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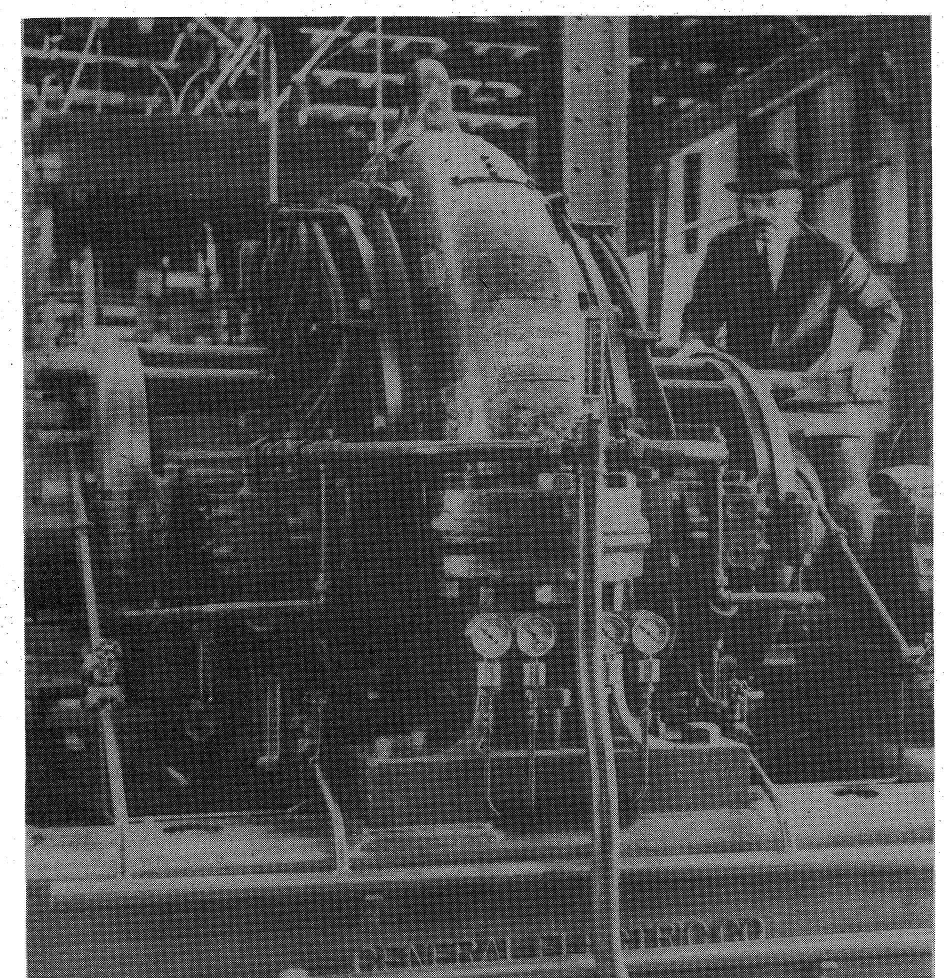

Alexanderson Alternator at Radio Central showing E.F.W. Alexanderson, inventor of the apparatus, watching it operate. (Courtesy of the Smithsonian Institution.)

THE RADIO CLUB OF AMERICA, INC.

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

The Radio Club of America, Inc.

324 SOUTH 3rd AVENUE, HIGHLAND PARK, N.J. 08904

Price $2.50

Organized for the interchange of knowledge of the radio art, the promotion of good fellowship among the members thereof, and the advancement of public interest in radio.

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TREASURER'S REPORT FOR FISCAL YEAR 1985

(October 1, 1984 — September 30, 1985)

RECEIPTS

Dues	$11,141
Contributions to Grants-in-Aid	3,350
Interests & Dividends	10,489
Advertising	3,284
Sale of Pins and Plaques	1,522
Sale of Diamond Jubilee Yearbooks	2,375
Miscellaneous — Banquet	1,437
Total Receipts	$34,194

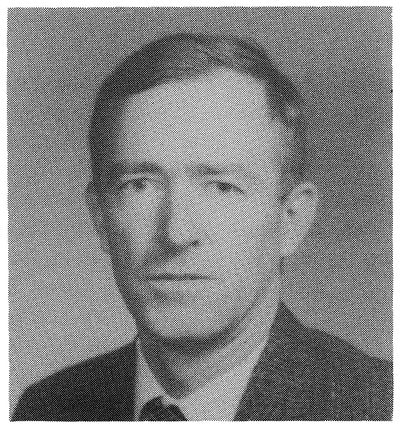
DISBURSEMENTS

Grants-in-Aid Scholarships	$8,000
Consulting Fee	3,000
Publication Expenses	5,030
Rent	600
Printing & Stationery	212
Addressograph & Office Supplies	516
Telephone	268
Postage	721
Meetings	2,446
Newsletter & Balloting	708
Legal & Accounting	627
Cost of Pins and Plaques	1,273
Miscellaneous	634
Total Disbursements	$24,035

Excess Receipts over Disbursements $10,159

THE ALEXANDERSON RADIO ALTERNATOR AND THE DISTINCTION BETWEEN ENGINEERING AND SCIENCE

by James E. Brittain, Ph.D. (M 1983, F 1985)



Ernest F. W. Alexanderson discussed the potentially revolutionary role of radio technology in a paper delivered at a meeting of the Institute of Radio Engineers (IRE) in November 1920. He observed that "radio makes the transmission of ideas from man to man and from nation to nation independent not only of any frail material carrier such as a wire, but above all, it renders such communication independent of brute force that might be used to isolate one part of the world from another." [1] Another theme of his paper was the intimate relationship that he perceived between electric power engineering and radio engineering, a connection that he credited with having led to the development of a central station for transoceanic radio transmission that was similar in many respects to a central electric power station. Despite the fact that radio employed frequencies of the order of a thousand times higher than those used in power transmission, Alexanderson found it quite remarkable that *"the generally established principles of the alternating current power technique could be applied to the radio technique almost without change"* (italics his.) [2]

According to Alexanderson, the transoceanic radio station reflected the contributions of two distinct groups of electrical engineers and a group of physical scientists. He credited the scientists with having given radio an important new impetus through their work on electronic tubes. He explained that the two engineering groups had pursued different aims and had employed "widely different modes of thought" with one "thinking in terms of power factor, kilowatts, and phase displacement, the other in terms of wave lengths, decrements, and tuning." [3] As Alexanderson indicated, in 1920, electrical power engineers did constitute a distinct engineering culture that was relatively unfamiliar with electronic tubes and radio principles. Their perspective is well illustrated by a comment made by Albert Hull, a physicist at the General Electric Research Laboratory, in a paper presented at a meeting of the American Institute of Electrical Engineers (AIEE) in 1921. Hull alleged that the power engineers in his audience generally associated electrons with "wireless magic and microamperes, read through a telescope. And so, as engineers, you view them with aloofness, as interesting playthings, not engineering tools."

The existence of two distinctive cultures in the electrical engineering profession persisted long after 1920. An editorial published in a General Electric technical periodical in 1940 employed the metaphor of two valleys separated by a mountain range that divided electronic engineering and the engineering of rotating electrical machinery. The editor stated that the two engineering cultures had developed more or less independently as they progressed down their respective valleys. The cultural separation was, in effect, institutionalized within the confines of the AIEE and the IRE, professional organizations that maintained separate identities for a half century until they merged in 1962. A substantial degree of cultural separation might also exist within the confines of a large manufacturing corporation such as General Electric that employed scientists, power and electronic engineers but maintained departments that specialized along product lines. An exceptional individual such as Alexanderson was able to cross the cultural and institutional barriers that divided scientists and the two cultures of electrical engineering. Alexanderson attributed many of his inventions and creative designs to his dual allegiance that enabled him to apply electronic thinking to non-electronic devices.

The Alexanderson radio alternator is a physical artifact that well exemplifies the creative interaction of scientific and engineering cultures during the early 20th century. A rotary electrical machine designed for the generation of powerful radio waves, this alternator was developed during the period from 1904 to 1918. The machine and the system of which it was part had a mixed ancestry in physics, radio engineering and power engineering. The contrasting views of the cultures were manifest especially in a dispute over whether iron should be used as the armature core of the alternator, a dispute that eventually was resolved by using the alternator itself as an instrument.

The General Electric Company where the Alexanderson radio alternator was perfected had evolved into a leading corporate center of the power engineering culture by 1900. The impetus for designing the radio alternator and the initial funding came from a customer who was a pioneer in American radio, Reginald A. Fessenden. Born in Canada in 1866, Fessenden received a liberal education at Bishop's College and undertook considerable self-study in science and mathematics. He worked for about two years in Thomas Edison's laboratory in New Jersey in the late 1880's and subsequently worked briefly for the United States Electrical Company and for the Stanley Electric Company. He then taught electrical engineering at Purdue during the years 1892-93 and taught at the Western University of Pennsylvania from 1893-99.

During the 1890's, Fessenden engaged frequently in theoretical and speculative physics at a level that was quite advanced — at least by late 19th century American standards. He developed an "electrostatic doublet" theory of atoms in solids that he used in an attempt to link data on the volume and spacing of atoms to macro properties of materials such as cohesion, tensile strength and elasticity.[4] In 1900, he published a long paper in the *Physical Review* dealing with fundamental theories of matter, electricity, magnetism and the ether. In the paper, he revealed a familiarity with the work of Maxwell, Hertz, Rowland, Heaviside, Poincare', Helmholtz and Fitzgerald.[5] In this work he was behaving more as a physicist than as an engineer.

Fessenden and some of his advanced students began to experiment with wireless telegraphy while he was still at the Western University. In 1899, he resigned his academic appointment to accept an offer from the U.S. Weather Bureau to develop a wireless system for communication between weather stations. This effort proved unsuccessful but in 1902, Fessenden persuaded two Pittsburgh bankers to invest in a new wireless firm known as the National Electric Signalling Company (NESCO) to develop the Fessenden communication system commercially. Becoming convinced that machine-generated continuous waves would be superior to the intermittent waves produced by other means, Fessenden persuaded Charles P. Steinmetz, the famous General Electric engineer-inventor, to undertake the design of a high-frequency alternator with the capability of generating up to 10,000 cycles per second (cps). The Steinmetz alternator was turned over to Fessenden early in 1903 but he found it to be inadequate to fill his needs and soon requested that GE undertake construction of an alternator of much higher frequency and power. Ernest Alexanderson was assigned to take charge of the Fessenden project and to design the new alternator late in 1904.

Alexanderson was by interest and by education a member of the electrical power engineering culture when he first began the effort to design a new radio alternator. Swedish by birth, he had graduated in electrical engineering from the Royal Institute of Technology in Stockholm and had devoted an additional year to advanced studies at the technical college in Charlottenburg, Germany. He first encountered the complex algebra method of alternating current analysis that was pioneered by Steinmetz while a student at Charlottenberg in the spring of 1901 and wrote a thesis paper comparing traditional graphical methods with those of Steinmetz. Alexanderson received a thorough grounding in machine design that included rotating electrical machines and also was introduced to the modern theory of electromagnetic waves. He came to the U.S. to seek employment and joined the GE Company in Schenectady, N.Y. in February 1902, beginning a fifty-year career with GE as an engineer-inventor. After a few months of work as a technical draftsman and in the Testing Department, he was assigned to the Alternating Current Engineering Department.[6]

Alexanderson soon earned a solid reputation as a designer of rotating electrical machinery such as motors used for railroad electrification. His mastery of the principles of alternating current circuits and machinery was his greatest single asset as an inventor and respected member of the power engineering culture. He demonstrated a mental grasp of the interaction of intricate combinations of armature and field windings. He could visualize the spatial and temporal relationships of rotating magnetic fields as a function of the multiple variables of machine design and load conditions. In contrast to Fessenden, Alexanderson showed little concern for the theories of modern physics but was content to leave these to his friends of the scientific culture such as Irving Langmuir of the GE Research Laboratory. The high-frequency alternator project did provide the young engineer with a welcome opportunity to meet and interact with members of the radio-electronics culture both in the GERL and outside the company boundaries. Alexanderson became a eager student of the principles of radio engineering and soon became the leader in a radio engineering enclave that was established within the electrical power engineering citadel at GE.

The high-frequency properties of iron became a pivotal issue in the design of the radio alternator and provoked a lengthy dispute between Fessenden and Alexanderson that illustrates their contrasting cultural perspectives. In his initial design completed in December 1904, Alexanderson proposed the use of a dual disc iron motor with slotted rims to avoid the need for high-speed rotation of electrical windings. The high frequency currents were to be induced in the windings of a stationary armature with a laminated iron core and the armature was to be situated between the rims of the two rotating discs. Upon receiving the proposed design, Fessenden approved the use of the rotating inductor discs but insisted that iron should not be used for the armature core. Since Fessenden was funding the project, Alexanderson prepared a revised design for a non-ferric armature but continued to express his personal preference for a laminated iron core design.

Together with copper, iron was the *sine qua non* of electrical power engineering since it provided a minimum reluctance in the magnetic circuits of electrical motors, generators and transformers. Since impurities affected strongly the magnetic properties of iron and because of the non-linear behavior of iron, machine designers had found it expedient to rely on empirical constants and graphs for the analysis and design of magnetic circuits that included iron. The designers of alternating current machinery frequently were skeptical about the value of analytic methods published by Fessenden and others that did not use graphical techniques. Fessenden alluded to this skepticism in a paper on the use of magnetic formulas in design when he mentioned the "gibes" that design engineers had directed at those who employed "ironless mathematics."[7]

With his background in physics and practical experience in radio engineering, Fessenden's conviction that iron should be avoided where possible at radio frequencies was quite reasonable given the state of knowledge at the time. It had been established by Steinmetz and others in the early 1890's that the hysteresis and eddy current losses of iron increased rapidly with an increase in the applied frequency. These losses could be tolerated and somewhat alleviated at power frequencies through the use of insulated laminations and through the selection of iron alloys that reduced magnetic hysteresis. Fessenden was well informed on the subject of magnetic science and evidently thought that his electrostatic doublet theory of atoms in metals could serve as a basis for a deeper scientific understanding. He had become convinced that an equation relating magnetic flux to magnetic field intensity in ferric materials was the "expression of a physical law" and not "merely an empirical statement."[8] He undertook a series of careful experiments in a effort to provide convincing proof that the equation, formulated by his former colleague, Arthur E. Kennelly, did express a "physical fact" and was "the touchstone" of modern electrical theory.[9]

Alexanderson and other members of the power engineering culture were not overly concerned over whether magnetic circuit equations were merely empirical rather than being based on atomic or molecular theories so long as they served the purposes of engineering design. Alexanderson was familiar with the Steinmetz iron loss equation but remained an agnostic over its implications for the use of iron in the radio alternator. In the absence of empirical data, Alexanderson relied on his experience and instincts for the belief that iron would at least be superior to the wood preferred by Fessenden as an armature core. Alexanderson approached the problem in terms of a natural extension of the established principles of power engineering rather than as a problem where different principles might be needed.

The dual-disc radio alternator with wooden-core armature was completed and shipped to Fessenden's transmitting station at Brant Rock, Massachusetts in August 1906. Surviving photographs of the Brant Rock facility appear more similar to a university laboratory of experimental physics than to an electric power plant in contrast to the radio alternator stations later designed by GE engineers.

The alternator at Brant Rock was employed in pioneering voice and music broadcasts in December 1906 that were witnessed by invited journalists and an engineer from the American Telephone & Telegraph Company. The machine performed fairly well although it failed to deliver as much power as Fessenden had anticipated at frequencies above 50,000 cps. One difficulty ultimately was discovered to be due to the slight mechanical deformation of the two rotary discs that caused their spacing from the armature winding to increase at high speeds. The Bell Company declined to purchase the rights to use the Fessenden system for radio telephony but did decide to approach GE about building a high-frequency alternator for possible use as a rotary telephone amplifier.[10]

The telephone alternator project was assigned to Alexanderson who took advantage of his experience with the machine made for Fessenden and made several changes in the design. He adopted a single-disc rotor and used a laminated iron core instead of wood for the armature.

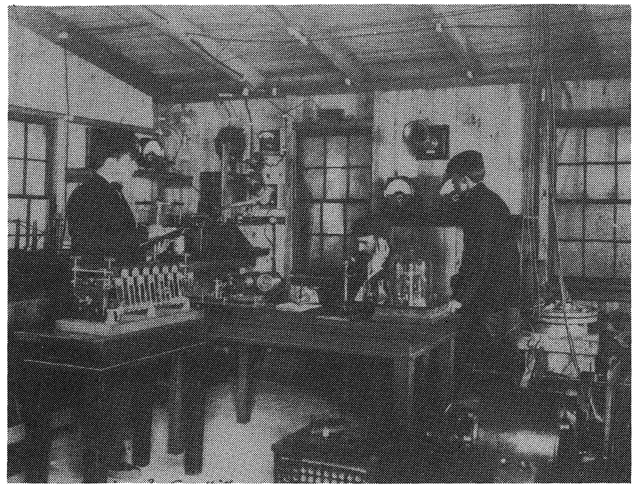


Figure 1. The Fessenden Wireless Station at Brant Rock. (Courtesy of Smithsonian Institution.)

Meanwhile the Fessenden contract for several additional radio alternators had been turned over to another department at GE and Fessenden did not learn of the telephone alternator for several months. When a reorganization of the Bell Company in 1907 resulted in the termination of its support of development of the telephone alternator, Fessenden decided to support Alexanderson's alternator work and to cancel the other developmental project at GE. Fessenden continued to express reservations about the of use of iron for the armature core and insisted that both iron and wood cores be fabricated to permit comparative tests.[11] In July 1908, Alexanderson reported to Fessenden that tests of the new alternator at a frequency of 60,000 cps had shown conclusively that the iron-core armature was "very much better" and increased the output power by a factor of five. The alternator was operated at its rated speed of 20,000 revolutions per minute that was required to generate a frequency of 100,000 cps, by December 1908.[12] This modified telephone alterantor became the prototype for a standardized high-frequency alternator that generated 2000 watts at 100,000 cps. Alexanderson later devised a modification of the armature winding that enabled the maximum frequency of the machine to be doubled to 200,000 cps without a further increase in rotor speed.

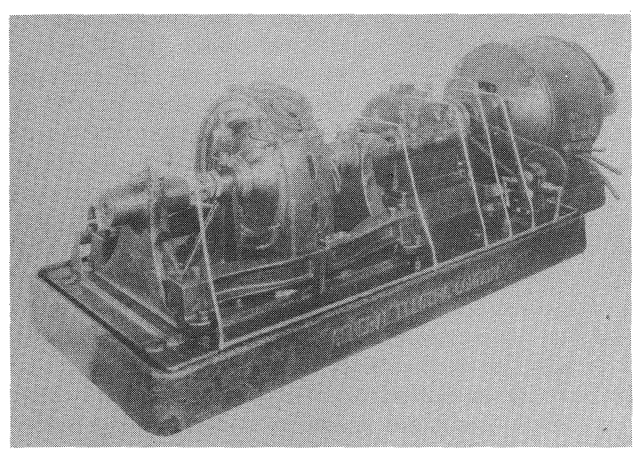


Figure 2. Typical Alexanderson Radio Alternator with 2000 watt rating. (Courtesy of Smithsonian Institution.)

The 2000 watt alternator proved its value as a scientific tool when it was used by Alexanderson and others to conduct a variety of high-frequency research projects. Alexanderson carried out a comprehensive investigation of the high frequency properties of iron using the alternator as a generator and reported his findings in a paper published in 1911. He stated that his data refuted the commonly held view "that iron does not respond to high frequencies." He demonstrated the design implications of his findings by including in his paper sample calculations of iron-core transformers for use at frequencies of up to 200,000 cps. His calculations indicated that the core dimensions and weight were decreased and the efficiency was increased for a transformer of a given power capacity as the design frequency was increased. [13]

Table 1

Alexanderson's Calculations for a Five Kilowatt Transformer at Various Frequencies

Frequency (cps)	60	10K	100K	200K
Dimension of Core (cm.)	4.65	2.41	2.06	2.00
Weight (kg)	19.5	2.70	1.70	1.50
Efficiency %	90	97	98.2	98.3

Charles Steinmetz, who had built his own reputation on the basis of an investigation on iron at power frequencies, praised Alexanderson for having created such a remarkable machine and for having used it to determine the behavior of iron at "these extremely high frequencies." Final vindication came in the form of a congratulatory letter from Fessenden who credited Alexanderson with having obtained the "first definite and dependable knowledge in regard to this subject." Fessenden continued that those who worked with high frequencies might now "go ahead and use iron without fear."

Alexanderson's motivation in undertaking this research was to extend the knowledge base of the design engineer who used iron, to much higher frequencies. His paper was not a contribution to the physical theory of materials although it provided a new challenge to the scientist of ferric substances. This constitutes an interesting case wherein an advance in engineering technique in the form of a new high-speed machine enabled the boundaries of engineering knowledge to be extended beyond the contemporary boundaries of physical science. As Edwin Layton has pointed out in a number of papers, the body of knowledge used in modern engineering has some of the attributes of that in science, such as that it is cumulative, systematic and can be taught. But the agendas of the basic scientist and the engineer generally are distinguishable and engineers frequently have not waited for complete scientific understanding before extending the limits of their materials.

Alexanderson also used the alternator to investigate the behavior of dielectric materials at high frequencies. In a paper presented to the IRE in November 1913, he stated that his objective had been to collect information that would enable the application of "systematic and scientific methods to the design of radio frequency circuits." [14] He described as "unexpected and striking" his discovery that corona loss and arc-over distance were approximately the same at radio frequencies as at power frequencies. A discussant called his paper a milestone in "our emancipation from insulation difficulties" and anticipated that the design of radio circuits that had been "empirical in the extreme" now could become as systematic as the design of magnetic circuits at power frequencies. Again his research was directed to filling the needs of engineering design rather than to basic science.

The Alexanderson alternator played an indirect but significant role in the initiation of a period of intensive research and development of electronic tubes at the GE Research Laboratory early in 1913. John H. Hammond, Jr. purchased two of the alternators to use in experiments on the remote control of boats and torpedoes by wireless means. The resulting contacts between Hammond and Alexanderson alerted the latter to the possibilities of the de Forest audion tube as an amplifier. He obtained sample audions from Hammond and turned them over to Irving Langmuir at the GE Laboratory where the erratic and gaseous audion was soon converted into a reliable high vacuum triode amplifier. The Alexanderson alternator served as a signal generator for the first tests of pliotron amplifiers fabricated at GE. Ironically, the increasingly high power and high frequency tubes produced at GE would supersede the radio alternator in the 1920's.

Prior to the first World War, Alexanderson alternators were acquired from GE for use in high-frequency research or radio experiments by the Japanese government, the U.S. Army Signal Corps, the Marconi Company, Columbia University and Harvard. Arthur E. Kennelly of Harvard collaborated with Alexanderson on an investigation using the alternator to determine how the physiological tolerance of humans changed as a function of frequuency. They reported finding that a man could tolerate approximately one hundred times as much electric current at 100,000 cps as at the power frequency of 60 cps. [15]

By 1914, the Alexanderson radio alternator was recognized as a prime candidate for use in transoceanic communication, a need that the outbreak of war in Europe made urgent. Alexanderson designed a more powerful 50,000 watt alternator that was constructed at GE and installed at a Marconi transmitting station in New Brunswick, N.J. in 1917. A still larger alternator with a power rating of 200,000 watts was completed at GE in 1918 and also was installed at the New Brunswick station. Twenty of the elegant and expensive 200,000 watt alternators were constructed by GE for installation in an international radio system to be operated by the Radio Corporation of America, a company organized in 1919. The hub of the system was a station known as Radio Central, located on Long Island, that was designed to handle radio telegraph traffic to Europe, South America and the Far East (Front cover). Alternator stations were installed in England, Sweden, Poland and elsewhere during the early 1920's. [16]

The radio alternator stations closely resembled central electric power plants, a reflection of the power engineering tradition from which the Alexanderson transoceanic radio system had come. Even the design of the transmitting antennas was affected by power engineering principles. Soon after the first radio alternator was installed at New Brunswick, Alexanderson departed from the accepted doctrine of antenna design. He used power engineering concepts to design an antenna structure that resembled a high-voltage power transmission line with long horizontal wires suspended from a row of steel towers. The result was a substantial increase in radiation per kilowatt of alternator output in comparison to earlier antennas that were thought to be more scientific. In another invention known as the barrage receiving system, Alexanderson used a design principle commonly used in the design of splitphase electric motors to design a radio receiver with reduced interference. Alexanderson and the other GE engineers who came from the power culture introduced such power engineering concepts as load factor and load diversity into the planning and management of the transoceanic system. For example, they pointed out that the peak demand for radio service to Europe, South America and the Far East would vary significantly depending on the time of day or time of year. Special toll rates were used as an incentive to stimulate and equalize consumer usage of the overseas service. In a paper published in 1924, Alexanderson characterized the alternator transmitting station as being like a "power station" that converted kilowatts to words. He defined the central problem of radio engineering as "to establish the relation between kilowatts input and words output." [17]

There was a centralizing trend in the electrical power industry in the 1920's that led to grandiose plans of regional and even national "superpower" systems in the United States. The dreams of the power centralizers such as Gifford Pinchot and William S. Murray came closer to realization, at least geographically, in the creation of an RCA super power transocean communication system that used the 200 kilowatt Alexanderson alternators and power engineering concepts that were adapted to radio.

The well-engineered radio alternator system enjoyed only a brief triumph as a salient of the power engineering culture into the field of radio. The Alexanderson alternator fell victim to a counter attack from the electronics culture that began to create vacuum-tube transmitters that were less expensive, sufficiently powerful and capable of much higher frequencies. Alexanderson himself helped to create what Edward Constant has termed a "presumptive anomaly" for the technology of the radio alternator.[18] Alexanderson used the alternator to obtain data that he used to formulate an equation for air friction less as a function of the diameter and velocity of a rotating disc. The loss was found to increase as the square of the rotor diameter and as the 2.7th power of the peripheral velocity. This led him to conclude that operating speeds much greater than 20,000 rpm were not feasible and would set a limit on the maximum frequencies that could be generated using rotating machinery.[19] In addition, Alexanderson encouraged the development of powerful vacuum tubes and research on long distance propagation of high-frequency waves at GE.

The intellectual exchange between the power engineering and the radio-electronics cultures went both ways. For example, Alexanderson employed concepts drawn from radio during the the process of inventing a phase converter for power systems.[20] A speed-control system for the radio alternator that he devised in 1915 was a synthesis of elements from radio-electronics and power technology. In a 1930 essay, Alexanderson suggested that radio had exerted an indirect effort on electrical power engineers by teaching them to think of electricity in terms of electromagnetic fields and electrons or ions in rarified gases rather than as a sort of "juice" in wires. He stated that the rediscovery of the virtues of the rotary power condenser was one result of "an adoption of Maxwell's theory by the practical engineer." [21] The dynamo amplifier or "amplydne" that was developed for industrial and military use by Alexanderson and his colleagues at GE in the late 1930's embodied electronic amplifier concepts in a rotary power machine.

A machine may sometimes capture the ephemeral spirit of an age as did the famous Corliss Centennial steam engine of 1876. Another may serve as a symbol of a major watershed in history as in the case of the giant salient-pole dynamo that Henry Adams saw in Paris in 1900 and that stimulated his essay on "The Dynamo and the Virgin." The Alexanderson radio alternator became for a brief time a symbol of American patriotism and a vehicle of cultural nationalism. By the time that such machines capture the attention of the public or the historian, their glory days may be almost over as was the case for the Alexanderson radio alternator by 1925.

Alexanderson's professional career as an engineer-inventor was spent near the boundaries of the distinctive cultures of power engineering, communications engineering, and electronics science and engineering. In terms of the mountain and valleys metaphor, he haunted the low gaps in the mountains where he might intercept conceptual messages or deliver novel devices from one culture another.

The history of the Alexanderson radio alternator provides some useful insights into cultural and stylistic characteristics of engineering and science. Not only are there significant differences between the cultures of science and engineering but distinctive cultures may emerge within a single engineering discipline. The occasional individuals who have been willing and able to penetrate the cultural barriers have found the experience a creative stimulus. Thomas P. Hughes has defined technological style as "the technical characteristics that give a machine, process, device, or system a distinctive quality." Hughes continues that "out of local conditions comes a technology with a distinctive style." [22] The Alexanderson radio alternator and the system in which it was a key element seem to exemplify well the concept of technological style. A superb machine is a testimony to the personal style of the designer just as a great painting reflects the skill and style of the artists. Reginald Fessenden, a principal actor in the paper, compared the engineer designer and the artist in a paper published in 1900. He wrote that the experienced designer could see a machine and recognize immediately that "that machine was designed by so and so" or else was "modelled after his style by a man who had worked in such a place. [23] Alexanderson's alternator was such a machine.

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8. R.A. Fessenden, "Magnetic Formulae," *Electrical World,* 23 (1894), pp. 834-35.
9. Fessenden, "A Determination of the Electric and Magnetic Quantities," pg. 95. The Kennelly equation took the form. $\Phi = \alpha + \sigma F$
10. Based on chapter II of my unpublished biography of Alexanderson.
11. Based on chapter III of my unpublished biography of Alexanderson.
12. Alexanderson to Fessenden, Dec. 5, 1908, Clark Collection in the National Museum of American History, Washington, D.C. (Hereafter cited as CC.) The formula used to calculate the number of slots in the armature for a specified frequency and speed of rotation was: p = 120 f/n, where p is the number of slots, f is the design frequency and n is the rotor speed in rpm. For example with a frequency of 100,000 cps and a speed of 20,000 rpm, 600 slots were required. The rotor required half as many slots as the armature or 300 for the example given. See Alfred N. Goldsmith, *Radio Technology,* (The Wireless Press, 1918), pp. 116-119.
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Adapted from a paper written by Dr. Brittain and originally published by Davidson College; reprinted with their permission.

TELEPHONE SERVICE COMES TO PITCAIRN ISLAND

Earlier this year A.T.&.T. began the first U.S. long-distance telephone service to Pitcairn Island, of *Mutiny on the Bounty* fame. The island has one telephone serving a population of 62 people, most of them descendants of *Bounty* First Mate Fletcher Christian and his fellow mutineers. Pitcairn Island, two square miles in area and about 4,000 miles east of Australia, is the remote, lonely outpost where Mr. Christian and partners set down roots in 1790 after taking over the *Bounty* and setting Captain Bligh adrift in a small skiff. Bligh and others from the crew miraculously survived, eventually sailing their tiny craft to a landfall on Timor Island northwest of Australia.

A.T.&.T.'s long-distance connections are routed through New Zealand to Pitcairn Island over HF overseas radio at a cost of about $12.00 for the first three minutes. U.S. callers must make reservations to place calls. Directory assistance is somewhat obscure at this moment . . .

Until now, communications between the Pitcairners and the rest of the world has been via boat-mail (ships visit the island irregularly) and HF radio. Tom Christian, the great-great-great grandson of Fletcher, is known to radio amateurs throughout the world as VR6TC. He is also the island's postmaster, pharmacist, meterologist and operator of the official HF radio link with New Zealand.

How long will it be before we read that satellite TV has come to VR6-land?

— William R. Gary, K8CSG **(M 1982, F 1984)**

COUNTERPOISE GROUND SYSTEMS for VERTICAL ANTENNAS THEORY VERSUS PRACTICE

Archibald C. Doty, Jr., K8CFU (M 1972, F 1984, L 1985)

Presented at the Technical Conference of The Radio Club of America, Inc., November 22, 1985.

In 1983, I was invited to make a presentation at the Radio Club of America's technical session during the Club's Diamond Jubilee meeting. My paper, at that time, told of the results of extensive testing that we had done of counterpoise ground systems used in conjunction with vertical antennas [1].

Those present will remember that the reported reseach results showed that an insulated counterpoise would provide an excellent artificial ground system even though it was somewhat smaller than the conventional buried radial system.

The rationale was that artificial ground systems using elevated or insulated radial wires collect the majority of the currents that they carry directly from the antenna and the balance as displacement currents from the earth below the wires. The losses involved in the passage of the return currents to the radials involves only their transference through air.

This is in sharp contrast with the situation involving return currents collected by conventional buried radials. Here, the currents must travel through high-resistance earth to get to the radials, and serious I^2R heating losses can occur.

The conclusion reached from our previous tests was summarized by Ed Laport as being: "It is more efficient to collect return currents from vertical antennas as displacement currents rather than as conduction currents!"[2]

This report is of a field trial of a small vertical antenna and a counterpoise ground system designed to benefit from the tests discussed in the earlier paper.

This field trial was made on the island of St. Pierre with John Frey, W3ESU who, along with RCA member Harry Mills, K4HU, and I are the troika who have been working on counterpoise ground systems — and more lately on folded monopole antennas — for the past five years, making some 20,000 measurements.

St. Pierre is a part of France that is 900 miles northeast of New York and 16 miles from Newfoundland. St. Pierre et Miquelon, as it is officially called, is composed of three islands. Langlade and Miquelon are the larger but have almost no year-round residents — and no electrical power! St. Pierre itself is only 5 miles from north to south, and has 6,000 residents living in its only town, also called St. Pierre.

In conjunction with our research work, we built two 1.8-MHz. vertical antenna systems using counterpoise grounds based on our research findings. The first of these had a counterpoise that covered almost an acre and a half — the second has a small, backyard counterpoise that we call a "Minipoise". We mentioned this antenna system briefly in our *QST* article[3], and in detail in Frey's *CQ* magazine article in the August 1985 issue. [4]

We thought that it would be interesting to learn if a small vertical antenna used in conjuntion with a small counterpoise would provide as good performance under difficult field conditions as it did at the fixed installations in North Carolina.

Our real problem in St. Pierre was as to where we could set up operations. As mentioned, all of the population, and the only power supply, is concentrated in one small town. Thus it was necessary for us to operate from the Hotel Robert which has been the location of many past operations by visiting Amateurs.

The only space available for our 1.8 Mhz. antenna was in the lot next to the hotel. This lot was 50 x 150 feet in size, backed up into a hill, and with a hotel on each side. The ground was rock fill, and you would need dynamite to install an 8-foot ground rod!

We erected a 42-foot top-loaded vertical antenna loaned to us by Barry Boothe, W9UCW. This was an improved version of Barry's famous "Minooka Special" antenna described in QST magazine in December 1974 [5].

Our ground sytem was a 48-radial counterpoise made of insulated wire lying on the ground. The ends of the radials were connected by a peripheral wire — which we had found advisable in our past test programs. Total time for erecting the vertical, and installing the counterpoise was about 2 hours.

In another hour we had our station unpacked, set up and operating. Our transceivers were a pair of Ten Tec Omni D's, plus a Ten Tec antenna tuner. We had a linear amplifier but used it in its lowest power setting to make sure that our RF output did not exceed the 100-watt legal limit.

Amateur radio operations started at about 10:00 p.m., when we got back from dinner, and ended around 3:00 a.m., so that we would not miss too much sleep.

The antenna system tuned-up perfectly. Unfortunately, band conditions proved to be poor that night, with high static levels reported from all directions. However, we did manage to work almost a hundred East Coast U.S. stations, and a couple of Europeans.

We had very high levels of atmospheric noise for the entire time that we were operating from St. Pierre. This was not entirely unexpected, so we tried installing two low noise receiving antennas of the type first described by H.H. Beverage (M 1920, F 1926, L 1971, H 1983) [6]. The road in front of the hotel ran NE/SW — just the right directions for Beverages aimed at the States and Europe. We first tried a 500-foot long Beverage — using insulated wire lying in the gutter, where it would not be seen. The next night we installed a 1,000-foot Beverage in the same manner.

In North Carolina these antennas would have worked beautifully as our ground conductivity there is low, and electrical ground is well below the surface. On St. Pierre, the results were dismal. The ground on which the antennas were lying is about 6-feet above sea level — and sea water has extremely high conductivity. So — the Beverages simply did not work. This was not entirely unexpected, for we knew that " — over an ideal ground the wave antenna (i.e., Beverage) would not operate at all" [7].

The following night things sounded better. We let a local amateur operate the station, and got a chuckle from his amazement when he was able to talk to a half dozen European stations in about 10 minutes. A few minutes later, an amateur in the Netherlands called in to tell us that he had just telephoned a mutual friend in Israel to tell him that we were on the air. We heard the Israeli in about five minutes, made two way contact, and then:

Silence!

All signals down at least 30dB and we had infinitely high SWR. After checking everything within reach, we concluded that the problem was in the top loading coil of the vertical. In the morning, we could see the problem; although we had been operating with low power, the top loading coil had heated up enough to soften the PVC pipe on which it was wound, and the entire top hat and coil had bent over 90 degrees!

After we took the vertical down — we bent the plastic pipe back into position by heating it on the hotel's kitchen stove, straightened it, and then fabricated a reinforcing sleeve to go over the top loading coil. After finishing these repairs everything was in fine shape again.

Back on the air that night, and conditions were quite decent except for deep fading. Contacts were plentiful to most of the U.S., and to Europe — on both CW and SSB.

To summarize:

- We were operating on a low frequency — 1.8 MHz — that is far from ideal for long distance communications.
- The traditional buried radial ground system for this frequency as described in the landmark paper by Dr. George Brown (M 1985, F 1986)[8], would require 120 radials totaling more than three miles of wire within a circle having a diameter of 270-feet. We were limited to a 50-foot by 150-foot lot between two hotels for our counterpoise ground system and used only 48 radials in this restricted space.
- We operated with low power of 100 watts.
- Propagation conditions were poor to fair, and not at all what could be expected during the winter. Fading was severe during most of the period, and atmospheric noises high.
- We operated from about 10 p.m. to 3 a.m. Thus we missed the so called "Gray Line" period at sunrise and dusk — when excellent propagation conditions can occur.
- The transmitting antenna was used also for receiving. Atmospheric noise has a major vertical component, and is thus emphasized by use of a vertical antenna for receiving.

In spite of all these limitations:

- We made more than 500 contacts in 5 nights of operations. These contacts were with all parts of the United States, excepting the West Coast. This was understandable, as we went to bed before propagation could be expected to that area.
- We worked 22 countries in North and South America, Africa, Asia and Europe. No Pacific contacts — again, because we missed the morning gray line opening to that area by going to bed "early".

Although our operating results can only be judged subjectively, it appears that they fully support the technical data on the unique characteristics of the counterpoise that were presented in the 1983 paper [1].

The conclusion reached from our St.Pierre trip was that:

FIELD EXPERIENCE HAS DEMONSTRATED AND HAS SUPPORTED THE THEORETICAL DATA THAT A COUNTERPOISE GROUND SYSTEM, EVEN WHEN USED WITH A SMALL VERTICAL ANTENNA UNDER FAR FROM IDEAL CONDITIONS, CAN PROVIDE EXCELLENT PERFORMANCE.

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TELECOMMUNICATIONS FIASCOS

by Donald K. deNeuf, WA1SPM (M 1972, F 1974)

Webster says FIASCO is a word of Italian origin, meaning "A complete and humiliating failure." There are some notable ones in the telecommunications field — a few resulting in tragedies. Among them these stand out:

R.M.S. Titanic Disaster (1912)

Much has been written about this tragedy. No one seems to have adequately explained why veteran Captain Smith ordered his ship to run at a speed of over 22 knots through a field of icebergs about which he had been adequately warned by wireless. The *SS California* was less than 20 miles distant at the time, but the single wireless operator had turned off his receiver and gone to bed for the night, of course not hearing the *Titanic's* frantic calls. The *California* could probably have saved many of the 1513 persons who drowned if she had come promptly to the rescue.

The incredible aspects, as far as the *California's* deck officers were concerned, was why they did not awaken the wireless operator to find out the reason for the signal rockets — which they saw being fired on the horizon. Instead they reportedly shrugged them off, stating they did not recognize them and did not understand what they meant!

Amelia Earhart Around the World Flight (1937)

A great deal has been published concerning the mysterious disappearance of Amelia Earhart and her navigator (one of the best), Fred Noonan, on the Pacific leg of the flight, and about the confusing records concerning communications — or lack of them. I recently had an extensive exchange of correspondence on the subject with Captain Al Gray, W1kA (ex PanAm), and Bob Gleason, W3KW (ex-Vice President, Aeronautical Radio, Inc.) Gray went into great detail about the radio equipment aboard Earhart's plane, the Coast Guard ship *ITASCA,* and at Howland Island, together with the known and probable shortcomings covering frequencies, power stability, atennae and operator experience.

Earhart consulted with PanAm about communications before her flight. To make a long story short, Gray says that after a two-hour conference, they told her there was just no way that satisfactory communication and DF work could be maintained for the flight she intended to make with the grossly inadequate equipment that she proposed to use. (In stripping the plane for the long flight, for example, the trailing antenna and weight were removed as a weight-saving measure, leaving only a small antenna strung between the wingtips and tail.)

Neither Gray nor Gleason subscribe to the theory of the alleged capture of Earhart and Noonan by the Japanese, and Gray says: "It was just a miserable show as far as communications were concerned but I suppose that people will come up with exotic theories for years to come . . . in my opinion it was simply a case of missing the island, running out of gas and going *into* the drink — simple as that."

Pearl Harbor Attack (1941)

Arguments, superstitions and allegations still are rampant as to this ghastly incident. They started anew in 1984 with the declassification by the government of over 300,000 related documents which were formerly marked SECRET. Some of these, it is said, "indicate" that the Japanese striking force was *not* on radio silence as claimed by historians for over 40 years, and that "certain DF tracking by the US" took place for several days before the attack.

Dr. E. Stuart Davis, consultant to F.D. Roosevelt, revealed a few years ago that the U.S. Navy in 1940 had secretly commandeered the old Commercial Pacific Co. submarine telegraph cable operating between San Francisco, Honolulu, Manila and China for the secure transmission of sensitive messages. This was done because the Japanese were known to be intercepting all traffic in the Pacific sent by HF radio via the Navy and Army facilities, and the commercial companies as well. (RCA, Press Wireless, Mackay and ATT public telephone — all used HF radio). But enemy spies eventually discovered this cable use and, to force all traffic back to radio, the cable was severed by a submarine of unknown identity several weeks before the Pearl Harbor attack.

One very questionable common theory persists that President Roosevelt "knew in advance of the forthcoming attack but chose to let it occur as a means of involving the U.S. in the war against Germany, Japan and Italy." But these research efforts all seem to have a habit of ending up in a blind alley with no positive proof.

There does seem to be documentation, however, that "Washington sent messages to Pearl Harbor" warning of the impending attack and that, at the time, sunspots were interrupting the normal radio circuits. If so, how could the originators of such vital messages have apparently failed so miserably in not demanding an urgent prompt acknowledgement — and, if not getting one, immediately putting them on the Navy's longwave FOX channels being copied continuously by all naval vessels?

Related, but not directly connected, was the Army radar operator on Oahu who spotted the attacking planes enroute to Pearl Harbor only to have his superiors shrug them off with an alleged "Oh, they're probably just some of our Navy planes coming in."

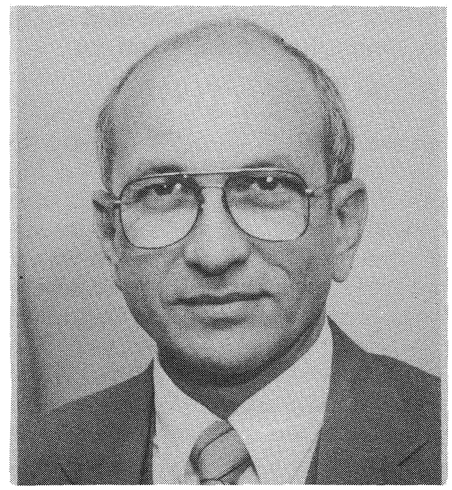
One of my friends in reading over the foregoing said: "Egad, you haven't even mentioned the telecommunications fiasco to end all fiascos —the Bay of Pigs affair of 1961 . . . If you could get the true story on this it would make your hair stand on end! However, everything is still highly classified — and those who were involved are unable to reveal any information because of swearing an oath of secrecy."

It seems unlikely that, at this late date answers to some of these questions will ever come to light.

TWO FACETS OF TELECOMMUNICATIONS

by James C. McKinney, (M 1980, F 1980)

James C. McKinney was the Guest Speaker at the 1985 Annual Awards Banquet. His address was edited for publication. Mr. McKinney is Chief of the Mass Media Bureau of the Federal Communications Commission, a Senior Broadcast Engineer of the Society of Broadcast Engineers, and is on the Board of Directors of the Radio Intelligence Division Association.



Broadcasting and Cable Television are my bag! Now I know that many in this room have made a very good living in the area of land mobile communications. If there is one big difference between the two industries: land mobile and broadcasting, it is that one concerns the communications needs of the businesses and industries that make this country the world leader in commerce and public services. Radio for the business community has long since left the area of luxury and has become an actual necessity in today's economy. We could no more compete in the world's markets without radio than we could without fuel to run our factories, or without computers to handle our paperwork. The "smokestack industries" must have efficient mobile, two-way voice and data communication systems if they wish to remain competitive in today's business world.

On the other hand, radio and television are essential to a free democracy. For example, how can Americans hope to survive without a daily dose of *Vanya White* and *The Wheel of Fortune?* (You know, they could make that show a bit more interesting if they would — just once in a while — choose a phrase that was not full of the letters RSTLN and E!)

But, seriously, Americans are privileged to receive the most news — the greatest amount of information about the world, the country, the cities and towns in which they live — of all the people of the world. Nothing can happen anywhere in this World, or even in a space shuttle or on the surface of the Moon, that is closed to the eyes of American television. Within minutes of the worst earthquake to hit Mexico or the most devastating volcanic eruption in Colombia, live television begins to flow into our living rooms.

What remarkable changes have occurred in the 35 or 40 years since commercial television began. And cable TV — today, I have over 100 channels of television in my own home. Every city council or school board meeting is carried live. Nothing of any importance to me as a citizen of Fairfax County is blocked from my view. The New England town meetings of yesterday now are available to all citizens, and the public events that affect my daily life are there for me to see, and to understand, and to participate in — or to leave alone, as I choose.

Those who criticize television today can no longer complain of a "vast wasteland." The field of television is as wide as the eye can see and as varied as the mind can imagine. Jacques Cousteau can take us to the ocean depths and Sally Ride can take us to the heavens. And Mike Wallace and Geraldo Rivera can take us places we don't even want to go. Bill Cosby bridges racial gaps and shows us common hopes, shared goals, and does it with a twinkle in his eye. Dr. Ruth Westheimer even talks about things that are too embarrassing to discuss in a mixed audience. From a technical standpoint, the weekly production of *Miami Vice* is clearly superior to all the rest and, in fact, superior to a fair percentage of Hollywood feature films — and I say that as an engineer.

Truly, broadcasting in the United States educates, informs, entertains and relaxes. But its strangest feature and the reason it is so very controversial rests not on the soft side of the medium but on its harsh facade — the television newsroom.

We all wish that television news was more accurate, more thorough, more fair, and generally better than it is. We wish that newsmen knew when to shut up and to stay out of hostage negotiations; and we wish that they would not embarrass us with questions to international personalities that should be handled by statesmen, not anchormen. We, in America, prefer that our international positions be established by Reagan, not Rather; by Shultz, not Koppel.

But I refused to be trapped by politicians of both persuasions who cry out for correction by government regulation. If the Commission has learned one thing in the past 30 years of well-meaning efforts to make the airwaves more fair, it is that those efforts are doomed to fail. The Parent-Teachers Association and friends would have the FCC mandate children's television. The National Association of Retired Persons would ask for television programs directed to the elderly. There is a group in California who want us to mandate TV service to handicapped persons, and some in Congress who believe there should be new laws to improve programs for minority groups. None should succeed. The heavy hand of government is not required to improve television today. Censorship is just as objectionable whether it works to delete a program that is planned to be shown or it mandates some other fare that bumps a planned program off the air. It was Clare Boothe Luce who observed correctly that:

"Censorship, like charity, should begin at home, but unlike charity, it should end there."

The Commission has had on the books for many years, a policy called the "Fairness Doctrine." Basically, it requires that broadcasters who present one side of a controversial issue of public importance also present contrasting viewpoints. Well, that sounds harmless enough until you realize that stations throughout the country deliberately avoid addressing some issues because they are controversial and *might* cause complaints to be filed — complaints which would bring down upon them the dreaded call from the FCC that could eventually result in the loss of their license and their livelihood. Well, this Commission sees very little that is "fair" about the Fairness Doctrine. We find it no longer serves the public interest. There is no law on any book that requires the *New York Times* to run an "OP-ED" page — the Constitution clearly prohibits such a statute. It seems to me that we have a clear choice in the U.S. We can mandate a Fair Press for broadcasting or we can have a Free Press. I opt for FREE! And I have no doubt that if television and radio had existed 210 years ago, the words that Thomas Jefferson penned: "Congress shall make no law that abridges the freedom of the press . . .", would have specifically added the phrase "whether written or electronic."

The government should never censor, and yet, every American should do so every day. That ON-OFF button on your TV set is very powerful. If enough of you turn it OFF, no show can succeed. And if your view of what is good and what is bad is wrong, then you should fail. Go read a book, go see a movie and know at least, that the Constitution is well; that our freedoms are intact.

And while we're on the subject of the power of the electronic press, let me say to you that no network executive who cares about his responsibilities should ever say proudly that he never interferes in his newsroom. There is nothing evil about an editor who edits. Problems experienced by networks from a public-relations standpoint generally flow back to errant newsmen who just could not seem to "get it right." Network executives have a clear responsibility, if not to their stockholders, then at least to the viewing public, to make sure that the news is reported accurately; that investigative pieces are handled with care and not with *prejudice.*

There is one more topic that should be discussed and that is the reason we pause once each year to honor the achievements of our peers. No honor is so sweet as that which is bestowed by one who knows the trials, tribulations and difficulties of the craft at hand, and the art that is being honored.

The Radio Club of America is an honorable institution peopled by the leaders of our industry. It is an honor simply to be a member, and for those so fortunate as to be recipient of its praise, the honor is multipled a thousand-fold. To the new "Fellows", I extend my sincere congratulations. And to the membership and officers, my thanks for inviting me to speak to you this evening. That invitation, too, was an award to me and it was sincerely appreciated.

Scientific change is the spark of history. Technical innovation is the fuel that keeps it in motion. Gathered in this room tonight are gears and cogs, the circuits and servos that keep American Industry on the move. It has been a privilege to join you this evening and to share your recognition with you.

Thank you very much.

La NEIL EITEL RESPONDS FOR FELLOWS

Mr. President, Members of the Board of Directors, Fellow Members, Ladies and Gentlemen:

Eleven years ago, when the Board of Directors accepted the applications of Bill and myself for membership in the Radio Club of America, I felt I had reached a goal.

I have had many goals in Amateur Radio. The most important was reached the day I received my Novice license. That day I called "Red", the instructor of my code class, and set up a schedule to talk to him after dinner. I am sure most of you who are Amateur radio operators can remember your first contact and how nervous you were; I will never know how I sent code that could be read, that evening.

My instructor had a Ham friend, Jack, living less than two blocks from me. When Jack turned on his rig that evening, he heard a voice talking to Red. Naturally he wanted in on this first effort of the new Novice, "Frank." Frank was my last name and much easier to send than La Neil, which is my first name. Red and Jack talked to me, a brand new Novice, for almost three hours.

I qualified for the Rag Chewers Club with that first contact. That was goal Number Two, and one that I didn't expect to make for at least a year.

Now, as the official respondent for the 1985 Fellows, I am sure that I speak for all of you when I say that we are proud to have our professional or amateur fields in which to continue our contributions to the radio industry. It is with deep appreciation and great honor that we receive our Fellowship Awards.

We thank you.

The annual meeting and banquet commemorating the 76th anniversary of The Radio Club of America was held November 22, 1985 at the New York Athletic Club. Two hundred thirty-five members and guests attended.

James C. McKinney (F), Chief of the Mass Media Bureau of the Federal Communications Commission, was the keynote speaker at the banquet, addressing the audience on the status of television broadcasting.

The annual meeting, held during the afternoon, included a technical seminar directed by Stuart F. Meyer, Executive Vice President. The technical speakers were: Dr. James E. Brittain, Professor of History of Science and Technology at the Georgia Institute of Technology, who presented a paper "The Yagi Uda Antenna, A Case Study in Telecommunications History"; Dr. Robert Lee Everett, Chief of the Antennas and Propogation Branch, Voice of America/USIA, who spoke on "The Voice of America: Past, Present, and Future"; and Mr. Arch Doty whose subject was "Top Band (160 meter) DXpedition to St. Pierre." A reception for members and guests followed.

The meeting concluded with the formal announcing of the election of officers and directors by Secretary Emeritus Frank Shepard during the dinner session.

The achievements of 34 members of the Club were recognized by their advancement to the grade of Fellow. Twenty-two were present at the Awards Dinner and received plaques from President Fred M. Link. Awards and citations also were made to Club members for distinguished services to the art and science of radio communications; those receiving recognition were: Dana Atchley (F) — Sarnoff Award; George Connor (LF) — Pioneer Citation; Austin G. Cooley (LF) — Lee deForest Award; Donald Fink (LF) — Batcher Award; Jerry B. Minter (LF) —Henri Busignies Award; John W. Morrisey (LF) — Allen B. DuMont Citation; and Fred Shunaman (LF) — President's Award.

Again, the successes of the meeting, reception, and banquet resulted from the generous contributions of 27 industry sponsors and friends of the club plus the hard work of the Banquet and Meetings Committees.

Twenty-two of the thirty-four members who were elected to the Grade of Fellow in 1985 were present at the Annual Awards Dinner and appear in the photo above. Seated: (L. to R.) Houston Stokes, Ph.D., Chicago, IL.; Andrew Bower, Niantic, CT.; Fred Hamer, Waseca, MN.; Joseph Pavek, Hopkins, MN.; Edward Rich, Winchester, VA.; Earl VanStavern, Ashland VA.; William Wickline, Willowick, OH.; and William Endres, Clifton, NJ.

Standing: (L. to R.) Stephen Gumport, M.D., New York, NY.; Leo Himmel, Washington, DC.; Alfred Mello, Providence, RI.; Anthony Yellen, Richmond Hill, NY.; Marvin Grossman, Cleveland, OH.; Robert Foosaner, Washington, D.C.; James Brittain, Ph.D., Atlanta, GA.; Mrs. La Neil Eitel, Dayton, NV.; W.B. Sloop, Raleigh, NC.; Gregory Stone, Ph.D., Northbrook, IL.; Lester Fisher, Dallas, TX.; John Mitchell, Schaumberg, IL.; Norman Coltri, Tabernacle, NJ.; and Luther Schimpf, Holmdel, NJ.

1985 Fellows not in photo: Herbert Becker, Los Alamitos, CA.; James Campbell, Santa Ana, CA.; Donald Christie, Round Rock, TX.; Theodore Cohen, Ph.D., Alexandria, VA.; Donald Cook, Fresno, CA; Jack Daniel, Cucamonga, CA.; Charles English, Cary, NC.; Henry Kreer, Glenview, IL.; Ralph Muchow, D.D.S., Elgin, IL.; Merle Parten, San Carlos, CA.; Richard Plessinger, Hamilton, OH.; and Donald Stoner, Mercer Island, WA.

In Memoriam
Deceased in 1984-1985

Bose, John H.
Brunet, Meade
deCubas, Jose D.
Egolf, Richard S., W4AEO
Fingerle, William E., W1JMV
Franklin, Robert E., W5OX
King, Frank
Kirk, George G., G4K)G
Klaus, Henry, W9AK

McCuin, William D., N3BGU
McDonald, Ramsey, W4OHD
McVey, Wilson C.
Meyers, Ray E., W6MLZ
Mumford, William W., W2CU
Page, Esterly C.
Raser, Edward G., W2ZI
Rider, John F., W2RID

Sands, Leo G.
Schwartz, Milton, W2SF
Selenius, Dr. O. Eric, W6JPX
Smith, George E., W4AEO
Smith, Myron T.
Stantley, Joseph J.
Waite, Amory H., Jr., W2ZK
Wallace, Don C., W6AM

SOME ASPECTS OF INTERFERENCE AND NOISE REDUCTION IN COMMUNICATION TYPE RECEIVERS

by James J. Lamb (M 1959, F 1958 L 1979)

Delivered before the Radio Club of America
May 26, 1936

The recent authorization of Amplitude Compandored Single Sideband (ACSB) radios by the Federal Communications Commission for use in the public safety, industrial and land transportation radio services, at 150 and 170 MHz, has brought new attention to the pioneering work done in the early 1930's by Jim Lamb.

Lamb, then Technical Editor of QST magazine published by the ARRL, wrote an article on his invention of a circuit to remove the effect of ignition noise pulses from high-frequency Amateur radio receivers. In November 1936, a more comprehensive article on the subject of noise reduction was printed in the Proceedings of The Radio Club of America following Lamb's presentation of this paper before the Radio Club on May 26, 1936.

The following is a reprint of that portion of Lamb's paper relating to "hole punching" techniques for removing impulse-noise effects on the high-selectivity stages of a receiver. Since originally invented, Jim Lamb's original work has been re-invented and re-discovered a number of times.

James J. Lamb died at his home in Cupertino, CA on February 13, 1986. A few days earlier, we had discussed the new popularity of his original design concept as a result of the increased interest in single sideband technology.

Stuart Meyer (F)
Executive Vice President

Viewed from a possibly pessimistic point of view it might seem that technical progress in our chosen field is in the nature of a perpetual penance laid upon us, and that we must run as fast as we can in a modern sort of wonderland just to stay where we are. The way of the first pioneer may be hard but sometimes we almost envy the young Marconi in that he had only to break through natural static, while man-made "static" was then still many years in the future.

The advances of civilization in other fields of endeavor are busily concocting new gadgets capable of bigger and better noise interference, such as the electric razor which has such excellent coverage — allwave and a block wide — and likely to go off at hours of the day and night all out of keeping with normal shaving schedules. Worse yet, we are not content with complicating life with ourselves in our *own* field but we also must show outsiders how to use radio frequency equipment for purposes other than communication, with the result that we find ourselves being ungratefully bitten by diathermy "shadows" and the like.

The general problem being interference, whether from man-made signals or noise, the attempts at solutions take the form of improvement in selectivity; that is, selectivity in the broad sense of discrimination against everything but the desired signal. While selectivity is ordinarily considered as related only to the frequency characteristic of the receiver, in this instance it will be considered also in relation to the amplitude and phase characteristics of the receiving system. It may be permissible to distinguish three forms of selectivity; frequency selectivity, amplitude selectivity and phase selectivity.

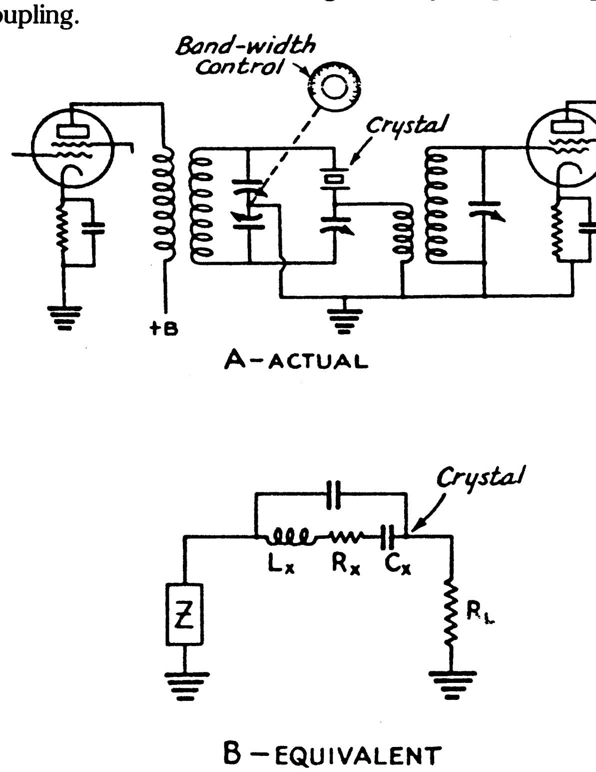
Frequency Selectivity

Perhaps the most widely used device for obtaining controllable high selectivity in communication receivers is the quartz crystal filter, used in the intermediate amplifier of superherterodyne receivers of the single-signal type. Two types of crystal-filter circuits are in general use, one of fixed sharpness of resonance with controllable symmetry, and the other of variable sharpness of resonance, also with controllable symmetry. This latter variable band-width type, which is adaptable to both c.w. telegraph and 'phone' reception, will be discussed here.

How Crystal Filters Work

Figure 1 illustrates the actual and equivalent circuits of a typical variable-selectivity quartz-crystal filter.[1] The crystal resonator is connected in a bridge circuit was shown in A, a two-section symmetric condenser forming two arms of the bridge, in parallel with a variable condenser which is used for adjustable tuning of the secondary of the input transformer. This arrangement gives an impedance stepdown of approximately 4 to 1 at the input. The primary of this transformer has approximately three times the inductance of the secondary, to which it is closely coupled, and is untuned. The primary of the output transformer is of such inductance and coupling as to match the output impedance to the series-resonance resistance of the crystal which is approximately 2500 ohms.

The crystal and rejection condenser in series with it form the other two arms of the bridge, the crystal providing the coupling.

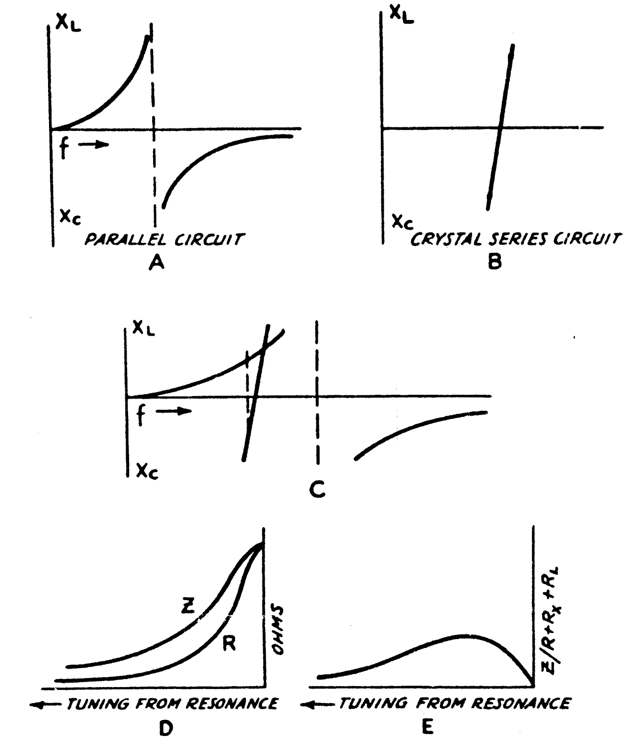


A, actual circuit of variable band-width crystal filter with adjustable rejection; B, equivalent circuit for illustrating variable band-width action.

FIGURE 1

Variable Band-Width Action

The equivalent series combination contains one half of the input circuit (across one section of the symmetric condenser) as well as the crystal and the primary of the output transformer. Series resonance occurs in this circuit when the capacitive and the inductive reactances are equal. Reactance variation of RL remains negligible over the range of operation, so that resonant frequency of the complete circuit depends on the reactances of the crystal and Z. The parallel-tuned circuit, Z, is therefore the variable, tunable over a resonant frequency range near the crystal's frequency by adjustment of the band-width control. This means that the reactance curves for the parallel circuit, as shown in Figure 2, will be shifted along the frequency scale as



A, reactance curves of parallel-tuned curcuit which is in series with the crystal; B, reactance curve of the series crystal; C, combined reactance curves of the parallel circuit and series crystal; D, impedance (Z) and resistance component (R) curves of the parallel circuit with tuning from resonance; E, variation in output voltage with tuning from resonance.

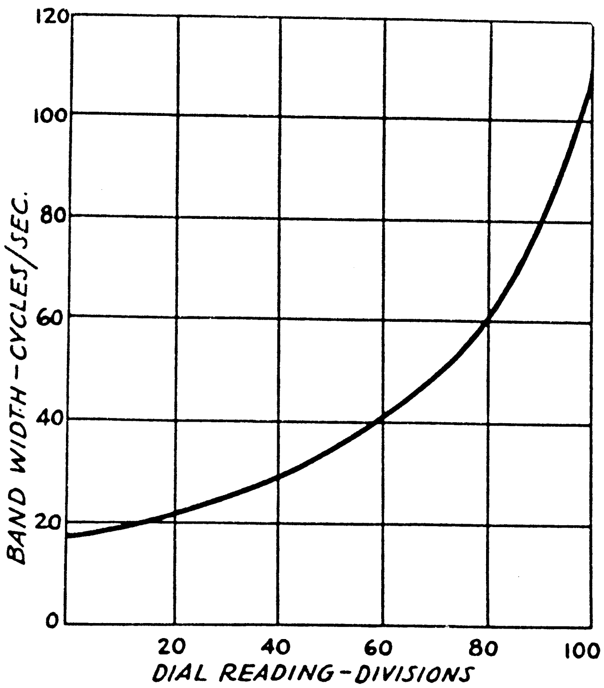
FIGURE 2

the condenser is adjusted. Now, since the crystal has an extremely high inductance-capacitance ratio as a series circuit, its reactance curve is very steep, as shown in Figure 2-B. Hence the resonance frequency of the parallel circuit can be changed over a considerable range with but negligible effect on the resonance frequency of the complete circuit, as illustrated by the combined curves of A and B in Figure 2-C. With the reactance component of Z tuned out by the opposite reactance of the crystal, the variation in tuning of the parallel circuit by the band-width control will introduce, practically, only the varying resistance component of parallel impedance in series with the crystal. The amount of this resistance determines the Q and, hence, the selectivity of the series circuit.

The voltage applied on the amplifier following the filter will depend on the current in the crystal series circuit. With this circuit resonant, the input voltage and series resistance will determine the current and, consequently, the output voltage. Now, both the input voltage and the series resistance are dependent on adjustment of the parallel-tuned circuit. Since the primary of the input transformer is not resonant, the voltage induced in series with the secondary will be comparatively constant over the small range required. Hence, the voltage applied to the series circuit, across the secondary (Z), depends on the secondary impedance. The impedance of the parallel circuit as it is detuned will change as shown by Curve Z of Figure 2-D, which curve also represents the voltage applied to the complete series circuit. Curve R of this figure illustrates the variation in the resistance component of the parallel impedance

Z. The resonance current through the complete series circuit is dependent on the applied voltage and the total series resistance. This current, and hence the output voltage, will be represented by the ratio of Z to the total resistance of the series circuit and will vary with adjustment of the band-width control as illustrated in Figure 2-E.

It is evident that the maximum band-width (minimum selectivity) and minimum gain occur simultaneously with the input circuit tuned to resonance. An intermediate value of selectivity and maximum gain occur with the parallel circuit slightly detuned. This maximum gain condition (which occurs where the resistance and reactance components of the parallel circuit are approximately equal) is referred to as the adjustment for "optimum selectivity". Minimum band-width (maximum selectivity) and a lower value of gain occur with the parallel circuit detuned further from resonance. Experimental verification of the variation in selectivity by operation of the band-width control is shown is Figure 3. Variation in gain with selectivity is shown by the curve of Figure 4. Data for these curves were obtained by measurements on an early type single-signal receiver using this filter circuit [2]

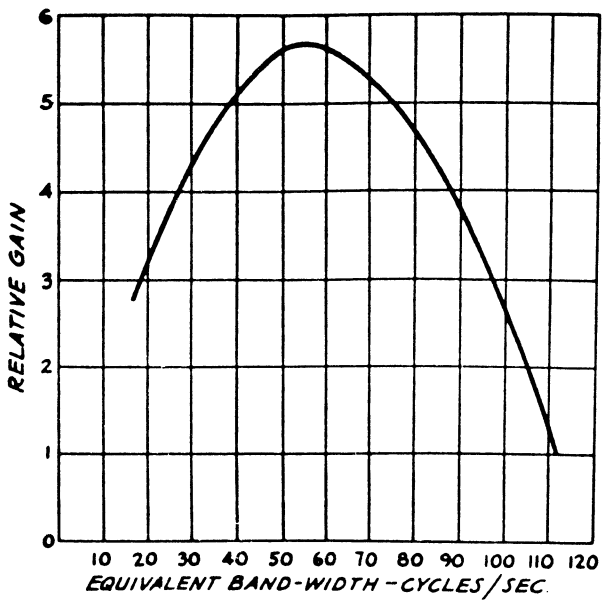


Experimental curve of the crystal-type S.S. receiver showing variation in band-width with tuning of the parallel circuit (Tuned to inductive reactive side of resonance).

FIGURE 3

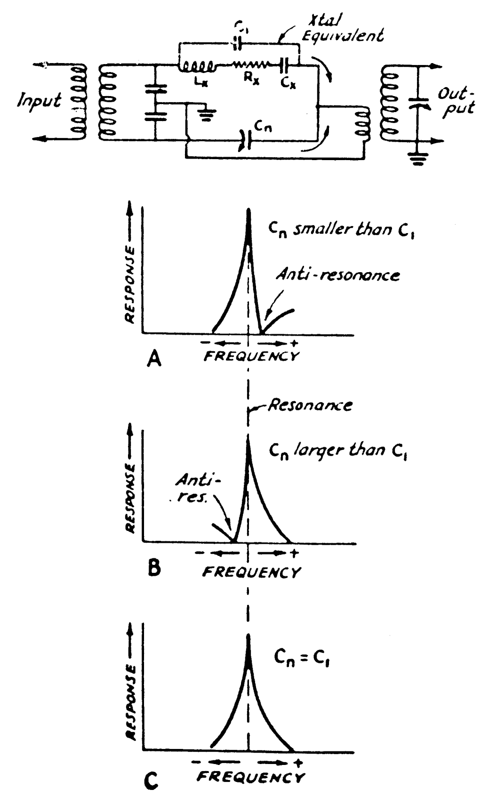
Rejection Action

As is well known from the equivalent circuit of the quartz crystal, the crystal is normally anti-resonant for a frequency approximately 1/2-percent higher than its resonant frequency. This results from the reactance of the shunt capacitance of the electrodes resonating with the inductive reactance of the crystal network at a frequency slightly above the latter's natural frequency. In the bridge arrangement of the crystal filter, this normal behavior is modified to shift the anti-resonant or rejection frequency to different values, both above and below resonance, within a limited range. The operation is illustrated by Figure 5.



Variation in gain of the filter circuit with adjustment of the band-width control (Cf E of Fig. 2)

FIGURE 4

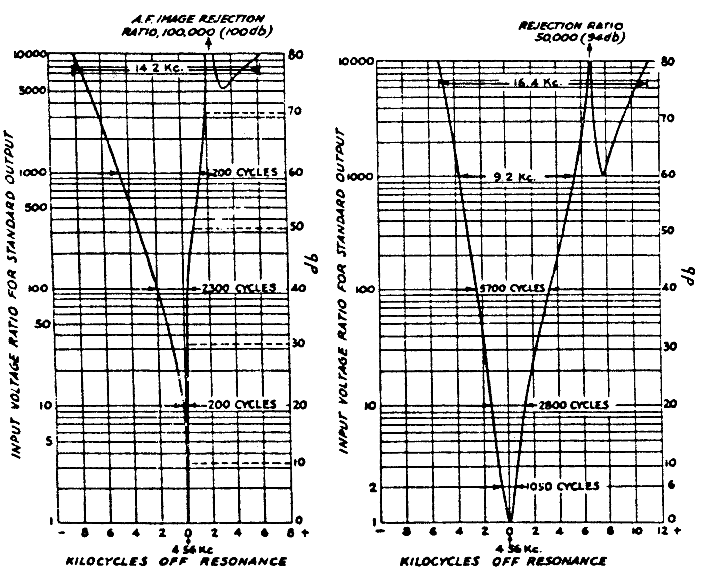


Illustrating the adjustable rejection action of the crystal filter, as used to eliminate heterodyne interference.

FIGURE 5

The diagram of this figure shows the filter circuit with the crystal in its electrical equivalent form. Voltage is applied through the condenser Cn in anti-phase to the voltage operating on the crystal circuit. This will be recognized as similar to the neutralizing action for bridge circuits.

Now it might appear that Cn serves only to balance out C1. However, in this instance Cn does *not* serve simply to neutralize the effect of the capacitance C1 and thus to prevent unselective transmission past the crystal, but rather, as Cn is varied from minimum to larger capacitance, *the anti-phase voltage serves to make the effective shunting reactance of C1 vary from its normal capacitive when the effect is as if inductance were substituted for C1.* In the latter condition, the shunt reactance having changed sign, the complete crystal network is effectively in parallel resonance (or is anti-resonant) for a frequency *below* the crystal's natural frequency. Thus, while having maximum response to the desired-signal frequency, the circuit can be adjusted to reject an interfering signal having a carrier frequency in the range from several kilocycles above to nearly the same amount below crystal resonance. The rejection is most prounounced with the band-width control at optimum selectivity, but remains highly effective at minimum selectivity, as shown by the curves of Figure 6. These curves are made from measurements on a standard HRO receiver using this type of variable band-width filter.

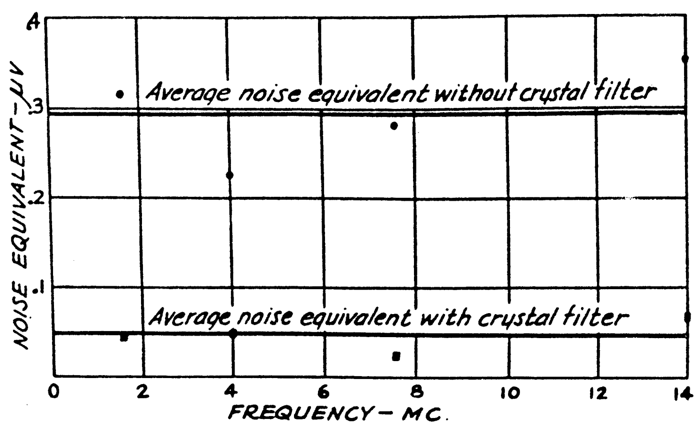


Maximum and minimum selectivity curves of a S.S. type receiver using the variable band-width crystal filter. Rejection adjustments are for two different interfering frequencies. Rejection is also effective on other side of resonance in both cases.

FIGURE 6

Frequency Selectivity and Noise

In addition to discriminating against undesired radio signals, the high-selectivity crystal filter also discriminates against noise, especially noise of the "hiss" type which consists of overlapping wave trains of noise pulses which are of amplitude comparable to that of the signal, or of smaller amplitude. As has been shown, particularly by V.D. Landon in a paper presented at the annual convention of I.R.E. in May, 1936, the peak and r.m.s. value of this type of noise varies as the square root of the band-width in a particular receiver. That is, the noise power is reduced in direct proportion to the reduction in band-width, and the effective voltage sensitivity of a receiver for c.w. signals is, therefore, increased as the square root of the ratio of reduction in band-width. Experimental verification of this improvement is shown in Figure 7, which is plotted from measured data taken on an early "single signal" type receiver, the noise being that of the receiver itself. The upper mean curve is for conventional superheterodyne selectivity with equivalent c.w. band-width of approximately 6600 cycles. The lower curve is for optimum crystal filter selectivity, the equivalent band-width being approximately 50 cycles. The ratio of improvement in effective voltage sensitivity is of the order of 20 db. At maximum selectivity of the filter (band-width approximately 20 cycles) the improvement would be approximately 50 db, while at the minimum filter selectivity (band-width of approximately 120 cycles) the improvement would be around 15 db.



Improvement in receiver noise equivalent with increased selectivity. Straight superhet values are for an equivalent band-width of approximately 6600 cycles, crystal filter values for e.b.w. of approximately 50 cycles. (N.E. varies inversely as square root of e.b.w ratio)

FIGURE 7

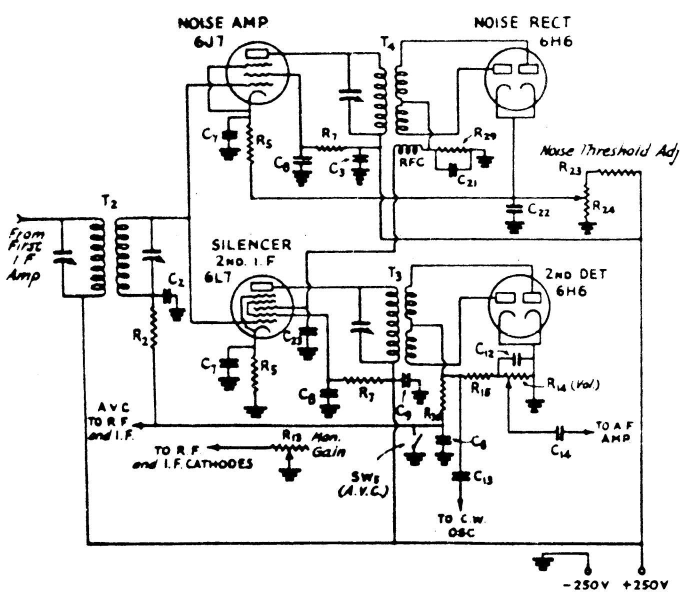
Amplitude Selectivity

While the high-selectivity circuit discriminates against "hiss" type noise in the manner just described, the behavior of the receiver is markedly different under the influence of high-amplitude noise pulse excitation.

As has been pointed out by V.D. Landon in the paper referred to above, the ratio of peak to effective values for "hiss" noise voltage remains constant at a crest factor of approximately 3.4, regardless of the receiver bandwidth, both peak and effective values being reduced equally as the band-width becomes smaller. When, however, the noise excitation is of a staccato nature and the discrete noise pulses are of short duration as compared with the time separation of successive pulses so that the wave trains do *not* overlap, this peak-to-effective ratio or crest factor varies with band-width, being greater for large band-width and becoming smaller as the band-width decreases. The explanation of this is, of course, that the individual wave trains generated within the receiver circuits by the noise pulses increase in duration and thus, the effective value increases relative to the peak value as the band-width is reduced through the improvement of circuit selectivity.

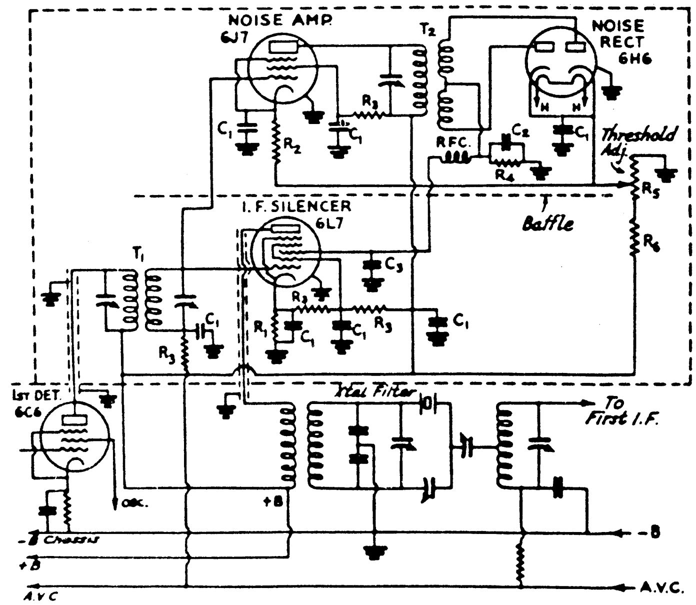
While high selectivity may perhaps be effective against this intermittent type of noise so long as it is of relatively small amplitude as compared to the signal, it becomes impotent when the action of the narrow-band filter circuit increases the duration of the individual wave trains and thus raises the effective value of the noise to a point where it becomes comparable with that of the desired signal. Incidentally, it is a happy fact that "hiss" noise voltage at the receiver's input circuit is generally of low amplitude, while high-amplitude noise is characteristically of the intermittent type.

Because of this, some means other than frequency selectivity must be employed in the case of noise pulses to bring down the effective value of the noise relation to the signal. And, in fact, the very characteristics of this type of noise suggest the method of its amelioration. Thus, since this type of noise is characterized by the fact that it occurs at relatively infrequent pulses — as compared with the frequency of other types of noise and as compared with the audio signal — the reduction of its effectiveness in interfering with the signal should result from its elimination through making inoperative the entire receiving system at the instant of its impingement. Indeed, it would be most effective to make the receiving system momentarily ineffective *just before* and during the impact of the noise pulse; and, indeed, this may be done by subjecting the signal to some delay in the receiving system while employing the noise pulse itself without delay in making the output portions of the receiving system inoperative for just sufficient duration as to wipe out the influence of the noise pulse. In practice, however, it has been found sufficient to provide for the effective reduction of the amplification of some one element of the radio receiver to substantially zero during all or part of the time during which the noise pulse would otherwise make itself troublesome.



Noise-silencing circuit applied to second i.f. stage of communication-type superhet receiver.

FIGURE 8



Silencing circuit applied between first detector and crystal filter of a S.S. type receiver.

FIGURE 9

For accomplishing this, two different circuit arrangments (3,4) have been devised and are shown in Figures 8 and 9. In both of these, the desired silencer action is obtained by providing several additional elements to an otherwise conventional superheterodyne circuit. Thus, a special noise amplifier stage is employed, including its own noise recitifer which, in Figure 8, feeds a biasing voltage to the silencer tube which itself is in the chain of amplifier tubes between the second detector and the intermediate frequency amplifier. Normally it acts as a portion of the I.F. amplifier but, on the impressing of a noise pulse on the noise amplifier and rectifier, becomes momentarily inoperative and thus protects the second detector from the influence of the noise pulse. It is, of course, essential that the silencer operation occur for only such values of noise pulse amplitude as exceed the signal amplitude, lest the signal itself interfere with its own free transmission through the system of the receiver. To provide for this requirement the "Noise Threshold Adjustment" is provided in the form of a manually controllable bias on the noise amplifier and on the noise rectifier.

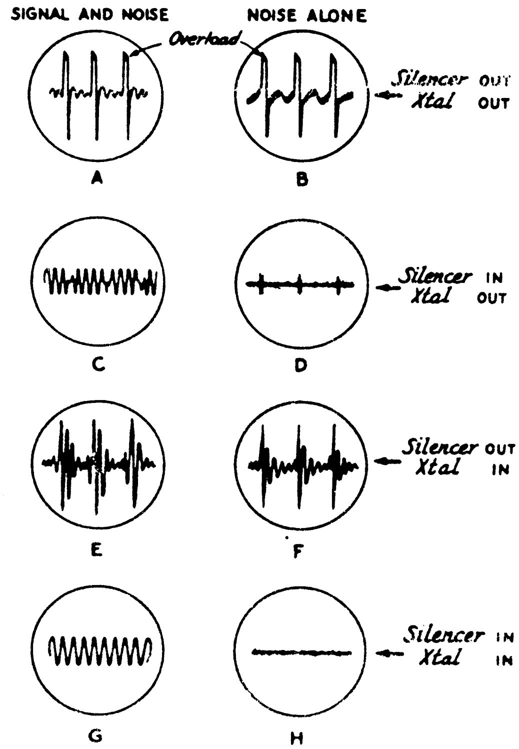
Such an arrangement as this provides very effectively for the reduction of the noise due to noise pulses of all kinds, such as result from the operation of other electrical equipment in the region of the radio receiving equipment. It is highly effective in connection with all radio telegraphic reception and for certain kinds of radio telephone reception but it must be admitted that for truly high fidelity radio transmission, its usefulness is markedly limited. Where, however, intelligibility — as in Amateur and commercial non-public radio service — is the primary requirement it serves most effectively to convert transmissions which would be otherwise quite unuseable to perfectly useable transmissions; and thus it provides much of value to many types of radio communcations.

The simultaneous use of these two methods of noise suppression, one useful in the reduction of the troublesome effectiveness of the hiss type of noises and the other useful in the reduction of the effectiveness of the pulse type of noise at the same time, suggests itself immediately and, indeed, has been found of great usefulness. It is, however, to be noted that in order that both expedients may be effective, it is essential that the silencer arrangements *precede* the crystal filter in the chain of amplification comprising the radio receiver since, if the order is reversed, the noise pulse when impressed on the crystal filter will, thus, be converted from its original form of that of a pulse of high amplitude and short duration to one of long duration and only little decrement and thus give it something of the characteristics of the signal itself and make it highly effective in interfering with the signal. When used in the proper order, however, in which the silencer circuit wipes out the noise pulse before it can be offered to the crystal filter, a most effective combination results.

The circuits of such an arrangement are shown in Figure 9 in which the silencer circuits follow immediately on the output of the first detector of a conventional superheterodyne type of receiver and in which the output of the multifunction silencer-amplifier tube feeds the crystal filter directly.

The effectiveness of this combination of noise suppression arrangements can, of course, be best appreciated by listening to its operation in the reception of signals. It has, however, been found possible to show by oscillographic analysis the wave forms resulting from its operation and thus provide some visual evidence of its effectiveness. This is indicated by the wave form reproduced in Figure 10 of which the four traces shown on the left hand column are those of the combined signal and noise under different conditions of noise suppression, while those shown in the four traces in the right hand column are those of the noise alone. Thus, in Figures 10 A and B, are shown the untreated noise and noise-signals which are characterized by the fact that the noise amplitude is not only so great as to vastly exceed the signal amplitude but so great as to cause actual overloading of the receiver circuits as indicated. In Figure 10D is shown the effect of the operation of the silencer circuits from which it will be evident how thoroughly effective these circuits are in reduction of the impulse type of noise. Figure 10C shows, similarly, how relatively free of the impulse type of noise is the signal as the result of the operation of the silencer circuits.

On the other hand, it will be noted from Figures 10 E and F, and their comparison with A and B, how markedly the crystal filter builds up the impulse noises so as to mask the signal completely. And in Figures 10G and H are shown the result of the operation of both the crystal filter and the silencer circuits. From these it will be noted that not only does the silencer circuit almost completely eliminate the influence of the impulse noise but the crystal filter does, to a surprising degree, fill in the "hole" in the wave form made by the operation of the silencer circuit.



Oscillograms of c.w. beat note output obtained with the S.S. receiver using the silencer circuit ahead of the filter. (Beat-note c.w. reception with spark interference.)

FIGURE 10

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THE COMPUTER PROGRAM

Arch Doty and Stephen Kreinhop, manager of the Tandy/Radio Shack Computer Store.

Ed Weingart, Fred Link and Larry Gross, manager of the Tandy/Radio Shack Computer Store.

The late Monte Cohen, AA4MC (M 1975, F 1980) bequeathed an appreciable sum to The Radio Club at the time of his death in 1982 with the proviso that the Club's Board of Directors should use the monies for the betterment of the Club. This sparked a plan to develop a computer program designed to the Club's unique dues and membership records requirements. In January 1986, the computer system was inaugurated.

After an extended search for suitable software, it became necessary to develop an in-house program using the Tandy/Radio Shack Profile Plus 4 software. With assistance from the Tandy Corporation, two Model 4 computers, two high-speed printers and associated accessories were obtained. In January, the last of the Club's records were transferred from written to magnetic format.

For the past 76 years, the records were laboriously maintained on 3x5 inch index cards and on more than 1,000 ledger pages. With the recent growth of the Club's membership, the hand-written records had become almost unmanageable.

The first use of the new computer system was to prepare the notices mailed to members whose dues became payable on January 1st. Preparation and mailing took about three man days — a sharp contrast with the three man weeks previously required. The mailing labels for the recent issues of the *Newsletter* and this issue of the *Proceedings* were computer-generated in 55 minutes rather than the days it previously needed.

The Computer Services Committe has spent hundreds of hours developing the software, obtaining the equipment and putting it into operation. Under the leadership of the committee chairman, Arch Doty, help was extended by the current committee: Jerry Stover; Tom Amoscato; Fred Shunaman; and Ed Weingart. Their activities were based upon work done by earlier committees headed by Joe Rosenbloom, and including George Apfel; Jerry Minter; Bill Andrews; and Mrs. Vivian Carr.

And a special thanks go to the many friends of the Radio Club who are associated with Tandy: Stephen Kreinhop, Manager of Radio Shack's store in Hendersonville, NC; Larry Gross, Manager of the Tandy/Radio Shack Computer Store in Bridgewater, NJ; and to the top management personnel at Tandy's headquarters in Fort Worth, TX. including Mr. John Roach, Chairman, Ms. Lynn Platania, Manager of Community Relations, and John Burman.

PHILIPS MOBILE RADIO'S NEW INTERNATIONAL CORPORATE CENTRE

In a move that reflects the importance Philips places on its mobile radio business, the board of management has established a new corporate centre for Philips' international mobile radio communications activities.

Philips Radio Communications Systems Ltd. (PRCS) officially came 'on-line' on the first of the year. Based in Cambridge, England, PRCS operates as a world-wide business unit within Philips' Telecommunication and Data Systems (TDS) product division. The new group's job is to manage mobile radio research, development, manufacturing, product policy and international marketing for a number of Philips companies engaged in mobile radio activities.

The Philips companies that initially come under PRCS's 'umbrella' are Pye Telecommunications Ltd. and Mobile Radio Management Ltd. (both Cambridge-based), AP Radiotelefon A/S in Copenhagen and Philips Communication Systems Ltd. in Melbourne, Australia.

According to PRCS's managing director, Ian McKenzie, the new group will "... facilitate market orientation and strategy development, speed up the decision-making process and ensure that quality plays in every aspect of our business." Mr. McKenzie is a native of Australia and a 25-year Philips veteran. Prior to his appointment as PRCS's managing director, he was group general manager of Philips Industrial Holdings Ltd. in Sydney, Australia.

Joining Mr. McKenzie on PRCS's top management team are Messrs. John House, Jan Zachariasse and John Tomkies. Mr. House is PRCS's finance director; his last appointment was finance director for Pye Telecommunications Ltd. Mr. Tomkies is the new group's technical director and he also came to PRCS from Pye Telecommunications Ltd., where he was managing director. Mr. Zachariasse is PRCS's commercial director; prior to this appointment, he served as chairman of Philips' Mobile Radio Management Ltd.

By concentrating PRCS at one site and giving it direct responsibility for international manufacturing, development and marketing, Philips now has an effective base from which to reach today's dynamic, world-wide, mobile radio market. Mr. McKenzie is very optimistic about the future prospects for Philips' newest corporate centre: "I am confident that PRCS has a unique opportunity to grow rapidly and profitably in a sector of the industry that is destined to see rapid growth and change."

PRCS's management team (from left to right): Messrs. John Tomkies, technical director; Ian McKenzie, managing director; John House, finance director; Jan Zachariasse, commercial director (and looking over Mr. House's shoulder is Philips' president, Dr. Wisse Dekker).

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A perfectionist even then, he kept taking his radios apart and rebuilding them, and designing antennas to go with them... each time making improvements and each time thinking of more improvements to make.

Now after 50 years as a ham operator, Jim keeps reaching out further — both as an antenna designer, and as an amateur. Because although his call sign has since changed to K7GE, and his QSL cards include nearly every country, he's still dreaming up more improvements... and putting his dreams to work.