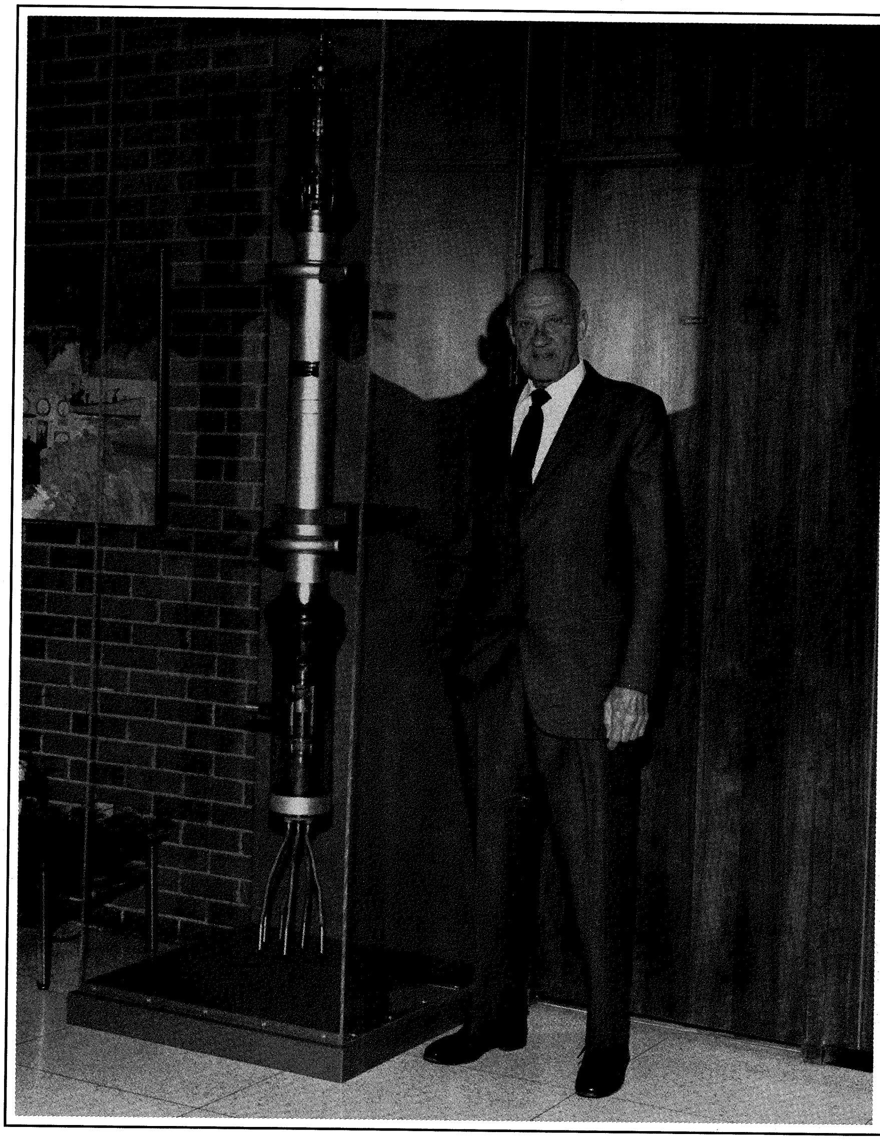
PROCEEDINGS OF

THE RADIO CLUB OF AMERICA, INC.

Founded 1909, New York, U.S.A.

November 1993



JAMES O. WELDON
1905-1993

THE RADIO CLUB OF AMERICA, INC.

Founded 1909, New York, U.S.A.

Executive Secretary: 11 Diamond Court, Glen Rock, NJ 07452

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Cover: *James O. Weldon (1905-1993)*

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SINCE 1979

By Robert M. McDonald

JAMES O. WELDON

1905-1993

The passing of James O. Weldon on April 19, 1993, closes an era in the world of high-power radio broadcasting.

As founder, former owner and past president of Continental Electronics, his vision and leadership is a legacy for us all. We extend to his family our condolences and sympathy in their loss of a husband and father, and hope that there is comfort in the memories of a man who lived a long and full life.

His accomplishments speak in their own way for themselves, but so profound was his influence on this organization and upon many of us who remain, and indeed upon the field of radio engineering, that we recall some of them here.

Mr. Weldon was born in Canton, Missouri, on March 15, 1905. As a young man he attended Culver-Stockton College where his father was a professor. He became interested in radio very early in his life, first as an amateur and then as a commercial telegraph operator. He studied at the University of Nebraska, and then began a full-time job as a radio station engineer in Topeka, Kansas. From 1927 until 1935 he was chief engineer at several early radio stations.

At KFKB in Milford, Kansas, he became associated with Dr. John R. Brinkley. He was sent to Villa Acuna, Mexico, to increase the power of Brinkley's station to 100 kilowatts. In 1938 he increased the power of this same station to 500 kilowatts, and it was then called XERA.

Although there was one other station in the western hemisphere, WLW, Cincinnati, operating in this power range, Mr. Weldon's transmitter was the first to use a "Doherty Amplifier" at this high power.

He was acquainted with Bill Doherty of Bell Labs who had published his paper on a "New High-Efficiency Power Amplifier" in the *Proceedings* in September 1936. This transmitter was quite successful since its innovative modulation scheme avoided the problems associated with high-level plate modulation transformers.

It used eight newly designed 320A tubes built by Western Electric. Only nine were ever built, and one is currently displayed here in our facility. XERA was the first of many "super power" transmitters built by Mr. Weldon throughout his career.

In 1940, he was a consultant with the Federal Telephone and Radio Corporation, and helped to design and build several 50 kilowatt radio stations around New York City.

He was a truly gifted man of many talents, a fine human being who, through his long and productive life, has left an indelible mark on radio engineering in the 20th century.

In 1942 he joined the Office of War Information and later became chief of that bureau. This bureau established the network which programmed all of the existing broadcast shortwave and medium wave stations during World War II, and also provided for the expansion of this network into what we know today as the Voice of America.

A definitive paper titled "The Early History of U.S. International Broadcasting From The Start Of World War II" was written by Mr. Weldon for the IEEE in March 1988, and describes this era of high-power broadcasting in detail.

After WWII he organized a partnership with Lester H. Carr, doing antenna design and general practice before the Federal Communications Commission. Following the war there was an expansion of commercial broadcasting, and in late 1946, he came to Dallas and organized a manufac-

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This item is reprinted from the May 1993 special edition of Continental Courier, *published by Continental Electronics Corporation, Dallas.*

turing company to build transmitters and phasing and coupling equipment that consulting firms were specifying. This was the beginning of the Continental Electronics we know today.

He began at 1728 Wood Street in downtown Dallas with a handful of employees. On March 8, 1951, he moved the business into a newly built facility on Buckner Boulevard which, although expanded many times, we still occupy today.

The 1950s were a busy time, and with the Cold War expanding, so did the demand for super-power transmitters. In 1950, in direct competition with RCA and their proposed plate-modulated transmitter, Mr. Weldon was awarded a contract by the U.S. Information Agency to develop a 1 megawatt medium wave transmitter using a "Doherty Amplifier." This became the 105-B.

The longwave version of this transmitter, installed in Munich, is described in the August 1954 *Proceedings*. Several of these transmitters are still in operation.

Among the biggest achievements by Mr. Weldon and his organization is the VLF station at Cutler, Maine. This was the most powerful VLF transmitter and the largest antenna system ever built at that time. Completed in 1960, it is a monument to his radio engineering skills.

There are 26 antenna towers ranging in height from 800 feet to 980 feet having a total weight of 8,500 tons. There are 36 additional 200-foot towers to support counterweights. Fifty thousand cubic yards of concrete were required for the antenna foundations, and 11 million feet of copper wire for the ground system. The transmitter is in excess of 2 megawatts.

This station is described by Mr. Weldon in an article in AFCEA's *Signal* magazine dated June 1961.

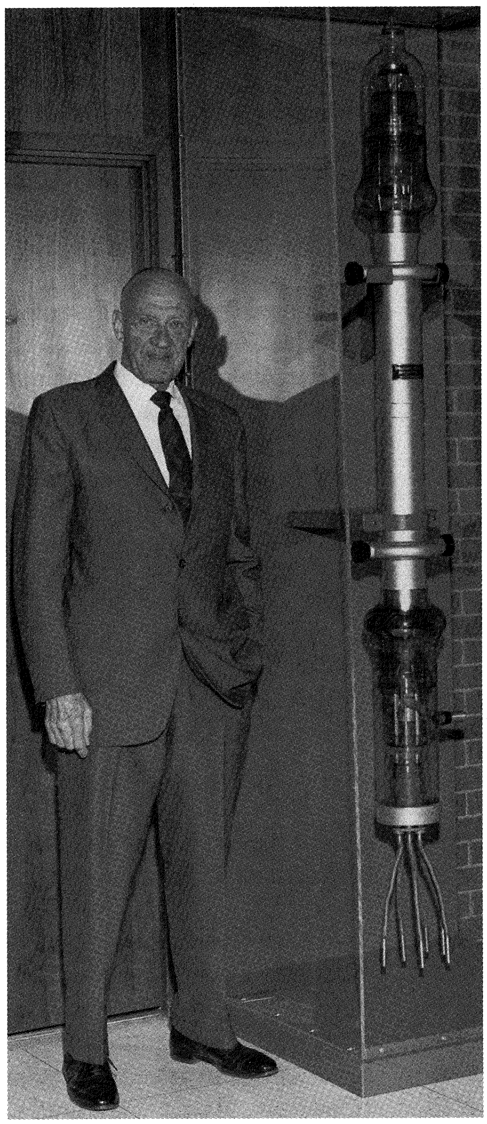
This was only the beginning. The Northwest Cape Station, finished in '67, had an even larger antenna. A total of eight VLF stations were built or retrofitted for our Navy, three new stations were built for NATO, one for Germany and one for India.

There were many other achievements in the '50s, including the erection of a prototype experimental curtain antenna here at the Buckner facility, and broadcasting program for the VOA from a new 500 kW shortwave, also being built here.

Super-power broadcast transmitters led to high-power radars, and in March 1958, the Irving Boulevard plant was opened to produce the Ballistic Missile Early Warning Radars (BMEWS). This plant, with about 90 employees, was in operation for approximately 2-1/2 years, and built the radars used in our Missile Defense Net around the Arctic Circle.

Following BMEWS was the Nike Zeus Acquisition Radar which progressed only through the prototype state.

The radar business grew, and through the early '60s there were significant contracts for instrumentation radars for the White Sands Missile Range, Kwajalein, and the Western Test Range. The company's high-power RF engineering techniques produced opportunities for equipment for particle accelerators, and many amplifiers were produced during the early and mid '60s for the national laboratories.



James O. Weldon, in 1979, stands next to one of the nine 320A tubes manufactured by Western Electric for use in the 500 kW XERA transmitter at Villa Acuna, Mexico, across the border from Del Rio, Texas. Eight tubes were used in the transmitter; the ninth was a spare.

In 1959, Ling Electronics purchased Continental Electronics from Weldon and Carr. This concluded Mr. Weldon's partnership.

In the months and years which followed, Ling Electronics became Ling-Temco, then Ling-Temco-Vought, then LTV. In the ever-changing conglomerate world, Continental became a wholly owned subsidiary of LTV-Electrosystems, now E-Systems, with Mr. Weldon as chairman of the board.

During the early '60s, Continental's Irving Boulevard plant was moved to the Luscombe Airplane Hangar at the Ling Temco facility in Garland, and remained in service until 1966. In 1962, Continental Electronics Products was established, and the commercial broadcast production, combined with the Ling closed-circuit TV product build by the Electron Corporation of LTV, was moved to 1050 N. Central Expressway. This effort was subsequently returned to the Buckner plant after almost three years.

Continental won an award from the Navy in 1966 to design and build 130 40 kW AN/FRT-85s and 17 200 kW AN/FRT-86s. This large contract spawned the construction of what we now call Building 5, completed in 1967.

In 1969, E-Systems sold Continental to Resalab, a company owned by ex-LTV people. Although still active, Mr. Weldon participated less in the management of Continental until 1972, when he again took control of Continental and made it a private corporation.

He took a very active position in the design of a 2 megawatt broadcast transmitter for Yugoslavia delivered in '75. This transmitter was a watershed of sorts, and led to super-power broadcast transmitters for Egypt, Jordan and Saudi Arabia. Some of these rank among the largest and most powerful in the world, every one of them built under his scrutiny.

Continental prospered during the late '70s, and in 1980, Mr. Weldon bought the Collins Radio AM/FM broadcast product line from Rockwell and absorbed this production line into the Buckner facility.

By the middle '80s, because of his age, he began to look seriously for a buyer for Continental who could provide the financial stability that the company needed. In May 1985, he sold Continental to Varian Associates, having just had his 80th birthday two months before the sale. He continued with Continental for three more years after the sale, came to work every day, and relished the opportunity to discuss and solve engineering problems.

Mr. Weldon formally retired in July 1988. He would stop by for a visit every few weeks, and was here a few days before he passed away. Continental's history during and after Varian is known to most of you today.

Mr. Weldon received many awards, was a Fellow in the Institute of Radio Engineers (now the IEEE), and was well known throughout the world by those involved in radio engineering. He was a truly gifted man of many talents, a fine human being who, through his long and productive life, has left an indelible mark on radio engineering in the 20th century. He will be missed by all who knew him.

James Weldon (F), AA5ST

James O. Weldon, AA5ST, 88 years old, passed away on 19 April 1993. When he was 86 years old, he passed his Extra exam.

Weldon founded Continental Electronics in Dallas, Texas, in 1946. He was known in the industry as "Mr. High Power." It was his designs that led to the development of the highest powered RF systems in the world. His knowledge and designs of high power led to the building of the first "super station" in North America. This station, XERA, was owned by Dr. Brinkley and operated out of Del Rio, Texas, with power of 500,000W.

It was Weldon's knowledge and abilities that led to the development of the Navy's two-million-watt VLF transmitter at Cutler, Maine (submarine communications). The station operates on 14.2 kHz.

In 1942, J.O. joined the Office of War Information, overseas branch, and became chief of that bureau. The broadcasting network which he helped to plan and construct during WWII ultimately became the Voice of America, or VOA, as it's called today.

It was through his vision of the programming of the network which he conceived, and later through the high-power transmitters built for the VOA and Radio Free Europe by Continental, that the message of America and freedom was first broadcast behind the Iron Curtain.

After the war, he organized a partnership firm of Weldon and Carr, consulting radio engineers, and in late 1946, he came to Dallas and established Continental Electronics.

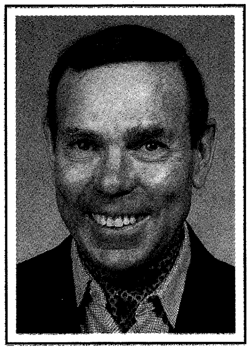
His techniques opened the doors to a whole new field in super-high-power radio transmissions. Continental, under his direction, built many of the million-watt stations for the Voice of America located all around the world. Thirteen transmitters of two million watts each were built for the government of Saudi Arabia. Super radars for the military were built, always under his masterful hands.

I worked for him in Continental's R and D lab for 38 years, and never have I met a man who won or deserved the respect of the community more than he.

His work opened a whole new field in radio. He was a pioneer in the design and construction of super power transmitters, held several patents, authored many papers, and in 1954 was awarded a lifetime fellowship in the Institute of Radio Engineers, now the IEEE.

We who worked under him will long miss his leadership. It is with the deepest regret that we say goodbye to the man known as "Mr. High Power," James O. Weldon, AA5ST.

—Edward Boh, W5AUY. Reprinted from the July 1993 edition of Worldradio *magazine.*



Fessenden and the Early History of Radio Science*

By John S. Belrose, Ph.D., VE2CV

Many scientists and engineers have contributed to the development of electromagnetic theory, the invention of wireless signaling by radio and the development of electromagnetic antennas needed to transmit and receive the signals.

Concerning the history of wireless communications, several names stand out above the others. The very possibility of wireless communications is founded on the researches of Clerk-Maxwell into the mathematics of electro-magnetism, researches so "pure" and abstruse that it took mathematicians several years to appreciate their significance.

Fessenden must clearly be the pioneer of radio communications as we know it today. I wonder how many of you have heard of him?

Today Maxwell's equations form the basis of computational electromagnetics. In the experimental verification of the results foretold by Maxwell's theory, use was made of the results of experiments in pure physics which Lord Kelvin had made forty years previously. Kelvin had set himself the task of investigating the way in which a Leyden Jar discharged, and found that, under certain conditions, the discharge gave rise to alternating currents of very high frequency.

Forty years later, Hertz was able to utilize these high-frequency currents to produce the first wireless waves, thus validating the theory of Maxwell.

Marconi was the first to describe and the first to achieve the transmission of definite intelligible signals by means of Hertzian waves. History has accredited him with the invention of an early form of radio telegraphy. His contributions to the history of radio communications are well known, and celebrated; but other experimenters took a hand, very early.

Do you know:

(1) Who first used the word and the method of continuous waves?

(2) Who was first to transmit voice over radio?

(3) Who devised a detector for continuous waves?

(4) Who first used the method, and the word *heterodyne*?

(5) Who was first to send two-way wireless telegraphy messages across the Atlantic ocean?

(6) Who was first to send wireless telephony (voice) across the Atlantic ocean?

(7) Who made the world's first wireless broadcast (voice and music)?

The answer to all seven questions is Reginald Aubrey Fessenden, a Canadian-born radio pioneer, working in the United States.

Fessenden must clearly be the pioneer of radio communications as we know it today. I wonder how many of you have heard of him?

It is perhaps appropriate that an Alexander Graham Bell Lecture should remember the contributions of Prof. Fessenden to the early history of radio science, since the work of Bell had a profound influence on his life. Bell developed a method of sending words over wires (the telephone). The idea of transmitting the human voice by wireless dominated the early radio experiments of Fessenden.

*15th Annual Alexander Graham Bell Lecture 1992, McMaster University, 12 November, 1992. This annual lecture is organized by the Communications Research Laboratory, Faculty of Engineering, McMaster University, Hamilton, Ontario.

Reggie during his boyhood in Fergus, Ontario, followed the work of Alex Bell in nearby Brantford with great fascination. But his inquisitive mind was well ahead of Bell's experiments.

The year was 1876, Reggie was 10-years old. His Uncle Cortez Fessenden, who played an important role in the development of Reggie's inquiring mind, had been invited to see a demonstration of the telephone at the Bell homestead on the 4th August. Bell's first long distance call, between Brantford and Paris, via Toronto, a distance of 113 kilometers, was made a few days later on the 10 August 1876.[1]

Reggie could hardly wait to meet his uncle after the demonstration to find out how it worked. In a conversation with his Uncle Cortez on the following day, which took place during a thunderstorm, Reggie was seeking an understanding about the transmission of sound over wires (the telephone).

"Uncle, how far do you think the roar of thunder can be heard? And have you noticed it comes booming down without a single wire to help it?"

"The thunder doesn't need a wire because it travels to us on a sound wave; with lightning it is an electric wave."

"Then why doesn't Bell shout on a wave?"

"He does. Bell gets his electric waves from a storage battery and those waves shuttle back and forth on the wire thus carrying his voice."

"But why is the wave on the wire. It strikes me that those wires are a crazy nuisance, the thunder doesn't need a wire, so why does Bell need one?"

"Heaven knows what direction his words would take without something to guide them," his uncle replied. "Is it not plain to you, lad, that the thunder is only a sound wave? Why, it wouldn't travel any distance at all unless you loaded the whack on a wave of electricity."

Cortez was not entirely satisfied with his answers to "Why a wire?" Being a good physics teacher, he was up on mathematics, and it appeared to him that there should be some way of using mathematics to explain the working of electricity and words and wires, but he had to admit to himself that it was simply beyond his ken.

"Words without wires," Uncle Cortez mused to himself. "I have never heard of such a nonsensical thing."

But his Uncle Cortez and the world would, when Reggie grew up.

Years later, in 1897, Reginald, now 31 years old, was again having a discussion with his uncle. "Look," he said. He threw a rock into Chemung Lake, near Peterborough, Ontario.

"See how the waves circle out where the rock hit? If they are going to carry the whole range of voice sounds, the Hertzian waves must radiate like that from the antenna at the transmitting end, and they must keep going in a steady stream until they encircle the antenna at the receiving station. They must never let up even for a split second."

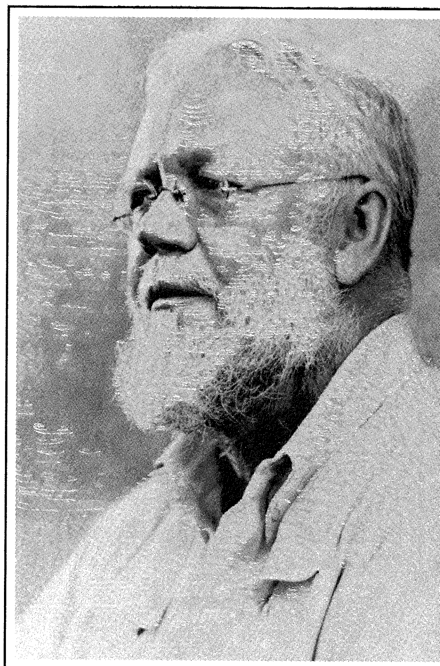
"I see," said his uncle. "In Marconi's scheme, they stop and go, stop and go."

Suddenly, after minutes of silence, Reg said, "continuous. That's the words that describes them, 'Continuous Waves'." [paraphrased from Raby][4]

And so our present continuous wave approach to radio communications was born. But generating CW, modulating the waves, and receiving them was yet to be accomplished.

Pre-radio science career

Reginald Fessenden may well be the greatest Canadian-born scientist, inventor and engineer.



Professor Reginald Aubrey Fessenden (1886-1932).

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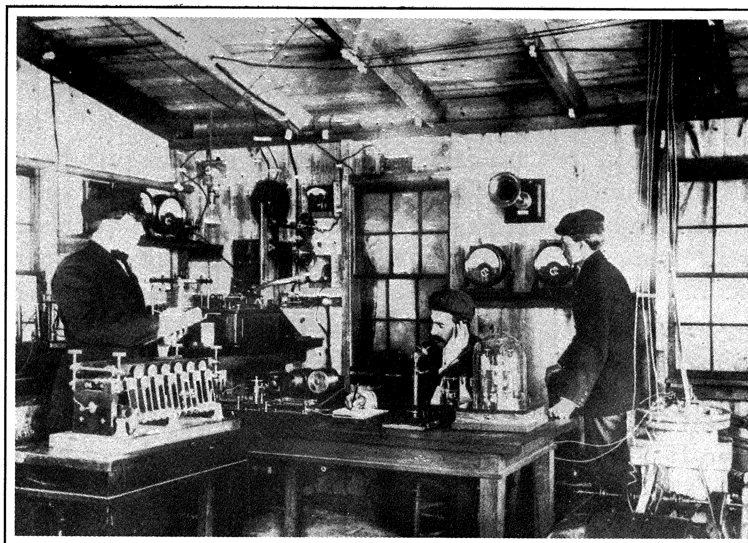

The interior of the radio shack at Brant Rock, with operators in transmitting position.

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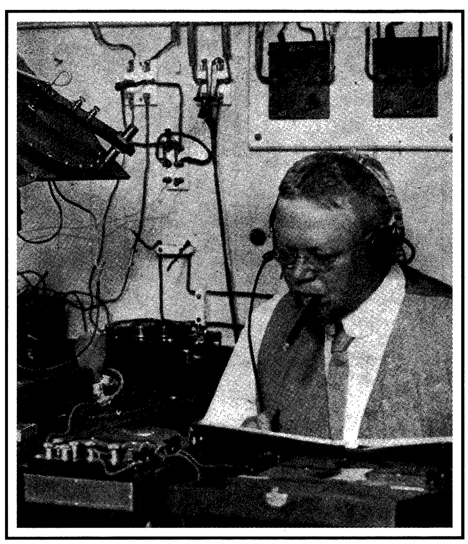
Another view in the radio shack. Fessenden is seated at the table on the right.

As a scientist he should be considered the intellectual peer of Lord Rutherford, Sir J.J. Thompson and Lord Kelvin. Oliver Heaviside and, particularly, A.E. Kennelly (co-discoverers of the Kennelly-Heaviside ionospheric layer) were his contemporary colleagues.

Fessenden operating the Brant Rock station.



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As an inventor, he held some 230 patents. As an engineer, he did not confine his expertise to one discipline but worked with equal facility in the chemical, electrical, radio, metallurgical and mechanical fields. Yet in spite of his brilliance, the number, and the continuing usefulness of his contributions, he is now virtually forgotten, except by a few. [2,3,4,5,6,7,8] In Susskind's [9] comprehensive review of the early history of electronics and wireless, no mention was made of him.

Reginald Aubrey Fessenden was born in Knowlton, Brome County, Canada East (now Quebec) on 6 October, 1866. The family resided at East Bolton (now Austin) at that time.

In 1871 the family moved to Fergus, Ontario, and in 1875 to Niagara Falls, Ontario.

Educationally, the young Fessenden was a prodigy. He attended De Veaux Military Academy, Niagara Falls, New York, for one year at the age of nine. He went to Trinity College School, Port Hope, Ontario, where he won prizes and the praise of the head master as one of the best students that he had ever had.

At the age of 16, he accepted a mathematics mastership at Bishop's College, Lennoxville, Quebec, where he became interested in science through private reading of the periodicals *Nature* and *Scientific American*.

In 1886, he accepted the principalship of Whitney Institute, Bermuda. Although he never lived in Canada again, he considered himself a Canadian, and he spent vacations at his uncle's cottage near Peterborough, Ontario.

Fessenden worked at Thomas Edison's laboratory, East Orange, New Jersey, from 1887-1890. When Edison gave him the task of producing a non-flammable insulation for electrical wires, Fessenden set out to learn all he could about elasticity.

The recognized authorities on the subject were Sutherland and Lord Kelvin, who held the view that both elasticity and cohesion were due to a gravitational attraction between the atoms. Fessenden was skeptical, and began a research study for a better explanation.

Using mathematics as a basis for his study, Fessenden concluded that atoms had to be spherical in shape, with a positive charge at their centers and a negative charge on their surfaces. He considered atoms as electrostatic doublets.

In a series of technical notes Fessenden proposed his *electrostatic doublet* theory of cohesion, and used it to calculate the physical and electrical properties of metals, reportedly showing that the cohesion, rigidity and Young's modulus came out right. [Squires][10], [Vosper][11] His paper entitled "The Law and Nature of Cohesion," published in 1892, was deemed preposterous by contemporary scientists, including Sir J.J. Thompson, Cavendish Laboratory, Cambridge, on the grounds that *since metals were conductors, the individual atoms must also be conductors and could not contain internal charges!*

Ironically it was Sir J.J. Thompson who, five years later, demonstrated that atoms were electromagnetically constituted.

In 1890, Edison encountered financial difficulties, and Fessenden was laid off. He went to work for Westinghouse.

▲ *The Brant Rock staff and operators. Fessenden is seated in the middle and to his right is his son (Reginald Kennelly), holding Mikums, his cat. Mr. Pannill is on the far left. Standing next to him is Jessie Bent, the secretary. Mr. Stein is on the far right.*

Here he tackled different problems. The method of using platinum connecting wires for an electric lamp made light bulbs expensive, and was covered by a patent. Fessenden found ways of fusing wires of iron or nickel alloys to the glass, greatly reducing the price. This breakthrough was a significant early step in the transition of electric light from a novelty to an everyday necessity.

He later developed silicon steel. Early transformers and electric motors were lossy due to hysteresis loss in the iron cores of the transformer and iron pole pieces in motors. Fessenden reasoned that replacement of the large carbon atoms in the steel by smaller silicon atoms would reduce the hysteresis loss, and in almost a century, no better method has been found than his silicon steel.[11]

In 1892, he accepted the chair of electrical engineering at Purdue University, and although he stayed there for only one year, he was responsible for establishing the Electrical Engineering Department at the university, and his influence is perhaps still felt today. [Geddes][12]

In 1893, the University of Pittsburgh persuaded him to accept the same chair in that city, largely because George Westinghouse was anxious to have Fessenden nearby and helped with a substantial honorarium.

In 1899, Fessenden attempted to return to Canada, but McGill returned his application for the chair of electrical engineering. The position was filled by a "professor" from Nebraska.

Fessenden never did graduate formally from a university, but because of the positions he held with Purdue University and the University of Pittsburgh he was hereafter referred to as Professor Fessenden. One can only speculate what might have happened if he had worked at McGill with Rutherford and Soddy.

Fessenden's inventive mind was already in evidence. By 1901, he already held nine patents with respect to incandescent lamps. His hobby of photography led him to the invention of what he called *microphotography*, an early form of microfilm. He also began experimenting with radio waves, and it is in the field of radio science that Fessenden made his greatest contributions.

Wireless telegraphy

Fessenden closely followed the work and research methodology of Heinrich Hertz, Thomas Edison and Alexander Graham Bell.

In 1900, he joined the U.S. Weather Bureau, which sought a system for transmitting weather forecasts. Unfortunately, he fell soon out with his superior at the bureau and resigned in August 1902.

In September, he secured the financial support of two Pittsburgh millionaires, T.H. Given and Hay Walker; and together they formed the National Electric Signaling Company (NESCO). While the partnership eventually collapsed (in 1912), Fessenden's greatest achievements occurred under its aegis.

It is interesting to note that Fessenden, in 1905, established the Fessenden Wireless Telegraph Company of Canada. Unfortunately, this venture never went anywhere. The Canadian Company never received support from his American partners. It acquired a transatlantic license from the British government, but not from Canada. *Only Marconi was licensed to erect towers in Canada and install radio equipment in Canada—a senseless government regularity ruling that held back the competitive development of radio in Canada for more than two decades.*

Marconi, for his transatlantic experiment in December 1901, employed a Braun type of antenna system, see below, and a spark transmitter designed and constructed by Fleming.

Marconi knew very little about his transmitter. It is interesting to speculate on whether Marconi drew the hand drawn sketch of "his" transmitter, labeled Marconi's transmitter, published in a 50th anniversary publication of the IEEE on the early history of wireless. This "transmitter" simply would not work.

Ratcliffe[13] has discussed scientists' reaction to Marconi's transatlantic experiment. The author has also pursued this subject. He modeled Marconi's Poldhu antenna system to determine its frequency of oscillation. But that is another story.

The technology of the era as exemplified by Marconi systems was based on the generation of radio waves by creating a spark, which can be likened to a *whip lash effect*. Let us digress for the moment and speak about spark transmitters.

Spark transmitters

The simplest method of producing high-frequency oscillations is to give an electrical shock to an oscillatory circuit consisting to an inductance and a capacitance in series. (See Figure 1a.)

This principle is used in the so-called spark transmitter.

Hertz's transmitter, in 1888, placed the spark gap across the terminals of the antenna, which was an end-loaded dipole. (See Figure 1b.) The equivalent circuit of an antenna at frequencies near its self resonant frequency is a series resonant circuit (L_a-C_a-R_a).

Marconi, following the lead of Hertz, employed such a spark transmitter, but his antenna was a monopole type, a wire fed against ground. Since the only conducting path for the transmitting antenna to ground was by way of a spark across the gap, the oscillations on the antenna were in very short bursts. (See Figure 3a.)

The natural L-C-R response of the antenna system was interrupted when the spark discharge ceased. The only connection to ground was through the low impedance of the spark discharge. But this *gap* was considered to be an essential element of the radiating system. Indeed, some contemporary mathematicians concluded on the basis of their "theoretical" studies that no antenna could radiate without a gap!

This not wanted gap was eliminated by Braun, a German physicist, who in 1898 patented a circuit in which the spark gap was in a separate primary circuit in series with an appropriate coil and condenser.

But the contribution of the Braun patent is perhaps as controversial as is the subject of who was the first to devise electromagnetic antennas. The German patent has been questioned. Nothing original was said about tuning, and the oscillating circuit was said to be much "slower," tuned to a lower frequency, than the antenna circuit.

If the coupling between the oscillating and antenna circuits is high, a double peaked amplitude frequency response will result, and while such a response is not wanted, both circuits should certainly be tuned to the same frequency. I say "not wanted," because this double-hump response in effect made the transmitter transmit a "double wave."

In fact, early radio regulations were introduced encouraging "single-wave" or "sharp" emissions, by limiting the amplitude of the second wave to say one-tenth the amplitude of the stronger, desired wave. Notwithstanding, Braun's "tank circuit" was coupled inductively to a secondary consisting of the antenna in series with a coupling coil in which the driving electromotive force was induced and which provided a continuous conducting path from the antenna to ground. Except for the later insertion of a transmission line between the antenna and the coupling coil, the Braun antenna arrangement provided the complete electrical equivalent of the present-day base-driven monopole antenna.

A Braun-type spark transmitter was a considerable improvement over the "simple" or "Marconi type transmitter." It consisted of a condenser and an inductor in series with a spark gap, across which is connected an induction coil. (See Figure 1c.)

The induction coil had a low voltage primary winding and a high voltage secondary winding. (See

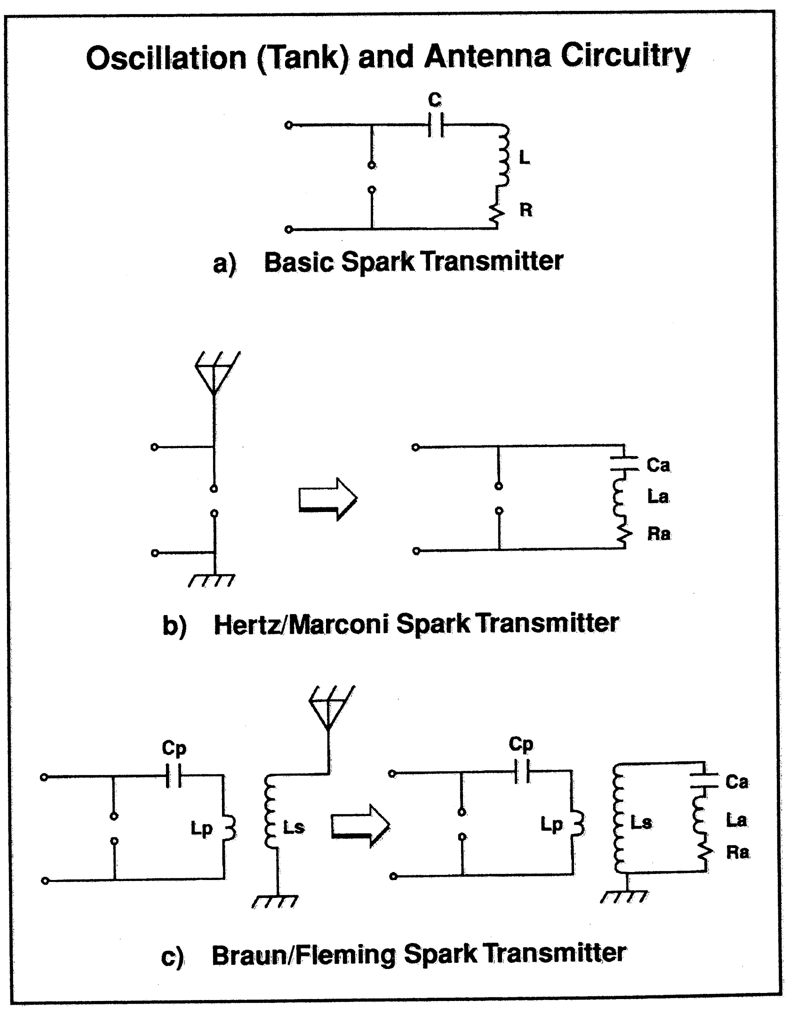

Figure 1. Sketches illustrating actual and equivalent circuits for spark transmitters.

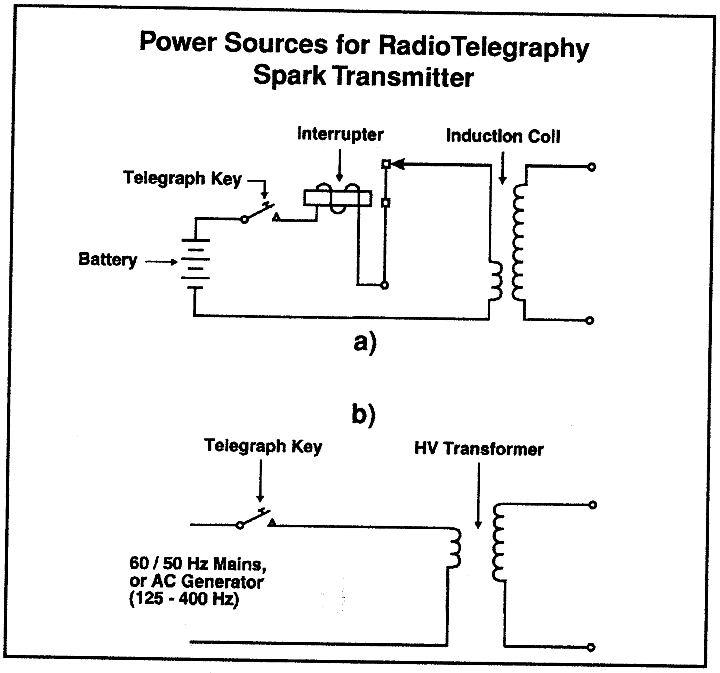

Figure 2. Power sources for telegraphy spark transmitters.

Figure 2a.) The low-voltage primary winding was driven by a battery and an interrupter, which made and broke the connection of the primary winding to the battery at some low audio frequency rate.

When the induction coil was working properly the condenser was charged up, and when the potential across it was sufficiently high to break down the insulation of air in the gap, a spark then passed. Since this spark has a comparatively low resistance, the spark discharge was equivalent to closing of the oscillatory L-C-R circuit.

The condenser now discharged through the conducting spark, and the discharge current took the form of a damped oscillation, at a frequency determined by the resonant frequency of the spark transmitter. The RF energy flowing in the inductor was inductively coupled to an antenna, which was tuned to the same frequency as that of the spark transmitter.

The induced oscillation in the antenna circuit was also a damped wave, but the period of oscillation was significantly longer than the oscillation in the primary. (See Figure 3b.) In effect, the primary is the "tank circuit" and the secondary the "antenna circuit".

Marconi's early telegraphy experiments were made using such a spark transmitter. However, it was the simple form of transmitter, spark gap across the antenna terminals, that he obtained his first successful results and demonstrated the possibility of wireless telegraphy by means of electromagnetic waves propagated over great distances.

The interrupter was a mechanical device, operating at rate corresponding to a low audio frequency. Thus, each time the key was pressed the receiver would "hear" a buzz (ignoring for the present that a suitable detector so that the operator could actually "hear" the sound of the transmitted signal had not been devised). The audio sound to be "heard" was the interrupter frequency accompanied by the ragged and irregular noise of the spark generated signal.

Most early radio experimenters followed or improved upon the Marconi method of signaling, because in their view a spark was essential to wireless. But later experimenters employed an AC generator and a high voltage step-up transformer, rather than an induction coil and battery, for the power source. (See Figure 2b.)

Fessenden's work in radio was important, not only for the results he secured, but because of its originality. From the outset he sought methods to generate and receive continuous waves, not damped waves, which started with a bang and then died away quickly. However, his early experiments had to make do with spark transmitters, the only means known at that time for

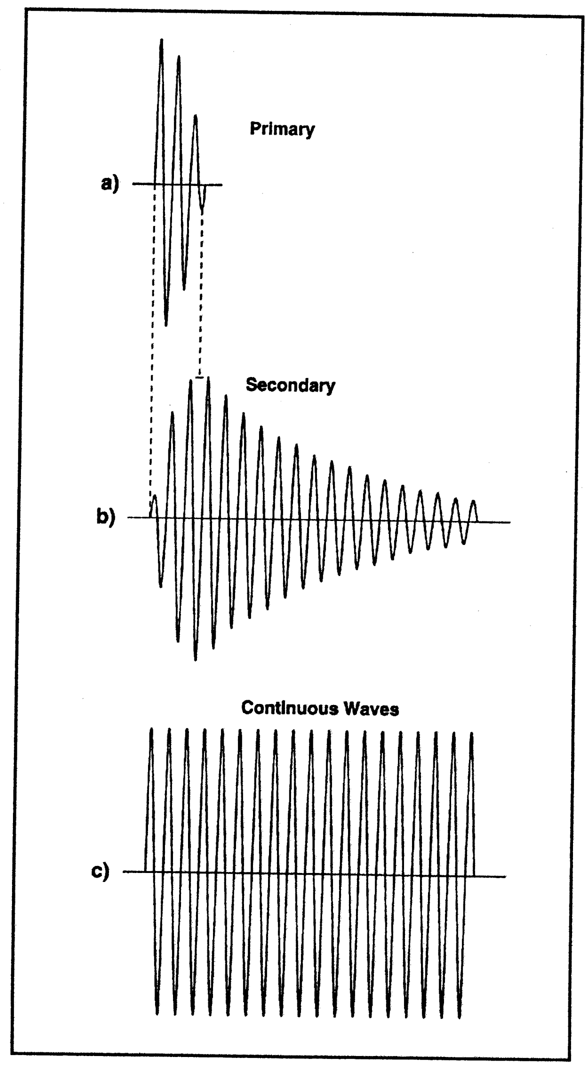

Figure 3. Idealized waveforms in the oscillation circuit (a); and the antenna circuit (b). Damped waves are much more noisy, broad, and capable of severe interstation interference compared with (c) undamped or continuous waves (cw).

generating appreciable power.

So he set his mind to make this type of transmitter more CW-like. This led to his development of the synchronous rotary spark gap transmitter. An AC generator was used, which as well as providing the energy for the spark transmitter, was directly coupled to a rotary spark gap so that sparks occurred at precise points on the input wave. The spark was between a fixed terminal on the stator and a terminal on the rotor, in effect the rotor was a spoked wheel, rotating in synchronism with the AC generator (See Photo 1.)

Thus, a higher spark rate was achieved, high compared with the frequency of the AC generator. But another advantage was realized, since in effect a rotary spark gap was a kind of mechanically quenched spark gap transmitter.

The oscillations of the primary circuit ceased after a few cycles, since when the rotating gap opened the spark ceased, and the antenna circuit continued to oscillate with its own damping. The quenched spark gap was more efficient, probably a less noisy, narrower-band signal compared with the unquenched gap, since any of the spark methods of excitation inherently involve consumption of energy in the spark, in addition to the energy losses occurring in the antenna circuit.

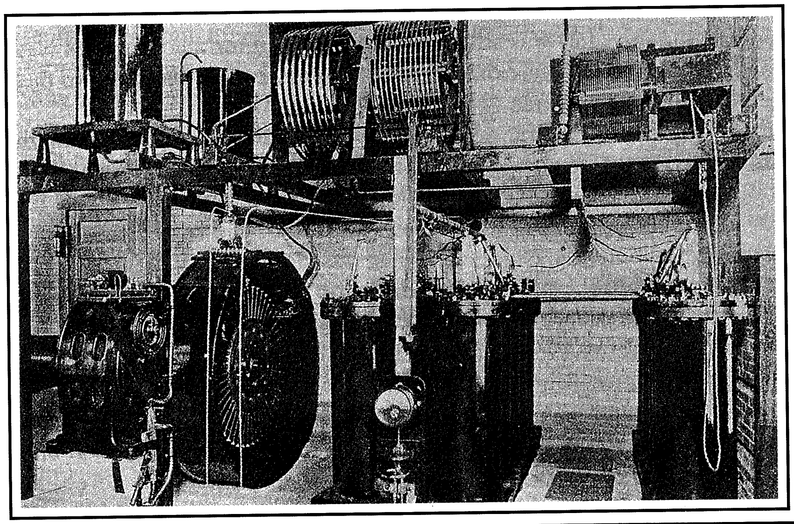

Photo 1. An early version of Fessenden's synchronous rotary spark gap transmitter.

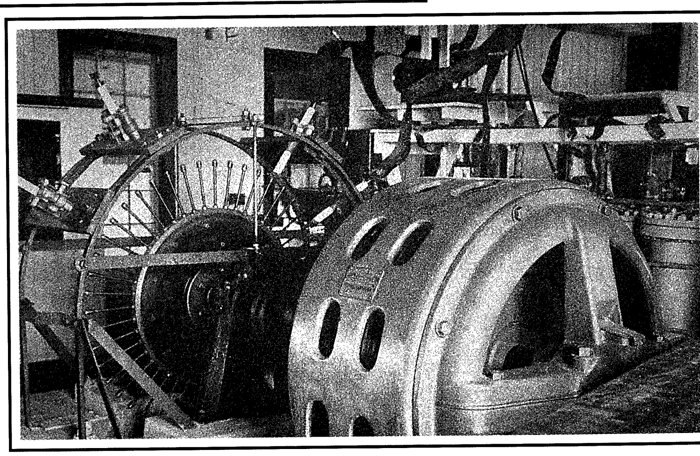

Photo 2. The Brant Rock synchronous rotary spark gap transmitter.

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Many forms of *quenched spark gap* transmitters were devised, described as *Wein* transmitters, but the Fessenden synchronous rotary spark gap transmitter was perhaps the best. With a synchronous spark gap phased to fire on both positive and negative peaks of a 3-phase waveform, precisely on the peak for maximum efficiency, a 125 Hz AC generator would produce a spark rate of 750 times a second.

These rotating gaps produced clear almost musical signals, very distinctive and easily distinguished from any signal at the time. It was not true CW, but it came as close as possible to that, and the musical tone was easily read through atmospheric noise and interference from other transmitters. (See Appendix A.)

His Brant Rock station employed a synchronous rotary spark gap transmitter, the largest one built to date. (See Photo 2.) It was completed on 28 December 1905. The rotary gap measured 6 feet in diameter at the stator and 5 feet in diameter at the rotor. Its rotor had 50 electrodes (poles), and its stator had four. Coupled to this rotary gap was a 125 Hz, 3-phase, 35 KVA alternator.

HF alternator for CW

Spectacular as was the Brant Rock transmitter, Fessenden, after achieving initial success, to be described, soon turned his attention to other directions, devoting his efforts to newer and better developments—the HF alternator.

Fessenden realized, as we have already noted above, that this stop-and-go system, the spark transmitter, was incapable of transmitting satisfactorily voice and music. A means of sending and receiving continuous waves was required.

The idea came to him during discussions with his uncle Cortez Fessenden, as I have already told you, while visiting with him at his cottage on Chemong Lake near Peterborough in 1897, and is described in his U.S. Patent No. 706,737, dated August 12, 1902.

But it was not before the fall of 1906, when Fessenden's HF alternator was developed to a point where it could be used practically (frequencies up to 100 kHz were possible), that continuous wave transmission became feasible.

Marconi and others working in this new field of wireless ridiculed Fessenden's suggestion that a wireless signal could be produced by applying an HF alternating current to an antenna. All were unanimous in their view that a spark was essential to wireless, an error in reasoning that delayed the development of radio by a decade.

Fessenden was right, but alone in his belief. "The whip-lash theory however passed gradually from the minds of men and was replaced by the continuous wave one with all too little credit to the man who had been right." [New York Herald Tribune][14]

To document the reaction of his colleagues to this departure from conventional transmission methods, spark or damped wave transmissions, we can note that J.A. Fleming in his book *Electromagnetic Waves*, published in 1906, said, in reference to Pat. No. 706,737, that "there was no HF alternator of the kind described by Fessenden, and it is doubtful if any appreciable radiation would result if such a machine were available and were used as Fessenden proposes."

Fleming was totally wrong, since 1906, the year in which his book was published, was the year of Fessenden's greatest achievements using continuous waves generated by an HF alternator, with one terminal of the alternator connected to ground and the other terminal to the tuned antenna. Certainly, the referenced statement did not appear in subsequent editions of Fleming's book.

Judge Mayer, in his opinion upholding Fessenden's patent on this invention, said, in effect it has been established that the prior art practiced, spark or damped wave transmission, from which Fessenden departed and introduced a new or continuous-wave transmission, for the practice of which he provided a suitable mechanism—which has since come into extensive use. [Kintner][15]

Initially, Fessenden employed various forms of arc transmitters and rotating spark gap transmitters with varying degrees of success. When he had perfected his HF alternator in 1906, Fessenden had achieved his goal, *viz.* a continuous wave transmitter, the frequency of which was not determined by aerial tuning but by the speed of the HF alternator. The aerial tuning only determined the power transfer from his transmitter to the aerial.

Subsequently, the HF alternator was replaced by vacuum tube transmitters, and nowadays by solid-state transmitters, but the basic principle of operation of the Fessenden transmitter is the same as that today.

As early as 1890, Tesla built high-frequency alternating current (AC) generators. One, which had 384 poles, produced a 10 kHz output. He later produced frequencies as high as 20 kHz. [Quinby][16]

There is no fundamental reason that such frequencies could not have been used for worldwide wireless communications; in fact, in 1919, the first continuously reliable transatlantic radio service, with a transmitter installed in Brunswick, New Jersey, used a 200 kW HF alternator operating at a frequency of 21.8 kHz.

However, practical antennas used in the early days of radio were not large enough to radiate efficiently at such a low frequency, so LF rather than VLF had to used. [For a description of the New Brunswick antenna, see Watt.][17]

Fessenden contracted the GE Company to build an HF alternator operating at speeds of 50-100 kHz. Alexanderson struggled for two years to develop such a machine, and in September 1906, GE delivered his best effort—which in Fessenden's view was a "useless machine."

The *Alexanderson alternator* did not meet Fessenden's specifications, since it operated at frequencies <10 kHz. It is not clear what had been improved over the Tesla alternator. When the shafts were spun by a steam engine to the unheard-of speeds required, the bearings got red hot and melted into chunks of solid steel.

So, Fessenden took upon himself to rebuild the machine. He must have persevered, day and night, in the usual way he attacked a problem, since by November 1906, he had succeeded in developing a machine that would operate at frequencies in the 50-88 kHz band.

The Fessenden HF alternator was a small machine of the Mordey type, having a fixed armature in the form of a fixed disk, or ring, and a revolving field magnet with 360 teeth, or projections. (See Figure 4.)

At a speed of 139 revolutions per second, an alternating current of 50,000 Hz and a terminal EMF of 65 volts was generated. The maximum output of the alternator at the above speed was about 300 watts. [Ruhmer][20]

Very little difficulty seems to have obtained in running the machine at so high a speed. A simple flat belt drive was used, and a thin self-centering shaft which entirely obliviated excessive vibration and pressure on the bearings. (See Photo 3.)

Fessenden later developed a HF alternator that had an output power of 50 kW. This machine was scaled up to 200 kW by the GE company, and put on the market as the *Alexanderson alternator*, named after the man who supervised the job. History forgot that Fessenden developed the prototype.

Zenneck[21] has described the Fessenden-Alexanderson high frequency machines. The rotor was

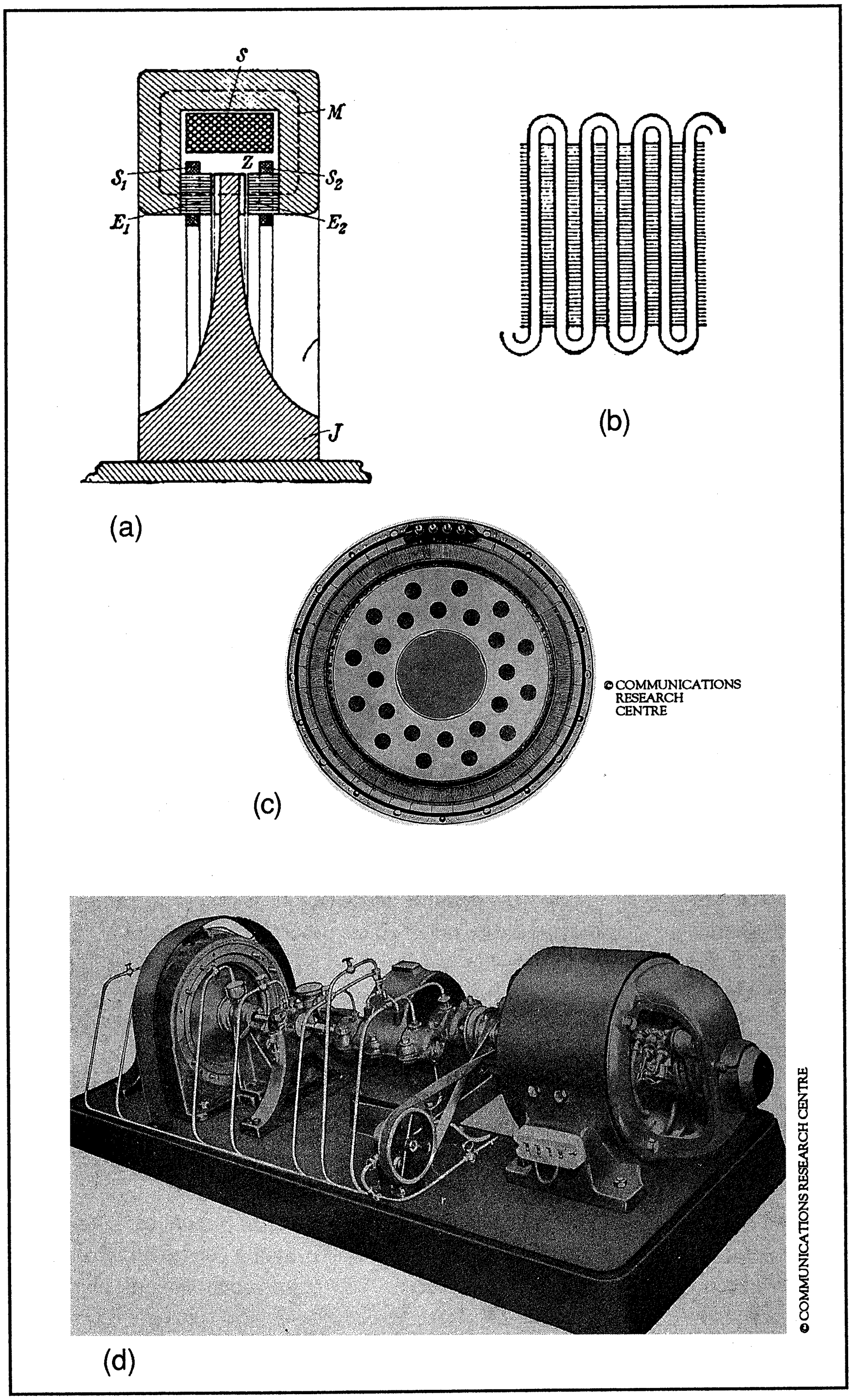

Figure 4. The Fessenden-Alexanderson HF alternator: (a) diagrammatic cross-section of one of these alternators; (b) the armature winding in which the e.m.f. was induced; and (c) one half of the completed armature. [after Zenneck][21]

shaped like the cross-section J, and had 360 teeth. (See Figure 4.)

The space between the teeth was filled with non-metallic material (phosphor bronze) so the surface of the rotor, J, was quite smooth, thereby preventing any loss due to air friction (windage). The armature windings S_1 and S_2, in which the oscillatory e.m.f. was induced, did not properly consist of coils, but a single wire wound in a wave shape form. (See Figure 4b.)

Any two consecutive U-formed wires could be considered as a pair of coils of one turn each, joined in series but so as to oppose each other. Figure 4c shows one-half of the completed armature.

Receiving continuous waves

The use of CW created problems for Fessenden, not only in regard to the generation of continuous waves but for reception.

First, at a distant station where the received signal was weak, and if it were receivable at all, one had to find and tune the receiver to this narrowband signal in the expanse of unused radio spectrum. The broadband spark signal was more easily found.

Second, the coherer-type detector used for reception of spark transmission was useless for detecting CW.

Fessenden was convinced that the successful detector for wireless signals must be constantly receptive, instead of requiring resetting as was characteristic of the coherer.

But this was more easily said than done. He first devised a hot-wire barretter, similar in nature to a miniature lamp of which the filament was made of Wollaston wire. From it he produced, as a result of an accident during the process of making his hot-wire barretter, a liquid barretter.

The hot-wire barretter needed to have the silver coating removed from a very short length of the wire by a nitric-acid treatment. It was during such treatment that Fessenden observed that one of several such barretters, in this silver-dissolving part of the process, was giving indications on a meter attached to the circuit of signals received from an automatic test sender sending D's.

An examination revealed that this one had a broken filament, while the others were complete. A brief investigation disclosed the fact that this Wollaston wire dipping into the 20% nitric-acid solution was far more sensitive and reliable than any other known type.

The word *barretter* was coined by Fessenden from his classical language background. The term is a deriva-

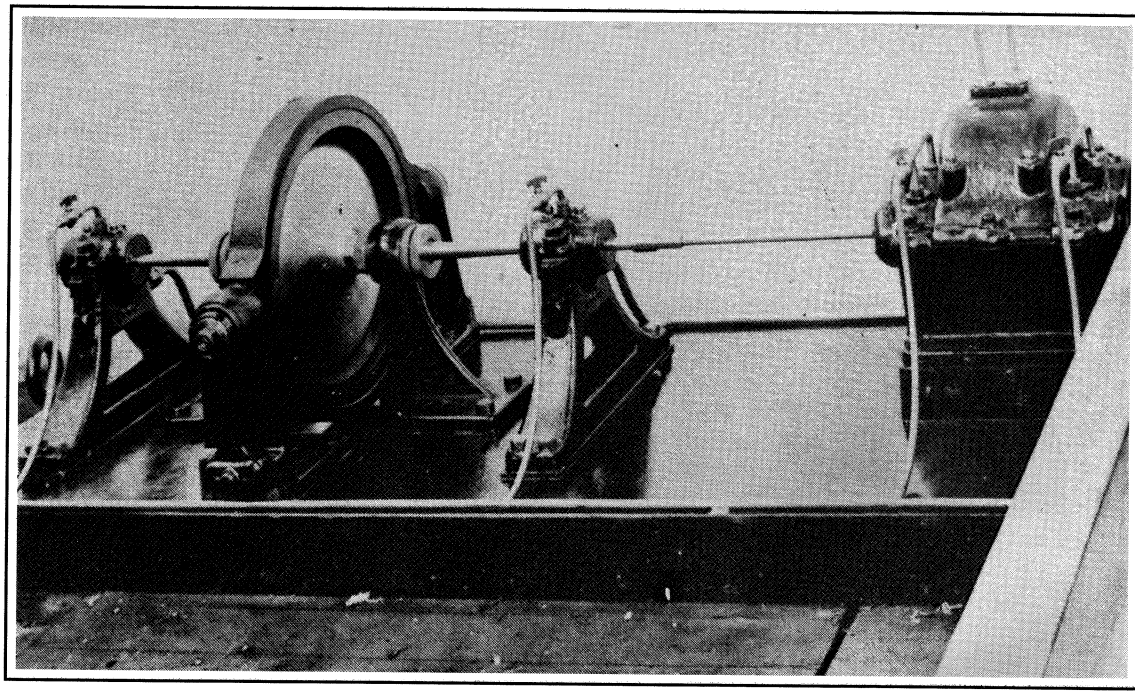

Photo 3. Fessenden's HF alternator.

tion from the French word *exchanger*, implying the change from AC to DC. For proper operation, the platinum-coated wollaston wire needed to make point-contact, lightly touching the acid solution (reference US Patent No. 727,331, 5 May 1903 for the basic detector; and No. 793,684, December 1904 for a sealed detector for shipboard use).

This detector was the standard of sensitivity for many years, until it was replaced by the germanium crystal detector, and by the vacuum tube in about 1913. This detector, when used with a telephone receiver in a local shunt circuit, gave such accurate reproductions that radio operators could identify several wireless telegraphy stations in the passband of the receiver by the different characteristics of the spark transmissions, just as a friend's voice is recognized by its peculiarities of tonal quality. And it made possible subsequently the reception of radio telephony (voice).

It is interesting to read a paper by Leslie A. Geddes, Purdue University, entitled "The Rectification Properties of an Electrode-Electrolyte Interface Operated at High Sinusoidal Current Density"[18] for a modern analysis of the Fessenden barretter type of detector. The authors became aware of Fessenden's pioneering work only after acceptance of their paper by the Journal. (See Addendum to the referenced paper.)

Fessenden's telegraphy transmissions employed a synchronous rotary spark gap transmitter, which was in effect a modulated quasi-CW method of signaling, well suited to detection by rectification.

But this rectifier-detector was useless for the reception of unmodulated continuous waves. All that would be heard would be clicks, as the Morse key was closed

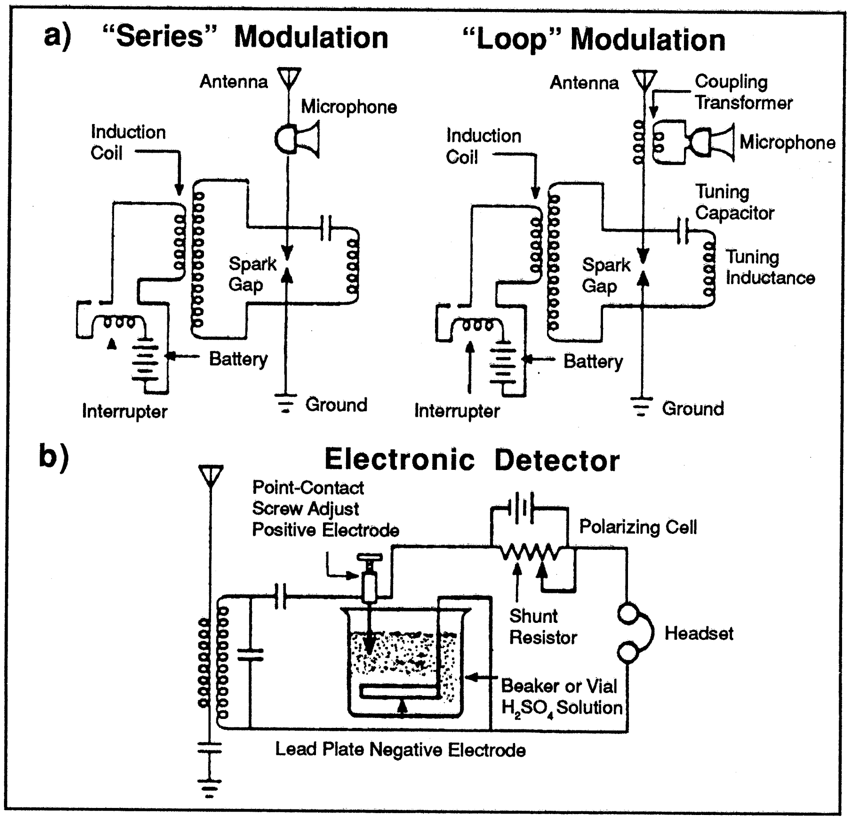

Figure 5. Two early versions of Fessenden's spark gap telephony transmitter (a) and receiver (b), which employed an electrolytic rectifier (needle point in a beaker of sulfuric acid) [after Geddes[7] from a sketch courtesy George Elliott].

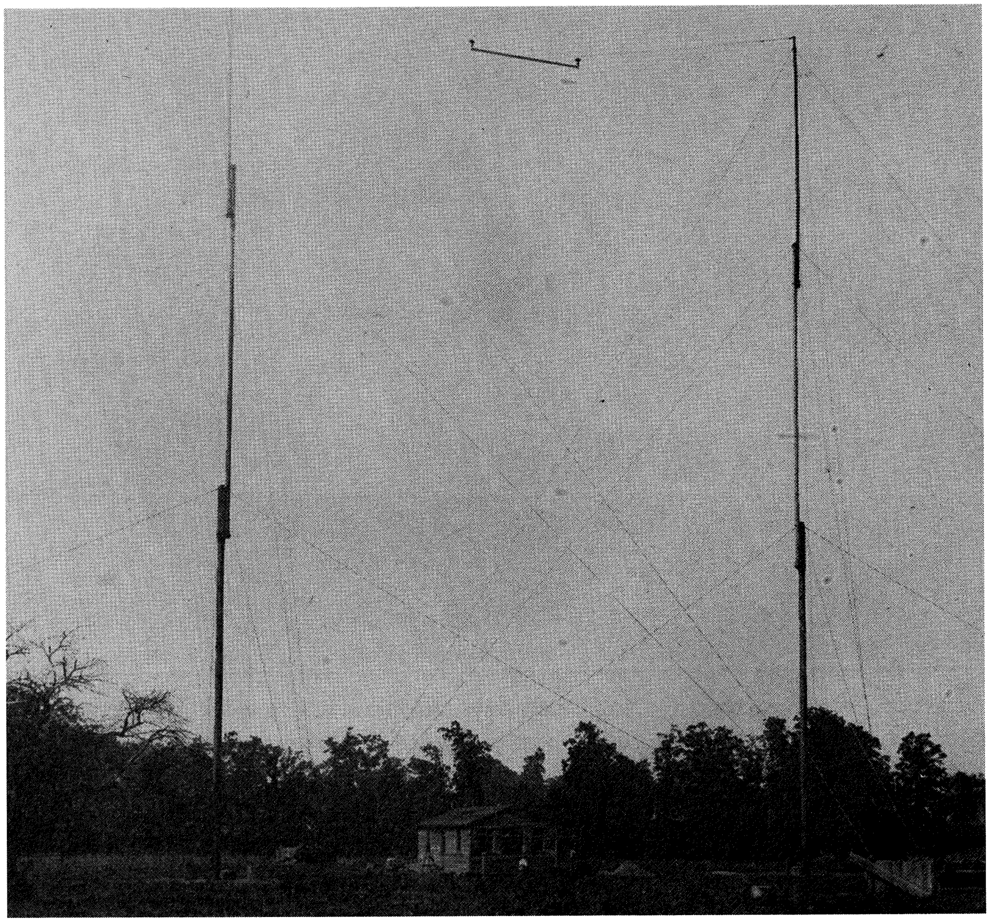

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Photo 4. Twin radio towers at Cobb Island.

Ruhmkorff induction coils, Fessenden noted that, when the telegraphy key was held down for a long dash, the peculiar wailing sound of the Wehnelt interrupter was reproduced with good clarity in the receiving telephone. This at once suggested that by using a spark rate above the voice band, wireless telephony could be achieved.

Professor Kintner, who was working for Fessenden at that time, designed an interrupter to give 10,000 breaks a second, and this interrupter was built by Brashear, an optician. The interrupter was delivered in January or February 1900, but experiments were not conducted until the fall of that year.

To modulate his transmitter, he inserted a carbon microphone directly in series with the antenna lead. (See Figure 5.) After many unsuccessful tries, transmission of speech over a distance of 1.6 kilometers was finally achieved on 23 December 1900, between 15-metre masts located at Cobb Island, Maryland. (See Photo 4.)

The received telephony transmission was reported to be perfectly intelligible, but the speech was accompanied by an extremely loud disagreeable noise due to the irregularity of the spark. (See Appendix A.) The first voice over radio was that of Reginald Aubrey Fessenden on 23 December 1900, and this is what he said:

"Hello", he undoubtedly shouted into his microphone, "one, two, three, four. Is it snowing where you are, Mr. Thiessen? If it is, telegraph back and let me know."

Barely had he finished and put on the headphones, when he heard the crackle of the return telegraphy message. Intelligible speech by electromagnetic waves had been transmitted for the first time in the history radio.

and opened.

Again Fessenden's fertile mind worked around this problem. He devised the methodology of combining two frequencies to derive their sum and difference frequencies, and coined the word *heterodyne*, derived from the joining of two Greek words *hetero*, meaning difference, with *dyne*, meaning force.

Today, heterodyning is fundamental to the technology of radio communications. Some radio historians consider that his heterodyne principle is Fessenden's greatest contribution to radio science. His initial heterodyne circuit is described in US Pat. No. 706,740, dated August 12, 1902 and his advanced heterodyne circuit, Pat. No. 1,050,441 and 1,050,728, is dated January 14, 1913.

Armstrong's super-heterodyne receiver is based on the heterodyne principle. Except for method improvement, Armstrong's superheterodyne receiver remains the standard radio receiving method today.

Spark telephony

Fessenden's one de-sire was to transmit voice without wires.

In 1899, while experimenting with spark transmission employing a Wehnelt interrupter operating the

Continuous wave telephony

By the end of 1903, fairly satisfactory speech had been obtained by the arc method, but it was still accompanied by a disagreeable hissing noise.

In 1904 and 1905, both the arc method and HF alternator method were employed. (The alternator at this stage of development operated at a maximum frequency of 10 kHz.) The transmission was however still not quite "perfect." [Fessenden][19]

In the fall of 1906, as we have already noted, the HF alternator had been brought to a practical shape. It could operate at speeds that produced frequencies as high as 100 kHz and was initially used for radio telephony transmission from Brant Rock to Plymouth, a distance of 11 miles, and to a small fishing schooner. But the transmission distance extended far beyond this range. (See below.)

The method of modulation was in a like manner to that used for his telephony spark transmitter experiment, *viz.* a carbon microphone in series with the antenna lead. The quality of the transmission was good, reported to be better than over wire lines at that time.[20]

Fessenden's communications successes

Fessenden's greatest radio communications successes happened in 1906.

On 10 January of that year, two-way transatlantic telegraphic communications was achieved—another first—between Brant Rock, Massachusetts, and Machrihanish, Scotland. James C. Armor, Fessenden's chief assistant, was the operator at Macrihanish, and Fessenden himself was the operator at Brant Rock.

During January, February and on into March 1906, two-way telegraphy communications was established on a regular basis, exchanging messages about the workings of the machines, and each day improvements were made. Fessenden and his team had beaten Marconi* at transmitting telegraphy messages both ways across the Atlantic. The frequency used was about 88 kHz.

Fessenden's sending apparatus consisted of a 40 horse-power steam engine driving a 35 KVA 125 cycle alternator, which in turn supplied current to transformers in which the voltage was raised to a value required to operate the spark. This was a rotating spark gap driven from the generator and arranged to give sparks at predetermined points on the voltage wave.

These synchronous rotating spark gaps produced clear, almost musical signals, very distinctive and easily distinguished from any signal at the time. They were superior to other signals commonly used at the time, which by comparison, were very rough and ragged.

Employing 420-foot umbrella top-loaded masts at each end of the link (See Photo 5, next page), three different frequencies were employed in the experimental communications between Brant Rock and Macrihanish. The results were carefully recorded and compared at various times of day and night and as a function of day of the month. See, for example, the records for the month of January, 1906, in Figure 6.

These records were perhaps the first field strength recordings ever made. Atmospheric conditions were also included in the records.

The encouraging results of these tests and the reaction of those listening in, far and wide, precipitated requests for Fessenden equipment. But Given and Walker refused to permit sales of the equipment, on the assumption that such sales would jeopardize their ultimate chances of selling the whole system in a package deal.

Then, at the height of excitement over the success in spanning the Atlantic with two-way communications, devastating news reached Brant Rock by cable. The Macrihanish tower had crashed to the ground in a winter storm on 5 December 1906. The station was never rebuilt.

New HF alternator

In November 1906, Fessenden and colleagues were conducting experimental transmissions using his newly developed HF alternator between stations at Brant Rock and Plymouth, Massachusetts. The station at Brant Rock was modulated by a carbon microphone connected in series with the antenna lead.

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*Marconi, who had succeeded in signaling, so he said, rather uncertainly across the Atlantic one-way on 12 December 1901 between Poldhu, Cornwall, and Signal Hill, Newfoundland, and on 15 December, 1902, between Glace Bay, Nova Scotia and Poldhu, Cornwall, had not yet succeeded in sending messages reliably over this distance even by one-way transmission.

Marconi, in this time period, was using frequencies about 10 times higher (820 kHz), which is the reason for his difficulty if not impossibility to receive the daytime signal radiated at the fundamental oscillation frequency of his antenna system.

Frequency trend as their work progressed is another contrast between Fessenden and Marconi.

Marconi's initial experiments in 1885 were made at centimetre wavelengths. To achieve communications over greater and greater distances, Marconi built bigger and bigger antenna systems, which resulted in a decrease of the antenna's fundamental oscillation frequency.

By 1904, his English antenna had become a pyramidal monopole with umbrella wires, and the frequency was 70 kHz.

In 1905, his Canadian antenna was a capacitive structure with a very large top-hat, and the frequency was 82 kHz.

Fessenden, on the other hand, was attempting to move up in frequency. His initial experiments using HF alternators were made at VLF (10 kHz), since this was the upper frequency of the early machines. However, he realized that for practical long-distance communications with realizable antennas, he had to use higher frequencies (50-100 kHz), besides which he wanted to modulate his transmitter for telephony and, therefore, had to use frequencies well above voice band.

He knew [reference Patent No. 706,737 filed 29 May 1901] that when the frequency of the alternator was very much less than the self-resonant frequency of the antenna system, that the principle fields would be electrostatic and magnetic (induction fields), which fall off as a high power of distance, and that the radiation field would be small. He knew that the "ether wave" had a wavelength that was greater than four times the monopole height. Clearly he had a good understanding of the fundamental principles of antennas and radiation.

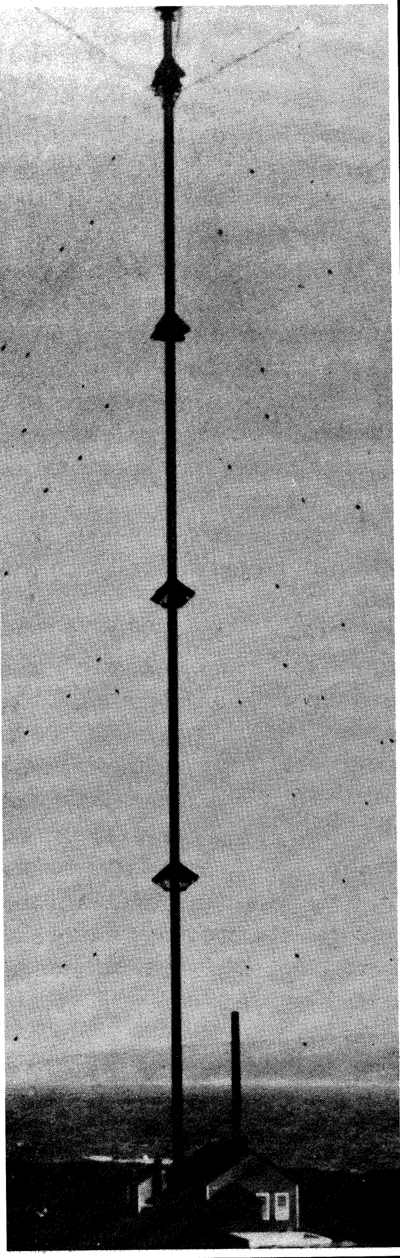

Photo 5. *The Brant Rock, Massachusetts, tower, with the radio shack at the bottom. The tall pipe extending above the transmitter building is the smoke stack for the steam engine, which was used (belt drive) to drive the AC generator for Fessenden's synchronous rotary spark gap telegraphy transmitter and, later, his HF alternator for telegraphy and telephony.*

About midnight, on an evening early in November, Mr. Stein was telling the operator at Plymouth how to run the dynamo. His voice was heard by Mr. Armour at the Macrihanish, Scotland station with such clarity that there was no doubt about the speaker, and the station log book confirmed the report.

Fessenden's greatest triumph was soon to come. On 24 December, 1906, Fessenden and his assistants presented the world's first radio broadcast.

The transmission included a speech by Fessenden and selected music for Christmas. Fessenden played Handel's Largo on the violin. That first broadcast, from his transmitter at Brant Rock, MA, was heard by radio operators on board U.S. Navy and United Fruit Company ships equipped with Fessenden's radio receivers at various distances over the south and north Atlantic, as far away as the West Indies. The wireless broadcast was repeated on New Year's eve.

The final days of King Spark

As CW systems were later developed (1905-1915), Marconi sought to use his spark expertise to achieve a semi-continuous timed spark that approximated to a continuous wave.

In a sense this was the ultimate Marconi spark transmitter and was used as the international transmitter at Caernarfon, Wales, for a few years. It was noisy, and a Poulsen arc was held in standby.

Eventually, the Marconi spark transmitter was replaced by a General Electric Company (Alexanderson) HF alternator. The Fessenden-Marconi competing radio technologies battle was over. Fessenden had won. His CW technology was the way to the future.

The U.S. Navy installed a high-power Fessenden rotary spark transmitter at Arlington, Virginia, in 1913, call sign NAA. This transmitter was subsequently replaced by an HF alternator, which was used for their VLF Fleet Broadcast at 33 kHz until the mid 1950s, but over the years the HF alternator was gradually replaced by vacuum tube transmitters, as are today's transmitters being replaced by solid state transmitters.

The three-element vacuum tube was well-known by 1915 to be capable of regeneration and oscillation. It could therefore generate CW. World War I spurred transmitting tube development. The rise of CW followed in post-war years.

Radio amateurs contributed to the demise of spark. Using spark and CW superpower, commercial and government stations were working intercontinental distances, yet, as 1921 began, no radio amateur signal from this side of the Atlantic had ever been reported heard in Europe.

The 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 a tent on a windswept Scottish beach and, using a Beverage wave antenna and frequencies near 200 metres, he copied nearly 30 American radio amateur signals.

CW stations outnumbered spark stations by almost two to one. CW had won the race. By 1924, spark was forbidden on the new 80-, 40-, 20- and 5-metre radio amateur bands.

Concluding remarks

Fessenden, a genius and mathematician, was the inventor of radio as we know it today.

Marconi finally had to admit that Fessenden was right, when in 1914 the Marconi Company purchased a license to Fessenden's patents from the National Electric Signaling Company (NESCO), which later

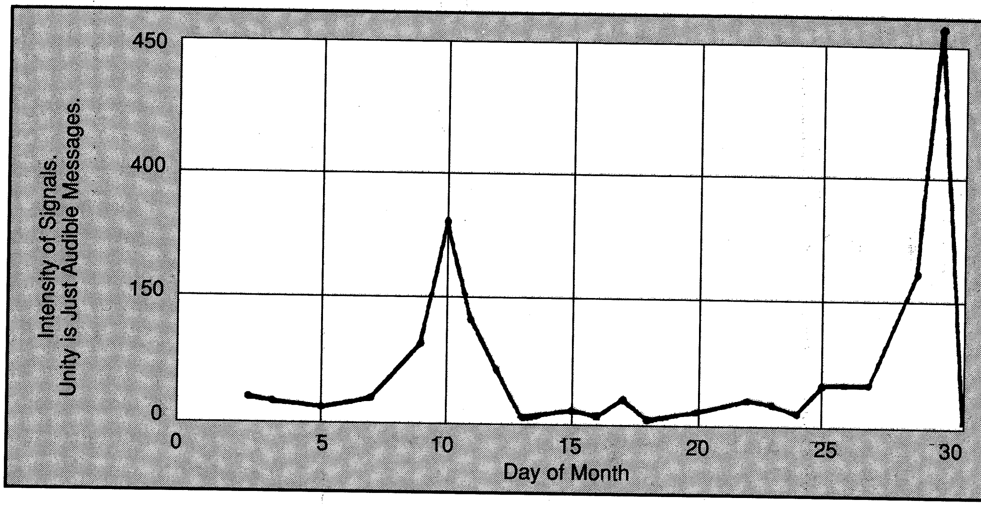

Figure 6. Curve showing variation of the intensity of transatlantic signals for the month of January 1906. Unity corresponds to a just audible message. Such a curve is certainly one of the first recordings of LF propagation data. [after Fessenden][19]

became the Radio Company of America (RCA).

Fessenden was at home in his laboratory, but out of his element when dealing with the business and political aspects of inventing. He never reaped until late in life any financial reward for his radio inventions, and was compelled to spend much time and energy in litigation.

Disagreement with his partners Given and Walker came to a head at the end of December 1910. While Fessenden was detained at a meeting in Pittsburgh, an attempt was made to shut down operations at Brant Rock and to remove his papers, but the quick-wittedness of his wife and the loyalty of most of his staff circumvented this maneuver, but only delayed his ouster from NESCO, which occurred on 8 January 1911.

Fessenden immediately launched litigation, first with NESCO and, subsequently, with GE, Westinghouse and, finally, with RCA, which was only settled fifteen years later when he received an out-of-court settlement for a half-million dollars from the Radio Corporation of America (RCA), which had long since acquired Fessenden's patents.

The Queen's University Library Archives holds a Fessenden declaration to the IRS in Washington in which he certifies that he received $500,000, with $200,000 of this sum going to his lawyers.

He certainly never reaped the financial rewards that were due him for his radio inventions, but he had the satisfaction of being proven right. *He was indeed the greatest wireless inventor of the age*.

To conclude, let me continue briefly in the vein in which I began, *viz*. Fessenden was an inventor who worked in many fields of science.

In addition to the inventions already mentioned, Fessenden gave us the radio pager (he called his device a *beeper*); he gave us *sonar*, which he demonstrated could detect icebergs, and his *fathometer* to measure the depth of water beneath the keel of a ship. (See below.)

He gave us turbo-electric drive to power ships; the first gyrocompass; the loop antenna; radio direction-finding; his *pheroscope* for submarines; a first TV receiver; ultrasonic methods for cleaning; electrical conduit; carbon tetrachloride; and tracer bullets.

Professor Fessenden was deeply disturbed by the sinking of the ocean liner *Titanic* on her maiden voyage to New York during the night of 14-15 April 1912. The vessel struck an iceberg just before midnight, and sank within two hours.

He considered that the *Titanic's* iceberg avoidance procedure (clear air vision from the crowsnest) to be very dangerous and that it should be replaced by a reliable system discovered by himself. Sonic frequency *echo sounding* could prevent a recurrence. He set his mind to perfecting this technology; later known as SONAR (Sound Navigation And Ranging).

The principle of such a sounder was to send a short duration burst of sound (frequencies up to 20 kHz) from a transducer located about 3 metres below the surface of the water, of such power that it would travel as far as several kilometers through the water.

When this wave came into contact with a solid object, such as an iceberg or the floor of the ocean, an echo was created. By measuring the time taken for the sound waves to travel out and the echo to return, it was possible to determine the distance to the object. During the period 1914 to 1925 Fessenden was granted over thirty patents for inventions using sonic frequencies. [Elliott][22]

In September 1914, the *USS Miami* tested Fessenden's *submarine electric oscillator* in the North Atlantic. Professor Fessenden demonstrated that indeed he could get distinct echoes from icebergs, as far as 4 kilometers from a very large iceberg.

The *USS Alywin*, in that same year conducting tests in the Boston Harbor, showed that Fessenden's sonic detection device could pick up the signals from a moving submarine from distances as great as 9 kilometers. In an associated test, the captain of one U.S.

submarine was able to direct the movements of another submarine several kilometers away by modulating the sonic signal by the Morse dot and dash method.

During U.S. involvement in WWI years, 1917-1918, the USN fastened Fessenden's sonic listening device to the hulls of many troop carriers. By picking up the sounds of submerged submarines, the transports could often escape torpedo attacks. Submarines lying silent on the ocean floor could also be detected using his echo sounder.

In the 1920s, Fessenden's depth sounder or fathometer became a common instrument aboard vessels of all sizes from large passenger liners to small fishing boats. It was used on cable-laying vessels.

Fessenden set to work to see if his echo sounder could be used as a geophysical tool to detect underground ore and oil deposits. This work led to his development of a new more efficient transducer, a piezoelectric sonar transducer. Not only was the device able to transfer more sound energy to conducting media, sea water or land, but the same device could be used for receiving. "Sound" frequencies as high as 60 kHz could be used.

His work involved with safety at sea won him the *Scientific American* Gold Medal in 1929. Other awards included the Medal of Honour of the Institute of Radio Engineers for his efforts in that field, and the John Scott Medal of the City of Philadelphia for his invention of continuous wave reception.

Reginald Aubrey Fessenden died in his house by the sea in Bermuda on 22 July, 1932. Burial was in St. Mark's Church cemetery, and over the vault was erected a memorial with fluted columns. On the stone lintel across the top were inscribed the words:

His mind illuminated the past
And the future
And wrought greatly
For the Present

Beneath the scribed words, in the picture writing of the ancient Egyptians was

I am yesterday and I know tomorrow.

His son summarized his greatest achievements in one sentence: *By his genius, distant lands converse and men sail unafraid upon the deep.*

During his brief tenure as principalship of the Whitney Institute in Bermuda, Fessenden met his future wife, Helen May Trott, in 1885. They were married in 1890 in New York City.

Helen must certainly have provided support for her husband in his work, and she must have had a considerable knowledge about his accomplishments. After his death she wrote the book *Fessenden Builder of Tomorrows*[22], and she must clearly have been responsible for seeing to the granting of seven patents after Fessenden's death.

Helen Fessenden died in 1980, and established by her will a Fessenden-Trott Trust, administered by the Bank of Bermuda Limited, Hamilton, Bermuda. This trust, in memory of Professor Fessenden, provides funds for scholarships awarded annually to Canadian students, U.S. students from Purdue and Pittsburgh Universities, and Bermudian students and family members studying at Canadian, UK or U.S. universities.

For Canadian students, four fellowships are awarded per annum. The Canadian program is administered by The Association of Universities & Colleges of Canada.

There are no direct descendants of Reginald from his side of the family, but the Fessenden family name is still maintained by descendants from other branches of the family. Fessenden's only son, Reginald Kennelly Fessenden, died in 1944 in a boating accident off the coast of Bermuda. The Trott name is still maintained by descendants living in Bermuda.

Most of Fessenden's inventions are taken for granted as a part of our everyday life, and few know, particularly the general public in his home country Canada, of the Canadian-born genius who provided the world with manifold benefits. History, through the effort of a few, will begin to remember Fessenden.

On 3 June, 1990, Brome County Historical Museum and Archives, Knowlton, Quebec, opened a small permanent exhibit and unveiled a plaque honoring Reginald Aubrey Fessenden and commemorating the 90th Anniversary of the first transmission of voice by radio on 23 December, 1900.

The Wellington County Museum and Archives, Fergus, Ontario, has just recently mounted the first of a series of exhibits entitled "Marks of Distinction—Celebrating the Achievements and Skills of Wellington County Residents." This first exhibit, opened by the Minister of Communications Canada on 5 February 1993, focuses on the life and work of R.A. Fessenden.

The Department of Communications, in collaboration with the Department of Industry, Science and Technology and the Natural Sciences and Engineering Council of Canada, in recognition of the life and heritage of Prof. Fessenden in the fields of radio sciences and communications, has just recently announced an undergraduate and postgraduate scholarship program to encourage students to continue with university studies in this field of science. The first of these scholarships will be awarded in the spring of 1993.

In the past we have lauded Marconi's successes. In the future we should also pay tribute to Reginald Aubrey Fessenden.

That concludes my lecture. Finally, I would like to tell you about a CBC-Shell Oil Company 1979 drama on Fessenden. This drama was one of a series entitled *The Winners*, and the particular drama was entitled "The Forgotten Genius." While the chronological sequence of events is not quite right, the story is factually correct.

Copies of this TV drama are available (VHS or 1-inch video) from: CBC International Sales, PO Box 500, Terminal A, Toronto, ON M5W IE6 (Tel. 416-975-3516)

John S. "Jack" Belrose (M), VE2CV, received his BASc and MASc degrees in Electrical Engineering from the University of British Columbia, Vancouver, British Columbia, in 1950 and 1952; and his Ph.D. degree in Radio Physics from the Cambridge University, England (Ph.D. Cantab) in 1958. From 1957 to present he has been with the Communications Research Centre (formerly Defence Research Telecommunications Establishment), Ottawa, ON K2H 8S2, where currently he is Director of Radio Sciences.

He has written many papers, lectures and chapters in several books, published in various professional publications and journals, and radio amateur magazines on topics of interest and personal research in the field of antennas and propagation, particularly, on HF and VLF antennas by modeling and measurement, VLF and LF radio propagation, and HF propagation in the high-latitude region.

Jack considers himself fortunate to work in a research environment in a field of interest to him. His professional research and hobby activities are rather closely related.

During his student and professional career he has been a member of several scientific and professional organizations. Currently he is a member of The Radio Club of America; he is the Canadian National Coordinator of the AGARD (Advisory Group for Aerospace Research ~Development) Electromagnetic Propagation Panel; a special rapporteur on VLF and LF propagation for CCIR Study Group 6; and he is a Technical Advisor of the ARRL. He has been a licensed radio amateur since 1949. His present call sign is VE2CV, which he has held since 1961; previously held call signs VE7QH and VE3BLW.

Jack is married, to Denise, nee Fenal, formerly of Paris. They have resided at their present address since 1959, have two sons, a married daughter and one grand-daughter. Camping, swimming, cross-country skiing, putting up and taking down antennas, and walking his dog every day, 25 years of walking an Irish Setter, keeps him physically fit.

John S. Belrose
17 Tadoussac Drive
Aylmer QC J9J 1G1
Canada

Appendix A — The Sounds of a Spark Transmitter

So far as I know, no one recorded for posterity the sounds of on-the-air spark signals.

Certainly, because of the tremendous variety of gap speeds for synchronous and non-synchronous rotary gaps, electrode shapes and number of electrodes in use, every spark station had its characteristic sound.

This characteristic of a spark transmitter was actually an advantage when there were a number of stations on the air. A spark signal was broad, and within the broad bandwidth of the simple receivers used, there could be several stations operating near the same wavelength with overlapping signals. Communications would have been more difficult if all the signals sounded the same.

Certainly, many of you who read this article will have seen, heard and smelled (the smell of ozone) an operating spark transmitter. Just the sound of an old rotary gap transmitter was good for appreciable DX.

Certainly, there are operating spark transmitters to be seen and heard, for example, the shipboard wireless transmitter at the Antique Wireless Association's Radio Museum, East Bloomfield, New York (curator Bruce Kelley, W2ICE/W2AN) or the early radio amateur type non-synchronous rotary gap spark transmitter at Fred Hammond, VE3HC's Radio Museum, Guelph, Ontario.

The American Radio Relay League headquarters' Educational Activities Department, Newington, CT 06111, has available for borrowing copies of a VHS videotape in which Ed Redington, ex-W4ZM (now a silent key) assembles a working spark transmitter piece by piece while describing his boyhood adventures (and misadventures) in spark communications.

But have you heard how the received signal sounded? We had not, so we constructed a 5 MHz spark transmitter using an automotive ignition coil for the induction coil to learn how a spark transmitter worked and how it sounded. This transmitter, we admit, is only a small spark transmitter operated under laboratory conditions.

We were particularly interested to hear how Fessenden's spark telephony transmitter might have sounded. Recall that, to modulate his transmitter, he inserted a carbon microphone directly in series with the antenna lead. Our spark transmitter was like the one shown in Figure 1C, excepting that L_p and L_s were not directly coupled, but instead were link-coupled through a short length of transmission line.

The frequency and the output spectrum of the transmitter is determined by the frequency response of the antenna system. Our "antenna" was an L-C-R circuit, with components chosen to simulate a 5 MHz

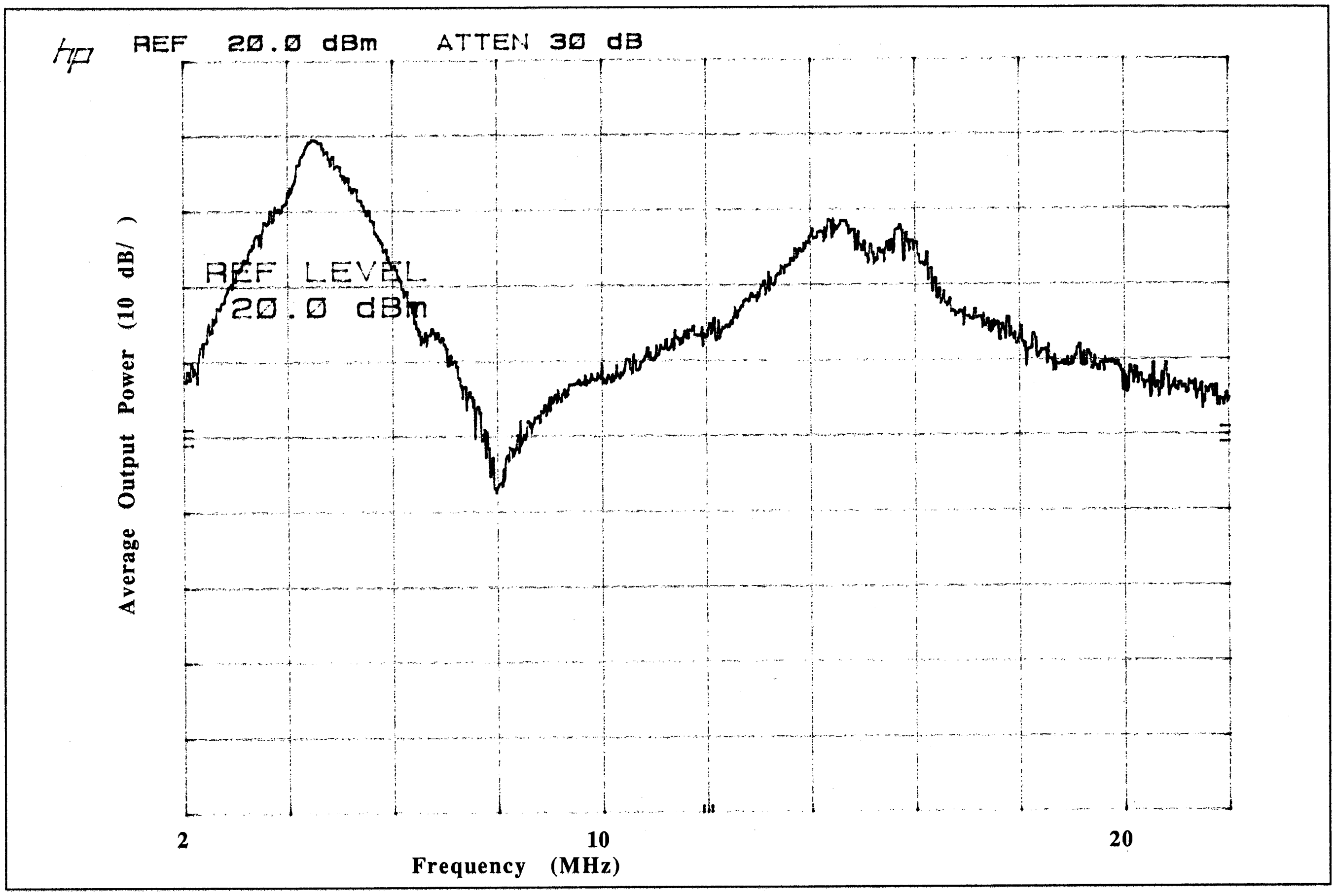

Figure 7. Relative averaged output spectrum for the author's 5 MHz spark transmitter (spark rate 750 sparks/second). Notice that the third harmonic of the fundamental oscillation frequency is only about 12 dB down, in spite of the fact that the antenna circuit (an L-C-R circuit having component values to simulate the fundamental resonant response of a 5 MHz quarter wave monopole) did not have a resonant response at this frequency. A real monopole would be resonant at three times the fundamental resonant frequency, and so our spark transmitter would radiate efficiently at this third harmonic frequency.

quarter wave monopole. The output frequency spectrum is indeed very broad, megahertz wide. (See Figure 7.)

Somewhat surprising is the magnitude of the third harmonic, in spite of the fact that our simulated antenna, unlike a real monopole antenna, was not resonant at the third harmonic frequency. Our receiver was a simple tuned circuit, a detector, a modern germanium diode and a tape recorder as a substitute for high-impedance earphones. High-impedance phones are hard to come by nowadays, as is a carbon microphone.

The signal of our spark transmitter sounds terrible on a narrowband communications receiver, but the receiver used for spark transmission reception was broadly tuned, and the recovered audio can be remarkably good, considering the source was initiated by a spark discharge.

To make recordings of the signal received, we had to relearn how to set up and "tune" a spark transmitter. The primary and secondary circuits, the "tank" and "antenna" circuits, must not be overcoupled, since this results in a double-peaked, extremely broad amplitude-frequency response.

The spark should take place between polished, hemisphere-shaped electrodes, not between pointed electrodes. And the widest gap possible consistent with regular sparking when the key is held down must be used, since otherwise the signal becomes all "mushy."

In effect, we "tuned" our transmitter by gradually narrowing the gap for the best received sound before making a recording at a particular spark rate. Thus, the signals heard and recorded using our spark transmitter were the best that could be realized. We did, however, demonstrate how the spark signal can change from a clear musical sound to a mushy unpleasant sound by using a gap too narrow.

We can attest to Fessenden's difficulty with operating, and modulating, a spark transmitter operating at 10,000 sparks per second for spark telephony. The gap adjustment is very critical.

When just the right width, the spark is sharply confined, the spark rate regular, the speech loudest, and the disagreeable noise least. Besides the problem with the disagreeable noise, the voice-induced resistance change, which modulated the antenna current via a carbon microphone inserted in series with the antenna lead, is indeed small. One had therefore to shout very loud.

However, the signal sounded like Fessenden described it: The words were perfectly clear, except that they were accompanied by an extremely loud disagreeable sound.

If you would like to have a copy of recordings made with our spark transmitter, illustrating: spark transmission using a mechanical interrupter, and simulated synchronous rotary spark gap transmissions for telegraphy; and spark transmissions for telephony, write to the author and send $10 to cover the cost of the audio cassette and handling and mailing.

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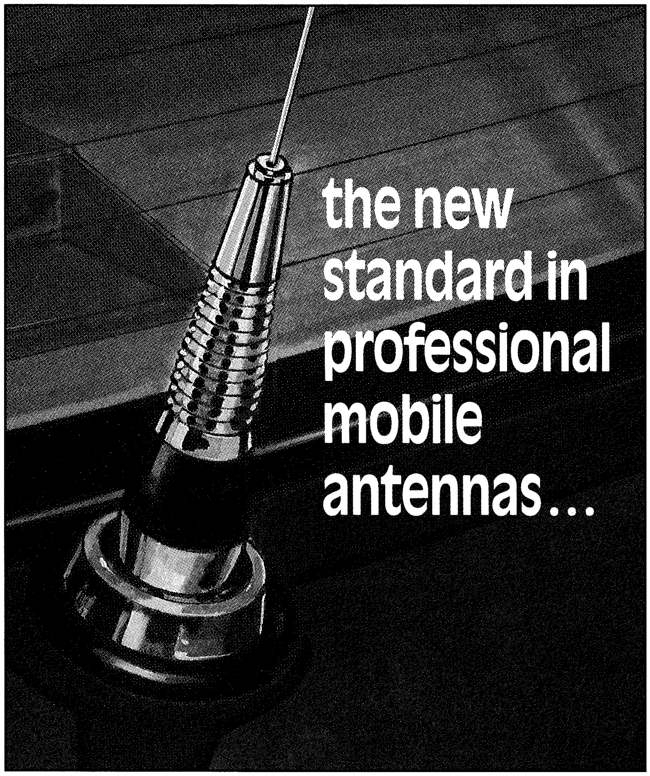

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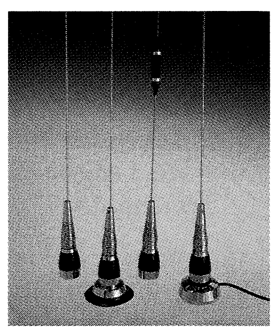

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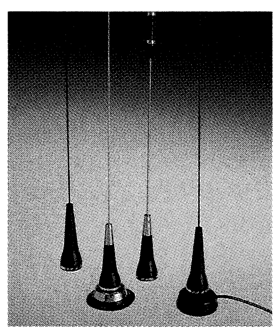

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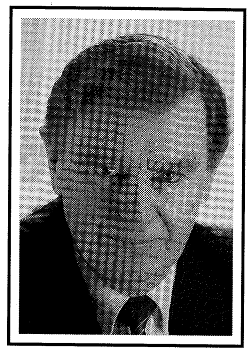
Was Carson Right About FM?



By Hugh G.J. Aitken, Ph.D.

Much has been written about the technical and commercial origins of FM radio.

Most of the literature focuses on the conflict between Edwin H. Armstrong and RCA over patent rights and spectrum allocations. The general tendency has been to depict Armstrong as a heroic genius, battling not only the entrenched power of a large corporation but also the skepticism of radio engineers.

This skepticism, we are told, resulted largely from acceptance by the profession of earlier research conducted by John Renshaw Carson in 1920-21. Carson suggested, had tried to prove mathematically that frequency modulation offered no significant advantages over amplitude modulation.

Armstrong proved him wrong by demonstrating empirically that FM reception offered a quality of reproduction, free of static interference, that AM could not match.

Careful authors

This is, I think, a version of radio history that most readers would recognize. It is, in my view, an over-simplification and misinterpretation of Carson's work. It is not, in fact, what most careful authors have written on the subject.

Lessing, for example, in his biography of Armstrong refers to Carson's 1922 paper to the Institute of Radio Engineers, which is often said to have given the "coup to FM", as "extremely able and mathematically sound" and correctly notes that his analysis was later confirmed by other mathematicians in the United States and abroad.

David Morton, in his contribution to The Radio Club of America's memorial volume, *The Legacies of Edwin Howard Armstrong*, points out that Carson's central purpose in the 1922 IRE paper was to prove that, "as a means of conserving spectrum," FM offered no advantages over AM.

Tom Lewis, in his book *Empire of the Air: The Men Who Made Radio*, characterizes the 1922 paper as "especially impressive and formidable" and summarizes its main conclusion as being that "FM with a narrow bandwidth would not work".

Mathematical analysis

The central point is that Carson's mathematical analysis was never disproved. Neither was his later finding, published in the *Bell System Technical Journal* in 1925, that even with ideal selective circuits in the receiver, "an irreducible minimum of interference will be absorbed."

Nobody has anything to gain by taking one iota of credit away from Armstrong. But one does not have to make Carson less in order to make Armstrong more.

Carson was one of A.T.&T.'s top mathematical analysts. If he had made an error in analysis, it would have been caught, either by the members of the IRE and the AIEE who heard his papers delivered, or by mathematicians who read them after they were published. But there were no errors of analysis.

So where does the problem lie? Those who say that Carson's findings put the damper on much further research into frequency modulation are correct. So are those who hold him responsible for much of the skepticism that greeted Armstrong's work—both before and after his dramatic demonstration to the IRE in 1936.

And there is no doubt that Armstrong proved that FM radio did work and that it had advantages, particularly in terms of static elimination, that AM could never have.

When two highly intelligent and well-informed individuals differ so profoundly it presents a problem to be explained.

Morton notes, as Lessing did before him, Armstrong's profound antipathy to the purely mathematical and theoretical approach to electrical engineering of which Carson was a master. And he suggests that Armstrong's strength lay not in mathematics but in the kind of visual and spatial thinking—seeing with "the mind's eye", as Eugene Ferguson has expressed it—that is often associated with creativity, in the arts and the sciences as well as in technology.

Opposite findings

These are useful and insightful observations but they hardly reach to the heart of the matter. Differences in personality and style between Carson and Armstrong there certainly were; but they do not explain why their findings seem so diametrically opposed.

There are other possibilities.

One is that the two men were pursuing different objectives and making different assumptions. To conceive of the differences between them as a matter of Armstrong being "right" and Carson being "wrong" is a great over-simplification. That is the interpretation that Armstrong put upon the matter.

Most later historians have adopted Armstrong's interpretation. If it is true that the victor in combat is the one who gets to decide what the history books will say, Armstrong was certainly victorious.

But it is not so clear that Carson ever thought of himself as having been defeated, or as having been proved "wrong". Armstrong and his admirers delighted in quoting the one sentence in Carson's 1921 article in which he permitted himself, injudiciously, to go beyond the limits of his mathematical analysis: "This type of modulation," he wrote with reference to FM, "inherently distorts without any compensating advantages whatever."

Lessing correctly comments that Armstrong "never allowed Carson to forget this blooper", but there is no evidence that Carson ever responded or that his reputation suffered in any way.

Is it possible that Carson was not "wrong"—not, that is to say, in terms of the problem he was tackling and the assumptions he was making?

At RCA's New Brunswick, New Jersey transmitter site in 1921. Sarnoff on the left; Einstein, Carson and Steinmetz at the center.

Static elimination

What problem was Carson tackling?

One confusion can be cleared up easily. The 1922 IRE article, "Notes on the Theory of Modulation", had nothing to do with the elimination of static.

Lewis appears to think otherwise. He is correct in saying that, for Armstrong, working in Pupin's Hartley Laboratory at Columbia, the elimination of static interference in radio reception was the prime problem to be solved.

He is not correct in attributing the same priorities to Carson. The 1922 article is not about the elimination of static; it is about spectrum conservation. Static is not even mentioned in the article.

The closest Carson comes is in his final paragraph when he examines the claim that arc transmitters, which used frequency-shift keying (the only kind of "frequency modulation" in use in 1921-22) produced fewer transient disturbances than on-and-off keying. But this was a question of what we would call key clicks, not of static.

Narrower bandwidth

Lloyd Espenchied was closer to the mark in his biographical sketch of Carson for the *Dictionary of American Biography*. He points out that some radio engineers in the early 1920s, faced with increasing spectrum congestion, entertained the idea that if they modulated the frequency of a carrier rather than its amplitude, the bandwidth of the emission could be narrowed.

This, and nothing else, was the conjecture that Carson examined in the 1922 article. He concluded that the conjecture was wrong: If you wanted a frequency modulated signal to carry the same range of audio tones as an amplitude modulated signal, it would need at least as much bandwidth on the spectrum and probably more. If you limited the bandwidth of an FM signal, you limited the range of audio tones it could carry.

And he was absolutely right. Narrow-band FM has proved to be a spectacularly effective mode of communication, particularly for speech transmission; but we do not use it to broadcast the Metropolitan Opera or any other program material that demands high fidelity.

Spectrum conservation

Espenchied connects this interest in spectrum conservation with the beginnings of radio broadcasting. This is plausible, but the timing is not quite right. Carson's article was received by the editor of the *IRE Proceedings* on 6 January, 1922, so we may presume that it was written during 1921.

This is a little early for serious congestion on broadcast frequencies. By January, 1922, the Department of Commerce had licensed no more than twenty-eight broadcast stations. It is true that in some areas this was enough to cause complaints of interference but it seems unlikely that spectrum conservation in broadcasting was in 1921 a high-priority item in A.T.&T.'s research agenda.

I suggest that what A.T.&T. and Carson were primarily concerned about was transatlantic radiotelephony. This, we know, was a field in which A.T.& T. had been intensely interested ever since its first transatlantic radio tests in 1915.

Single-sideband

The tests were taking place and the work was being done in an area of the spectrum where congestion was already a problem and where the wide bandwidth required by frequency modulation would have been a serious drawback: the very low-frequency bands. Work on the theoretical side of long-distance radiotelephony had been Carson's first assignment with the Company, and it was in connection with that work that he discovered single-sideband suppressed carrier transmission (U.S. Patent 1448382, filed December 1, 1915; issued March 27, 1923).

Single-sideband transmission offered real possibilities for spectrum conservation, which FM did not. Lewis, curiously, describes SSB as "a novel method of sending several messages simultaneously".

Several virtues have been claimed for SSB but this is not one of them. Single-sideband did, however, make it possible to eliminate or suppress the carrier frequency and one redundant set of sidebands.

Small wonder that Carson, with transatlantic radiotelephony on the very long waves in mind, found little to say in favor of frequency modulation in 1921. By the early 1920s Ernst Alexanderson and his colleagues at General Electric were already calling attention to the serious congestion that existed on the very low frequencies.

These were the days, we must recall, before the discovery of ionospheric "short wave" transmission. In 1921 professional opinion was virtually unanimous that, if there were to be such a thing as long-distance radio, it had to be on the very long waves. And there was very little elbow-room in that region of the spectrum.

Selective circuits

Much the same kind of misunderstanding has afflicted Carson's 1924 article, "Selective Circuits and Static Interference," presented to the A.I.E.E.. I have pointed out that the 1921 article has nothing to say about static but much about FM.

The 1924 article has a great deal to say about static, but it never mentions FM. Once again the key to correct interpretation is close attention to the text. What is Carson's central point in this article? Simply that adding one selective filter after another to a receiver circuit will yield progressively diminishing returns in terms of reducing static interference.

On the other hand, piling one filter circuit on another in this way will have a distinctly negative effect, since after a point the filters begin to "ring"—the circuit, as Carson expressed the matter, becomes "sluggish".

And, once again, Carson takes the opportunity to underline the advantages of single-sideband.

Did Carson's 1924 article say that it was impossible to eliminate static? No: The conclusion of the article was simply that, if static were ever to be eliminated, it would not be by adding one highly selective filter after another.

And here again, I suggest, Carson was correct. When Armstrong proved that FM did eliminate static, he did so not by multiplying sharply peaked selective circuits but by adding an amplitude limiter.

Static as AM

The breakthrough was Armstrong's realization that static was amplitude-modulated. Eliminate all amplitude-modulated components from the signal and you eliminate the static.

What does all this amount to? Not much, unless you are interested in getting your history straight. Nobody has anything to gain by taking one iota of credit away from Armstrong. But one does not have to make Carson less in order to make Armstrong more.

Armstrong was a technological genius and modern radio owes him an incalculable debt. At the same time, he had within him a combative, confrontational streak that impelled him always to depict himself as the winner in an uneven contest.

This shows up prominently in his fights with Sarnoff over patent rights and spectrum allocations to FM as against television. It also shows up in the way he saw—and led later historians to see—his differences with Carson over bandwidth requirements and protection from static.

But we do not have to make Carson smaller in order to make Armstrong larger. Carson was a theorist and a mathematical analyst—the man who made Heaviside's operational calculus for the first time a useful analytical tool for engineers.

Armstrong was an experimenter and technological innovator, a man who preferred graphics to formulas and elaborate circuit hookups to mathematical proofs. More fundamentally, perhaps, Carson always worked within the limits of a problem as presented to him. Armstrong preferred to redefine the problem.

Clear facts

So let us hear no more about whether Armstrong was right and Carson wrong. The facts are clear and they do no discredit to either party.

Armstrong did not invent or discover frequency modulation. He did invent circuits that for the first time made the reception of frequency-modulated signals feasible and advantageous. In particular he made the intellectual breakthrough that recognized static as an amplitude-modulated phenomenon.

He had the great good fortune to achieve that breakthrough at the moment in history when technological progress had made the VHF frequencies available. Without that new space in the spectrum—space enough to accommodate the bandwidth that high-fidelity, static-free FM transmission required—Armstrong's discoveries might have remained interesting laboratory experiments.

Acknowledgments:

My thanks are due to Morton Eisenberg K3DG, of Delray Beach, Florida, whose questions first sent me back to re-reading Carson's articles, and to Professors James Brittain and Paul Nahin for helpful readings of an early draft.

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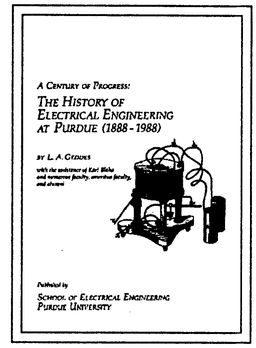
Hugh G. J. Aitken, Ph.D. (F), is a retired professor of economic history at Amherst Colege, Amherst, Massachusetts. His amateradio station call sign is W1PN. Aitken has received the Dexter prize and the Leonardo da Vinci medal from the Society for the History of Technology. His books include Syntony and Spark *and* The Continous Wave, *published by Princeton University Press.*

Police Radio

By L.A. Geddes, ME, PhD, FACC



Purdue's association with the first police radio originated in the summer of 1927 with Robert Batts, an undergraduate Electrical Engineering student who just happened to take a job in Detroit repairing radios. He was working his way through college.

A few years earlier, in the belief that radio could be of value in fighting crime, Commissioner W.P. Rutledge of the Detroit Police Department had purchased a radio transmitter, obtained a license from the Federal Radio Commission, and started transmitting on 833 kHz under the call letters KOP.

Since there were no radio-equipped patrol cars at the time, the program material was confined to lists of stolen cars. Soon, however, the programs began to contain music and entertainment, which caused a certain amount of internal and external conflict and cast doubt on the "type" of license the station held.

There followed a bitter controversy; and, on the threshold of a breakthrough in police communication, bureaucracy triumphed. The station was closed on Oct. 8, 1925, just as studies were begun (although with unsatisfactory results) on an earphone-equipped radio receiver in a patrol car.

Despite this setback, Rutledge knew that radio could offer more than the communication method available at that time, which consisted of patrolmen calling in regularly from police boxes in different locations in the city. Criminals, however, who were aware that patrolmen were required to call in hourly, soon learned the patrol routes and schedules ad were able to choose the best time and place to carry out their business.

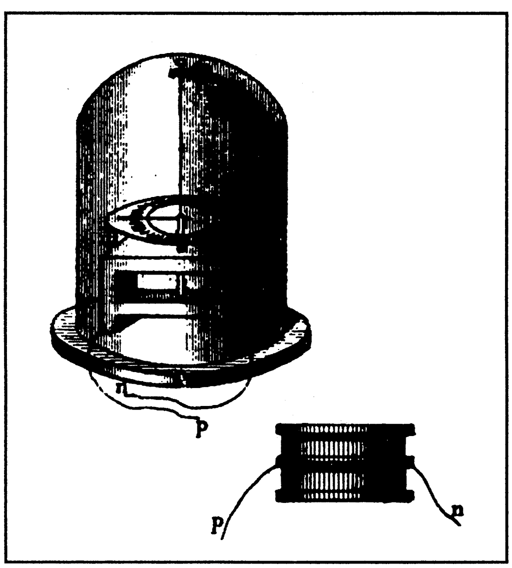
Since there were no radio-equipped patrol cars at the time, the program material was confined to lists of stolen cars. Soon, however, the programs began to contain music and entertainment, which caused a certain amount of internal and external conflict and cast doubt on the "type" of license the station held.

Improved police boxes which ad a colored light that flashed to indicate that a patrolman should call in were a little better, but in practice, considerable time could pass before the call was made. It was obvious to Rutledge that a radio-equipped patrol car could speed aid to a troubled area in a very much shorter time.

It was thus, in summer 1927, that Robert Batts took a job in Detroit, where he met Kenneth Cox, a motorcycle patrolman, who showed him through the police department. Prior to this time, Batts had built a portable battery-operated radio receiver that drove a loudspeaker and had, moreover, used it in an automobile with a view to locating sources of radio interference.

He suggested to Cox that such a receiver could be used in a police car to receive messages, but Cox was unaware

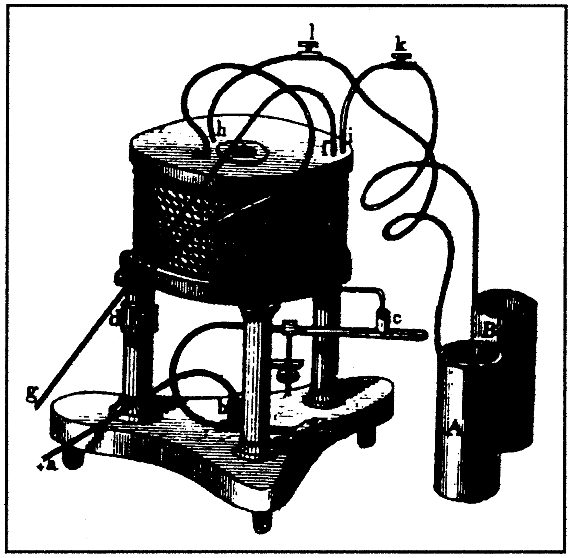
Astatic multiplier.



that the Detroit Police Department had a transmitter somewhere in storage.

Batts returned to Purdue in fall 1927 to start his junior year in electrical engineering. On Oct. 31, he received a letter from Cox telling him that the KOP transmitter had been located and asking him to put his ideas about police radio on paper. Batts did so. Cox took the proposal to Commissioner Rutledge, who was more than receptive.

On Jan. 28, 1928, Batts received an invitation, by telegram, to come to Detroit and start building the police radio system. Three days later, Cox sent a second telegram urging Batts to come, adding, "No letter to follow." Torn between opportunity and education, Batts reluctantly left Purdue to accept the position in Detroit.



When he arrived in Detroit, he met Rutledge, examined the transmitter which was stored in the police station, and presented his plan. He knew that a downtown station would be adversely affected by buildings and power lines, so he had the transmitter moved to a hayloft in the harbormaster's building in nearby Belle Isle and immediately started to work on designing a receiver suitable for patrol cars.

Batts could not, however, be put on the payroll, despite Rutledge's enthusiastic support. Weeks went by, his money ran out, and he had to take a job with the J.K. Hudson Company selling and repairing radios. It seemed, since Batts was not to be a patrolman, that there was no way to hire him. In his spare time, meanwhile, Batts continued to design and build the police-car radio receiver.

Finally, the Detroit Police Department found a way to employ him, and he was able to devote all of his time to making a radio receiver suitable for a patrol car. Batts' design was based on the newly introduced screen-grid tube, with its ideal input characteristics. The receiver was a three-stage, tuned-radiofrequency superheterodyne, with a two-stage audio amplifier.

Because considerable loudness was needed, he designed and built an efficient heavy-duty loudspeaker. The whole receiver was shielded by a copper box and operated from an external storage battery (on the runningboard) and B and C batteries (under the floorboards). The antenna was woven into the fabric of the car.

Meanwhile, they had obtained another license, with the call letters W8FS; and at 8:00 a.m. on April 7, 1928, the first transmission was received by patrol car #5. Before long, 45 cars were equipped with police radio receivers. By May 4, 1928, a police radio receiver had been installed in one of the harbormaster's boats.

The success of the police radio system in Detroit attracted national attention. In September 1929, Cleveland installed a system and started operation. In mid-1929, Cox went to Chicago to establish a radio system there; and in October Batts went to Indianapolis to establish the first police radio system in Indiana — and the fourth in the United States.

These first radio systems provided only one-way transmission; however, the number of times a patrol car was just around the corner from a crime was truly remarkable. The establishment of even one-way police radio did much to halt the crime wave created by the gangsters of that time. Two-way police radios appeared a few years later in 1933.

Robert Batts remained with the Indianapolis police department, rising to the rank of captain. When he retired, he moved to Florida, where he died recently.

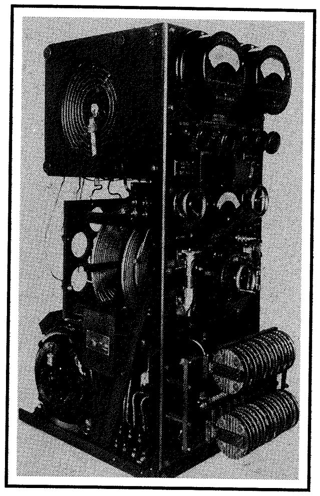
It is instructive to summarize what this young EE undergraduate accomplished. He solved the difficult problem of interference by shielding the receiver. He developed noise suppressors for spark plugs. He designed and built the first radio receiver with low battery drain, one that was capable of producing considerable volume from a loudspeaker.

Finally, he built the first receiver that could withstand vibration and impact. To prove the latter points, he dropped the receiver on the floor in Commissioner Rutledge's office; then he turned it on, and it worked.

L.A. Geddes (M), ME, PhD, FACC, is Showalter Distinguished Professor Emeritus of Bioengineering at Purdue University.

SOS No Longer On 600 Meters

By Bruce L. Kelley (LF), W2ICE



W.S.A. 1 kW quench-gap transmitter with five pre-tuned wavelengths. The gaps are at lower right with the built-in motor-generator rear left.

As of Aug 1, 1993, all U.S. Coast Guard communication stations and cutters discontinued monitoring the distress frequency of 500 kHz (600 meters) and ceased all CW operations in the medium frequency band.

The reason: the availability of more efficient and reliable modes including INMARSAT, Radio Telex (SITOR), MF-HF SSB and VHF phone, EPIRBS and NAVTEX. The move was predictable since, for economy reasons, shipping interests have in recent years discouraged CW operations, preferring automated equipment for faster, more accurate traffic handling and significant cost reduction, thus eliminating the need for radio officers.

The United States government, however, has not completely abandoned 500 kHz since NAVTEX transmissions will still be sent on 518 kHz. Also, as of Aug. 1, the International Maritime Organization (IMO) required all ships of 300 tons or heavier to carry NAVTEX receivers on all voyages more than 75 miles offshore.

NAVTEX is an international standard method of sending notices to mariners with small, low-cost printing receivers installed in the radioroom or wheelhouse. The printed information may include coastal weather forecasts, marine advisories and warnings as well as search and rescue information.

The 600-meter maritime operation has a tradition dating to the earliest days of radio. The obvious need for cooperation among maritime nations resulted in the first International Radio Telegraphic Conference in Berlin in 1903.[1] A second conference in 1906 found most maritime nations agreeing on basic principles relating to procedures in the event of a disaster at sea.

Participants addressed the advisability of a uniform distress call: the British delegates favored CQD, CQ being the call used on English railroads with *D* added for wireless. (Witness the *Titanic* transmission of both CQD and SOS sent by Marconi operator Jack Phillips.)

The Germans were using SOE and, with equal firmness, held out for its adoption. After considerable debate, SOS was agreed upon.

In 1912 the third International Conference convened in London. As a result of the *Titanic* disaster earlier in the year, the conference brought about major regulations and uniformity in international operation.

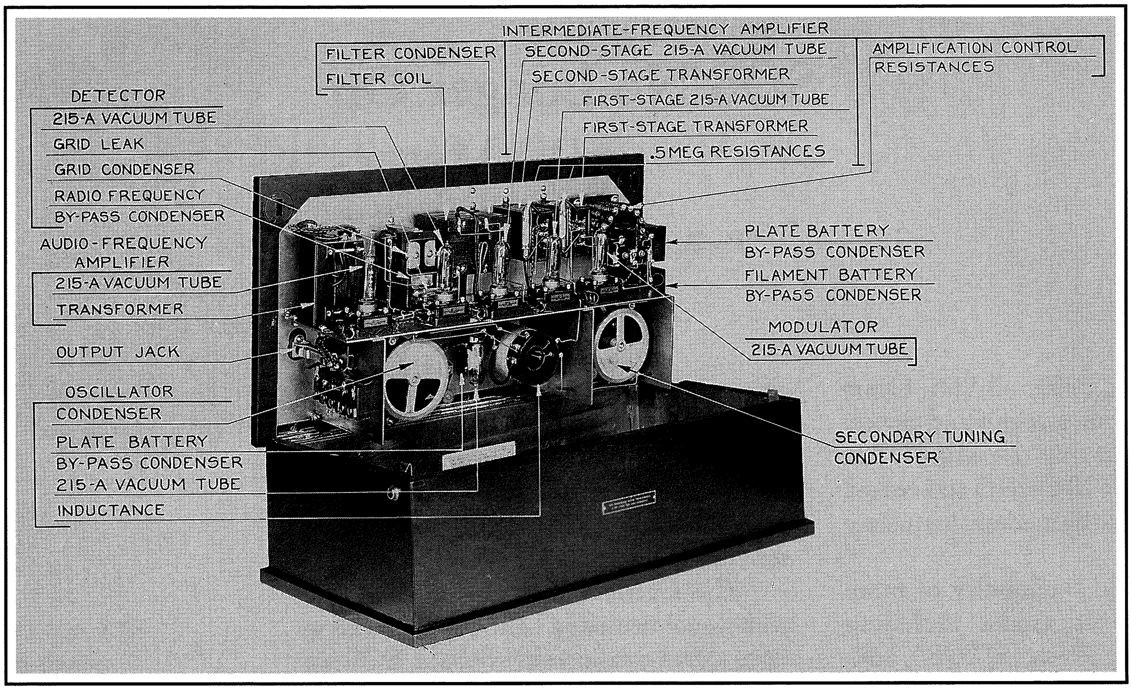
Our government confirmed an earlier requirement of an emergency auxiliary power source and two or more operators for continuous watch on certain large passenger-carrying vessels. The conference also confirmed the use of 600 meters as the distress wavelength, although some interests favored a shorter wavelength of 300 meters.

The 600-meter maritime operation has a tradition dating to the earliest days of radio.

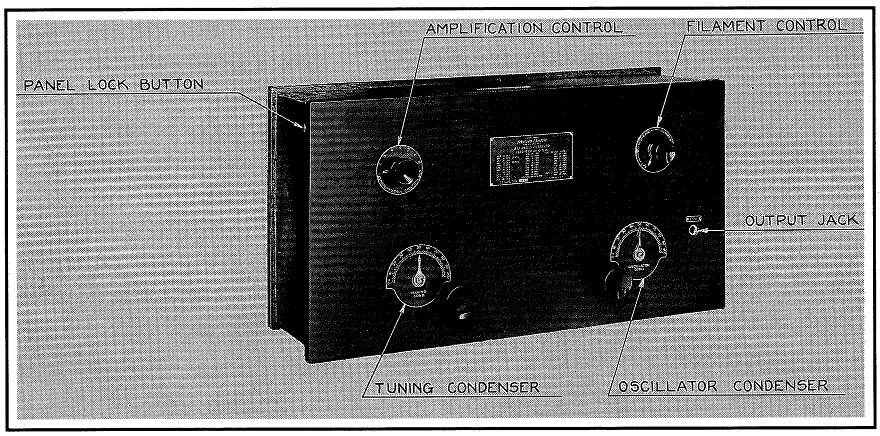
Until after World War I, maritime communication operation changed very little. However, the early '20s saw the explosive advent of AM broadcasting, which proved to be incompatible with the broad signals from antiquated spark transmitters.

Interference was most severe along the Atlantic coast and areas bordering the Great Lakes. There was dual conflict: Spark transmitters interfered with broadcast listeners, and non-selective ship receivers could not tune out nearby AM broadcasts.

The government issued a ruling that



Western Electric Type 4-D monitoring receiver. The superheterodyne receiver uses six Type 215-A tubes and is enclosed in a metal-lined cabinet. The 4-D was considered the ultimate in 1925 receiver design.



500 kHz distress calls took absolute priority over all other forms of communication.[2] This ruling required broadcast stations to have an hourly scheduled watch on 500 kHz by a licensed commercial operator. In the event of a disaster the station was to remain silent until all disaster traffic had been cleared.

By 1929, the watch was no longer required for most broadcast stations, and in 1933, it came to an end. The photos above show a popular Type 4-D monitoring receiver made by Western Electric for use in broadcast stations.[3] Using Armstrong's superheterodyne circuit, the set had six 215-A tubes and was considered the ultimate in 1925 receiver design.

The Washington Conference of 1927 came at a time of great change. Delegates to the 1912 conference had been concerned only with maritime operation, whereas at the 1927 meeting, delegates from 80 countries had interests involving newly discovered shortwaves and public broadcasting.

Ship-to-shore traffic on or near 500 kHz was still being handled by spark or arc transmitters, although they were rapidly being replaced by modern CW on ships of U.S. registry.

At the 1932 and 1938 Madrid Conferences, overseas nations vigorously opposed any move to eliminate spark transmissions, mainly for economic reasons. Spark was slowly disappearing during the '30s, and a ruling in 1935 banned such transmission from U.S. shore stations, limiting it to maritime emergency use, a regulation that did not apply elsewhere. I have been told that Swedish, Norwegian, Danish and other vessels on occasion used spark well into the '60s!

An interesting development in the '30s was the auto-alarm for use on vessels carrying one radio operator. In the event of a disaster, international radio law required the auto-alarm signal to be transmitted before the distress signal, thereby summoning operators on ships within communication range to the radio room to intercept the actual SOS.[4]

The operator of the distressed ship would send a series of dashes at the rate of 12 per minute, each having a duration of four seconds with spaces of one second duration, after which he would send the SOS and other information. One of these devices is in the Antique Wireless Museum and consists of a metal box with red light mounted on the front panel. The unit is connected to the output of a receiver tuned to 600 meters.

I understand that auto-alarms are still required on the 2192 kHz radiotelephone channel on vessels displacing more than 300 tons.

Since the '30s, operation has indeed changed with the use of the newly assigned high-frequency channels for commercial and emergency traffic. But what is the present status of 600 meters in this modern world of high-tech, solid state, digital, satellite and other wonders of modern communication?

Tuning in around 500 kHz, one can hear low-power NAVTEX stations on 518 kHz, an occasional CW station handling traffic with Canadian VCS or perhaps the lone independent WSC at Tuckerton. If the QRN isn't too bad, one may pick up WNU in New Orleans sending his traffic list on 478 kHz or another independent shore station, WLO in Mobile.

In European waters, nearly 60 shore stations, including a NAVTEX transmission, may be heard.[5]

Undoubtedly, this CW operation will not suddenly cease, since hundreds of vessels still use MF transmitters and receivers. Understandably, owners with an eye to economy are reluctant to purchase newer HF and satellite equipment.

Additionally, many older vessels still use vacuum tube receivers and transmitters such as the popular American transmitter for 500 kHz operation, which consists of a pair of parallel 813s in the final made by either RCA Radiomarine or Mackay Radio/ITT.

The recent move to eliminate the ship's radio officer may not prove as beneficial as hoped. Even the best equipment can fail, and in the event of a power failure, a jammed satellite dish or another mechanical or electrical problem, only trained personnel can handle the emergency.

Then there is another factor to consider. For example, a ship asking for help on one of the several HF SSB frequencies might find that the only vessel in the area is monitoring 500 Khz, or the opposite might hold true.[6] Then too, in foreign waters, there could be a language barrier with voice transmission.

Obviously, I am partial to CW operation, but I am sadly aware that it is only a matter of time before the use of Morse code will cease, bringing the end of an era.

Ironically, to comply with the new Global Maritime Distress and Safety System (GMDSS), the FCC will continue to require a code examination for radiotelegraph commercial licenses. And a fair share of Third World vessels still use CW.

I'm reminded of the story of an old radio amateur and ship operator who was recently asked what radio equipment he would like if he were in a lifeboat in the mid-Atlantic. Begrudgingly, he admitted he'd favor the latest signaling device such as EPIRBS. But he added that he'd feel more comfortable if he also had amateur capabilities on the 20 and 40 bands!

References

1. Schroeder, *Contact at Sea*, p. 110.
2. *Old Timer's Bulletin*, Antique Wireless Association, Vol. 18, No. 3
3. Sterling, *Radio Manual*, p. 471.
4. Sterling, p. 473.
5. *Monitoring Times*, "Utility World" column, March 1993.
6. Schroeder, p. 58.
7. Emergency Position Indicating Radio Beacon.

The final message

A misty-eyed Coast Guard radioman tapped out the following final goodbye message on 500 kHz:

CQ de NMC now closing down continuous watch on 500 kHz and ceasing all Morse code services in the MF band.

As we conclude our watch on 500 kHz, we wish the maritime community fair winds and following seas. We are proud of our tradition and long-standing services on MF which began in 1901 with the revenue cutter *Service* actively experimenting with wireless as a regular means of communications on land and sea to the first installation aboard cutter *Grant* in 1903.

Our first distress call from an American ship was received on 10 Dec 1904 by *Relief Lightship 58* at the Nantucket Shoals station. This consisted of the word "help" followed by a request for aid. By act of Congress on 4 May 1910, every passenger ship and any other ship carrying 50 persons or more, leaving any port in the U.S. was required to be equipped with radio.

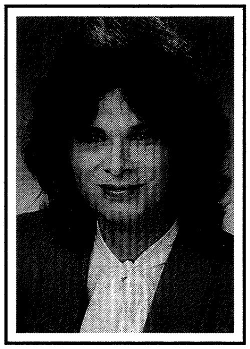
Necessity for improvement in apparatus and methods was emphasized when over 1,500 lives were lost in the *Titanic* disaster of April 1912. Since then, the Coast Guard has faithfully and diligently listened to 500 kHz, copying and responding to numerous calls from mariners in need of assistance at sea.

We have also provided you with thousands of urgent, safety and navigational warnings and related CW assistance over the years. We now look forward to serving you on the next generation of communications equipment and systems via the Global Marine Distress and Safety System (GMDSS).

From all Coast Guard radiomen and women, we bid you 73.

De NMC QRU CL AR SK . . (dit dit) 2351Z JUL 31 1993

—*Frederick O. Maia (S), W5YI, from* W5YI Report



Readers Respond To Our Survey

By Rikki T. Lee (M)

In our May issue, we presented a questionnaire asking Radio Club of America members about themselves and the *Proceedings*.

During the summer, only 16 members filled out and sent in their surveys. Although we cannot claim any scientific validity from such a small sample, some interesting insights can be derived from many of the answers.

Ham radio continues to be a motivating factor for members to join the association.

When did you join the Radio Club of America?

For an association that's nearly 85 years old, it seems that a majority of the members joined in recent history. Here is a percentage breakdown of those who responded:

1970s — 25%
1980s — 50%
1991-1992 — 12.5%
Not sure — 12.5%

The earliest year given was 1977; the latest was 1992.

Are you an amateur radio operator?

Ham radio continues to be a motivating factor for members to join the association. Sixty-two percent said yes; 38% said no.

I joined the Radio Club of America because...

Some answers included:

"...it was one way to make contact with prominent people in the electronics field."

"...of interest in the history of radio technology."

"...of its excellent *Proceedings* and professional reputation."

"...of my lifelong interest in radio and electronics."

"...I believe in the preservation of the rich heritage of fantastic ideas and inventions in communications."

"...[it is] another source of learning."

"...[of my] vast interest in radio pioneers."

I have attended the Radio Club of America events (breakfasts, banquets, etc.)...

Almost always — 6%
Often — 6%
Rarely — 57%
Never — 31%

My interests in radio consist of the following:

Because more than one response was solicited, the total equals more than 100%. Here are the responses, in descending order of percentage checked off:

Ham radio — 69%
HF/SSB — 56%
Emerging technologies — 56%
Mobile/wireless data — 50%
Monitoring/shortwave — 50%
Conventional two-way — 44%
Trunked radio — 44%
Cellular — 44%
Microwave — 44%
SCADA/telemetry — 38%
Paging — 31%
Satellite — 31%
Packet data — 19%
Cordless telephones — 19%
Meteor burst — 13%

Other interests include early operating systems, broadcast, avionics, RFS/RFI, etc.

My major viewpoint as a Radio Club of America member is as...

Consultant — 25%
Engineer — 25%
Manufacturer/representative — 13%
Distributor/dealer — 13%
End-user — 6%

Other — 18% Answers included SMR, teacher/educator and "experienced bystander."

Please don't change the* Proceedings *at all. It's good just as it is.
I agree — 81%
I disagree — 6%
No comment — 13%

***I think non-technical articles on radio topics would be a good thing to publish in the* Proceedings.**
I agree — 75%
I disagree — 12.5%
No comment — 12.5%

***Please rank the top three types of articles you'd prefer to read in the* Proceedings.**
The responses were weighted and ranked in order of importance:
1. History of certain radio technologies — 35%
2. Member profiles — 17%
3. Future technologies — 11%
4. History of the Radio Club of America — 9%
5. Technical theory for technical readers — 8%
6. Technical theory for non-technical readers — 7%
7. Technical applications for non-technical readers — 6%.
8. Technical applications for technical readers — 4%
9. International applications — 2%
10. Membership events — 1%

On "other" topic was written in: first-person accounts of events or engineering work, even recent.

***I would like to read more about the Radio Club of America, benefits of membership, events and member profiles in the* Proceedings.**
I agree — 44%
I disagree — 6%
No comment — 50%

***I always read the* Proceedings.**
Always — 87%
Often — 13%

I think the present level of technical articles is...
For this question, 81% gave the answer "just right." Only 19% responded "too high." No one checked off "too low."

If you have any additional comments, please send them to Don Bishop, P.O. Box 4075, Overland Park, KS 66204-0075.

Book Review

Critical Connection — The MSS Story

Reviewed by Arch Doty

When you learn that *Critical Connection* is a book published by Motorola to tell the history of "Motorola Service Stations," there might be a temptation to dismiss the book without even reading it.

That would be a dreadful mistake.

Critical Connection is not a self-serving "vanity book" sponsored by a manufacturer, but, rather, is the well written and fascinating history of the land mobile industry.

The first sections of the book present the early history of land mobile communications in this country. Details are provided on the contributions made to the industry by Edwin Armstrong, the Galvins, Dr. Dan Noble and many others. The pioneering work and technical leadership of Fred Link and Link Radio is detailed in several references.

The development of the "Motorola Service Station" is then described — the concept that first made land mobile communications practical, as it provided the installation and servicing facilities that are the cornerstone of the industry.

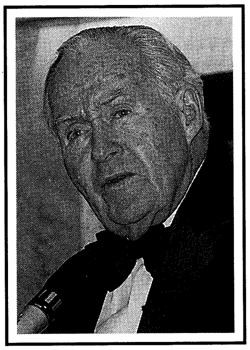
A significant portion of the text which follows consists of historical and personal narrations provided by many of the pioneer independent electronic specialists who established and operated the service facilities that comprised Motorola's Service Stations.

Kathi Ann Brown as done a superb job in compiling and presenting this excellent history of the land mobile industry and the men who were responsible for its conception and for developing it.

Critical Connection by Kathi Ann Brown, is published by Motorola University Press.

The book may be purchased by mail, telephone or facsimile to Susan Schneider, Associate Publisher, Motorola University Press, 3701 E. Algonquin Road, Suite 250, Rolling Meadows, IL 60008, tel. 708-576-3142; fax 708-538-3692. The price is $20 plus $3 shipping and handling.

Arch Doty (F) lives in Fletcher, North Carolina.



The Issue Is Safety

By Robert W. Galvin

Heightened consciousness of the electromagnetic energy issue was thrust upon us abruptly again a few months ago.

I say "again" because for decades transitory concerns about energy from power lines, microwaves, cathode ray tubes, RF (radio frequency) transmitters of various kinds, etc. have surfaced. Each time responsible people eventually have dealt responsibly with each issue. Typically, because the presumed concerns have proven essentially unwarranted, the issue abates....

Frankly, I am impressed that we the people deal as soberly as we do with the barrage of the scary...assaults.

Frankly, I am impressed that we the people deal as soberly as we do with the barrage of the scary...assaults. It seems that no sector of nature is immune—apples, medicine, TV, etc., etc. Almost everything is claimed to be inimical to something else.

And, of course, many things taken to excess, used to excess, or tested at excessive levels can be harmful. Most elements and energy levels used alone and in moderation are useful and harmless. Sometimes, if associated with a different harmful element or an overpowering energy level, an incremental effect may be observed.

Credible science is challenged to the extreme to interpret simply and understandably the complex evidence and soft fact from frequent fictitious allegations....

[W]hat are we to do? We, the private sector? We (you) the public authority?

Recommitting to safety

We must recommit to the safety of the products and services we offer and authorize and see to such an improved public understanding.

That word recommit means, first, that we have been committing ourselves to safety all along at the corporate and [C]ommission levels. Second, it means we will unswervingly do all of the next responsible things to affect and ensure future safety and see to its understanding....

We must deal with both subjects in the context of all electronic phenomena not just cellular telephones that were the subject of the recent exaggerated publicity.

The industry has been responsibly concerned about safe use for as long as I can remember and that spans some sixty years of experience....reinforced by so many others who have contributed to the entire industry's invaluable, safe service to society....

Forms of energy

Radio communications use electrical energy and acoustic energy so that we can carry a message over long distances. Acoustic waves, radio frequency and light are all forms of energy. The greater the distance over which energy must be propagated, the more controlled power it will take.

The processing and controlling of this energy used for communications is one part of the science of electronics which in controlling the flow of electrons allows us to produce effects like oscillating or vibrating

On April 28, 1993, Robert W. Galvin (F), chairman of Motorola's executive committee, gave the keynote address at the 1993 Eugene C. Bowler Foundation Annual Dinner and Awards Presentation. Galvin responded to recent concerns about electromagnetic energy and addressed how the industry should react. Following are selected excerpts from Galvin's speech. This article is reprinted with permission from the July/August 1993 Business Radio magazine, copyright 1993 by the National Association of Business and Educational Radio Inc., Alexandria, VA.

signals whose energy can be amplified or muted.

With the passage of time we have learned to use higher and higher signal frequencies in what you manage as the spectrum and which literally can carry the frequency of our voice tucked inside the higher frequency from the transmitter to the receiver....

Controlling energy

Energy. As obvious as it should be, it is important to emphasize that scientists and engineers from the very beginning of understanding their employment of energies—any energy—have naturally asked questions related to safety. Quite obviously, energy, if misused, could hurt. You and I have great control over an energy source by the action of our foot on a gasoline pedal in a car. If we press that pedal too far, too long, we can hurtle our car in a potentially injurious way.

Scientists and engineers have universally asked the question with each new means of controlling and activating any energy what limits are important for safety purposes. This common sense, self-interested as well as public interest question has guided the radio industry safely from the beginning....

In the responsible dialogues that have been taking place regarding the safety of cellular portable telephones, there is no evidence that there is cause of cancer as a function of the use of a portable or car cellular telephone. Along with the conclusion, responsible people suggest we need more research.

We want to address that particular issue also. We concur. We concur because that has been our practice for some 50 years. We always know we're going to do more research. We're always wanting to confirm and we're always wanting to learn about the possible effect of the next variation, if any, in the use of our science so that whatever that is doesn't create a threat.

Confirming safety

So when one deals with the concept of desirability of research, it does not have to be cast as an act of doubt. Rather it should be cast as an act of contemporaneously confirming when the new product is available that each new stage of development has the same safe qualities and consequences that all the past products had demonstrated.

...[S]ome suggested guidelines for our consideration as the private sector and the public authorities pursue the ongoing role of research and as we recommit to the safety of the products and services you authorize and we offer and strive for an always reassuring understanding by the public. Our guidelines should at least include the following:

1. All members of the product and service industries should have a say and contribute valid input.

2. Major size members of the industries should fund all appropriate research.

3. Centralized research should be conducted wherever possible.

4. A corporate safety research result should be cooperatively shared with a coordinating entity.

5. Appropriate public authorities' positions are to be respected and full cooperation accorded to such authorities.

6. Sound scientific principles must guide the determination and conduct of the research; to and including the timely disclosure of mature interpretable data.

7. Accredited scientific institutions will be accorded full unimpeded authority to research and reports.

8. If, as is validly done in other technology fields such as chemicals, research is conducted at radical levels or conducted on test subjects already carriers of a disease, all care must be taken to accurately interpret and communicate the results when the study has reached its interpretable conclusion.

9. As much as possible the industry should report to the public the citable scientific information as an industry and of course guard against inconsistencies in any independent interpretation of the safety issue to the public.

10. If we ever find that a new variation of our technology practiced to commercial standards causes or initiates an adverse health effect, it should be revised to safe standards or withdrawn.

Responsible accounting

Such a finding should responsibly account for the details involved and be differentiated from what I am confident otherwise will be a continuing string of version after version of wireless products like portable radios that will not only safely serve their owners but will continue to save countless lives while daily providing security, convenience, and productivity to all mankind.

THE RADIO CLUB OF AMERICA, INC.

Founded 1909, New York, U.S.A.

MEMBERSHIP DIRECTORY FORM

Dear Member:

The tear sheet is from the 1964 Membership Directory. That directory really was a *Who's Who in The Radio Club of America.* Our Board of Directors believes that in 1994, 30 years later, we should publish another *Who's Who in The Radio Club of America,* and we'll need your help. Inside, we've prepared a questionnaire listing the kind of information that we'll need to prepare a directory similar to that of 1964. We ask that you complete the questionnaire as completely as possible, then return it to us. It'll be a bit easier for you and it'll help us a lot if you'll do that right away.

If you have a resumé or curriculum vitae, please send it along. It'll help to give us a more complete picture of you — and speaking of pictures, if you have a photograph you like and that you think might look good in our publications, then send it along, too.

Please do complete and return the questionnaire as soon as you can. It'll be a great help, and we'll sure appreciate it.

Thanks a lot.

Warmest regards,

John Morrisey

P.S. If you have been profiled in another *Who's Who,* please send along a photocopy. Thanks.

...nie... ...dent ...
Wa... ...d DeWald ... Corporation; Senior Me... RE, Member Fidelity Lodge 1100 New York, AIEE.

GODLEY, PAUL F. (F) 1914 - Consulting Radio Engineer, Paul Godley Co., Great Notch, N. J.; res. Old Quarry Rd., Great Notch, N.J.; b. Garden City, Kans., 9/25/1889; ed. Defiance College & University Illinois; married professional experience United Wireless Tgh. Co. 1909; radio instructor 1909/11; Radio Engineer Brazillian Govt. Amazon River Radio Service 1912/13; Independent VT circuit research 1914/15; partner Adams Morgan Co. 1915/24 also, design engineer Marconi's Wireless Tgh. Co. 1918/19; Technical Editor, Wireless Age 1918/19; design engineer Liberty Electric Co. 1920; Receiving Operator ARRL Trans-Atlantic Tests 1921; Radio Editor Newspaper Enterprise Assn. 1922/24; Organizer VP & GM Farrand Mfg. Co. 1924/25; VP Chalmers-Godley Corporation, 1926/27; Consulting Radio Engineer 1926 to date; Radio Club of America President 1939, VP 1923/25, Director 1915/17, 1919/22, 1926, 1931/33; Armstrong Medal 1950 for IBCG reception at Ardrossan, Scotland; Marconi Memorial Award, Veteran Wireless Operator's Association 1947; Life Member I. R. E.

GOLDSMITH, DR. ALFRED N. (HM) 192 - Consulting Engineer, 597 Fifth Ave., N.Y.C.; b. New York, New York September 15, 1888; ed. College of the City of New York, Columbia University; married; interested ... since 190...

The Questionnaire

To assure that the information is published accurately, we need your help:

- In preparing the questionnaire, please type information or letter neatly.
- Please do not use abbreviations.
- Please limit responses to the information requested.
- You may omit any information that you do not wish to have published and that you do not feel is pertinent to your listing in the *Who's Who Membership Directory.*
- Please return form to: John Morrisey, 45 South Fifth Street, Park Ridge, NJ 07656.

The Radio Club of America, Inc.
Biographical Data Form for 1994 Membership Directory

NAME ____
(Last) (First) (Initial)

RESIDENCE ____

PLACE AND DATE OF BIRTH ____

MARITAL STATUS ______________ CHILDREN ______________________________

PROFESSION AND EMPLOYER (Principal) ____

(Secondary) ____

EDUCATION:

(Earned Degrees)	(School)	(City/State)	(Year of degree or attendance)

(Honorary Degrees)	(School)	(City/State)	(Year of degree or attendance)

PROFESSIONAL CERTIFICATION: ____

MILITARY SERVICE & AWARDS: ____

____

PROFESSIONAL EXPERIENCE: (List in chronological order ending with current position)

(Position)	(Organization)	(City/State)	(Year: from - to)

CAREER RELATED ACTIVITIES: (Professional Memberships, Current Directorships, etc.)

TECHNICAL ACHIEVEMENTS

TECHNICAL PUBLICATIONS:

Publication Fields: ______________________________

____

Books Authored: ______________________________

____

____

Books Edited: ______________________________

____

____

PATENTS:

Patent Fields: ______________________________

Number of U.S. Patents Issued: __________ Most Significant Patents: ______________________________

____

RADIO CLUB OF AMERICA HONORS & AWARDS: ______________________________

____

RADIO CLUB OF AMERICA OFFICES: ______________________________

____

OTHER TECHNICAL SOCIETIES: (Include Grade of Membership and Honors Awarded) ______________________________

____

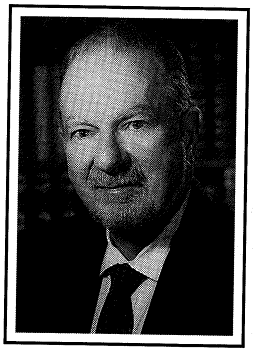
AMATEUR RADIO: (Include Call Letters and Years of Experience) ______________________________

HOBBIES: ______________________________

____

FRATERNAL ORGANIZATIONS, SERVICE CLUBS, ETC.: ______________________________

____



Frank A. Thatcher (F)

Frank A. Thatcher, P.E., died April 24, 1993, in his home in San Francisco, after a long and valiant battle with cancer. He was 64.

A San Francisco native, he served as a communications officer in an Air Force fighter squadron during the Korean conflict. He received a BSEE degree from UC Berkeley in 1960. During college, he worked nights as an electronics technician at Pacific Telephone. He was promoted to engineer upon receiving his degree. Early in his career, he was also a microwave sales engineer with Raytheon Co. in Massachusetts.

He founded a radio engineering and consulting company, Frank Thatcher Associates Inc., in San Francisco in 1971, and was president of that firm until his death. During these years he and his firm became well-known in the radio-telecommunicationcs engineering community. They have provided professional services to many public agencies in the Bay Area and throughout the U.S., including police and fire departments, power and water utilities, and transit districts.

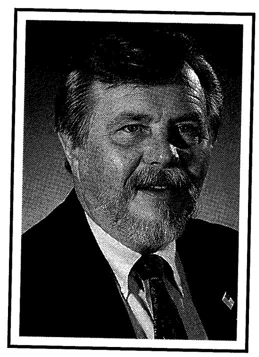
Frank was instrumental in founding the Santa Clara Chapter of the Vehicular Technology Society of the IEEE, and continued as an active participant in its activities. He was responsible for organizing the very successful 1989 VTS Annual Conference held in San Francisco. He started an annual VTS one-day seminar held in Berkeley each year, which as also been successful. The firm that he founded will continue to support the IEEE in his honor.

Frank was a Fellow of the Radio Club of America, and a member of the National Society of Professional Engineers, APCO (Associated Public-Safety Communications Officers), and the Association of Federal Communications Consulting Engineers. He was a long-time member of the San Francisco Press Club, and served on their board of directors.

Frank Thatcher Associates Inc. will continue to provide professional services under the management of Charles Ostrofe, P.E. It will continue to specialize in planning and engineering mobile radio systems for public-safety and transit agencies, microwave radio systems and radio SCADA systems, as well as to offer general telecommunications engineering services. The firm has recently formed business affiliations with two similar firms, Hatfield and Dawson Inc. in Seattle, and Suffa and Cavell Inc. in Fairfax, VA. These affiliations will expand the professional resources available to the firm, as well as provide additional presence in the eastern and northwestern U.S.

Frank is survived by his wife, Shirley; his sister, Selma; two sons, Frank Jr. and Peter; and one grandson, Philip.

—From Frank Thatcher Associates Inc.



Bertram Erickson (F)

Bertram "Bert" Erickson, a long-time employee of E. F. Johnson Company, died of a heart attack on June 19, 1993, in Waseca, Minnesota. He was 56 years old.

Bert made many friends in the radio communications industry, especially through his work with E. F. Johnson dealers and his involvement in various industry organizations and trade shows. Bert was a member of the Radio Club of America, and was elected an RCA Fellow in 1990.

After a tour of duty with the U.S. Navy in the mid-1950s, Bert studied electronics at City College of San Francisco. He worked for Secode Electronics for a few years, co-owned a printing business until 1969, and then joined an E. F. Johnson subsidiary, Rydax Electronics in San Rafael, California. Bert moved to Waseca in 1978 and worked for both Johnson's radio products and components divisions. At the time of his passing, he was the company's media marketing specialist.

Bert is survived by his wife, Linda; two children by a previous marriage, Mark and Jennifer; and two step-children, Eric and Andria.

—From the E. F. Johnson Company

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Think

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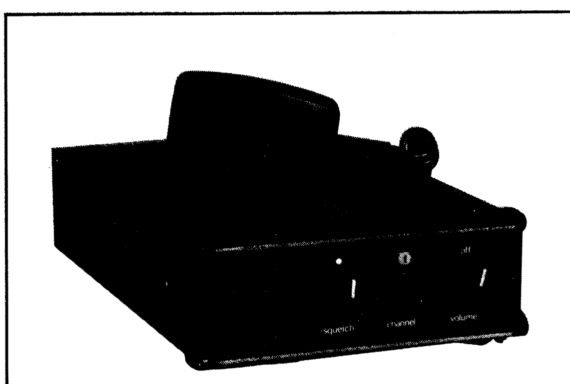
systems.



Amtol

RADIO COMMUNICATIONS SYSTEMS, INC.

main office: 150-47A 12th road • p.o. box 93 • whitestone, n.y. 11357

718-767-7500

Gaetano (Tom) Amoscato president

Anthony Natole vice-president

355 butler street
brooklyn, new york 11201
(718) 797-3770

30 garden street
new rochelle, new york 10801
(914) 576-3604

Celwave Donates $1,540 To Grant-In-Aid Fund

Steven L. Aldinger (F), right, presents a check for $1,540 for the Grant-In-Aid fund to president emeritus Fred M. Link during the Radio Club of America breakfast meeting at the International Mobile Communications Expo in Anaheim, CA, in March 1993.

Mark Newman from Allen Telecom Group and Lisa Milner from Motorola won the 1993 Celwave 5K Fun Run conducted during the International Mobile Communications Expo in Anaheim, CA, in March.

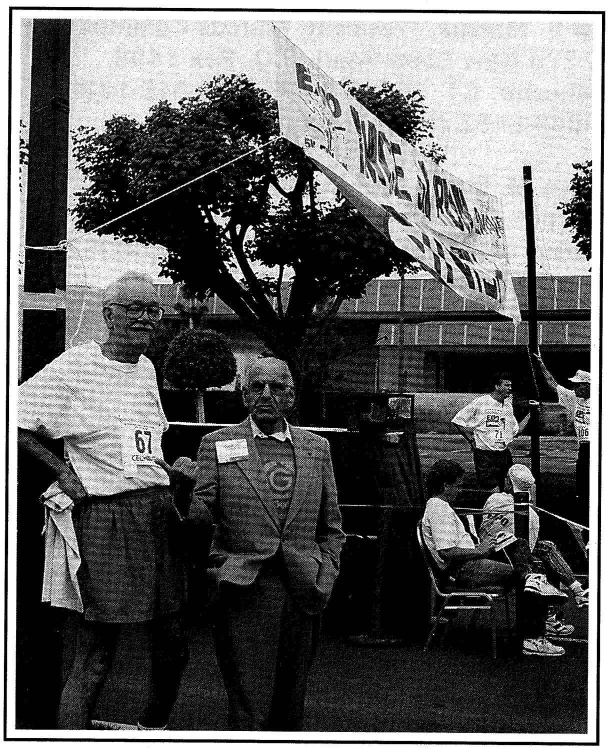
Celwave, Marlboro, NJ, donated the $1,540 proceeds of the event to the Radio Club of America's Grant-In-Aid fund. The fund primarily provides scholarship money to college students whose studies are connected with the radio art. A junior high school program that uses amateur radio as an educational focus receives support from the fund, too.

Celwave vice president of sales and marketing Steven L. Aldinger (F) presented a check for the Grant-In-Aid donation to president emeritus Fred M. Link during the RCA breakfast meeting in Anaheim, CA, in March 1993.

The 1993 5-kilometer run drew 130 participants and was the second of its kind sponsored by Celwave. The 1992 event drew 185 participants and raised about $1,700 for the Grant-In-Aid fund.

Celwave's advertising agency, Becker-Jani, suggested the promotion to Celwave after having coordinated similar promotions for other clients. Aldinger suggested that RCA would be the best organization to benefit from the proceeds.

The 5-kilometer runs are complicated affairs that involve insurance coverage, standby emergency services in case they are needed, track preparation, police cooperation and permits. Tri-A-Run handled the arrangements for the 1992 event. In 1993, Becker-Jani used the services of Race Pace.



Raymond C. Trott, P.E. (F), left, stands next to president emeritus Fred M. Link after completing the 5-kilometer run sponsored by Celwave for the benefit of the Radio Club of America's Grant-In-Aid fund.

BUSINESS DIRECTORY

Gaetano (Tom) Amoscato, President, Amtol Radio Communications Systems, Inc., 150-47A 12th Road, Whitestone, NY 11357, 718-767-7500, 718-767-9858 (FAX)

George M. W. Badger, VP, Director of Marketing, Svetlana Electron Devices, 3000 Alpine Road, Portola Valley, CA 94028, 415-233-0429, 415-233-0439 (FAX)

Andy T. Bower, Marketing Services International, P.O. Box 217, Cherry Tree, PA 15724-0217, 814-743-6527, 814-743-6631 (FAX)

William D. Cheek, Sr., President, Commtronics Engineering, P.O. Box 262478, San Diego, CA 92126-2478, 619-578-9247 voice 1-6 PM, 619-578-9247 (FAX) 6-1 PM

Mark E. Crosby, President, Industrial Telecommunications Association, 1110 North Glebe Road, Suite 500, Arlington, VA 22201, 703-528-5115, 703-524-1074 (FAX)

John E. Dettra, Jr., President, Dettra Communications, Inc., P.O. Box 18864, Washington, DC 20036-8864, 202-965-4664, 202-965-4666 (FAX)

Richard W. Ehrhorn, President and Chairman, Ehrhorn Technological Operations, Inc., 4975 North 30th Street, Colorado Springs, CO 80919, 719-260-1191, 719-260-0395 (FAX)

Gary Eisenberg, Communications Consultant, Communications Planning, P.O. Box 9151, Bardonia, NY 10954-9151, 914-634-6795, 914-638-4408 (FAX)

William E. Endres, President, Tele-Measurements Incorporated, 145 Main Avenue, Clifton, NJ 07014-1078, 201-473-8822, 201-473-0521 (FAX)

R. James Evans, President, Evans and Evans Associates, Inc., 2803 Southwood Drive, East Lansing, MI 48823, 517-351-3252

Joseph J. Fairclough, WB2JKJ, The Radio Club of Junior High School 22, NYC, P.O. Box 1052, New York, NY 10002-0912, 516-674-4072, 516-674-9600 (FAX)

Rafael A. Garcia, President, Teletrol, Inc., P.O. Box 530153, Miami Shores, FL 33153, 305-756-1111, 305-759-4632 (FAX)

Charles A. Higginbotham P.E., Owner, Higginbotham Associates, 85 Aspen Meadows Circle, Santa Rosa, CA 95409, 707-539-8638, 707-539-8638 (FAX)

Lawrence M. (Larry) Hollingsworth, Owner, Lawrence Hollingsworth Consulting, 2888 Lee Road, Silver Lake, OH 44224-3731, 216-923-4337, 216-923-7747 (FAX)

Duane L. Huff, Director, New Technologies, Comcast PCS Communications, Inc., 151 West Ethel Road, Piscataway, NJ 08854-5928, 908-777-2916, 908-777-0105 (FAX)

William O. Hunt, Chairman of the Board, President & CEO, Intellicall, Inc., 2155 Chenault, Suite 410, Carrollton, TX 75006-5023

Leonard R. Kahn, President, Kahn Communications, Inc., 222 Westbury Avenue, Carle Place, NY 11514, 516-222-2221

John H. Levergood, President, Broadband Communications Grp., Scientific-Atlanta, Inc., 4386 Park Drive, Norcross, GA 30093, 404-903-5017, 404-903-6299 (FAX)

Jack Manon, Manon Engineering Inc., 515 Kirkland Way, Kirkland, WA 98033, 206-827-7449, 206-827-7099 (FAX)

Bruce S. Marcus, President, Marcus Communications Inc., 275 New State Road, P.O. Box 1498, Manchester, CT 06045-1498, 203-646-1839, 203-649-8492 (FAX)

Stephen M. Meer, VP - Systems Integration/Engineering, SCC, Inc., 5710 Flatiron Parkway, Boulder, CO 80301, 303-447-8352, 303-447-8446 (FAX)

Randy K. Murray, President, Redi-Call Communications Co., 543 South Bedford Street, Georgetown, DE 19947, 302-856-9000, 302-856-9143 (FAX)

Joseph Y. Nasser Ph.D., President, Center for Public Safety Studies, Inc., 595 North Nova Road, Suite 207, Ormond Beach, FL 32174, 904-676-7518, 904-677-9181 (FAX)

Emily C. Nelms, Director of Marketing, American Personal Communications, Inc., 1025 Connecticut Ave., NW - Suite 904, Washington, DC 20036, 202-296-0005, 202-296-0018 (FAX)

Paulla A. Nelson-Shira, President, Radio Resource Magazine/Pandata Corp., 7853 East Arapahoe Court, #1900, Englewood, CO 80112, 303-771-8616, 303-771-8605 (FAX)

Armond M. Noble, Publisher, Worldradio, 2120 28th Street, Sacramento, CA 95818, 916-457-3643, 916-457-7339 (FAX)

Donn R. Nottage, President, NRM Marketing Group, Inc., 7 Fennell Street, P.O. Box 421, Skaneateles, NY 13152-0421, 315-685-8991, 315-685-6199 (FAX)

Scott D. Prather, Technical Manager, InterLink Communications, 6810 South Tucson Way, Englewood, CO 80112, 303-649-2032, 303-792-2516 (FAX)

George A. Praul, Manager, Telecommunications Services, SE Technologies, Inc., 3605 Vartan Way, Harrisburg, PA 17110, 717-541-8630, 717-541-8649 (FAX)

Ted Rappaport, President, TSR Technologies, Inc., P.O. Box 10727, Blacksburg, VA 24062-0727, 703-552-8324, 703-552-TECH (FAX)

Jack Reichler, President, Meridian Communications, 23501 Park Sorrento, #213A, Calabasas, CA 91302-1355, 818-888-7000, 818-222-2857 (FAX)

Stan Reubenstein, Manufacturer's Representative, Aurora Marketing Company, 2018 South Pontiac Way, Denver, CO 80224, 303-758-3051, 303-758-6630 (FAX)

Patricia Schod, Manager, Media Relations, Motorola - Land Mobile Products Sector, 1301 East Algonquin Road, Schaumburg, IL 60196, 708-576-6612, 708-576-6601 (FAX)

Carolyn Servidio, HCS Telecommunications, 1110-G Burnett Avenue, Concord, CA 94520, 800-346-6442, 510-676-3387 (FAX)

Herschel Shosteck Ph.D., President, Herschel Shosteck Associates, Ltd., 10 Post Office Road, Silver Spring, MD 20910-1192, 301-589-2259, 301-588-3311 (FAX)

Calvin D. Smith, Owner, RF Products, 1930-D Murrell Road, Rockledge, FL 32955, 407-631-0775, 407-631-0775 (FAX)

Tom Smith, Owner, Marketing Masters, 8300 Killian Drive, Miami, FL 33156, 305-253-3289, 305-255-0523 (FAX)

Richard G. Somers, President and C.E.O., American Mobile Systems, Inc., 21160 Califa Street, Woodland Hills, CA 91367, 818-593-3000, 818-702-6185 (FAX)

B. Dennis Starling, Vice President, Auto-Comm Engineering Corporation, 3014 Cameron Street, Lafayette, LA 70506, 318-232-9610, 318-237-8807 (FAX)

Eric D. Stoll Ph.D., P.E., Sr. Staff Engineer, AlliedSignal Aerospace, Guidance and Control Systems Div., M/C - 4/25; US Route 46 East, Teterboro, NJ 07608, 201-393-2534, 201-393-6540 (FAX)

William S. Taylor, President, Free Trade Distributors, Inc., 59 Old Bloomfield Avenue, Pine Brook, NJ 07058, 201-808-8862, 201-808-8865 (FAX)

Raymond C. Trott, P.E., President, R.C. Trott Consulting Engineers, Inc., 1425 Greenway Drive, Suite 350, Irving, TX 75038, 214-580-1911, 214-580-0641 (FAX)

CROSS REFERENCES

AlliedSignal Aerospace, Guidance and Control Systems Div. - Eric D. Stoll Ph.D., P.E.
American Mobile Systems, Inc.
Richard G. Somers
American Personal Communications, Inc.
Emily C. Nelms
Amtol Radio Communications Systems, Inc.
Gaetano (Tom) Amoscato
Aurora Marketing Company
Stan Reubenstein
Auto-Comm Engineering Corporation
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Center for Public Safety Studies, Inc.
Joseph Y. Nasser Ph.D.
Comcast PCS Communications, Inc.
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Dettra Communications, Inc.
John E. Dettra, Jr.
Ehrhorn Technological Operations, Inc.
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Evans and Evans Associates, Inc.
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Herschel Shosteck Associates, Ltd.
Herschel Shosteck Ph.D.
Higginbotham Associates
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Industrial Telecommunications Association
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Lawrence M. (Larry) Hollingsworth
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Bruce S. Marcus
Marketing Masters
Tom Smith
Marketing Services International
Andy T. Bower
Meridian Communications
Jack Reichler
Motorola - Land Mobile Products Sector
Patricia Schod
NRM Marketing Group, Inc.
Donn R. Nottage
R.C. Trott Consulting Engineers, Inc.
Raymond C. Trott, P.E.
Radio Resource Magazine/Pandata Corp.
Paulla A. Nelson-Shira
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RF Products
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George M. W. Badger
Tele-Measurements Incorporated
William E. Endres
Teletrol, Inc.
Rafael A. Garcia
The Radio Club of Junior High School 22, NYC
Joseph J. Fairclough, WB2JKJ
TSR Technologies, Inc.
Ted Rappaport
Worldradio
Armond M. Noble

PROFESSIONAL DIRECTORY

GAETANO (TOM) AMOSCATO
Communications Consultant
150-47A 12th Road,
Whitestone, NY 11357
718-767-7500,
718-767-9858 (FAX)

WILLIAM J. BRAGG
Satellite Broadcaster, Television Broadcast Engineer, Museum Founder
2001 Plymouth Rock,
Richardson, TX 75081
214-690-3636,
214-644-2473 (FAX)

WILLIAM D. CHEEK, SR.
Communications and Information
P.O. Box 262478, San Diego, CA 92126-2478
619-578-9247
voice 1-6 PM, (FAX) 6-1 PM

JOHN E. DETTRA, JR.
Consulting Engineer
805 25th Street, NW,
Washington, DC 20006
202-965-4664,
202-965-4666 (FAX)

RICHARD W. EHRHORN
Mfg. RF Power Amplifiers & Generators
4975 North 30th Street,
Colorado Springs,
CO 80919
719-260-1191,
719-260-0395 (FAX)

GARY EISENBERG
RF Site Consulting and Management
P.O. Box 9151,
Bardonia, NY 10954-9151
914-634-6795,
914-638-4408 (FAX)

R. JAMES EVANS
Land Mobile Communications Consultant
2803 Southwood Drive,
East Lansing, MI 48823
517-351-3252

JOSEPH J. FAIRCLOUGH, WB2JKJ
Educational Consultant
P.O. Box 1052,
New York, NY 10002-0912
516-674-4072,
516-674-9600 (FAX)

CHARLES A. HIGGINBOTHAM P.E.
Land Mobile Telecommunications
85 Aspen Meadows Circle,
Santa Rosa, CA 95409
707-539-8638,
voice and FAX

LAWRENCE M. HOLLINGSWORTH
Telecommunications Consulting
2888 Lee Road,
Silver Lake, OH
44224-3731
216-923-4337,
216-923-7747 (FAX)

JACK M. JANICKE
Magnetic Design and Testing
122 Bellevue Avenue,
Butler, NJ 07405
201-838-6348

LEONARD R. KAHN
Consultant
222 Westbury Avenue,
Carle Place, NY 11514
516-222-2221

JAMES KREUZER
Buy and Sell Early Radio and Electrical Books
P.O. Box 398,
Elma, NY 14059
716-681-3186,
voice and FAX

JAMES A. LANG P.E.
Microwave Engineering
24591 Summerhill Court,
Los Altos, CA 94024
415-948-5914

FRED M. LINK
Radio Communications Consulting
Robin Hill Farm,
P.O. Box 901,
Pittstown, NJ 08867-0901
908-735-8310,
908-735-9209 (FAX)

BRUCE S. MARCUS
System Consulting, Interference Location & Suppression
275 New State Road,
P.O. Box 1498,
Manchester, CT
06045-1498
203-646-1839,
203-649-8492 (FAX)

IAN M. MCKENZIE
Advisor-European and Asia/Pacific Telecom Industry
12 The Fairway, Bar Hill,
Cambridgeshire,
UK CB3 8SR
44-954-782662,
44-954-780729 (FAX)

PROFESSIONAL DIRECTORY

STUART MEYER
Land Mobile Radio Consultant
2417 Newton Street,
Vienna, VA 22181
703-281-3806,
703-281-3868 (FAX)(24 hr)

RAY MINICHIELLO P.E.
Communications Consultant
45 Shaw Drive,
Bedford, NH 03110
603-472-9746,
603-666-3664 (FAX)

DONN R. NOTTAGE
Manufacturers Representative, Consultant
7 Fennell Street,
P.O. Box 421,
Skaneateles, NY 13152-0421
315-685-8991,
315-685-6199 (FAX)

GEORGE A. PRAUL
Telecommunications Systems Consulting Services
3605 Vartan Way,
Harrisburg, PA 17110
717-541-8630,
717-541-8649 (FAX)

TED RAPPAPORT
Wireless Communications Consulting and Instrumentation
P.O. Box 10727,
Blacksburg, VA 24062-0727
703-552-8324,
703-552-TECH (FAX)

JACK REICHLER
Antenna Sites, So. California
23501 Park Sorrento, #213A
Calabasas, CA 91302-1355
818-888-7000,
818-222-2857 (FAX)

STAN REUBENSTEIN
Manufacturer's Representative - Rocky Mountain States
2018 South Pontiac Way,
Denver, CO 80224
303-758-3051,
303-758-6630 (FAX)

FRANCIS J. RODRIGUEZ, M.S.
Consulting: Communications Systems & Tariffs, "Smart" Building Systems
10 Woodbridge Center Drive, TAI,
Woodbridge, NJ 07095
908-855-6889,
908-602-0990 (FAX)

EDWARD A. SCHOBER P.E.
Broadcast Consulting Engineer
402 Tenth Avenue,
P.O. Box 367,
Haddon Heights, NJ 08035-0367
609-546-8008,
609-546-1841 (FAX)

FRANCIS H. SHEPARD JR., P.E.
Consulting Engineer
16 Lee Lane, Countryside,
Summit, NJ 07901
908-273-5255

TOM SMITH
Manufacturers Representative
8300 Killian Drive,
Miami, FL 33156
305-253-3289,
305-255-0523 (FAX)

WILLIAM TORBICK
Management/Executive Search, Business Consultant
226 Ivy Lake Drive West,
Forest, VA 24551-1041
804-525-7246

RAYMOND C. TROTT, P.E.
Land Mobile/Microwave Communications Consultant
1425 Greenway Drive,
#350, Irving, TX 75038
214-580-1911,
214-580-0641 (FAX)