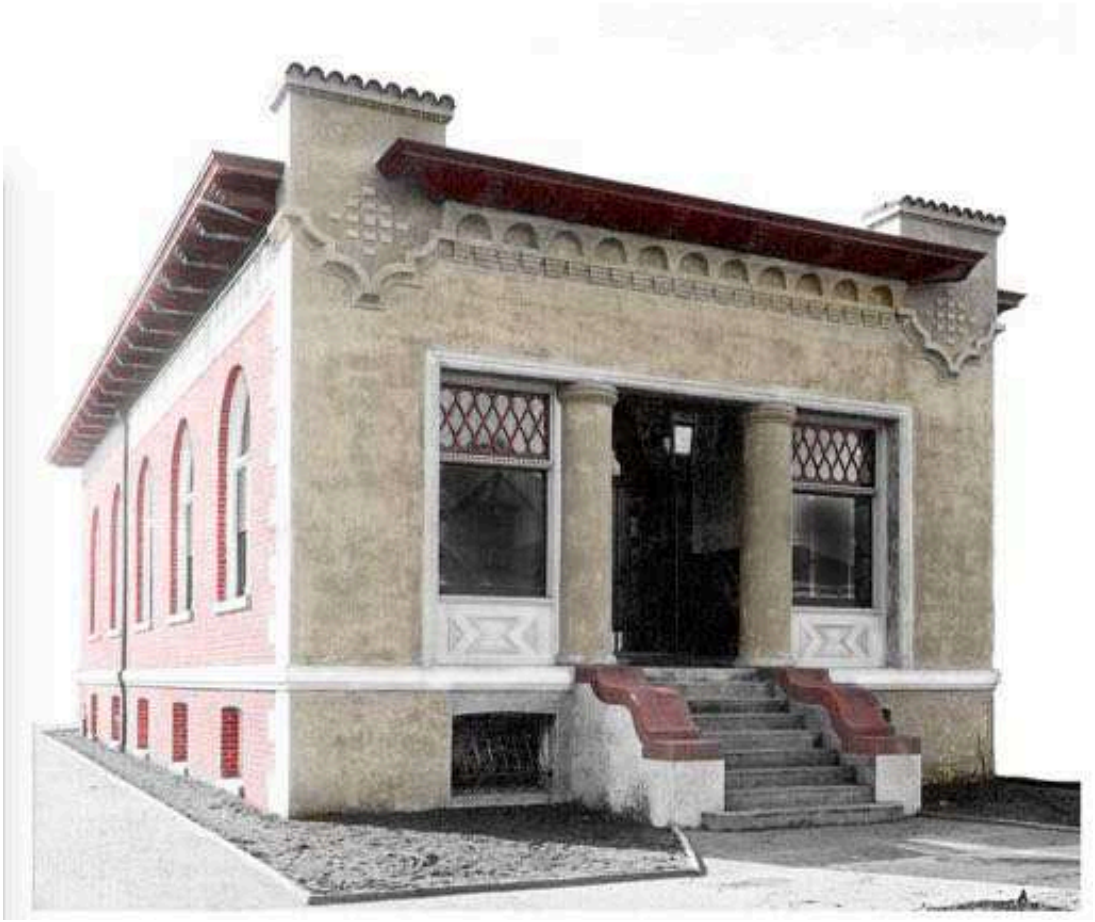
Long Wave Radio

A Presentation to the Mount Diablo Amateur Radio Club

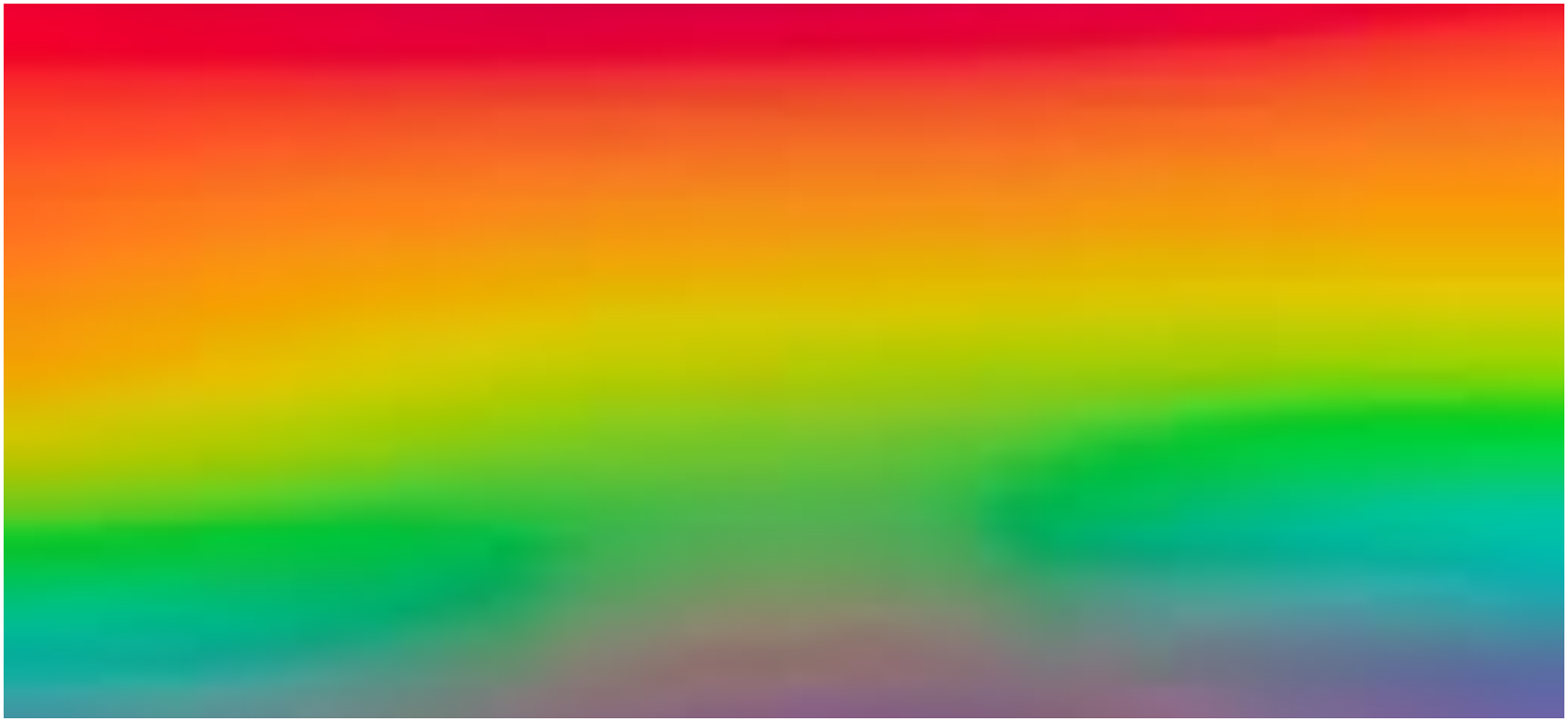
by Bart Lee, K6VK

From the California Historical Radio Society

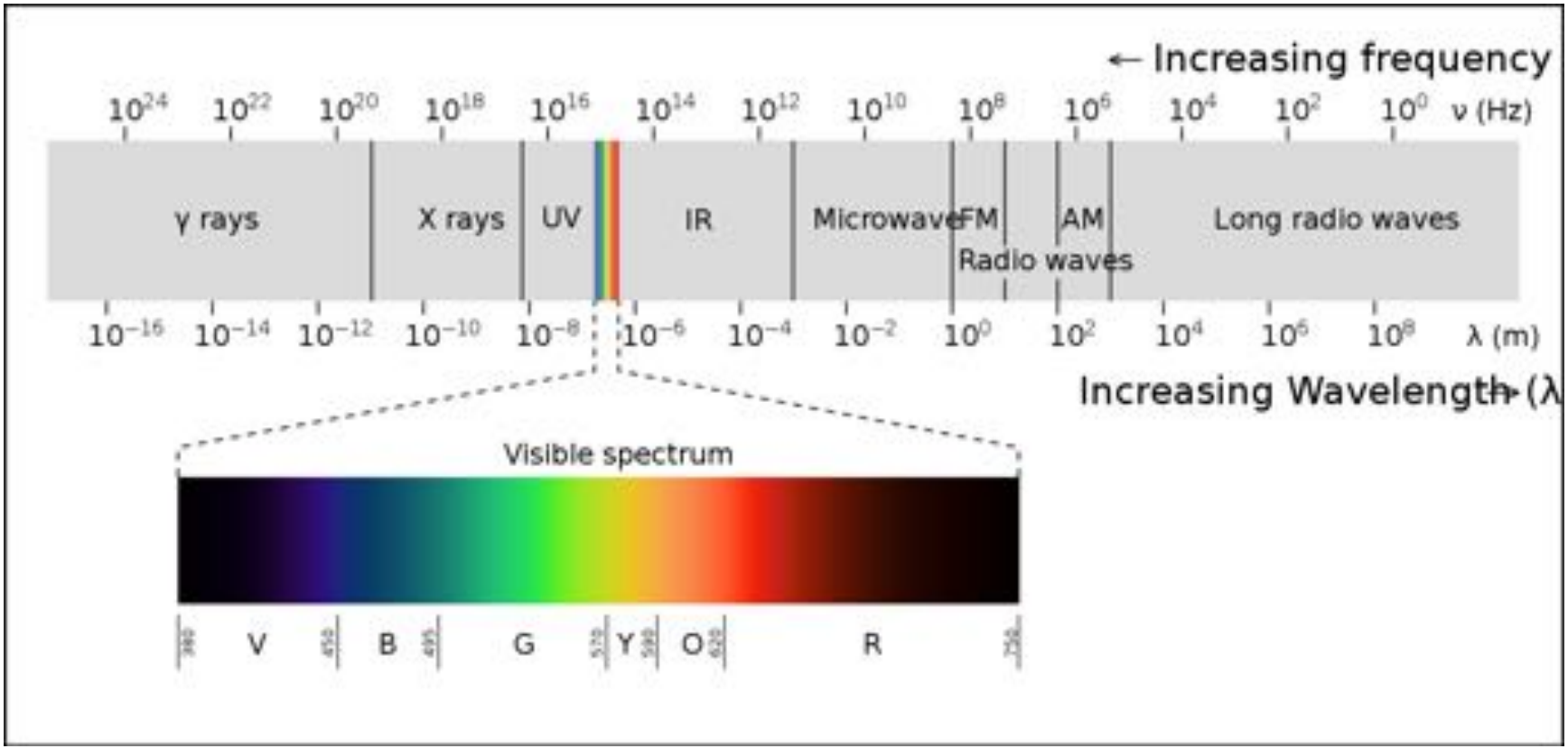
The CHRS Museum as it will be Restored as of 1901



Light is a tiny sliver of the electro-magnetic spectrum, from zero to gamma rays (see Maxwell, etc.)

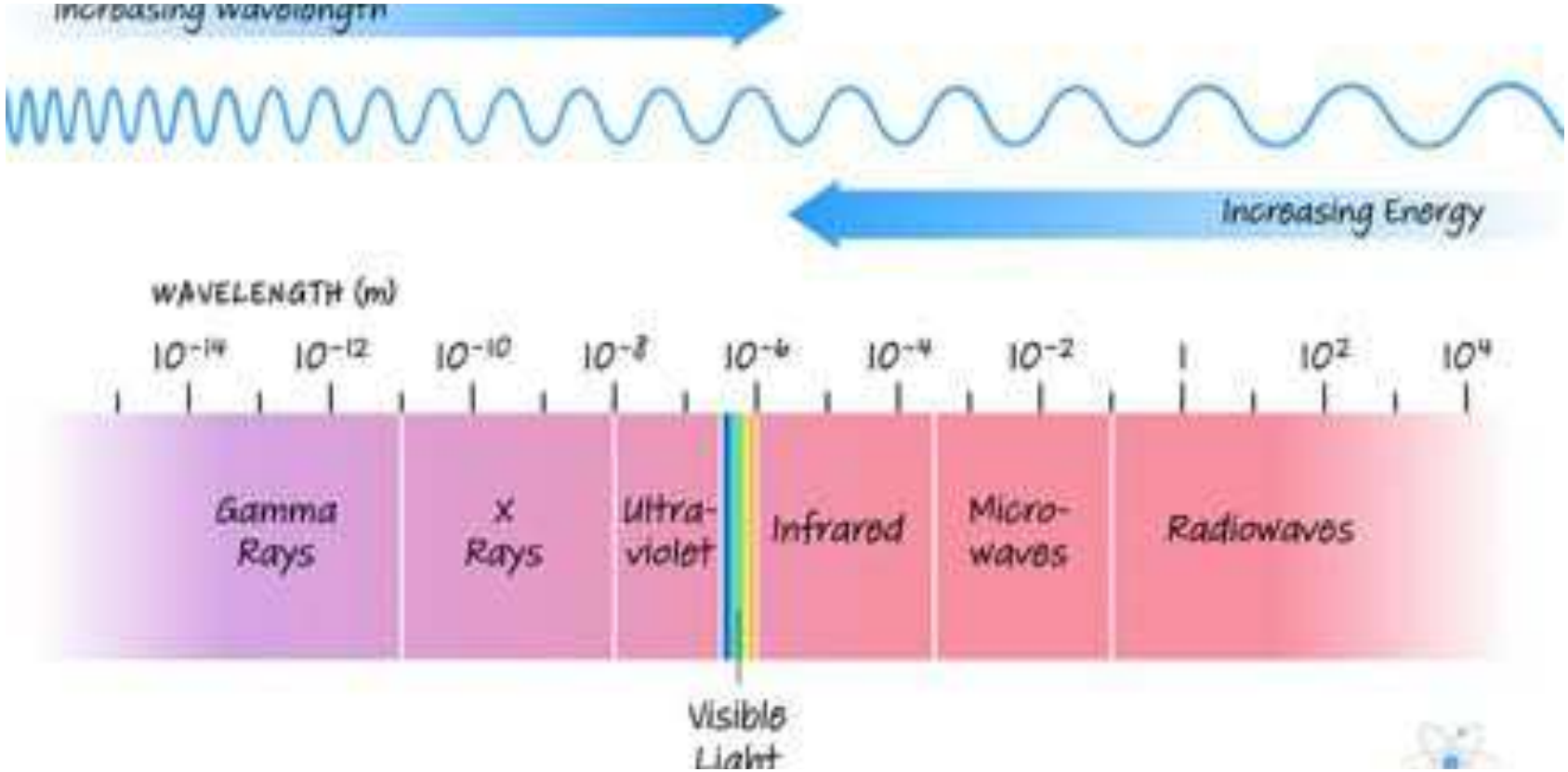


Radio Waves are longer than light waves, WAY longer (see Hertz, etc.); their photons just have less energy*



* So… they "vibrate" less frequently …

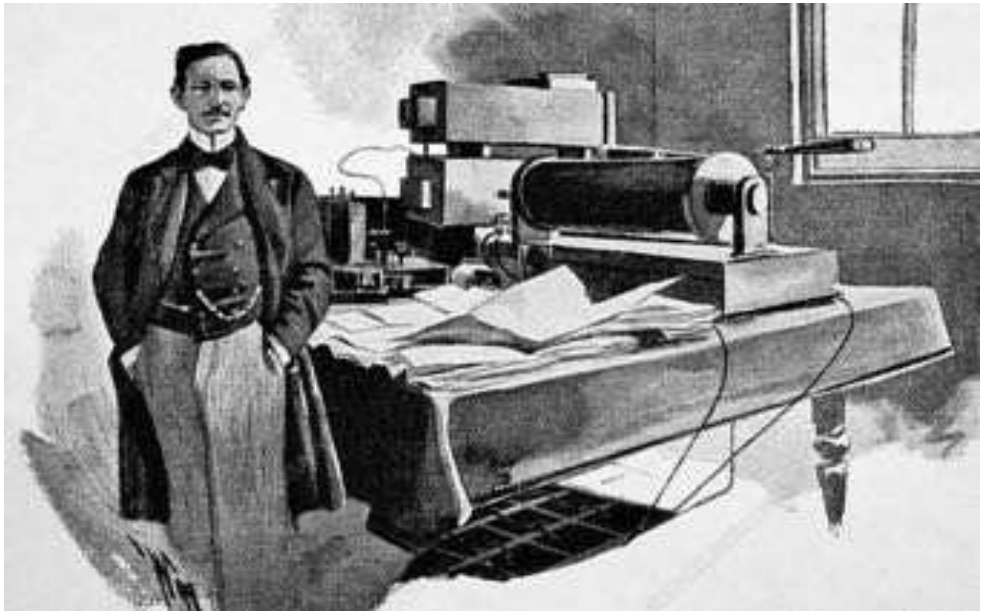
Radio works from 8 KHz or less to 300 Gigahertz or more; “Long Wave Radio” means those frequencies below the AM broadcast band, 0.540 KHz down to ten KHz or less. The lower the frequency, the longer the radio wave, i.e., the longer the distance between wave peaks, as the wave travels at the speed of light, measured in meters (e.g., 20 meters).



Long Wave Amateur Radio

- Two New (world-wide) bands:
  - 630 Meters = 472 KHz
  - 2200 Meters = 137 KHz
- Mostly digital transmissions (e.g., WSPR), but some CW and in Los Angeles, on 630 m,
  - single side band QSOs.

We owe it all to Bill Marconi and Jameson's Irish Whiskey



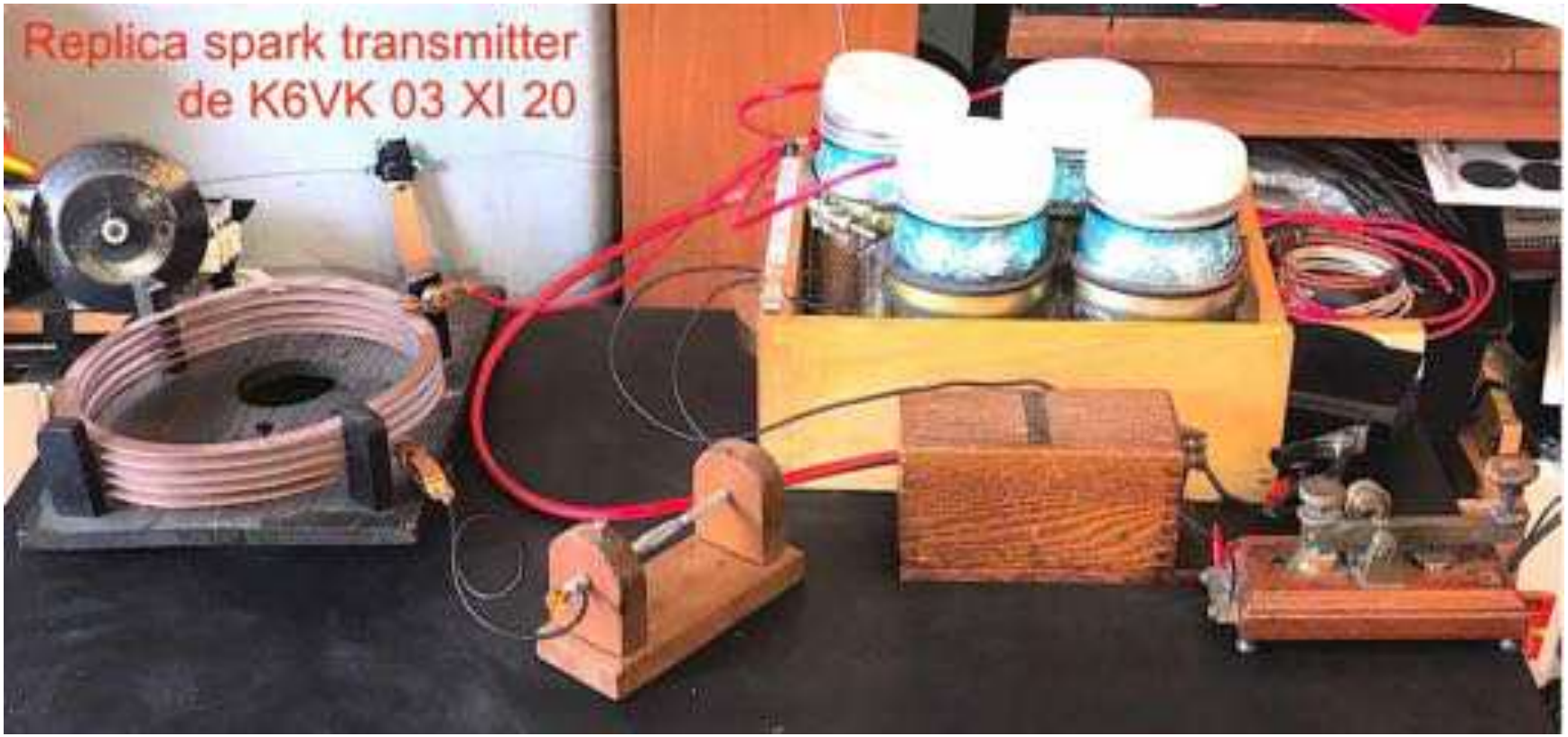
Marconi's mother, Annie Jameson, seems to have arranged Jameson money to fund the "start-up" Marconi company in the 1890s in London.

200 Meters and Down – Oh! Oh !

- Before 1912, amateur radio enthusiasts could operate anywhere in the then-available radio spectrum, almost always below 1500 KHz or 200 meters wavelength, "Long Wave" as we think of it now. Spark Gap transmitters reigned.
- The 1912 Radio Law outlawed amateur radio below 1500 KHz, 200 meters or only "200 Meters and Down."

- I made a replica pre-1912 spark gap transmitter for the California Historical Radio Society, using period-appropriate parts >>>

A Replica Spark Transmitter with Leyden Jars, too!



And the First Spark!!!

CHRS Holds Much Long Wave Gear

-- Photos by Walt Hayden and Cynthia Reinholtz

Marconi (Canada) Long Wave Receiver

HalCun Loose Coupler, c. 1916

Haller-Cunningham, San Francisco, Selling Marine Radio Equipment

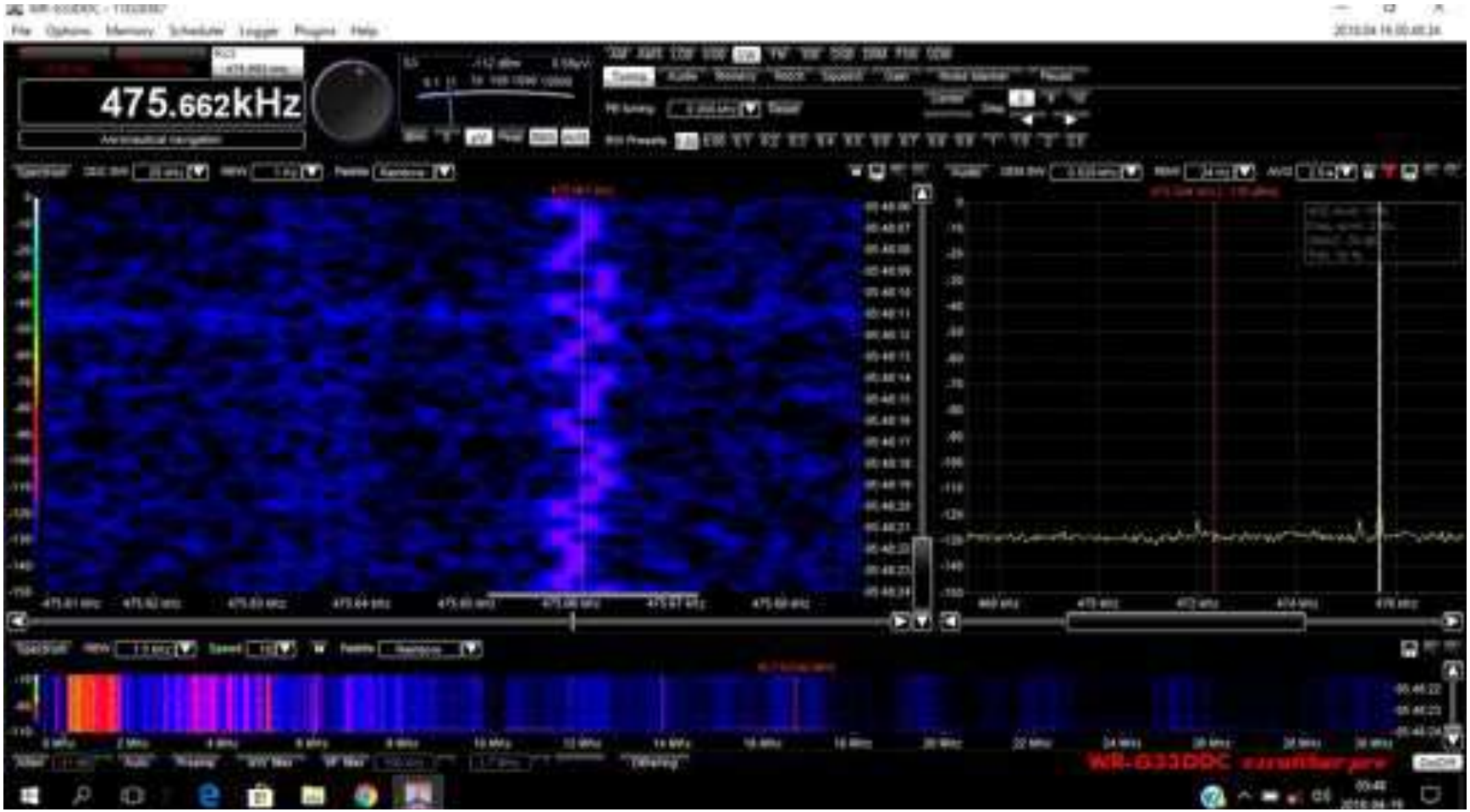
Spark Gap Transceiver WW-1 era

Mackay Marine Long Wave Receiver

WW-II ARC-5 Long Wave Aircraft Radio

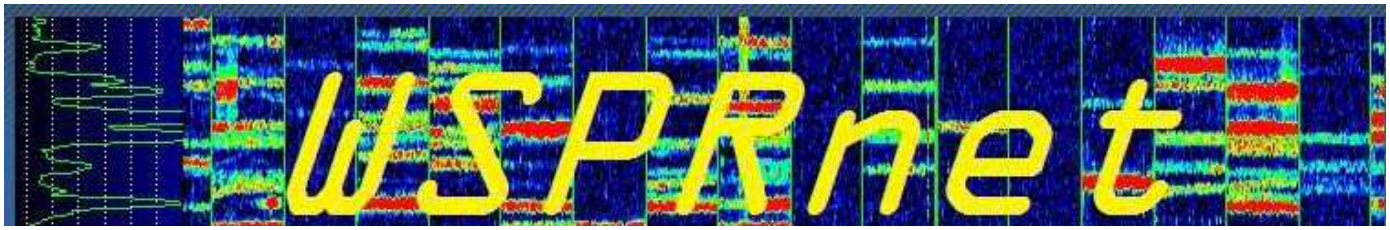
AMELIA EARHART'S LONG WAVE RADIO AND LOOP

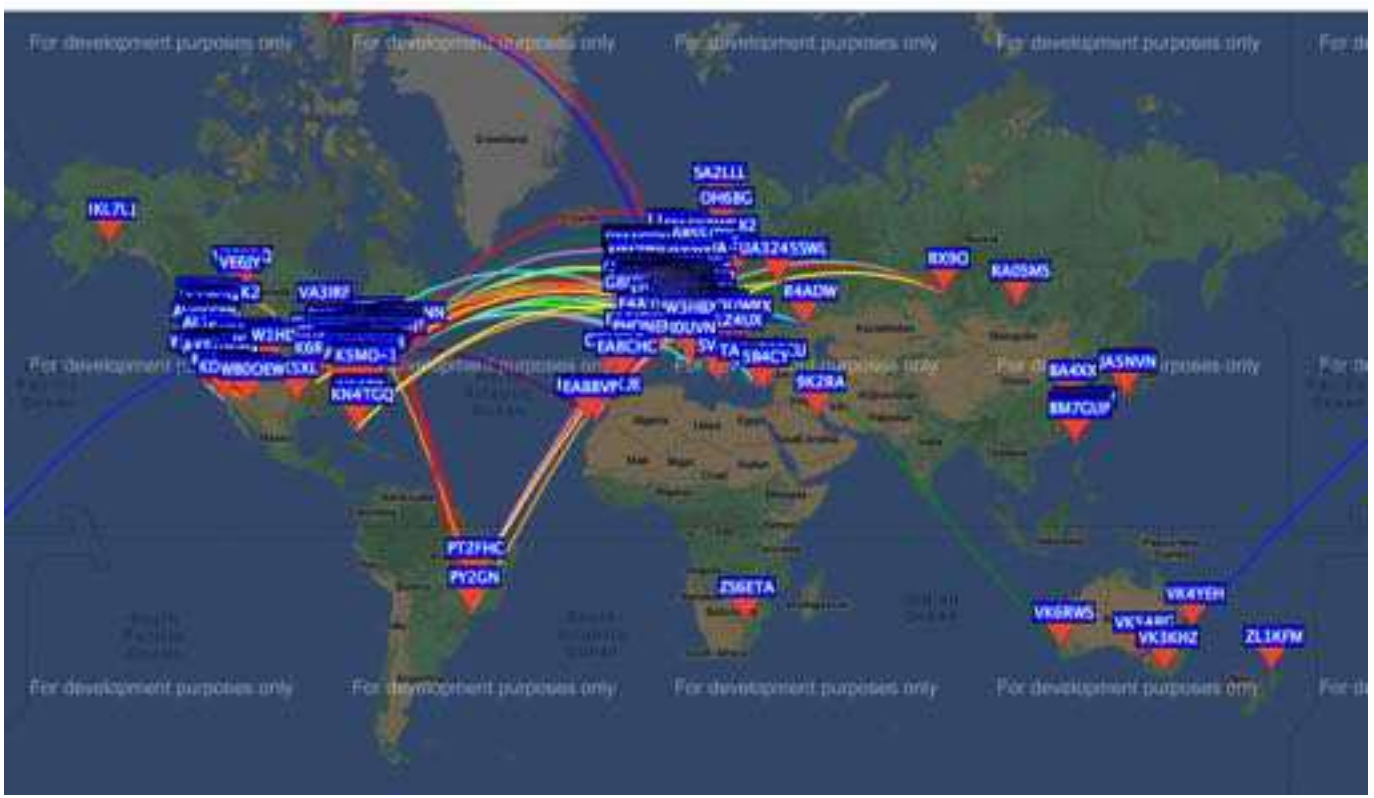
Resurrected Long Wave (Digital) Amateur Radio, Today



630 m 19 IV 18 0549 UTC 475.662 KHz WSPR Capture @ K6VK

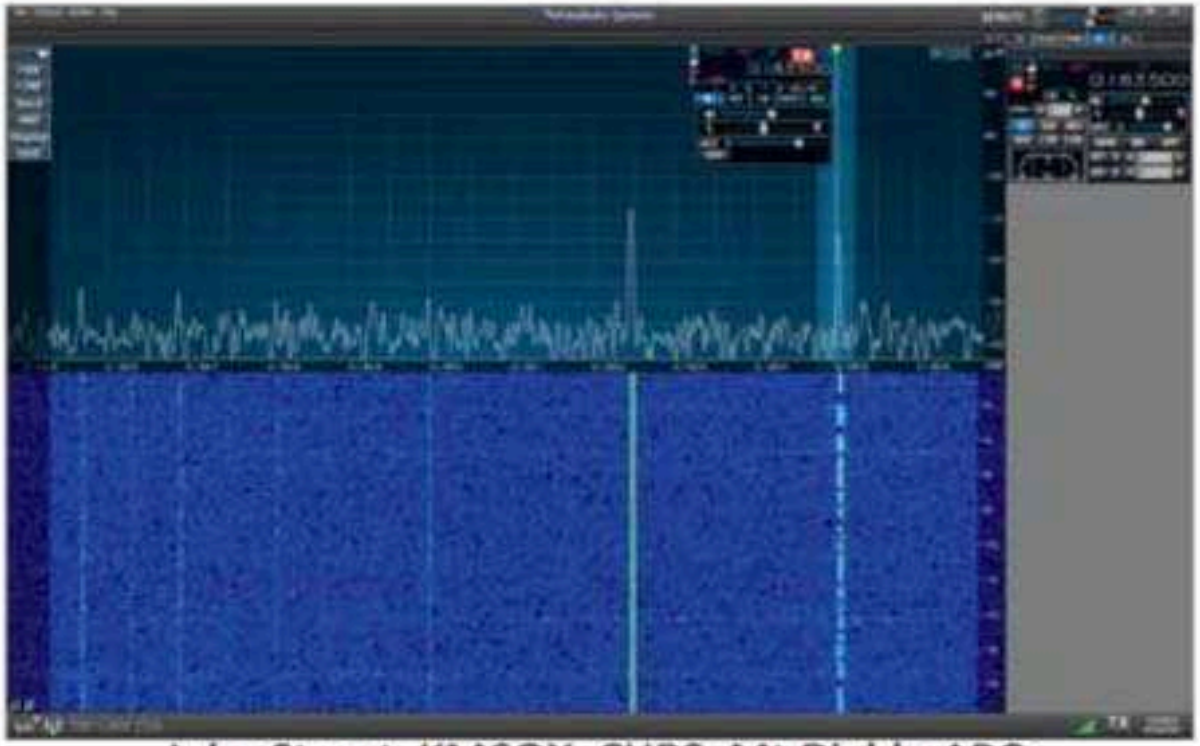
Weak Signal Propagation Reporter





LONG WAVE EXPERIMENTERS

LoFer Beacon WH2XVN



John Stuart, KM6QX, CHRS, Mt Diablo ARC;
Pixel Loop and Flex Radio, Lafayette, CA (first heard at K6VK)

Fig. 35. A record of receiving the Part 5 LoFer beacon WH2XVN on 183.5 kHz. (John Stuart)

183.5 KHz

LONG WAVE RADIO, THEN…

- PRIMARILY SPARK SYSTEMS, THE FIRST…

"BOLINAS HIGH POWER" NOW KPH, EMPLOYED THIS MARCONI NEARLY 300 KW ROTARY SPARK – "THE ROCK CRUSHER" ABOUT 1916

ARC SYSTEMS (CW)

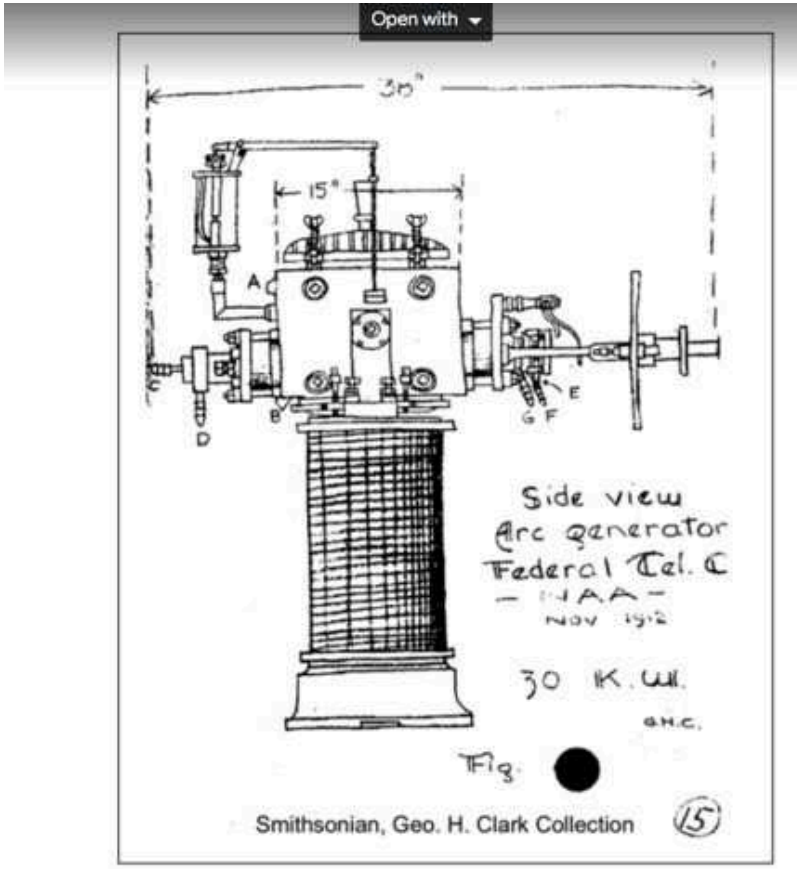


Fig. 13. A drawing by radio historian George H. Clark of a navy 30 kW arc as of 1912. (Smithsonian, Clark Collection, Bart Lee copy)

FEDERAL IN SAN FRANCISCO
PIONEERED ARC SYSTEMS, 1910

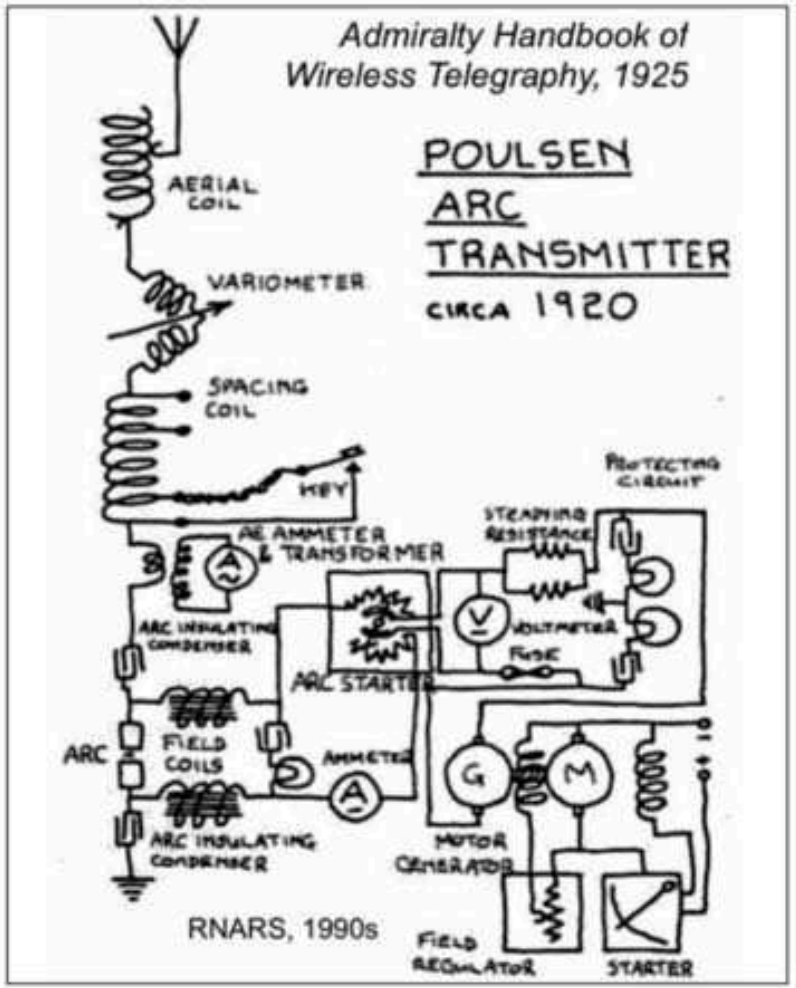


Fig. 12. A schematic diagram of Poulsen arc transmitter, circa 1920. (Cover of a 1994 Royal Navy Amateur Radio Society (RNARS) *Communicator*, 1994; schematic from the *Admiralty Handbook of Wireless Telegraphy*, 1925).

A MEGAWATT ARC – WW-I

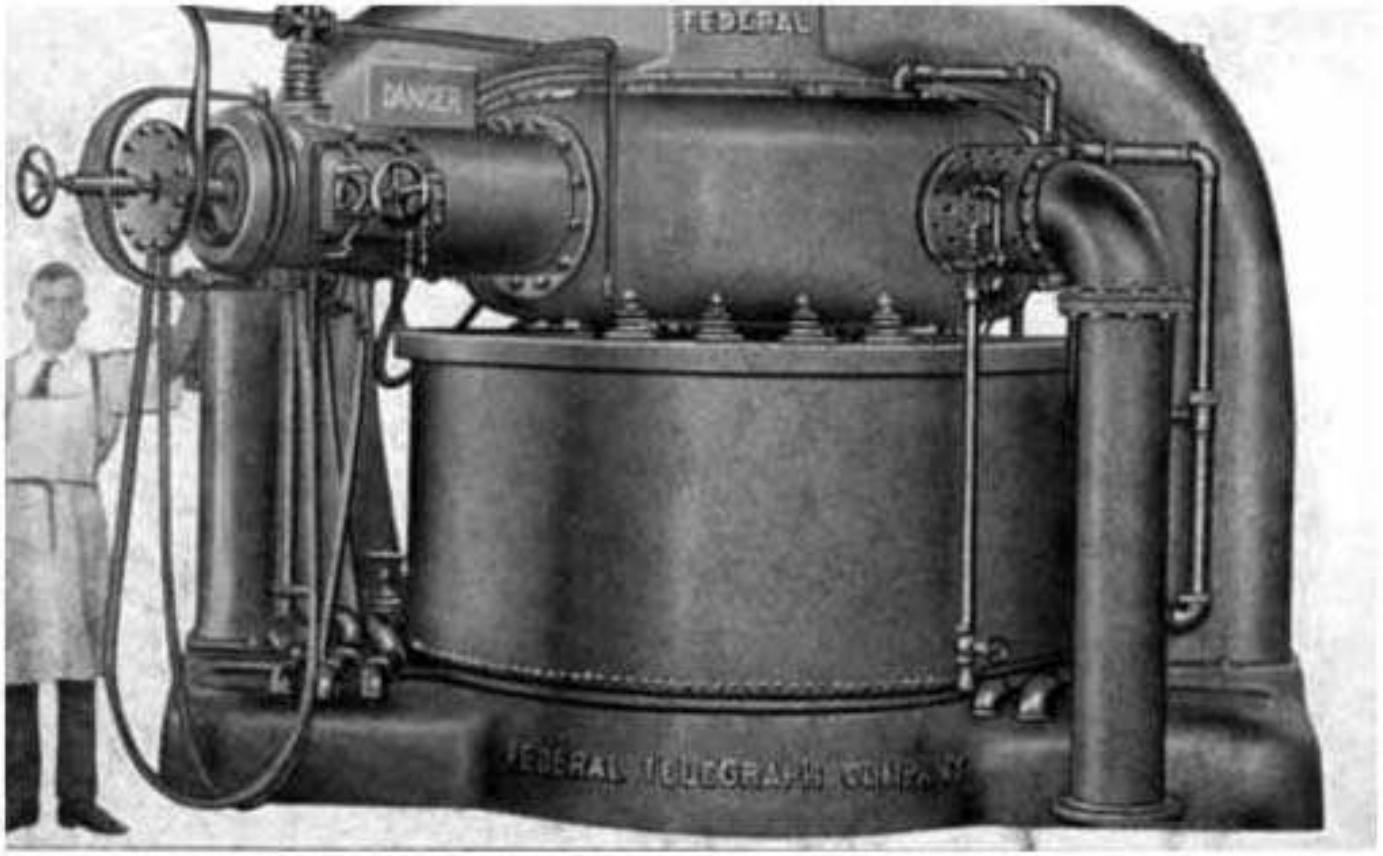
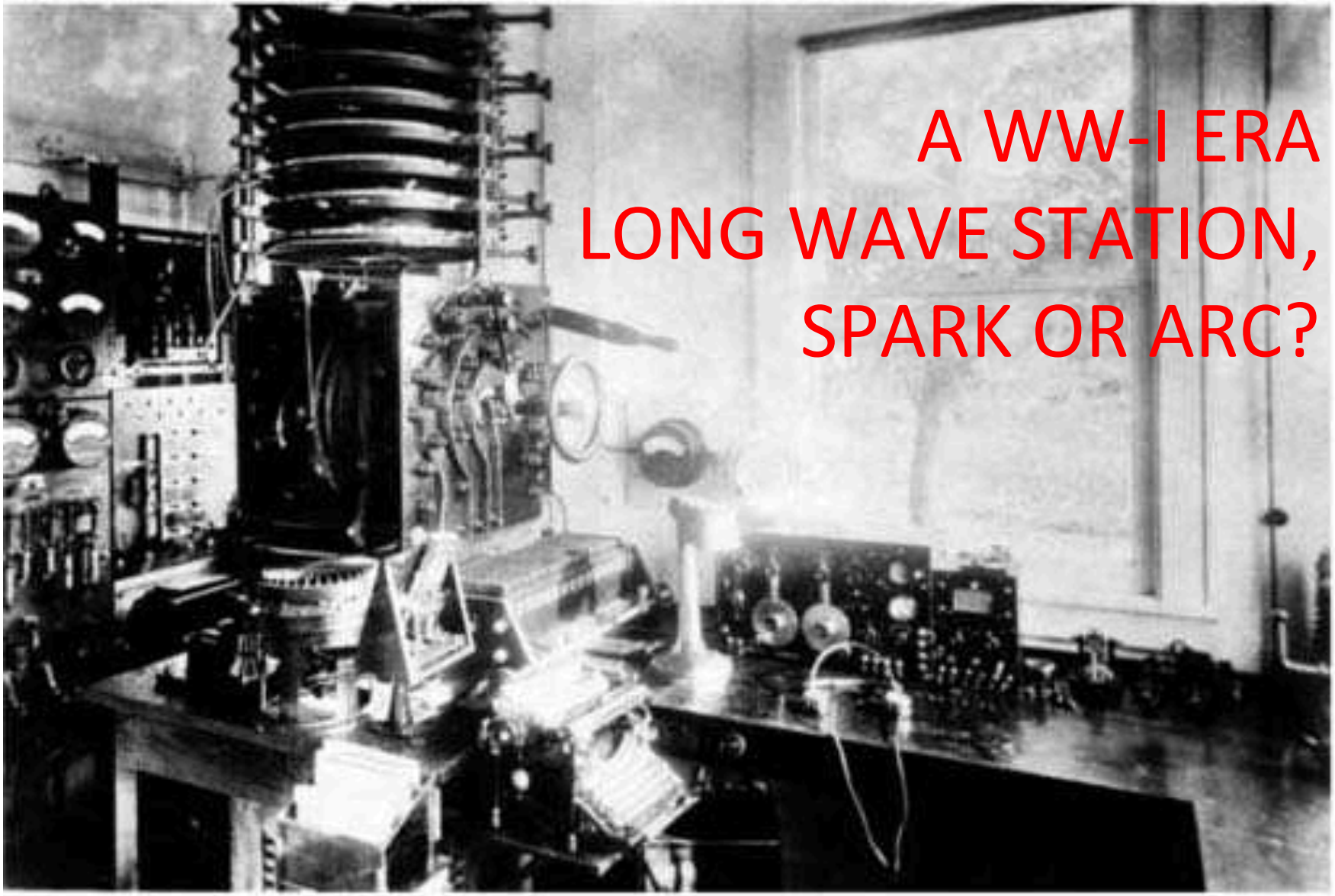


Fig. 14. A one megawatt large Federal arc, circa 1918, which operated in France circa 1920.



A WW-I ERA LONG WAVE STATION, SPARK OR ARC?

Fig. 7. A spark station, Navy or commercial dating from around WWI. This photo comes from the family of John Staples, and is known only as "Uncle Adrian's Radio Station." (John Staples)

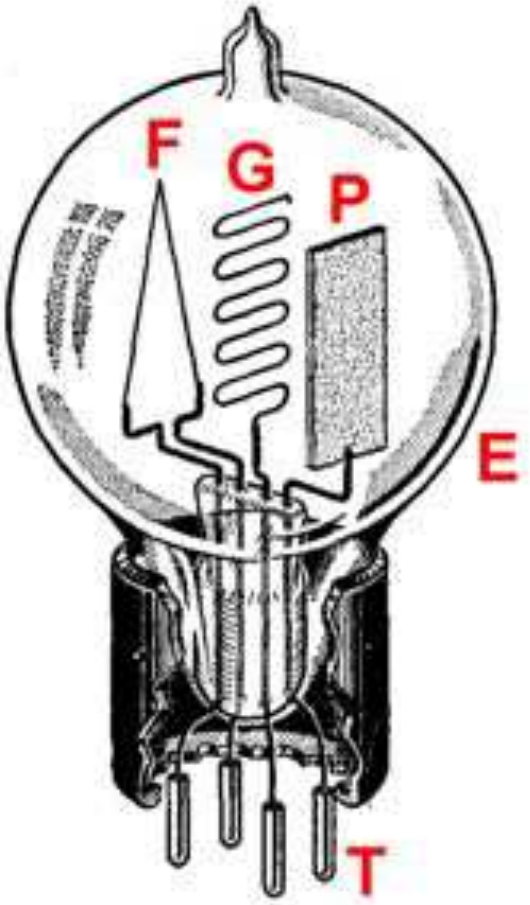
THE ALTERNATOR (CW)

THE SURVIVING SWEDISH RCA ALTERNATOR TRANSMITTER, SAQ (BART LEE PHOTO, 2018)

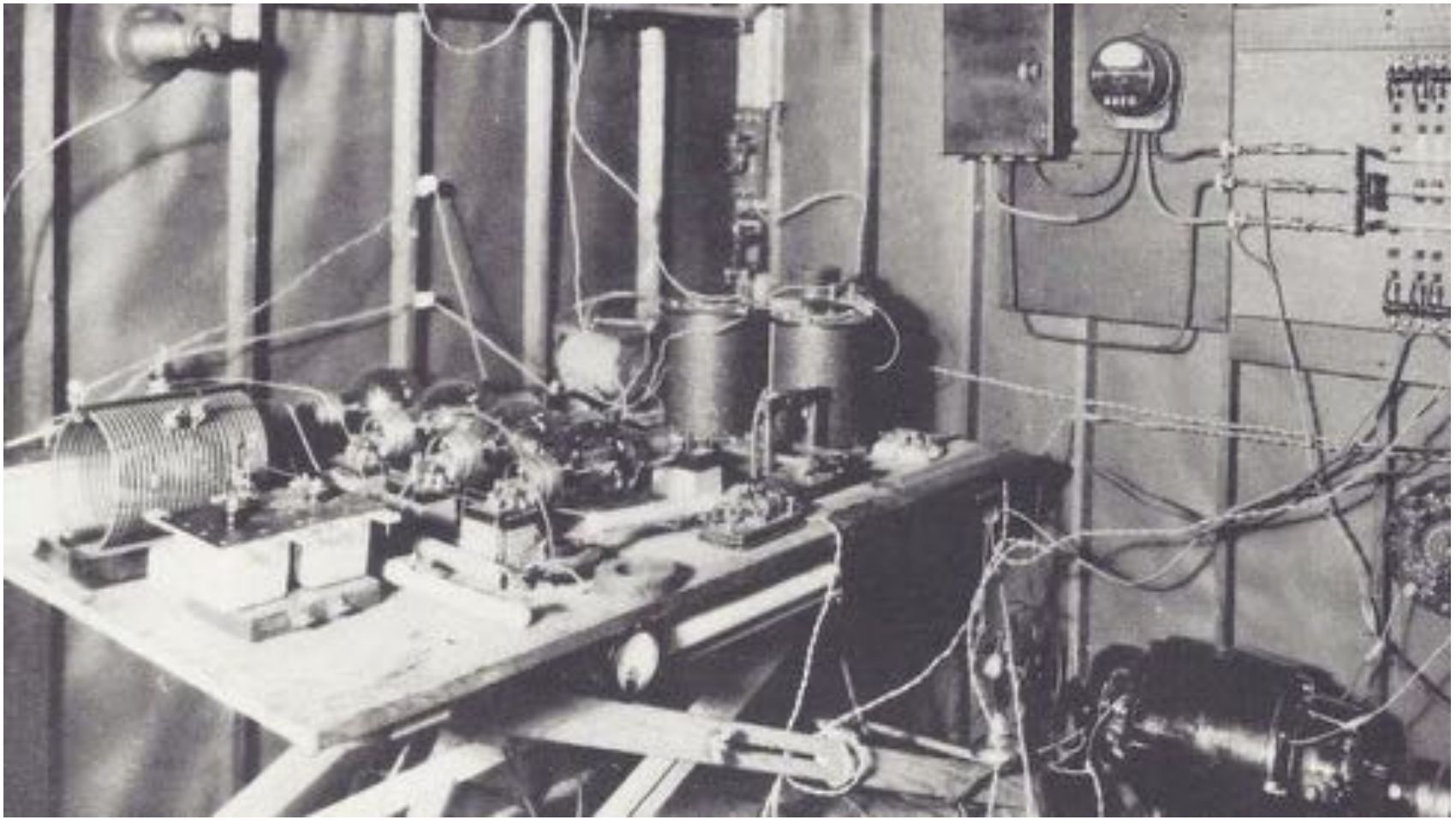
1930s USN LONG WAVE RADIO

Washington, DC area: Navy Receiving Center, 1930s

THE VACUUM TUBE COMETH, LONG WAVE DIE-ETH (or not?)



HAMS KILL LONG WAVE !!



N1BCG GETS ACROSS THE ATLANTIC, 1921 – WITH VACUUM TUBES! ON SHORT WAVE! MARCONI FOLLOWS – AND THAT'S THE END OF LONG WAVE (OR NOT?)

Long Wave after Short Wave…

- Radio Navigation, Marine and Aviation ("PNT")

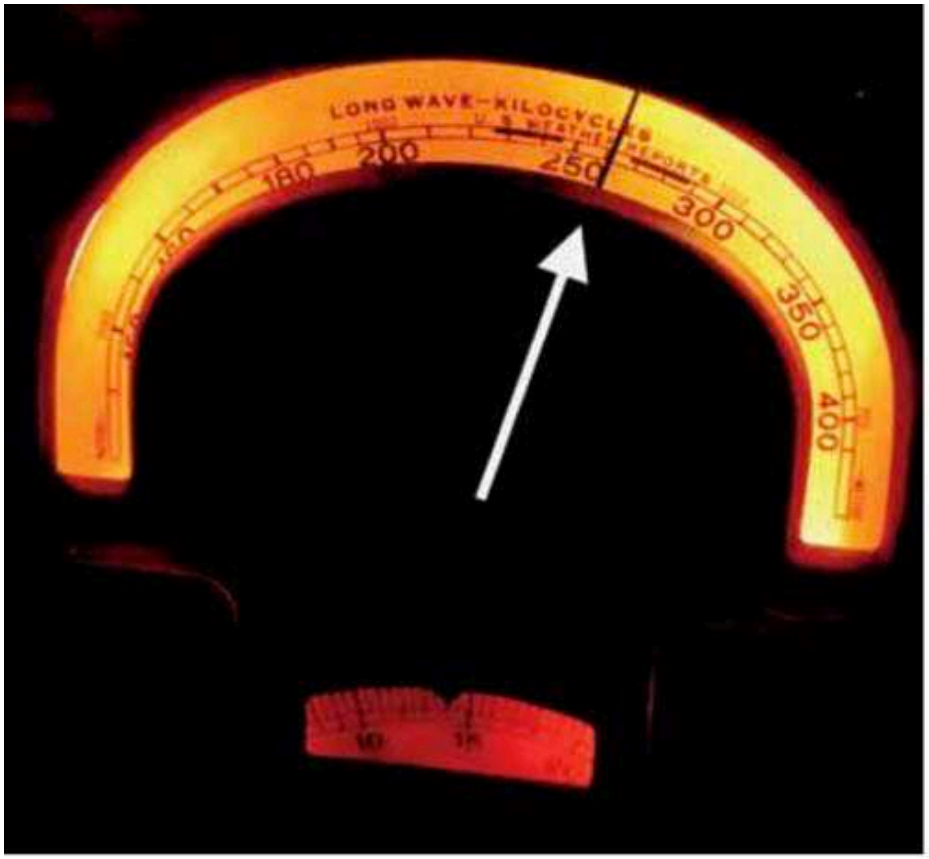


Fig. 25. The dial showing the "Weather Band" around 250 kHz, on a 1936 RCA 10K console radio. (Author's collection)

Aviation Weather 1920s to 1970s

Persisting Long Wave Radio

- Aviation Beacons (to this day… but… dying fast)

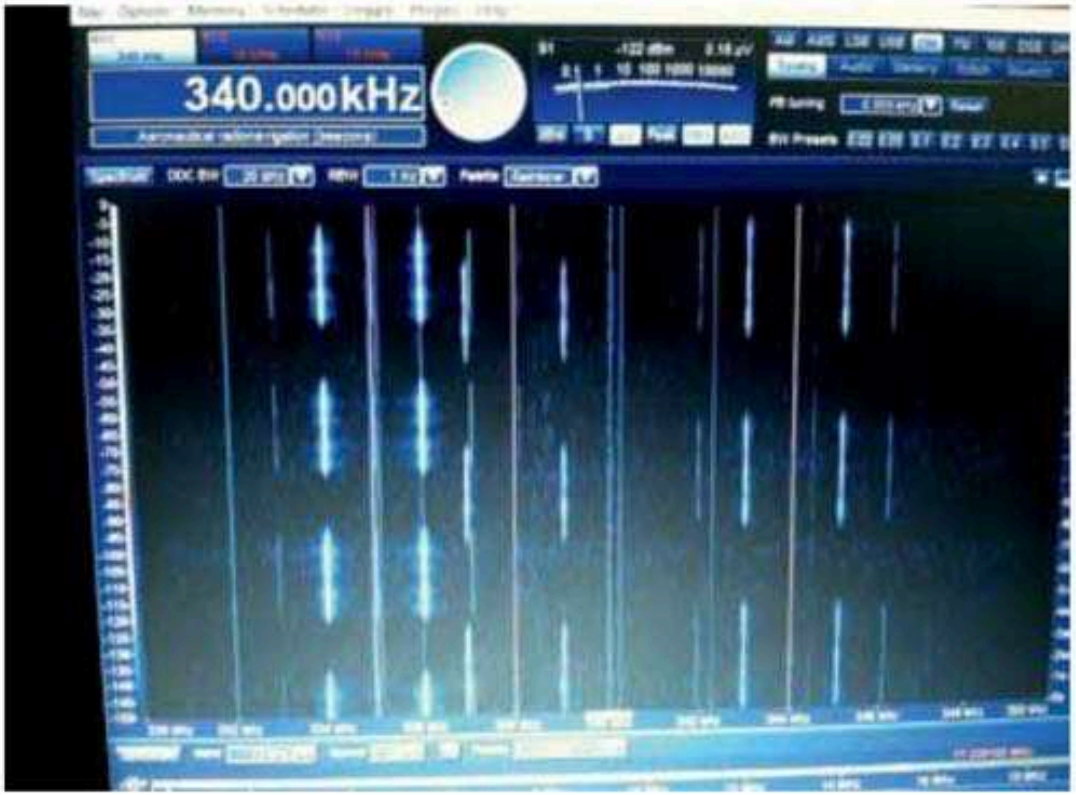


Fig. 24. Station CC in Contra Costa County, CA at 335 kHz, a typical LF beacon for an airfield. (Author's screen cap)

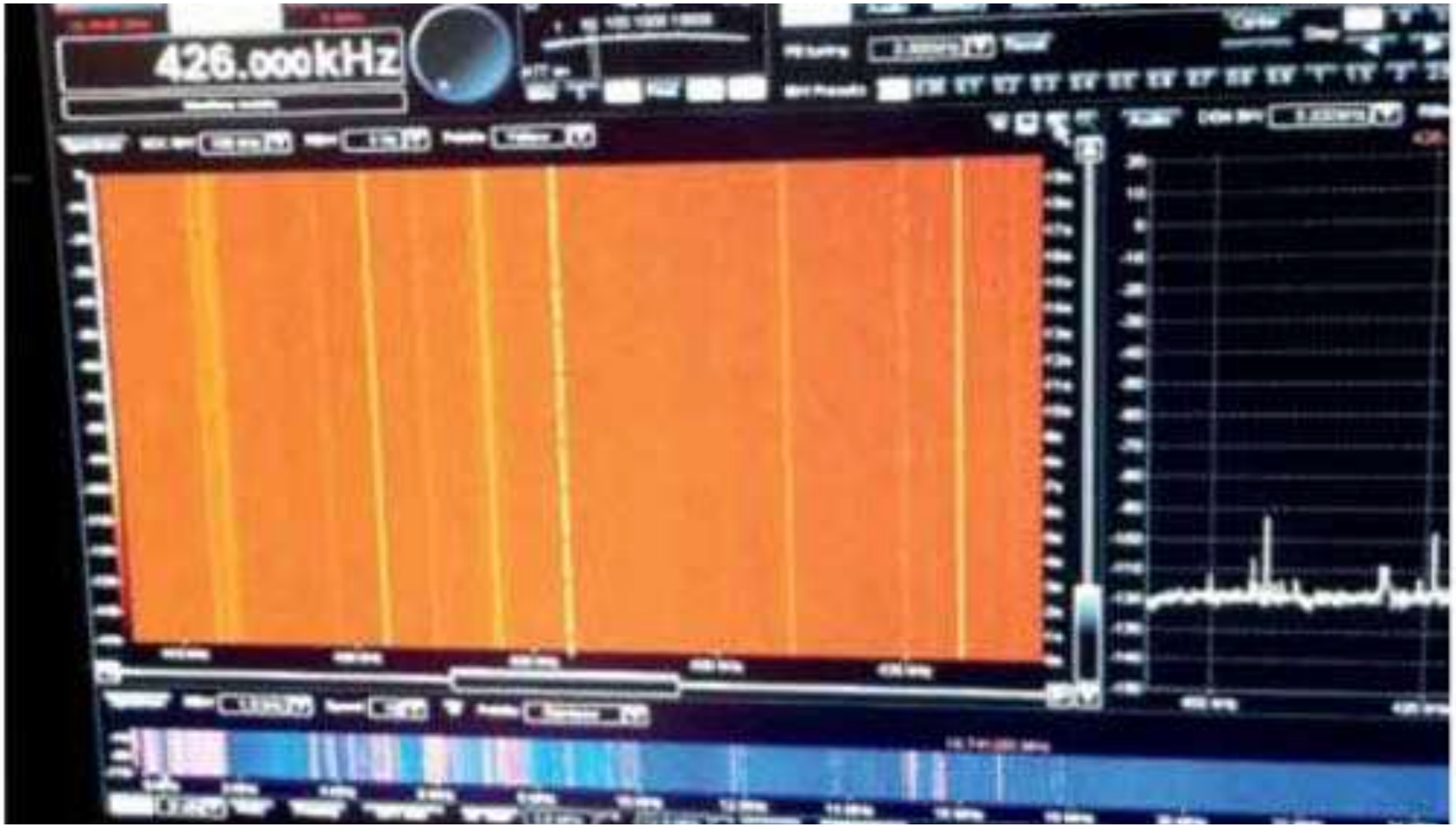
335 KHz "CC"
Concord, CA
Off the Air…

Long Wave Broadcasting …

- Radio Broadcasting in Europe, etc. (still … but… maybe as few as eight still on the air)

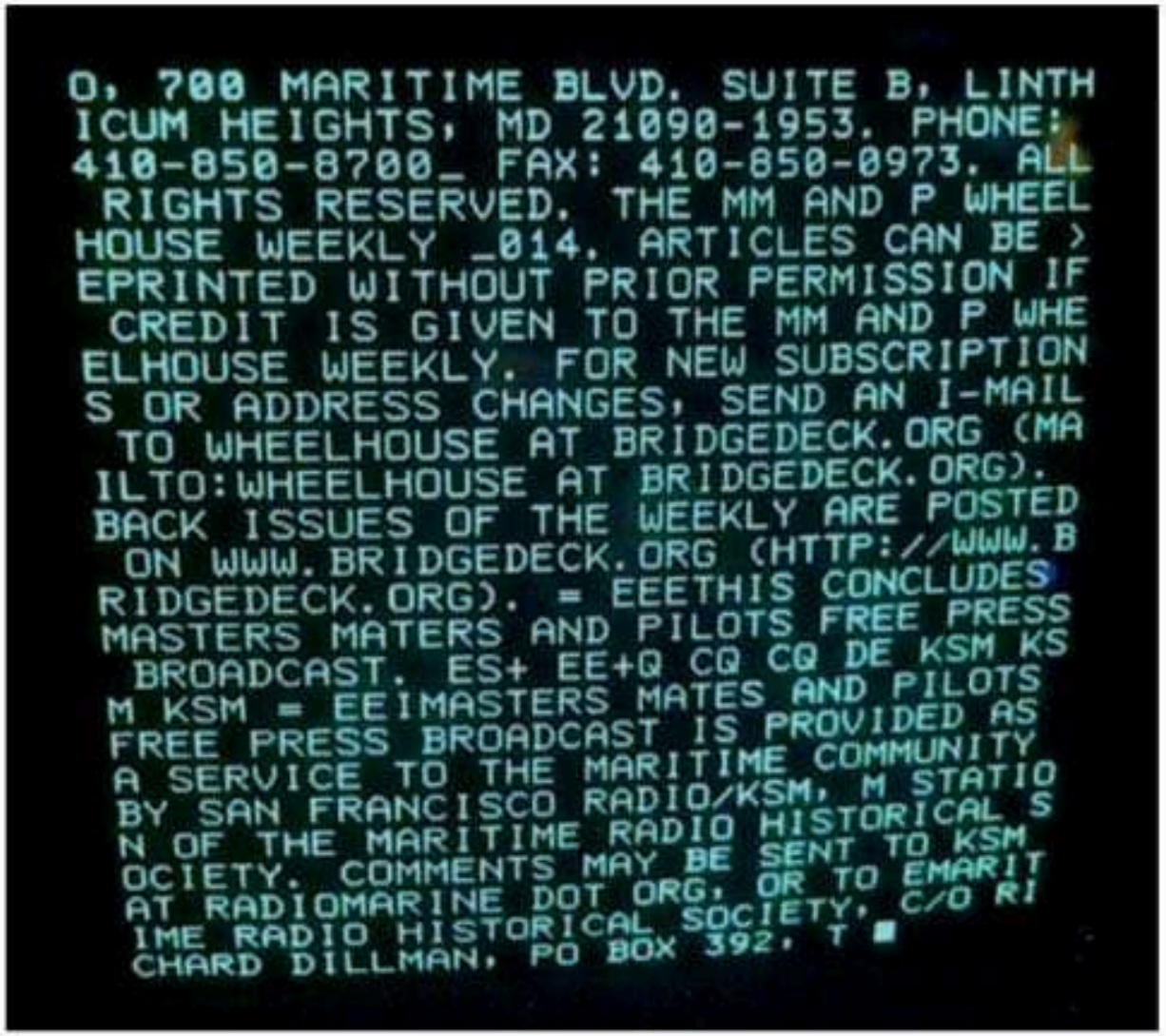
A long-gone long wave radio station that was on 252 KHz

Avocational Long Wave: KPH, KSM



Morse code from KSM (=KPH) Bolinas, CA, on 426 KHz

Maritime Radio Historical Society



Yet Long Wave Radio Thrives…

- PNT (Position, Navigation and Time)
- NAVTEX Coastal Radio warning and weather texts – and distress traffic
- Naval and Military Communications

PNT: WWVB 60 KHz

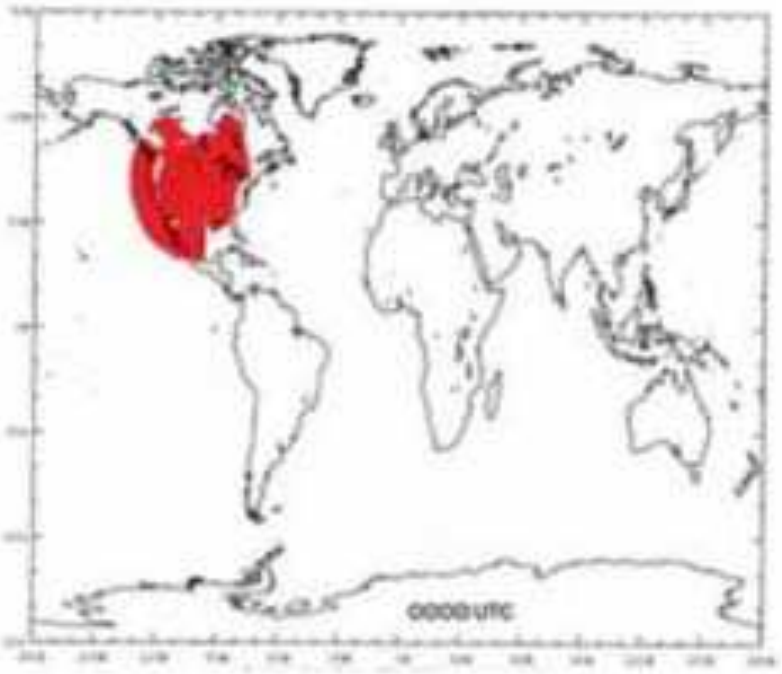


Fig. 17. Day range, WWVB, 60 kHz. (NIST)

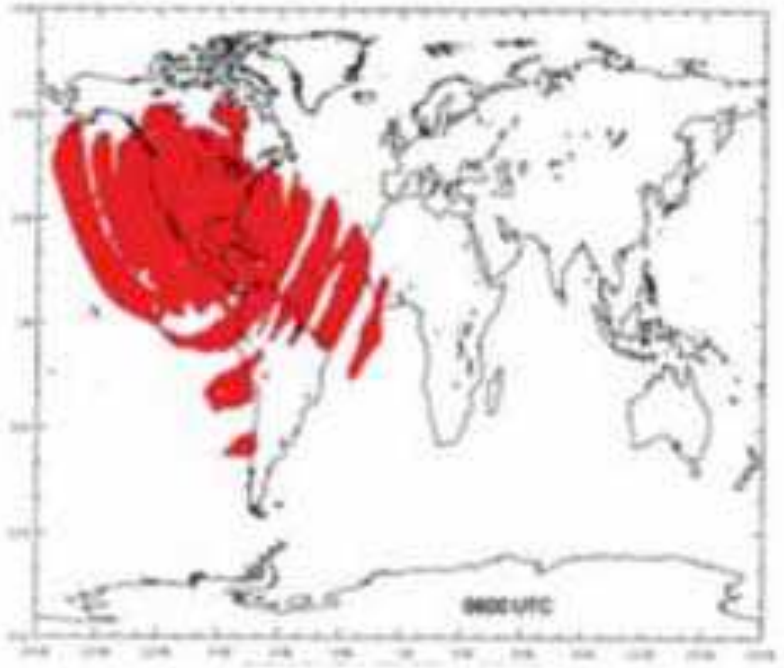


Fig. 18. Night range, WWVB, 60 kHz. (NIST)

The Basis for our “Atomic Clocks”; China, Japan, UK, Russia, France *etc*. also transmit PNT data on long wave.

PNT: RUSSIAN ALPHA STATION for Submarine Navigation

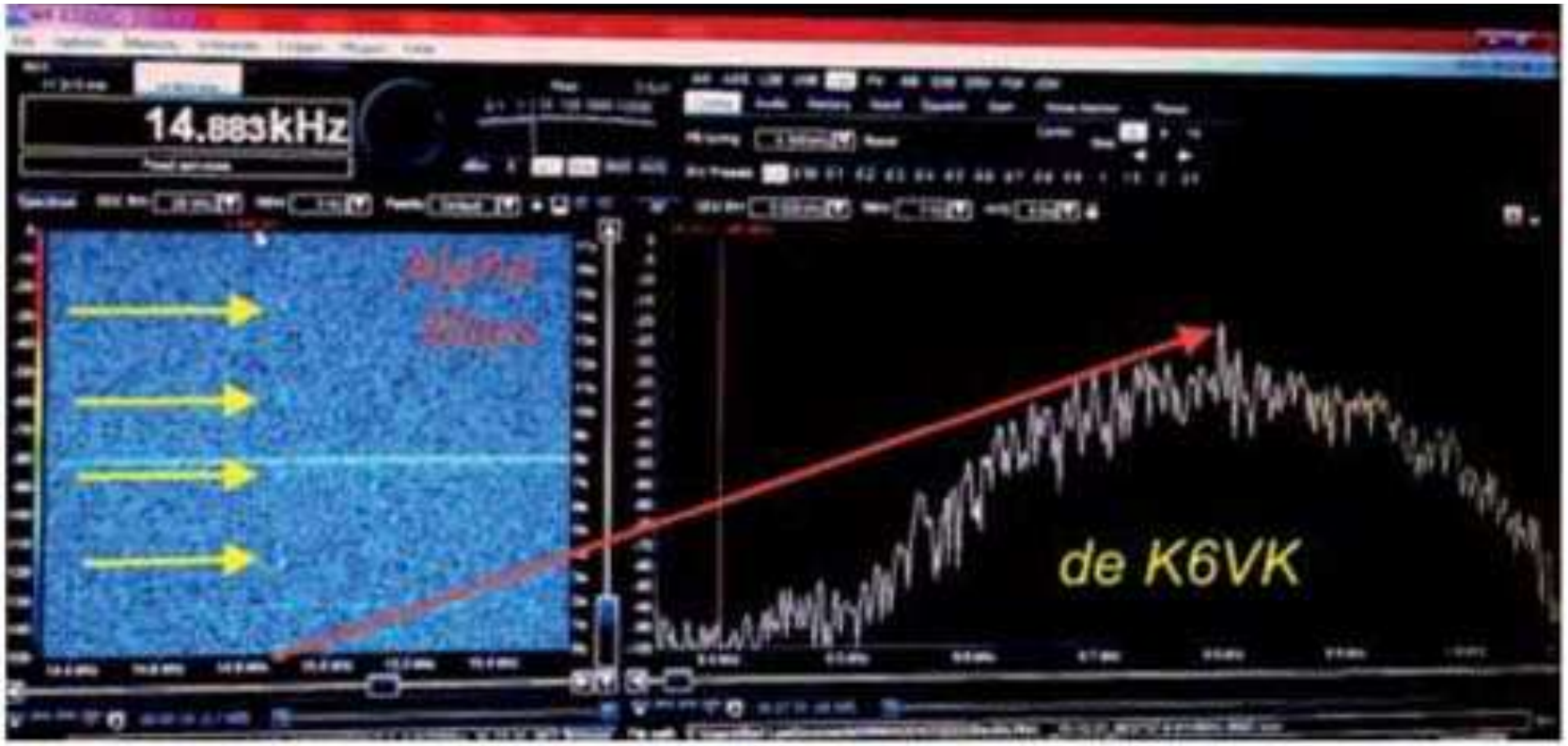


Fig. 22. Audio analysis of the Russian Alpha VLF station at 14.881 kHz on December 31, 2015, at 14:57 UTC at K6VK. (Author's annotated screen cap photo)

ALPHA STATION (ONE OF SEVERAL) 14.883 KHZ

NavTex – International @ 518 KHz

Naval ***Long*** Long Wave -- VLF

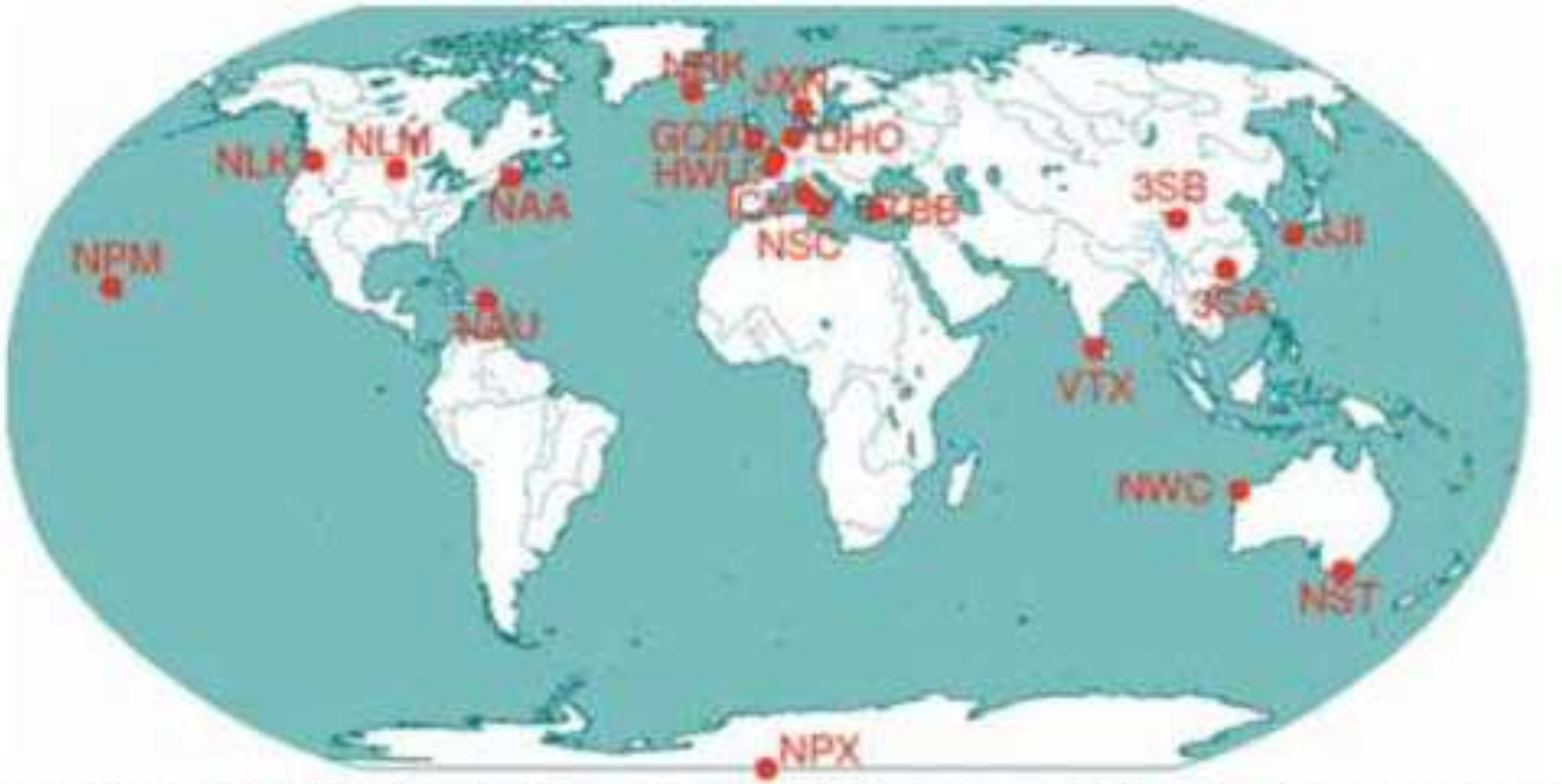


Fig. 20. Most of the VLF stations of the world appear on this map; NPX in Antarctica is perhaps notional.

TEN KHZ TO ABOUT 80 KHZ,
MOSTLY AROUND 25 KHZ
– MOSTLY FOR SUBMARINES

US NAVY VLF STATIONS

Station	Frequency (kHz)	Location
NPM	21.4	Lualualei, Hawaii
NAA	24.0	Cutler, Maine
NLK	24.8	Seattle, Washington
NML	25.2	LaMoure, N. Dakota

FOUR NAVY VLF 200 HZ STATIONS – AND A MYSTERY 800 HZ SIGNAL!

Fig. 38. A strong (32 microvolt), 800 Hz bandwidth MFSK VLF signal appeared at 22.7 kHz on May

A NAVY AIRCRAFT VLF TRANSMITTER

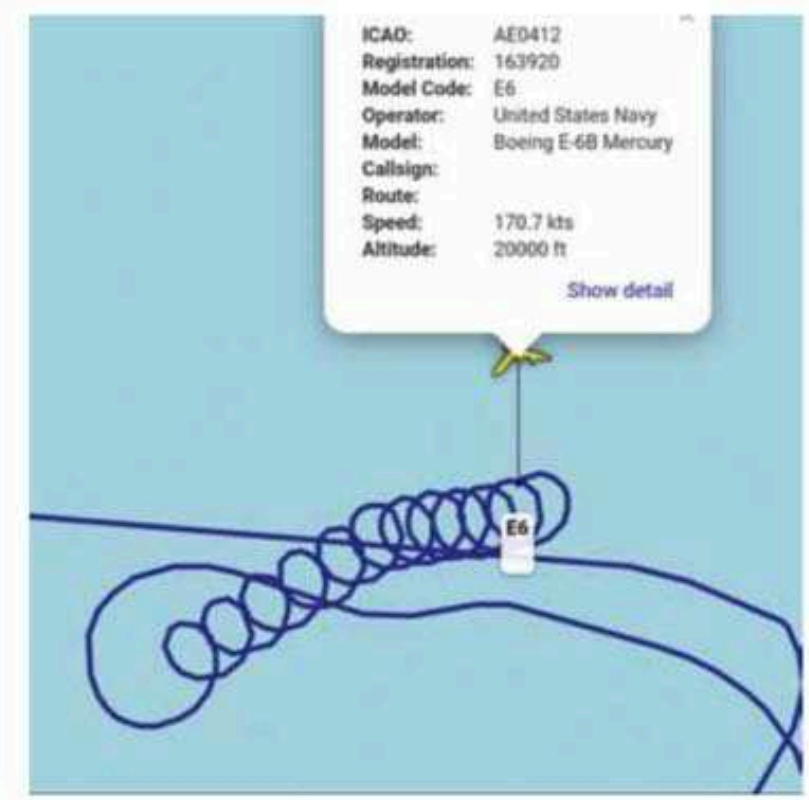


Fig. 39. As plane-spotting goes, this is as good as it gets; this diagram with data was posted by "Evergreen Intel @vcdgf555" on Twitter on December 12, 2019. The note reads "ICAO: AE0412, Registration: 163920, Model Code: E6, Operator: United States Navy, Model: Boeing E-6B Mercury, Callsign: (blank), Route: (blank), Speed: 170.7 kts , Altitude: 20000 ft. (Evergreen Intel @vcdgf555)

A NAVY “TACAMO” VLF AIRCRAFT

THIS PLANE SENDS THE 800 HZ VLF SIGNALS TO SUBMARINES BELOW – TARGET UPDATES?

ECLIPSE VLF – CITIZEN SCIENCE

VLF (AND OTHER) SIGNALS CAN CROSS AN ECLIPSE PATH – HERE 2017

25.2 KHZ NML SIGNAL STRENGTH BEFORE, DURING AND AFTER THE ECLIPSE

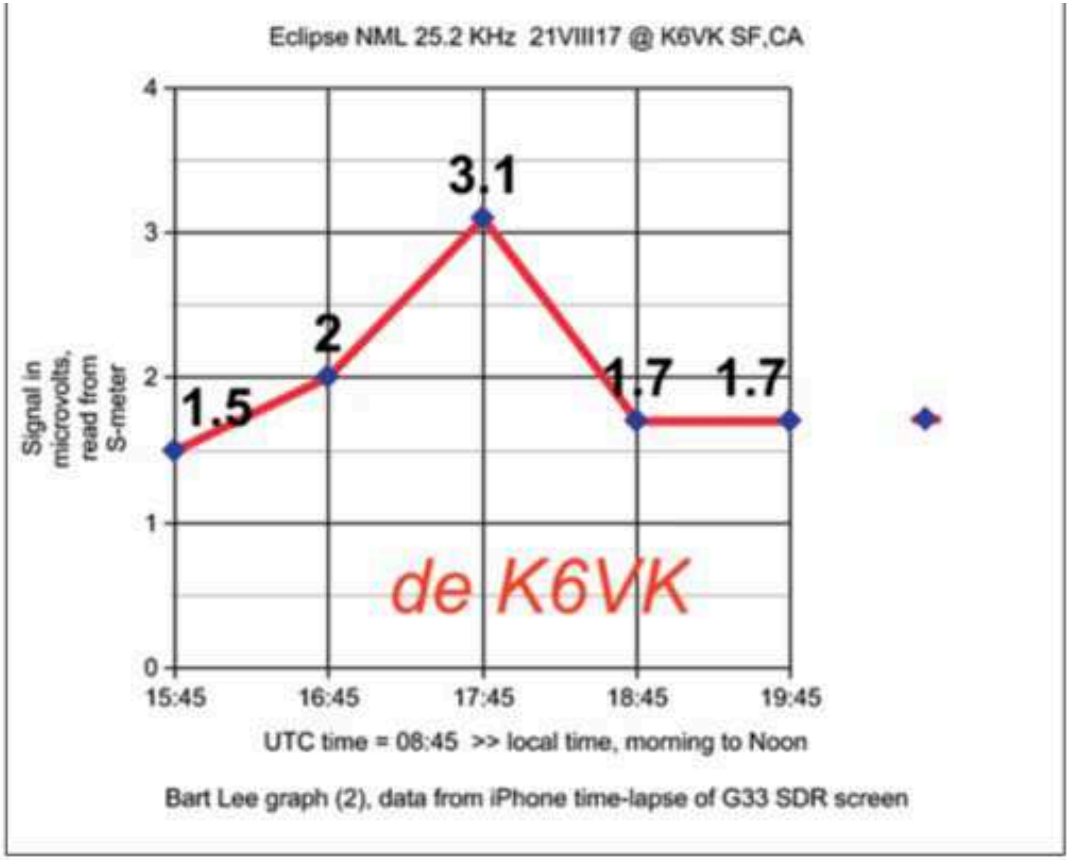


Fig. 46. Graph of increase in VLF station NML (ND) signal strength in California during the eclipse, 6dB+. (Author)

SDR IMAGE OF ECLIPSE MAX SIGNAL

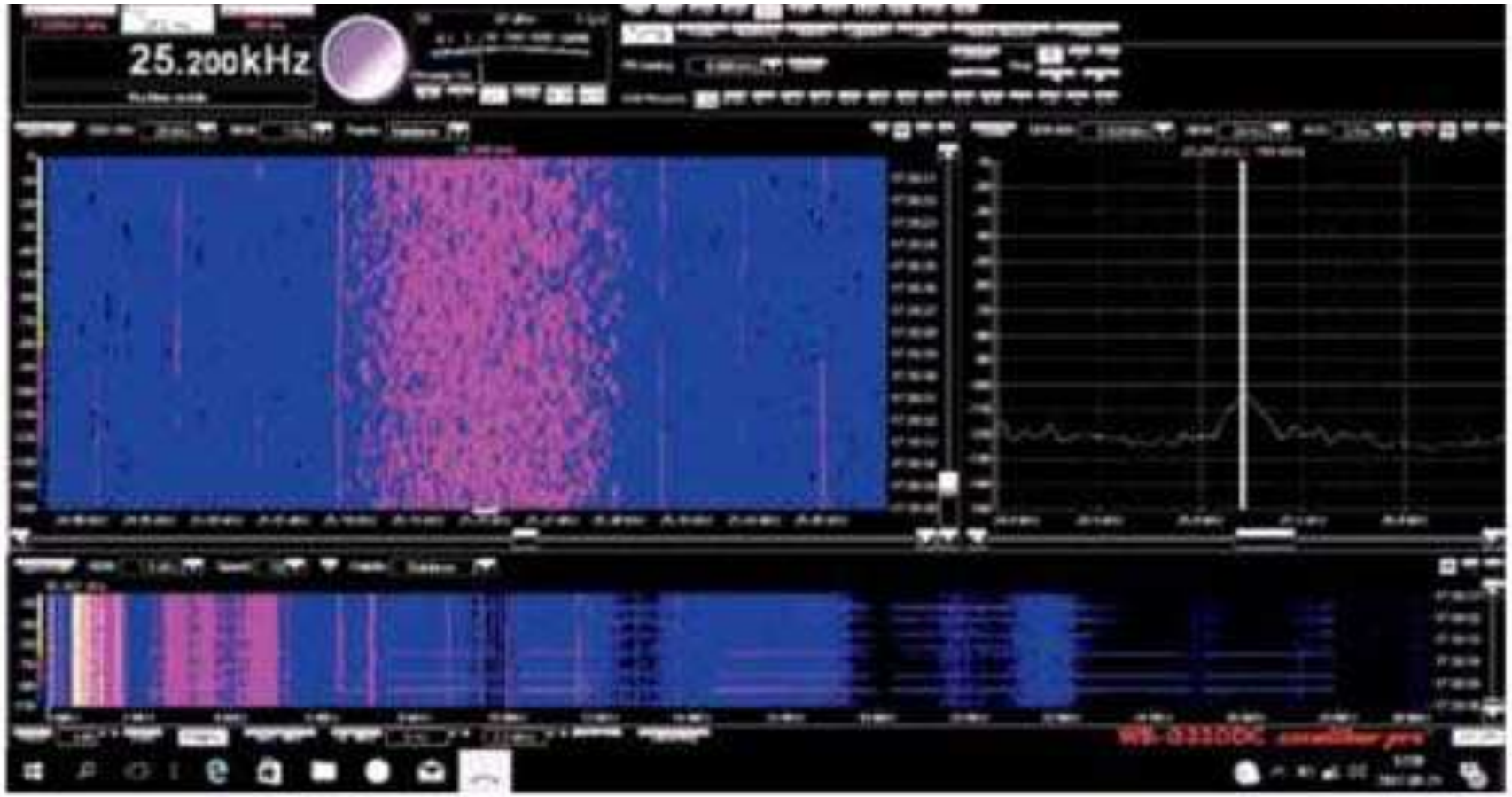
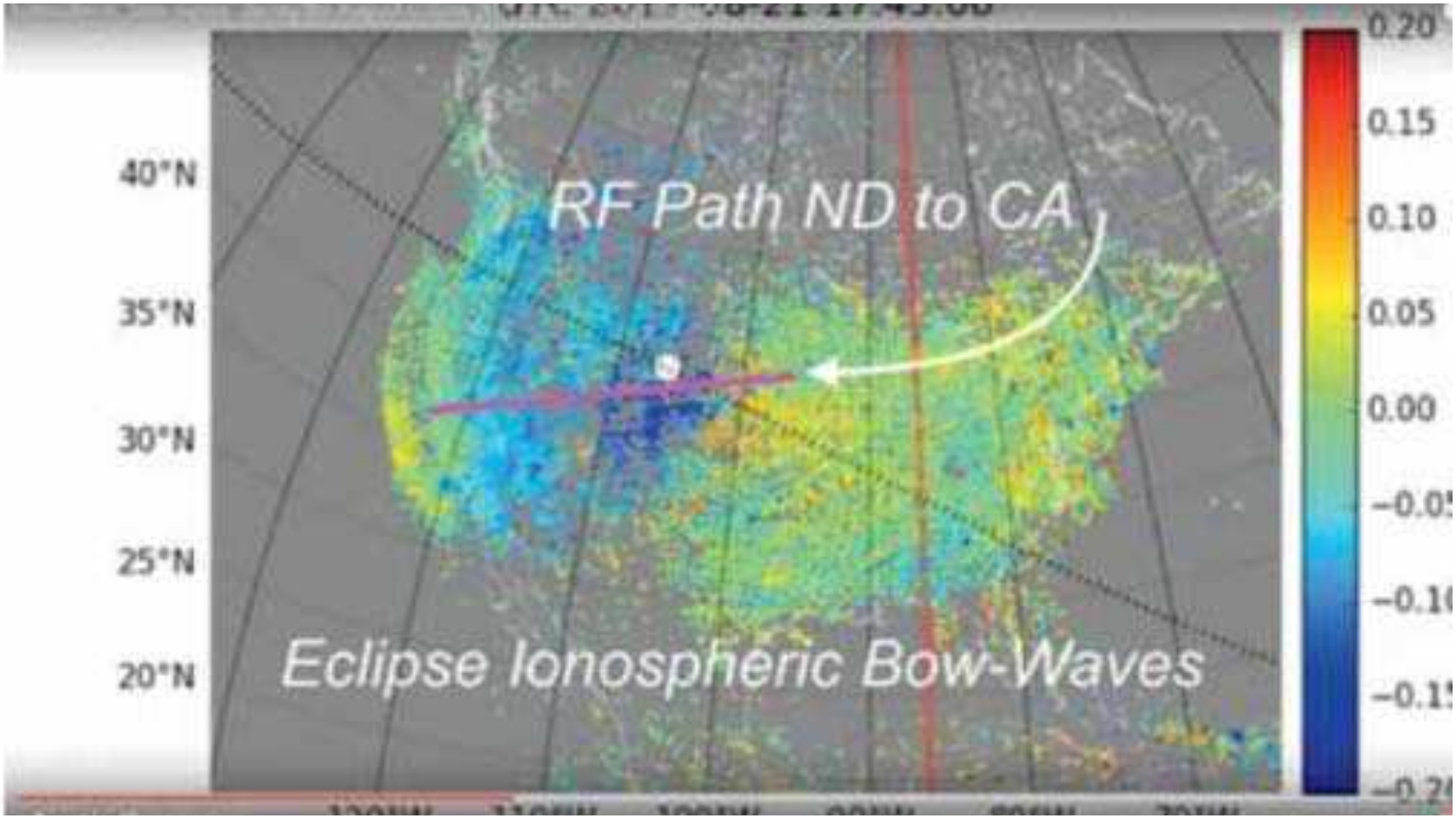


Fig. 47. Maximum signal strength at K6VK at maximum umbra intersection, 3.1 microvolts.

ECLIPSE IONOSPHERIC ‘BOW-WAVE’ STRENGTHENS VLF PROAGATION



https://skyandtelescope.org/astronomy-news/solar-eclipse-made-bow-waves-earths-atmosphere/

RADIO SCIENCE, 2024

- "…the next total solar eclipse … will pass over the United States on April 8, 2024. While the Moon's shadow will not go coast-to-coast, its 3,400-km- long path, nearly 80 km wider than 2017's path of totality, will pass over the central and eastern U.S., from Texas to Maine."
- A less-than-total annular eclipse will pass over the US in October, 2023.
- Time to get out those SDRs!

CHRS Appreciates Mt Diablo ARC's Contribution to the Museum

And thanks for looking at this presentation and listening!

73 de Bart, K6VK (19 V '23) ##