brothers when they said man could fly, and remember that this is 1914, so the aforementioned inventions are not that mature. Without being pedantic, it is typical that in all of his books Tom Swift takes the reader gently by the hand and adds a little educational content to what are mostly adventure stories. Tom was likely admired by both the young reader and his or her parents. He was wholesome. He was smart. Tom concludes with an explanation of the difference between sound and light waves, saying the speed of light is "186,000,000 miles a second." (Page 5) Can this be right? This error rings the real science professor's bell! It seems that the correct answer is 186,000 miles per second. And while it is not as fast as Tom's wrong answer, it is fast enough to power the Internet of today with its billions of miles of fiber optic cables, sending 1s and 0s of light, allowing you to read this on your iPhone. But this error is a serious one, and because these volumes make a pretense of enlarging the knowledge base of the 1914 young reader, it is hoped that in later printings this mistake was corrected.



The Bell Photophone initial drawing (1876) from the Bell papers, Library of Congress. Bell also used selenium as a receiver for his modulated light wireless device, but you needed line-of-sight otherwise it wouldn't work. A voice modulated a mirror which reflected light waves, picked up at the receiver using a selenium call, battery and telephone earphone. Another version of the transmitter used a carbon microphone, a DC supply and an arc.

Tom does ask his dad a question, and again its veracity is suspect: "Why can't I send light waves over a wire as well as electrical waves?" (Page 6) For technical accuracy, he needed to say that light reflected from a person or object is collected by a lens and converted by a camera pickup tube or solid state sensor to an electrical analogue, and that goes over the wires, just like the audio. Light waves themselves do not travel over a copper wire. But Tom doesn't give up and he tells his father about a recent experiment in what was called wire photo, a still picture scanned on a spinning drum and sent over a telephone wire, the receiver using a galvanometer to shine variations in light and dark areas of the transmitted photo onto photo sensitive paper. In this explanation he is essentially correct. There is a lot of science in the early pages of this volume, some accurate, some not. Finally, he tries to explain the basic principle of his device to send pictures along with the telephone voice, and for this he favors the selenium cell. This light-sensitive element was used by Alexander Graham Bell in his 1890 "Photophone."

Swift would be on solid theoretical ground using the Bell experiments if he was explaining the transmission of audio only, but twenty five years after Bell's work, the Swift device followed the wrong scientific path. One of Bell's transmitters used a DC arc modulated by a carbon telephone, and there was such a device used experimentally by the railroad about the time of this book. Tom Swift writers, like some fiction writers, try to base their stories on real content from the newspapers. This was no exception. Where the mistake was made was in assuming selenium could be used for picture, explained by Tom as using reflected light. The fact is, selenium was sensitive to light variations and generated a corresponding current that could be heard using headphones. Bell called it a Photophone because it transmitted voice on a beam of modulated light, a bright arc or reflected sunlight, and received using that variation in light falling upon selenium.

Meanwhile, there is a story here, and if it follows the Swift format it will involve righting a wrong, or that series favorite, industrial espionage. But first a rescue as an airplane and pilot crash into the Swift laboratory, the flyer clings to the chimney and calls for help. While the rescue is being debated, the narrator steps up, freezes the action, and reminds the reader of the previous adventures and inventions, one of which was *Tom Swift and his Wizard Camera*. It described an invention that was just a movie camera with a timer that turns on a motor and cranks the film, absent the cameraman. The purpose of this is to get movies of jungle animals without endangering a camera operator. As it turns out the rescued flyer is a friend of Mr. Damon, who it seems has just lost his fortune at the hands of a crook. But turn the pages as there are days of experimentation by Tom and his friend Ned, as they attempt to get the picture part of the new invention to work. They have fashioned a closed-circuit telephone in the lab, and each of the boys is in a specially-designed phone booth equipped with a selenium-coated metal plate on which the picture of the caller is to appear. Bad science.

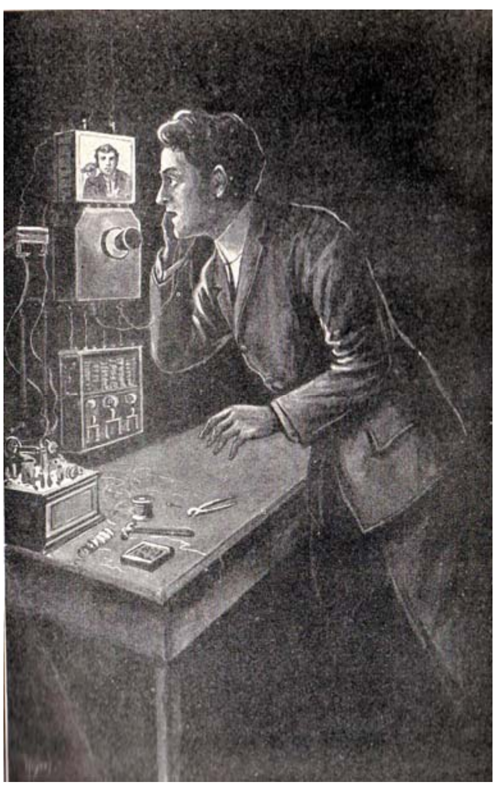
The Bell Picturephone was introduced at the 1964 World's Fair, exactly 50 years after Tom Swift "invented" it!

No wonder it is not working. Tom relates to Ned that he needs to try a new type of selenium. It must be noted here that there were many real inventors using selenium for its light-sensitive properties, most notably Lauste, who had patented a sound on film system for motion pictures in 1912. (see *Lee de Forest, King of Radio, Television and Film*, Springer Science 2012) The Lauste invention, like that of Bell and Earnst Ruhmer, used earphones since the sound detected from light falling on selenium was very low in volume and vacuum tube amplification had not been realized. And it must be said that all of these experimenters used selenium to convert light variations to sound, not to a picture as Tom Swift was promoting. So Tom was fundamentally wrong in his use of selenium, even though in this story he presented a mini-lecture to Ned on the element and where it is found. It is likely that the author used his creative license to add picture to the selenium-based device. The other likely scenario, obviously speculation, is that the writer did not have a decent understanding of the science of the day that he was reading about in the popular press or *Scientific American*. In any case, the entire premise of this invention was wrong. But remember, Tom Swift is the new centuries' H.G. Wells, and in each of these genres, there was just enough plausibility to make the reader think, "why not?"

Leaving the lab and selenium behind, Tom and Ned take their boat out on the lake and are run down by a mean man, described as a bully, resulting on their boat taking on water. The older man in the offending boat is drawn by the writer as a blowhard, and has the unfortunate name of Shallock Peters. He threatens to sue Tom for being in the way. He is ugly, described as: "a stout-bodied and stout-faced man, with a florid complexion nearly the color of his boat, red." (Pg39) He is known by Ned to be an unscrupulous businessman. It's back to the lab and a few more weeks of experimenting with no success. He father continues to tell him that it will never work. You should listen to your father, Tom. Next Tom visits Mr. Damon, and to connect the dots it turns out that the same Shallock Peters has defrauded Damon of his entire fortune. Clearly he is the bad guy of this story. Where is the Consumer Protection Financial Bureau when you need them?

So at this point in the book there are three "problems" that need to be solved. First, the photo-telephone, the topic of dozens of pages. In his explanation of the device there has been a lot of bad science, but this is Tom Swift and his stories are expected to be science fiction. The second issue is how to save Mr. Damon's fortune which was taken from him by the evil Peters. The third issue is related, and that is how Tom and Ned will get the better of Peters for sinking their boat. This latter issue is resolved quickly, as an attorney for Peters offers Tom $500.00 for the boat repairs, more than adequate. But what the lawyer really wants is to suggest a stock sale by his client Peters to fund one of the Swift inventions. Tom is skeptical, refuses, and shows the representative the door. The man is angry: "You will regret this. You will be sorry for not having accepted this offer." (Page 67) It is clear that the Peters problem will not go away.

Tom continues to beat the dead horse that is the photo-telephone: "I'm going to try a totally different system of transmission. I'll use an alternating current on the third wire, and see if that makes it any better. And I'll put in the most sensitive plate I can make." (Page 68) His next plan is to wet the selenium plate with water because, "even in a little puddle of water on the sidewalk you can see yourself reflected." (Page 77) Come again? Would you like your telephone wet or dry? Well, that didn't work either and Tom was getting discouraged. We also learned that his test telephones used what he called an "acoustical amplifier," described: "These amplifiers were somewhat like the horn of a phonograph - they increased or magnified the sound, so that one could hear a voice from any part of the shop, and need not necessarily have the telephone receiver at his ear." (Page 121) And from this is learned that the word amplifier was used in 1914, the year of this writing, as the telephone company was amplifying calls using mechanical amplifiers, and the phonograph model for amplifying using the horn had been around since 19th century Edison. Although not implicitly used in this story, the mechanical amplifier method consisted of a carbon telephone microphone, battery and earphone in a enclosure to acoustically amplify. It would be at least a year before Lee de Forest would sell his vacuum tube amplification patent to the telephone company, thus introducing electronic amplification. A second thing learned from this sentence was something implied in the Swift lab - that the workers were all men, thus the "his ear."



Tom in his lab using the Photo Telephone.

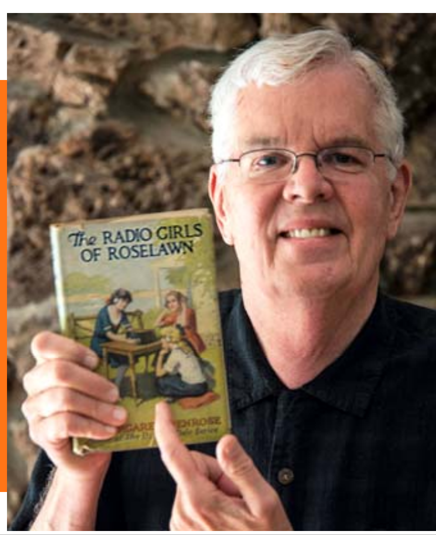
But now, in what has been a series of major misunderstandings until now, the purpose of the photo-telephone is made clear when a 1000 volt current is accidentally added to the telephone circuit, causing a picture to appear on the screen. Just a still picture, one frame? Is this what Tom had in mind? It seems so as he explains: "The young inventor had put in a new plate, carefully putting away the old one with the picture of the giant. (Koku was in the phone test booth so his picture was taken) This plate could be used again, when the film, into which the image was imprinted, had been washed off." (Page 125) This book is more than half over and this is about still pictures sent electrically? Tom does clarify at least one purpose for the device: "The photo-telephone is a fact, and now persons using the wire can be sure of the other person they are conversing with." (Page 126) So every phone booth is equipped with a selenium plate, a darkroom, and pictures are taken without a conventional camera. And because we already know that the sub-title of this story is "the picture that saved a fortune," you may assume that the climax involves Mr. Damon and Tom's invention du jour. A hint is offered by Ned: "Could you arrange it so that the person who was talking to you would have his picture taken whether he wanted it or not?" (Page 133) This invention will be used to fight crime as well as trample civil rights as Tom explains: "I could conceal the sending plate somewhere in the telephone booth. That might be a good way in which to catch a criminal. Often crooks call up on the telephone, but they know they are safe. Now if I could get a photograph of them while they are telephoning." (Page 132)

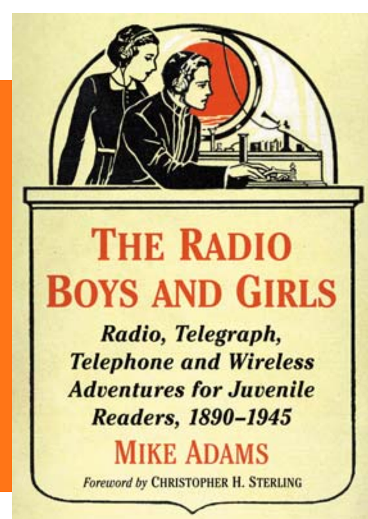
There is a word used to refer to the criminals who absconded with Mr. Damon's fortune, saying it was taken by the "sharpers." This obsolete bit of slang is one of the few older words found in this volume, many less than in other volumes of the same era. Soon, Tom learns that the kidnapped Mr. Damon was being held for ransom, and a phone call with directions telling Mrs. Damon where to bring the rest of his fortune, and the land deeds, would be forthcoming. Tom does find out that the first call originated from the local drug store, and of course he makes arrangements to set up his device so as to record the face of the caller/sharper. He also sets up other photo-telephones in other remote pay phone booths the criminals might use. Shopton is a very small town. Tom hopes to get evidence that will convict, and several times he tells Ned that just because he believes someone is guilty, he has to get actual evidence that will stand up in court. In this belief he is doing the reader a good service, just in case said young reader does not understand the rules of evidence: "You see it takes quite a combination of evidence against a criminal, evidence that will convict him," said Tom. (Page 173) One of the story elements analyzed in this book is the relationship between the often reckless boy heroes and the authorities, and in this case Tom Swift uses this opportunity to express how he understands the arrest and conviction process, the legal system. He is careful, nothing is taken for granted.

So the kidnapper called as hoped from one of the specially-prepared phone booths, Tom recorded the picture, and rushed it into the dark room for developing: "The photo-telephone had done its work. Whose image would be found imprinted on the sensitive plate? Tom's hands trembled so that he could scarcely put it in the developing solution." (Page 183) The end is near. And as was expected, the picture from the phone device's plate was the original bad guy Peters: "There, imprinted on it by the wonderful power of the young inventor's appliance, was the image of the rascally promoter." (Page 185) The evidence was enough to get warrants: "It's a new way of convicting using the photo-telephone - but I guess it's a good one, said the judge who signed the warrants." (Page 197) Now as Tom closed in on the evil Peters, another bit of obsolete slang is used following car trouble: "Broken front axle! We're dished." (Page 203) "Dished" meaning screwed! But as luck would have it, the car broke down right in front of the kidnappers house so Mr. Damon is saved: "Bless my pocketbook, I don't care if my fortune is lost, as long as I am alive and can get back to my wife." (Page 213) Of course the fortune is recovered, and all ends well. Says Ned: "The plotters are in prison for long terms, and Mr. Damon is found, together with his fortune. The photo-telephone did it." (Page 215) This is how all Tom Swift adventures end, the bad boys in jail, and another invention vindicated. And while this adventure was thin on science, it did use the visual image to solve a useful problem, the warrantless gathering of evidence.

This story may remind you of the ubiquitous cameras now in every store, parking lot, and street corner. The major premise, that of seeking incontrovertible visual evidence is solid. The ancient adage, a picture is worth a thousand words, holds true today. Nevertheless, you have to read these books knowing that much of they believe about technology is wrong. Reading this today with your STEM education, at least you know where Tom went wrong, and perhaps you could forgive him for his lack of knowledge and perspective circa 1914. This story also presents an earlier analogue era, one in which you have to develop the picture and wait for the result.

Author Mike Adams is Professor Emeritus at San Jose State University where he was the long time head of the Radio-TV-Film department and the Associate Dean of the College of Humanities and the Arts. He is the author of seven books. He is the CHRS Board Chair, its official photographer and auctioneer of vintage radios at CHRS Radio Central in Alameda.





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How I Molded My Feet

By Richard Quam

This article appeared in the January 2016 Volume 37, Number 1 issue of the Horn of Plenty, a monthly publication of the Puget Sound Antique Radio Association. The article is generously and graciously provided by Richard Quam, article author and the editor of the Horn of Plenty.

No, not my feet. Please allow me to explain.

I acquired a Radiola 60 a few months back and it was missing the four round feet that should have been attached to the bottom of the cabinet at the corners. Dirk van Veen, a fellow Pugent Sound Antique Radio Association member, was kind enough to loan me one from his Radiola 60 to make a mold.

Fig. 1: Sample foot from a Radiola 60 to be used as a model to reproduce the part in resin.

This would be my first attempt at molding a part and research led me to compounds made by the Alumilite Corp. Their products are available online and at the Hobby Lobby stores.

This is what the sample foot looked like. It's about 2 inches in diameter and 3/4 of an inch tall (Figure 1).

I chose Alumilite's High Strength silicone mold compound. It has high tear strength, great flexibility for parts with undercuts, and does not require a release agent.

Fig. 2: Sample foot placed in the form.

Fig. 3: Pouring the mold compound.

I used a short piece of 4-inch plastic drain pipe for the form, attached to a CD case with RTV. The sample was held to the CD case with a piece of double-backed tape so it wouldn't float when the mold compound was poured in. (Figure 2)

The two-part mold compound is easy to use with its 1:1 mix ratio. After mixing, it was poured into the mold. (Figure 3)

Even though it was supposed to be cured in a couple of hours, I let it sit overnight.

The flexibility of the silicon rubber made it very easy to release the original part (Figure 4).

Fig. 4: Sample foot removed from the mold.

Alumilite RC-3 resin uses two chemicals.

Fig. 5: Pouring the two resin chemicals A & B into a cup.

Fig. 6: Mix thoroughly.

Fig. 7: Pour the resin into the mold.

The details picked up by the mold were amazing; Several small aging cracks in the original part were visible.

The casting resin was Alumilite's AlumiRes RC-3, with a cure time of seven minutes. It contains two 16-ounce bottles that are mixed 1:1 by volume or weight. Be sure to have everything ready because once mixed, you only have two minutes to make the pour (Figure 5).

The kit provides two small measuring cups. I poured the resins into a 4-ounce Dixie cup for mixing and stirred with the provided wooden paddle (Figure 6).

The mixing went quickly and provided me with enough time to pour before the 2-minute pot-life limit expired (Figure 7).

The resin changes color during the curing process and ends up as an off-white (Figure 8). The company does offer tinting compounds for different colors.

Releasing the casting from the mold was simply a matter of slightly twisting the mold and the casting popped out. I was able to mix and mold the four feet in well under an hour. Unfortunately, I failed to take a photo of the final casting. You will have to take my word that it was an exact duplicate of the original.

The Alumilite company web site <www.alumilite.com/> has a wealth of information with some excellent tutorial videos on casting parts.

Fig. 8: Resin curing in the mold.

Visit the Puget Sound Antique Radio Association at http://www.pugetsoundantiqueradio.com/

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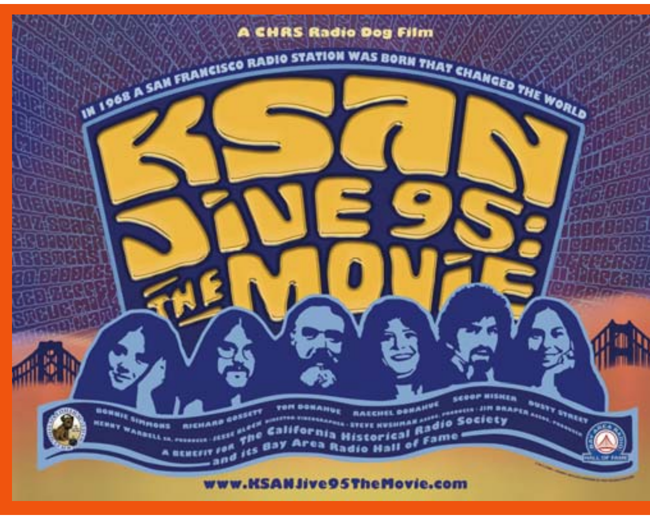
KSAN Jive 95: The Movie

Our CHRS Radio Dog Production, **"KSAN Jive 95: The Movie"** continues in production. But making a feature length documentary is costly. We are seeking to raise $150,000 to produce this film. The KSAN Jive 95 story is perfect for CHRS to tell and immortalize in film as it is an important part of our mission to preserve and present local radio history. KSAN, during the period 1968-1980, was pivotal in the development of our popular culture. This film will raise awareness and refresh remembrances of a time when a radio station could create change and really make a difference in so many ways.

Part of our recent grant from the Rex Foundation was earmarked toward the KSAN Movie project. We commissioned famous poster artist Wes Wilson for a movie poster. Wes and his daughter Shirryl Bayless collaborated to create this outstanding poster.

Now it's your turn to help. Please visit www.ksanjive95themovie.com and see how you can get great perks for donating to this project and help to preserve the KSAN Jive 95 legacy.

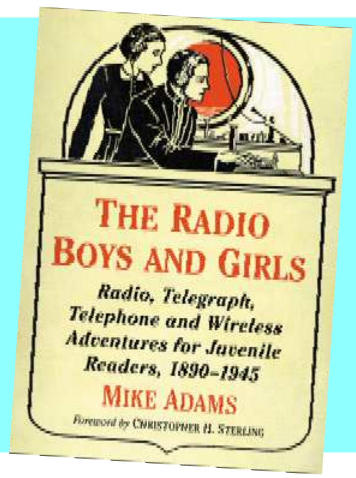


CHRS Publications

The Radio Boys And Girls—Radio, Telegraph, Telephone and Wireless Adventures for Juvenile Readers 1890-1945 is the latest book by Mike Adams, It captures the genre of series fiction about wireless and radio was a popular in young adult literature at the turn of the 20th century and a form of early social media. Before television and the Internet, books about plucky youths braving danger and adventure with the help of wireless communication brought young people together. They gathered in basements to build crystal. They built transmitters and talked to each other across neighborhoods, cities and states. By 1920, there was music on the airwaves and boys and girls tuned in on homemade radios, inspired by their favorite stories.

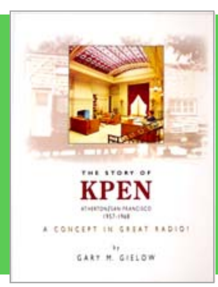
This book covers more than 50 volumes of wireless and radio themed fiction, offering a unique perspective on the world presented to young readers of the day. The values, attitudes, culture and technology of a century ago are discussed, many of them still debated today, including immigration, gun violence, race, bullying and economic inequality.

Available now at Amazon.com



The Story of KPEN: A Concept in Great Radio! CHRS member and Broadcast Legend Gary Gielow has written a new book chronicling the tales of two young men from Stanford, he and James Gabbert, who brought Stereo and new ideas to the FM radio band in the late 1950s and 1960s. This book is the definitive history of KPEN 101.3 FM, the 2015 BARHOF Legendary Station. 100% of the proceeds benefit CHRS.

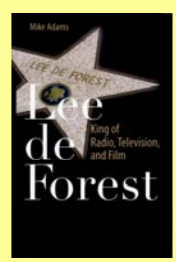
Available in the Museum Store or on the website.



Behind the Front Panel: The Design and Development of 1920's Radio by David Rutland has been re mastered by Richard Watts for CHRS. With emphasis on radio technology, Rutland describes the development of 1920s tubes and radio circuitry designs by De Forest, Marconi, and other inventors and manufacturers. A classic!

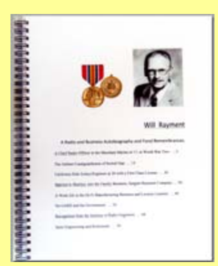
Buy at Amazon.com

Also available in the museum store



Lee de Forest

Bay Area Radio



Will Rayment

KSAN Live Jive CD

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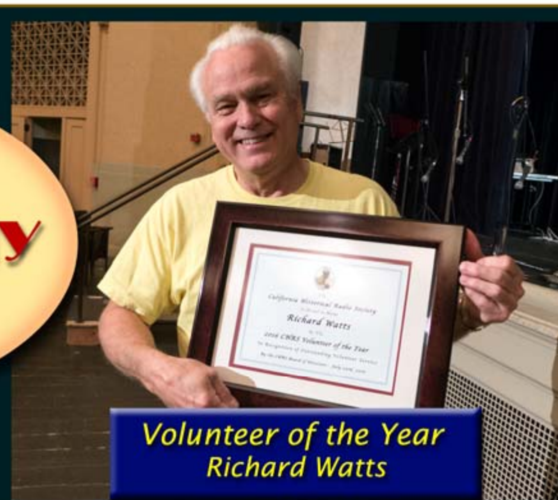

Volunteer of the Year
Richard Watts

Silent Auction

Auction Gallery

Radio Day Surplus Sale