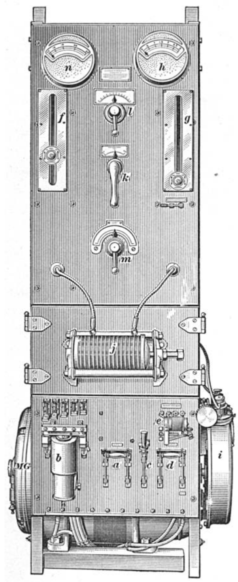
BY RONALD R. THOMAS

The Radio Spectrum: Utilizing a Scarce Resource

The radio spectrum has always been a scarce, valuable resource. Over the years, a small number of technical innovations have had a tremendous impact on its effective utilization by amateur and commercial operators. These innovations have improved the bandwidth and stability of radio signals, enhanced frequency sharing, and made it possible to utilize ever-higher frequencies. Unfortunately, the importance of these innovations has long been forgotten. However, without them, radio communications would never have been practical.

The 1900s

In the early 1900s, amateur and commercial radio operators used spark to generate radiotelegraph signals for two-way communications. Those spark signals were very broad and used a great of the radio spectrum. Tuned circuits helped to make the signals much less wasteful of spectrum space. Tuned circuits were created by combining capacitors and inductors to resonant at a specific frequency for transmission and reception.



Typical 2kW marine spark transmitter of the early 1920s.

From the very beginning of radio, there has been frequency sharing with its associated interference problems. Sometimes sharing has consisted of simply listening before transmitting on a shared frequency. In other cases, sharing has relied on distance to achieve effectiveness; two stations on the same frequency might be far enough apart to avoid interfering with each other.

Early radio operators developed good listening skills and were able to hear weak spark signals through the interference from other stations. Those operators simply accepted the situation as they found it and made the best of it.

During World War I, amateur radio operators were forced off the air, which somewhat reduced the interference problems. However, after the war ended, amateurs were once again allowed to resume operations and many of the old interference problems returned.

The 1920s and 1930s

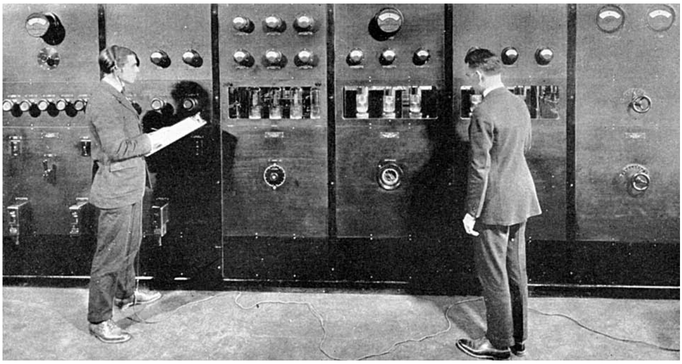
In the 1920s, interference problems were somewhat reduced when spark signals were replaced by tuned circuit, vacuum tube generated continuous wave (CW) signals. Those signals were narrower and more stable than spark signals, and they more efficiently utilized the radio spectrum for two-way radiotelegraph communications.

By using a variable capacitor with an inductor, a radio signal could be generated over a small range of frequencies. Plug-in inductors (coils) enabled other frequency ranges to be selected. Ultimately, plug-in inductors were replaced with permanently-installed inductors wired to a switch, which simplified the selection progress.

Vacuum tubes were able to generate signals at much higher radio frequencies. This opened up a whole new portion of the radio spectrum at the short-wave frequencies and eventually at the very high frequencies (VHF) and ultra high frequencies (UHF).

During the 1920s, one temporary solution to the interference problem was to move the amateur radio operators to the short wave frequencies, which were deemed useless for long distance communications. Amateurs soon discovered that those frequencies were actually extraordinarily well suited for long distance communications, and commercial operators also started using them.

AUTHOR'S ADDRESS: 6415 CHASTAIN DR. NE. ATLANTA, GA 30342



Broadcast transmitter put in service by AT&T's station WEAF in 1924 was the first to incorporate crystal control.

During that era, frequency stability continued to be an ongoing problem. With changes in temperature, the resonant frequency of a tuned circuit can also change and cause a transmitted signal to drift from its original frequency. In addition, exact frequency selection is difficult with a variable capacitor. Therefore, in the 1920s, more effective vacuum tube transmitters were created by utilizing quartz crystals for precise frequency control. Amateur radio operators did some of the pioneering work in this area.

During this period, amplitude modulated (AM) radiotelephony came into existence for two-way voice communications. These signals were much broader than radiotelegraphy signals, and interference problems became even more of a concern. AM also began to be used for a new activity called "broadcasting" (one-way communications for entertainment and educational purposes).

By the 1930s, frequency stability on the AM broadcast band became extremely important. Listeners did not want to search for their favorite station or deal with interference from other stations. Program sponsors wanted AM broadcast reception to be as simple as possible. Therefore, the quartz crystals in AM broadcast transmitters were often mounted in ovens to control their temperature, which further improved their frequency stability.

In the 1920s and 1930s, directional antennas began to play an important role in improving the utilization of the radio spectrum. Particularly in the AM broadcast band, there was a need for more stations to be able to operate without interfering with each other. AM directional antennas helped to reduce interference and improve frequency utilization. Directional AM antenna systems use two or more vertical radio towers and associated tuned circuits to achieve a directional radiation pattern. Larger systems, using six or eight towers, can create a very complex pattern that protects a number of other stations, on the same frequency, from interference.

Directional antennas also came into existence for use on the short wave frequencies and eventually on the VHF and UHF bands. Some of those antennas were physically fixed and used electrical techniques to obtain a directional capability, while others were physically rotated.

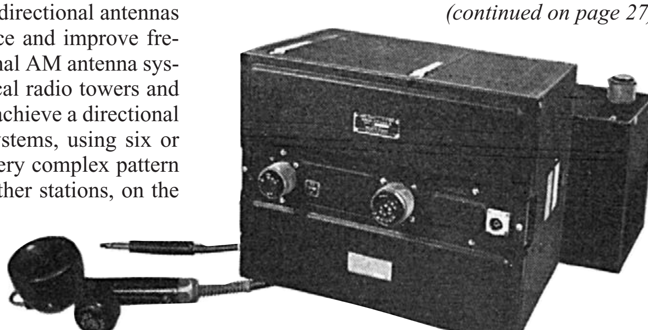
On the receiving side of the equation, the creation of superheterodyne receivers provided-single knob tuning and improved the ability of receivers to reject interfering signals. Those receivers quickly became very popular with amateur and commercial radio operators as well as AM broadcast home listeners and remain the standard even today.

1940s and Beyond

During World War II, there was a significant move by the military services toward VHF and UHF operations, which opened up more frequency spectrum. After the war, two-way radio and broadcast television transmissions heavily populated those frequencies.

In the 1950s, crystal control was commonly used for VHF and UHF operations. Unfortunately, using one crystal per frequency was an

(continued on page 27)



Famous World War II SCR-522 transmitter/receiver covered 100-156 MHz, had four remote-selected crystal-control channels.

I really started from scratch with this project, helping to survey the land and determine the placement of the four transmitting towers. I even got involved in the installation of the ground system, tower foundations, coax transmission lines, etc. The towers were made locally by Tower Construction Co., originally the Wincharger group. All studio equipment was Raytheon. KCOM went on the air in 1948.

The station was strong on sports and farm broadcasts. It had a number of remote pickups from neighboring towns as well as from churches in Sioux City. KCOM was sold in 1954 and is now (as of January, 1990) operating as KMNS. About this time, I became involved in the construction of another new station in the area, KTIV television.

KVTV (now KCAU), another TV outlet, had gone on the air in 1953. KTIV followed in 1954. Our studios were at 10th and Grandview and the transmitter was at 54th and Rustin Streets. The 550-foot tower was made in Sioux City by Tower Construction Co., and it was topped by a six-bay Super-Turnstyle RCA Antenna. The transmitter was a DuMont 25-kW unit, one of the first designed for color operation.

We had planned to be on the air for the 1954 World Series, but didn't make it because of the poor signal on the microwave link from the studio to the transmitter. The problem was caused by a large tree in the path, and was eventually corrected by raising the tower supporting the microwave reflector from 100 to 140 feet.

Our hours of operation were basically from 4:00 p.m. to 10:30 p.m., ending with the 10 o'-clock news. The first evening shows were all NBC: *People are Funny, The Liebman Spectacular, Television Playhouse,* and *The Loretta Young Show*. We also carried such programs as *Pinky Lee, Howdy Doody, The Sid Caesar Show, Robert Montgomery Presents, Milton Berle* and *You Bet Your Life* as well as a variety of local programming. Our studio was equipped with the first Vidicon camera for movies and slides. In May of 1955, at a time when most stations were operating with less than 25 kW, we went up to our maximum authorized power of 1000 kW.

(*At this point, Al's story jumps ahead 10 years to 1965—ed)*

1965 was a year of construction, carried out in conjunction with KVTV. Translator booster stations were installed at Norfolk, Neligh, and O'Neill—in NE—to bring better TV to these communities. The translators at Spence, IA were updated. Later in the year, KTIV began operating from a 2000-foot tower east of James, IA. (Another project carried out in conjunction with KVTV.)

The tower was a complex engineering project. The FAA would not let us use existing maps to locate it. We had to survey from the original bench marks and obtain the exact ground elevation. The locations and elevations for the guy anchors had to be determined within inches because the cables were cut to length before shipping. Bob Engelhart, Chief Engineer, and I worked with Finley and Rath on all these surveys.

Since this was before the days of calculators, our math was done using 7-place log tables. We all had to agree on every calculation or we did it over. The only real accident that occurred during construction happened when I fell off a stepladder onto a concrete pier—breaking my foot. I finished the job on crutches.

THE RADIO SPECTRUM, *continued from page 23*

expensive proposition when there was a need to transmit on a large number of frequencies. Therefore, synthesizer circuitry was created to permit a small number of crystals to generate signals on a large number of frequencies.

By the mid 1950s, radio hams were adapting single sideband suppressed carrier (SSB) technology in order to significantly relieve spectrum crowding in the heavily populated amateur bands.—ed.

During the 1960s, computer technology enabled signals to be generated with extremely precise frequency control. Digital, rather than analog, tuning became common for both amateur and commercial operations.

In the 1970s, work began on cellular telephone systems, and in the 1980s these systems became large users of the UHF radio spectrum. Frequency sharing reached a new level of sophistication with the development of cellular systems. Computer control makes it possible to share a large number of cellular frequencies within the same metropolitan area. This enables thousands of people to utilize their telephones without interfering with each other.

Today, the demand for frequencies for voice and wireless data communications applications seems almost insatiable. Therefore, the radio spectrum will continue to remain a scarce resource, requiring careful utilization.