The Final Days of Ham Spark

Generations before today's ham nostalgists took up the plaint that "real radios glow in the dark," the *realest* real radios whined, roared and hurled blue lightning. What on earth could have made "the visible and mighty heart of radio" fall still?

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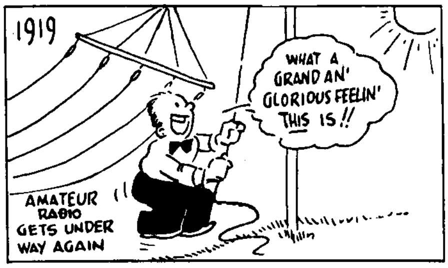
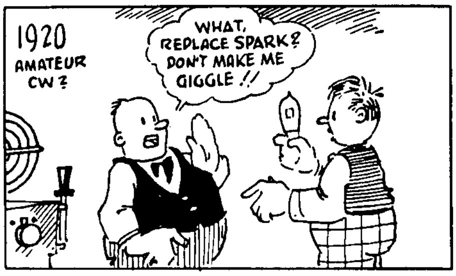
September 26, 1919, was a red-letter day for Amateur Radio. On that day, the US government announced that the ban on transmitting by amateurs, imposed on transmitting and receiving in April 1917, was lifted. The ban on receiving had been lifted in April 1919.

It took some time for hams to obtain new licenses and get their prewar rigs set up again, but by November hordes of stations were back on the air. Of those early days, Arthur L. Budlong wrote:[1]

King Spark!
Grown now to full maturity, developed and perfected by years of pre-war and war experience, it reached its highest peak in the succeeding eighteen months. Glorious old sparks! Night after night they boomed and echoed down the air lanes. Night after night the mighty chorus swelled, by ones, by twos, by dozens, until the crescendo thunder of their Stentor bellowings shook and jarred the very Universe! A thousand voices clamored for attention. Five-hundred-cycle's high metallic ring. The resonant organ basso of the sixty-cycle "sync." The harsh resounding snarl of the straight rotary.
Character: Nervous, impatient sparks, hurrying petulantly. Clean-cut business-like sparks batting steadily along at a thirty-word clip. Good-natured sparks that drawled lazily and ended in a throaty chuckle as the gap coasted down-hill for the sign-off.
Survival of the fittest. Higher and higher powers were the order of the day.
The race was on, and devil take the hindmost.
Interference.
Lord, what interference!
Bedlam!
Well, it could not be Utopia.

It's probable that at that heady time no one thought that this cacophony of ham spark signals would disappear within a few short years, never to be heard again. So far as we know, no one recorded for posterity the sounds of one of those early nights, but you can still hear a spark rig and learn about its construction in a video available from ARRL HQ for loan to affiliated clubs,[2] or see, hear and *smell* one working at the Antique Wireless Association Museum.[3]





Anatomy of a Spark Rig

In basic form, a spark transmitter (Fig 1) consisted of a high-voltage transformer, a condenser (capacitor), a spark gap and an oscillation transformer. The transformer charged the condenser. At a high voltage, the spark gap fired and discharged the condenser into the oscillation transformer, which *rang*—in effect, reverberated electrically—producing a *damped wave*, so named because its successive oscillations diminish in strength. The longer the transformer rang, the narrower on-the-air signal would be.

Fig 2 shows the idealized waveforms in the primary and secondary of the oscillation transformer. The gap was supposed to discharge the condenser as rapidly as possible, then *quench*—extinguish—immediately to keep efficiency high. The resonant frequency of the condenser/oscillation transformer/antenna combination broadly determined the transmitter's operating wavelength.

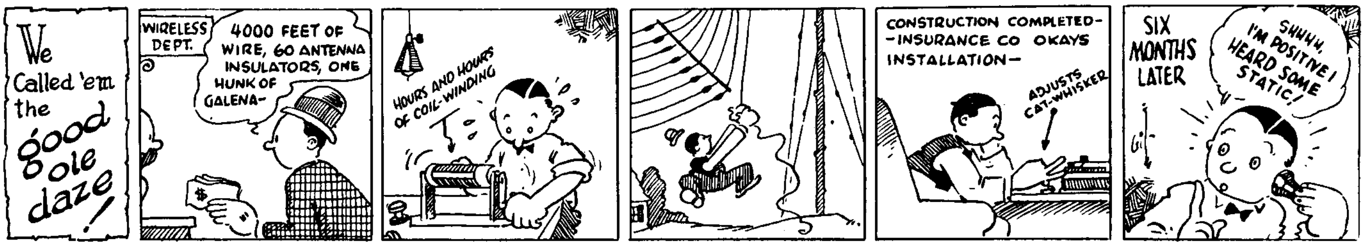
Transformers and Condensers

Hams usually purchased their high-voltage transformers. A so-called "1 KVA" model (Fig 3) might produce 25,000 volts. Although good high-voltage mica and Leyden-jar condensers were available, many hams made their own. These consisted of plate-glass sheets with metal-foil circles glued to each side, all suspended in a tank of oil. Few hams knew their condensers' actual capacitance; they merely added or subtracted plates until they got the results they wanted.

The All-Important Gap

A spark transmitter owed much of its on-the-air sound to the type of gap it used.

[1]Notes appear on page 32.



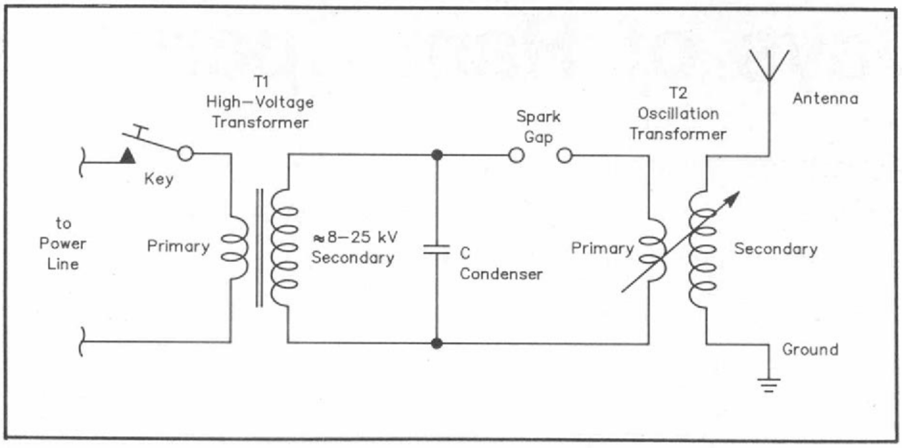


Fig 1—In basic form, a spark transmitter consists of a *condenser* (capacitor), C, that charges with high-voltage ac from a step-up transformer (T1) with each key closure. When the voltage across C builds up high enough, a spark jumps the gap, discharging C through the primary of *oscillation transformer* T2. The spark's low resistance connects C1 in parallel with T2's primary, forming a tuned circuit that resonates at the operating wavelength. The spark pulse *shock excites* this tuned circuit into a brief and diminishing (*damped*) oscillation at this wavelength. The oscillation transformer secondary, which also resonates (with the antenna and associated reactances) at the operating wavelength, couples this energy to the antenna. Practical spark transmitters included *safety gaps* across C and T1's secondary, and *kickback preventers* (graphite rods, capacitors and/or RF chokes) that kept the rig from destroying its components or setting the house on fire!

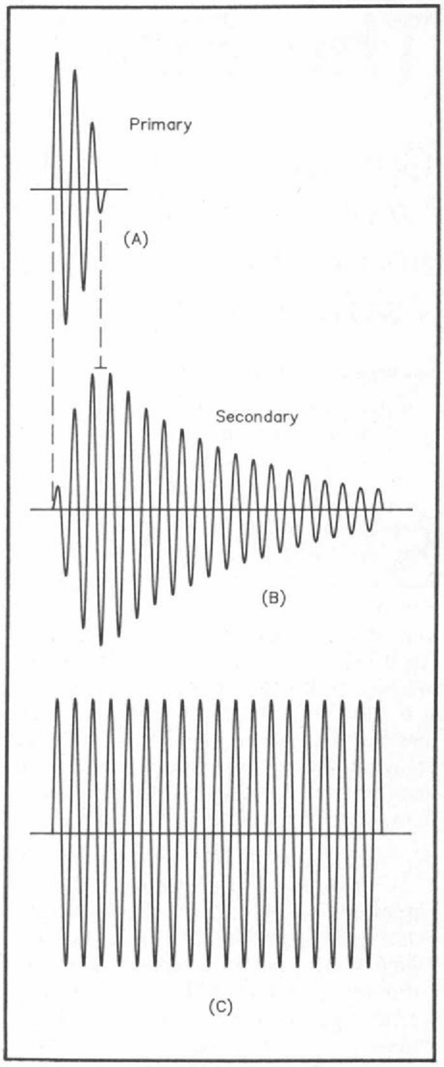


Fig 2—Waveforms in the oscillation transformer primary (A) and secondary (B). *Damped waves*, both are much more spectrally "dirty"—broad, and capable of severe interstation interference—than the *undamped* or *continuous wave* shown at C, although B (the signal applied to the antenna) is cleaner than A because it takes longer to die out and more closely approaches C. US radio laws governed the spectral purity of spark signals by specifying their *logarithmic decrement* (δ), a number equated with how many full cycles a damped wave completes before dying out completely.

Early spark gaps consisted merely of metal contacts on an insulating base (Fig 4). The raspy transmitted signal of a station using one of these would be modulated at twice the ac-line frequency (120 Hz with 60-Hz ac)—a tone too low for good readability through noise and interference. A major practical drawback offsets the plain gap's apparent simplicity: Its spark quenches poorly even with very wide electrode spacing, sometimes leading to continuous arcing that blew ac-line fuses and closed a station down in a hurry!

Spark communicators solved the plain gap's tone and quenching problems with one solution: the *rotary* gap, sometimes called just *rotary*, that mechanically interrupted the spark with a motor-driven wheel (Fig 5). The relative movement between a rotary gap's whirling and fixed points quenched its spark by brute force.

Interrupting the spark hundreds of times a second also modulated the spark with a higher, more musical tone to help the signal better cut through interference and static. The more electrodes, and the faster the rotary gap turned, the higher the modulating frequency. Heated debate on whether higher or lower tones were better was common; asking almost any ham with a rotary for opinion on "high note versus low" would net you an earful!

Merely interrupting the spark with a rotating wheel meant that the spark discharge might occur anywhere on the ac-line waveform. This *non-synchronous* or *asynchronous* operation was relatively inefficient because it caused successive discharges to differ in strength, varying the excitation of the oscillation transformer. And an asynchronous rotary's tone represented a mix of twice the line frequency and its rotor's spark-interruption rate. The *synchronous* rotary gap, a means of keeping the spark-discharge strength uniform by keeping it in phase with the line-ac waveform, solved these problems but introduced another. Synchronizing a rotary for one discharge per line peak at 60 Hz unavoidably set the spark rate to 120 Hz, giving a tone generally considered too low. "Commercials" solved this problem by using motor-generators to power their syncs with higher-frequency ac; 500-Hz supply, which gave a 1-kHz tone, was common. The overall expense of using a synchronous gap *and* getting a high tone made them relatively uncommon in amateur stations. Most hams used asynchronous rotaries and put up with reduced efficiency and a less-pure tone.

Spark transmitters using rotary gaps can be described with one word: *deafening*. The crackling rasp from even a small spark set could make your ears ring, and some commercial installations could be heard *for miles* if the wind was blowing just right! (As if the danger to hearing wasn't enough, the spark also manufactured the pungent, poisonous gas *ozone* [O_3], which we now know to be a health hazard.) *Quenched* gaps quieted the roar by confining the

"Something Fearful and Wonderful"

The advanced amateur station of those days was something fearful and wonderful, a combination of witchcraft and execution chamber. . . . but ah, what a beautiful thing a well-made rotary was! Here was where dreams were made. Here, in its crashing blue-white spark, was tangible evidence of its might. No matter if it could be heard for blocks—as indeed it could, unless it were put in a double box. No matter if it blinded the operator as well as made him deaf, and gave him red-rimmed eyes from its vaporized zinc electrodes. What if it did lose much of the energy in light, heat and sound; was it not the visible and mighty heart of radio?—*Kenneth B. Warner, W1EH, "Silver Anniversary," December 1940* QST

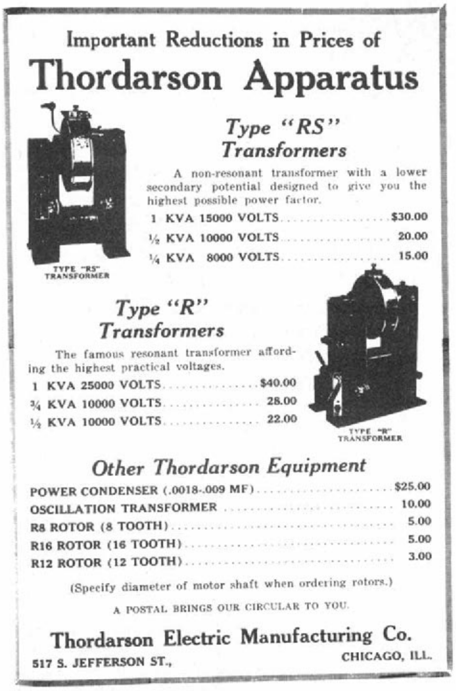


Fig 3—This April 1921 *QST* ad for Thordarson high-voltage transformers seems to reflect falling demand for spark gear.

spark within a series of airtight chambers formed by machined metal discs and insulating washers. Quenched gaps were nearly noiseless and, because they quenched the spark so rapidly, more efficient than equivalent open-air gaps. Like plain gaps or synchronous rotaries, though, a quenched gap produced a tone at twice its line-supply frequency—with 60-Hz ac, 120 Hz, considered too low for serious use. Like a synchronous rotary, getting a higher tone from a quenched gap meant using higher-frequency ac supply. Thus, quenched gaps were relatively uncommon in ham shacks.

The Oscillation Transformer

Hams built or bought their oscillation transformers, the windings of which consisted of heavy brass or copper strap. The primary had few turns; the secondary many more. Some hams used only a single-turn primary. Fig 6 shows a commercial model. Because the oscillation transformer's windings acted as a double-tuned circuit, overcoupling its primary and secondary could cause a double-humped response that made the transmitter transmit "a double wave." By 1920, the US radio regulations encouraged "single-wave" or "sharp" emission by limiting the amplitude of any second wave to one-tenth the amplitude of the stronger, desired wave.

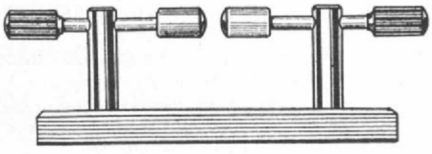


Fig 4—There's nothing fancy about a plain spark gap—just two electrodes mounted on an insulating base and capable of width adjustment. But its low tone with 60-Hz supply, its inability to quench the spark rapidly, and its tendency toward continuous arcing made spark communicators favor rotary gaps. (from Bucher)

The Personality of Spark

With the tremendous variety of gap speeds, electrode shapes and number of electrodes in use, every spark station had its own characteristic tone. This was actually an advantage. A spark signal was broad, and with all hams operating near the same wavelength with overlapping signals, communication would have been even more difficult if all signals sounded the same. Many spark stations could be identified by their tones alone, without waiting to hear their call signs. Because spark signals were broad, beat-note reception was not used; especially before World War I, modest ham stations used only diode detectors—sometimes a non-oscillating vacuum tube, but, much more commonly, a diode consisting of a galena or silicon chunk contacted by a thin wire (*catwhisker*). Regenerative detectors, operated below the point of oscillation for spark reception, were just coming into amateur use as *QST* debuted in December 1915. They offered the additional (and tantalizing) capability of *undamped-* or *continuous-wave* (*CW*) reception—tantalizing because, with them, spark-bound hams could listen in on the growing acceptance of CW by commercials.

Limits of Wavelength and Power

The Radio Act of 1912 limited Amateur Radio operation to 200 meters and shorter wavelengths,[4] at a maximum power input of one kilowatt. At first, hams tended to violate the 200-meter limit because of the general belief, common to commercial and Amateur Radio users alike, that longer wavelengths meant better DX. Enforcement of radio regulations was relatively lax. As for power, physics and the 200-meter restriction made it difficult for hams to exceed 1 kW input with the components available. Antenna (*aerial*) technology was primitive, the main idea being to get as much wire as high into the air as possible, commonly in the form of a **T** or inverted **L**, and maximizing its RF-current drain as indicated on the station RF ammeter.

As far as we know, very few hams experimented with CW transmitters before World War I. In government and commercial circles, CW, produced by high-power *arc* transmitters, had begun proving itself superior to spark transmission a few years before ARRL's founding in 1914. The three-element vacuum tube was well-known by 1915 to be capable of regeneration and oscillation. It could therefore generate CW, but—with the tube available to

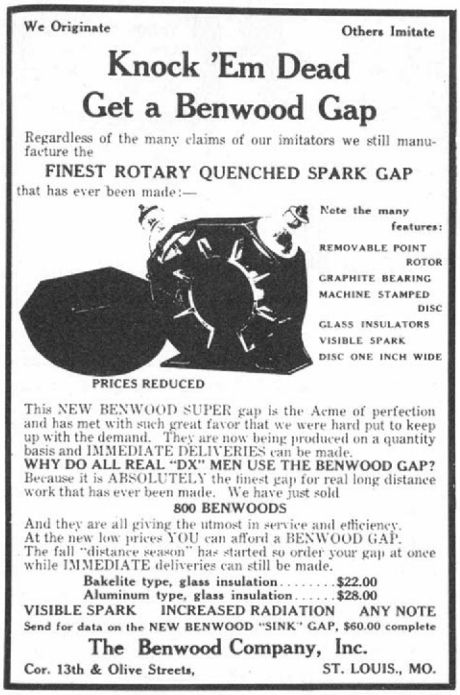


Fig 5—Most hams used asynchronous, motor-driven rotary gaps to get good quenching and a musical spark tone. A wide variety of rotaries appeared on the market; here is the popular "Benwood" as advertised in August 1921 *QST*. Some hams made their own rotaries: Hiram P. Maxim (1WH, 1ZM, 1AW and W1AW), co-founder and first president of the ARRL, built "Old Betsy," which had four electrodes and ran at 7000 rpm, giving a spark rate of 467 Hz—a pleasant tone to copy.

amateurs—only at tiny, impractical powers incomparable to those achievable with spark. World War I spurred transmitting-tube development and gave hams who worked with radio communication during the war hands-on experience of what CW could do.

The Rise of CW

Shortly after US amateurs returned to

Fig 6—This oscillation transformer (from an ad in June 1921 *QST*) uses two brass-ribbon *pancake* windings. Hams varied its coupling by changing the distance between the primary (lower winding) and secondary.

the air in 1919, occasional ham CW signals could be heard. Urged on by *QST*, more and more hams built CW rigs. This was hampered at first by the unavailability of suitable tubes. A West Coast company named Moorhead produced and advertised "five-watt"—plate dissipation, not output—transmitting tubes for hams. The newly formed Radio Corporation of America, which had acquired the patents controlling the production and sale of vacuum tubes for such purposes, promptly sued Moorhead. By 1921, spurred by the broadcasting boom, RCA was marketing a variety of high- and low-power transmitting tubes—improved versions of tubes that had been produced in quantity during the war. Hams bought them, too, and amateur CW stations gradually increased in number. Spark began to decline, but tradition and the fierce loyalty of its adherents kept it alive.

Using spark and CW, superpower commercial and government stations were working intercontinental distances at will by the time the US entered World War I in 1917. Yet, as 1921 began, no ham signal from this side of the Atlantic had ever been reported heard in Europe. At the 1-kW ham power limit, were the wavelengths "200 meters and down" *really* useless for international DX after all? ARRL sponsored one-way transatlantic tests in December 1921, and sent Paul Godley, 2XE, a well-known amateur and engineer, to England with the latest receiving apparatus. Godley set up in a tent on a windswept Scottish beach, and during the test period copied nearly thirty American hams, CWs outnumbering sparks almost two to one. Godley heard a spark signal first—1AAW, apparently a bootlegger, ragchewing near 270 meters—but CW had won the race.

Despite this, many die-hard spark enthusiasts held on—for a while. Many gave up ham radio completely rather than convert to CW. To them, spark embodied a romance that CW could never evoke. They lamented that all CW signals sounded the same and lacked individuality—something certainly not true of spark!

By 1922, advertisements for spark components were fast disappearing from the pages of *QST*, and HAM-ADS was full of spark sets for sale, probably with no takers. The radio world swung inexorably away from spark and toward CW—so swiftly that spark was forbidden on the new 80, 40, 20 and 5-meter amateur bands when we got them in 1924.

Three years later, spark was officially prohibited for use by US amateurs in the new regulations that arose from the Washington Conference of 1927. But there was no body left to bury. In December 1923 *QST*,[5] Porter Bennett, 5IP, had nostalgically written:

> *"Here it is, OM. The idea hit me while listening in last night. Nary a spark did I hear, and I thought how good it would be to hear one closing down with the power still on and the note descending on the 'dah-de-dah.' But all I could hear were signals that stopped with a sudden abruptness that left something lacking. C.W. is better than spark and I like it better, but the ringing of the cowbells sounds sweet to a farmer still."*

Spark was dead.

"You Could Have the Time of Your Life"

....Well, there you were, except for the gadgets such as blocking condensers, 'phones, kick-back preventor, change-over switch and a key with contacts as big as dimes to carry the heavy current. What could you do with it? You couldn't do much in the summer, particularly at night, because of the static. You couldn't hear anything when anybody else was sending in the same town, because a nearby signal occupied the whole tuner. But given a break, you could talk for miles, many miles. And given a really good break, a crisp clear winter night in the wee hours after the young squirts with the spark coils had gone to bed, you could have the time of your life and actually work for hundreds of miles...if the signals didn't fade out, if interference didn't start up, if you didn't blow a condenser, or if you didn't lose that critical adjustment. Of if the cops didn't run you in for maintaining a nuisance, or a wind blow down your masts. And you could investigate the phenomenon known as kickbacks-into-the-power-wiring and, as we twice did, set the house on fire. Or the phenomenon known as corona losses, watching the great fuzzy blue caterpillars on the high-voltage points of your antenna system. Or involve yourself in endless arguments over high note versus low, what the power is in a freely oscillating circuit, or how the coupling ought to be to obtain a "pure" wave.

Those, friends, were the days from which Amateur Radio has come.
—Kenneth B. Warner, W1EH, "Silver Anniversary," December 1940 QST

Notes

1. A. Budlong, *The Story of the American Radio Relay League*, as excerpted in C. de Soto, *200 Meters and Down* (West Hartford: ARRL, 1936), p 60. Available from the ARRL Bookshelf as #0011.
2. Write to HQ's Educational Activities Department to request order forms and a copy of our AV-library rules for borrowing free-loan VHS copies of this tape, in which Ed Redington, W4ZM (now a Silent Key), assembles a working spark transmitter piece by piece while describing his boyhood adventures (and misadventures!) in spark communication.
3. J. Cain, "Mastodons, Mummies and Magic Eye Tubes," *QST* Apr 1991, pp 15-18.
4. The Department of Commerce granted some experimental, school and amateur stations special authority to handle traffic at 425 meters and additional wavelengths per ARRL recommendation. These stations used call signs beginning with *X*, *Y* and *Z* respectively; Hiram Percy Maxim held one (1ZM).—*Ed.*
5. P. Bennett, "From the Land of Blue Lightning" *QST*, Dec 1923, pp 22-23.

Additional References

H. Aitken, *Syntony and Spark: the Origins of Radio* (Princeton, NJ: Princeton University Press, 1985).

H. Aitken, *The Continuous Wave: Technology and American Radio, 1900-1932* Princeton, NJ: Princeton University Press, 1985).

ARRL staff, *Fifty Years of ARRL* (Newington: ARRL, 1965). Available from the ARRL Bookshelf as #0135.

E. Bucher, *The Wireless Experimenter's Manual* (New York: Wireless Press, Inc, 1920).

E. Bucher, *Practical Wireless Telegraphy* (New York: Wireless Press, Inc, 1917).

A. Goodnow, "Across the Gap: An Appraisal of Spark Radiotelegraph Engineering," *The A.W.A. Review*, Vol 2 (Holcomb, NY: Antique Wireless Association, 1987), pp 21-70.

S. Kruse and D. Richardson, "The Importance of Higher Voltages for Amateur Spark Communicatiom, *QST,* May 1922, pp 27-32.

T. Lewis, *Empire of the Air: The Men Who Made Radio* (New York: HarperCollins, 1991).

T. Mayes, *Wireless Communication in the United States* (E Greenwich, RI: The New England Wireless and Steam Museum, Inc, 1989).

J. Stokes, *70 Years of Radio Tubes and Valves* (Vestal, NY: The Vestal Press, Ltd, 1982).

G. Tyne, *Saga of the Vacuum Tube* (Indianapolis: Howard W. Sams and Co, Inc, 1977).

K. B. Warner, "The New Short Waves," Editorials, *QST*, Sep 1924, p 7-8; and "Changes in Amateur Regulations," *QST*, Dec 1927, pp 24 and 30.

Cartoons by Phil Gildersleeve, W1CJD, from May 1934 *QST.*