From: http://www.davidsarnoff.org/kil-chapter01.html, September 9, 2020

Pioneering in Electronics

Chapter One - The Pioneers

One night during the summer of 1920, an unknown party on an errand of larceny broke into a small wooden shack near Riverhead, Long Island. Undetected, he made off with his bulky loot—a war-surplus tent, complete with poles, pegs, and guy ropes. Whether or not he knew it, he had stolen RCA's first laboratory.

The tent had been erected at the Riverhead site in the spring of 1920 as the field headquarters for a handful of young engineers. Their assignment: to attack a series of problems in America.

Only a few months before, on October 17, 1919, RCA had emerged as a new corporate entity from a background compounded of foresight and precaution. The foresight consisted of a realization that long-distance wireless communication, having proven its value in wartime, possessed an extremely promising future as a commercial service. The precaution was injected by officials of the United States Navy, openly concerned over the fact that the United States was at this time completely dependent upon foreign-controlled companies in the field of long-distance wireless service. Most important among these was the British-controlled Marconi Wireless Telegraph Company of America. (p. 13)

The principal native American asset at this point was the Alexanderson alternator, a powerful generator of continuous radio waves and perhaps the most promising single piece of apparatus available for transoceanic communication. Created by E. F. W. Alexanderson, Swedish-born electrical pioneer serving the General Electric Company, the alternator gave the United States the world's most powerful voice for long-range radio service.

Early in 1919, the proposed sale of alternators and patent rights to the American Marconi Company was delayed at the request of the Acting Secretary of the Navy—Franklin D. Roosevelt. Officials of the Navy and the General Electric Company entered into a joint exploration of possible alternatives to allowing the equipment—and continuing control of transoceanic wireless—to pass into foreign hands. The result, after considerable negotiation, was the organization of a new, wholly American enterprise, the Radio Corporation of America.

The new company took over the wireless facilities of the American Marconi Company and was charged with primary responsibility for maintaining radio communication circuits to and from the United States. Within two years, two further steps were taken to pull together the principal activities in the burgeoning field of radio. The first was an agreement which permitted the new corporation to use all radio patents of General Electric and the American Telephone and Telegraph Company. The second, in 1921, was a cross-license agreement by RCA, General Electric, and the (p. 14) Westinghouse Electric Company, removing barriers which had pre-vented the Joint use of patents to provide the most efficient and up-to-date radio service.

Seldom has an infant company started life with so varied an array of assets. Two of these were of particular importance to the future growth of research in RCA. One was a mandate to expand and improve long-distance communications. The other was an im-pressive collection of human talents for business and technical leadership.

Among the executive recruits to the new corporation, for example, was David Sarnoff, who became RCA's General Manager. This was the young man who, four years previously, had startled the management of the American Marconi Company with his proposal for development of a "radio music box" to supply entertainment and information by wireless to millions of homes—an utterly radical concept at a time when radio was regarded, if at all, entirely in terms of point-to-point communication.

In the technical field, the new organization was equipped with a small group of talented young radio engineers under the supervision of E. F. W. Alexanderson, who added to his General Electric functions the responsibilities of Chief Engineer for RCA. This nucleus of a research staff was headed by Harold H. Beverage, an antenna expert who left Alexanderson's staff at General Electric to undertake as an RCA engineer a task which he has since described as one of "trying to perk up reception." (p. 15)

Disregarding the capabilities, RCA research in 1920 established something of a record for humble beginnings, even for a nation which cherishes the log cabin and the one-room schoolhouse as the legendary breeding grounds for greatness. The war-surplus tent, erected on the site of the future RCA receiving station at Riverhead, was the first and for some months the only RCA laboratory. Under the canvas commenced a program of field research under the direction of Beverage, who had been closely associated with Alexanderson in development and testing of the cumbersome but effective "barrage receiver" used for transoceanic reception during the war.

The barrage receiver was essentially a directional antenna system consisting of two long wires. With these, it was possible to balance out interfering signals coming from a direction other than that of the desired signal. Working with the system at Otter Creek, Maine, in 1919, Beverage had discovered peculiar differences in the reception quality of the two antenna wires, and he set out with commendable enterprise to determine why. Proceeding to Riverhead with the establishment of operations at the Long Island site, he continued his experiments with the help of Philip S. Carter, another of the pioneering technical group, who had been assigned by Alexanderson to set up the field laboratory and to supervise wire-laying operations for tests of reception from South America.

E. W. Kellogg and Chester W. Rice, working at General Electric, had reasoned that a long wire would act as a directional antenna if it could be made to couple to the radio waves traveling in space. (p. 16) Beverage's discovery and further experimental work now showed that directivity of reception was sharply pronounced with the use of progressively longer wires, as the strength of the incoming signal built up along the length of the antenna. At one stage of the experiment, a single antenna wire was stretched over the unbelievable length of nine miles. This work, supported by the theoretical analyses of Kellogg and Rice and the mathematical analyses contributed by Carter, resulted in the first major achievement of research in RCA—the wave antenna. Long-distance radio was now provided for the first time with a simple, single, highly directive receiver operating over a broad range of wavelengths with no tuning adjustment.

This pioneering step in Beverage's task of "trying to perk up reception" brought with it the first professional honor of the scores that have since been awarded to RCA staff members. In 1923, the Institute of Radio Engineers conferred its Morris Liebmann Memorial Prize upon Beverage for development of the wave antenna. Setting the pattern for many future applications of successful research, the decision was taken immediately for commercial develop-ment and use of the wave antenna. Kellogg and Rice joined Beverage at Riverhead to complete the urgent task, and within the year the wave antenna had become a highly useful part of the transoceanic communication service.

With a growing staff and an expanding mission, the RCA research program was shifted in mid-1920 from its weather-beaten tent to the more durable and slightly more dignified shelter of a 15-by-15 foot wooden shack newly constructed on the Riverhead site. Perhaps (p. 17) with thought of its future historical value, the tent was carefully folded and stored beneath a bench in the new quarters. It was from this spot that the canvas vanished some weeks later, leaving RCA with nothing more than a memory of its first research installation.

By the end of RCA's first year, the field research program in long-distance communications had been further strengthened by the addition of more specialists. Among them were Clarence W. Hansell, whose service to RCA in the succeeding years included outstanding contributions to radio transmission techniques, and Nils E. Lindenblad, whose subsequent work at RCA produced major advances in antenna design and, in later years, led to pioneering development of electronic cooling techniques. Both Hansell

and Lindenblad took up quarters in the Woolworth Building in New York City because of the dearth of space at the Long Island site. They were followed into the RCA research ranks by George L. Usselman, a pioneer in transmitter research, and by H. O. Peterson, a young Navy veteran of World War I, who was destined with Beverage to make basic contributions to the art of short-wave reception.

During these early days of wireless communication, both trans-mitting and receiving equipment were limited to long-wave, low-frequency operation. The alternator, for example, functioned in the frequency range between 10 and 100 kilocycles, at wavelengths of thousands of meters. Up to 1920, there appears to have been little or no idea of the long-distance characteristics of short waves, although amateur operators at that time were communicating successfully over long distances at night with wavelengths of 180 to 200 meters. (p. 18)

The intensive effort to improve commercial wireless facilities brought a radical change in this picture after 1920. Investigations by Marconi in England and by General Electric and Westinghouse in the United States indicated that short waves around and below 100 meters might cover greater distances than had been achieved by long waves, and with less susceptibility to atmospheric disturbances. At the same time, advances in the electron tube art made possible the development of vacuum tube transmitting equipment to replace the alternator, opening the way to shorter wave, higher frequency operations. In 1922, the RCA group, working with General Electric engineers, installed at the Long Island RCA station the first vacuum tube transmitter used in transoceanic radio telegraph service. While this equipment marked a major technological advance, it still operated in the long-wave region of the frequency spectrum.

In short-wave development, the role of the RCA group was limited initially to that of “interested observers,” according to Beverage. It was in this role, however, that Beverage and Peterson in 1923 made a contribution of fundamental importance to short-wave communication. Listening one day to experimental transmissions at 110 meters from KDKA, the Westinghouse station in Pittsburgh, Pa., Beverage discovered that the carrier and its sidebands, forming the complete radio signal, faded in random fashion. This suggested that the components of the signal had followed different paths from transmitter to receiver. It followed that there might be different fading characteristics in reception of the same signal only a short distance away. (p. 19)

This is just the way it turned out. Beverage and Peterson set up experiments with receiving antennas spaced initially some nine miles apart. By stages, they decreased the separation to only half a mile. They found that fading in the KDKA signal did not occur simultaneously at both antennas, but that it tended to remain strong at one while fading at the other. By combining the outputs of the receivers associated with the two antennas in such a manner as to be independent of the phase relations between the two receivers, it was possible to overcome random fading to a very large extent. This principle, known as space diversity reception, was to become and remain an important technique in short-wave radio communication.

In October 1924, theory and practice were shaken by an epoch-making discovery. From the Marconi station in Wales came a 32-meter signal that was received clearly on Long Island during daylight, but faded at night. This was startling confirmation of a theory that had developed through a series of experiments by Marconi during the previous two months, indicating that daylight range increased with a decrease in wavelength. At Riverhead, the discovery “really set us up on edge,” according to Beverage.

At the time of the Marconi discovery and test, Hansell, Lindenblad and Peterson were preparing to test the possibility of relaying European long-wave signals from Belfast, Maine, to Long Island by means of a short-wave system operating at frequencies from 120 down to 140 meters. Peterson was, in fact, en route at the moment to Chatham, Mass., to make measurements on the short-wave transmissions from Belfast. These tests soon confirmed the (p. 20) conclusions of the Marconi transatlantic experiment. From this point on, long-distance communication by short-wave became the major concern of the RCA group and of the communications business.

The growing activity was now crowding the research and engineer-ing facilities at Riverhead. In 1925, a new laboratory was established at Rocky Point, Long Island, to study problems of transmission. The ques-tion of reception remained in the hands of the group at Riverhead. The transmitter work fell largely under the active supervision of Hansell, who already had made a pioneering contribution in the application of quartz crystals for precise frequency control at the Belfast transmitter—apparently the first commercial use of this now-standard technique.

Plunging enthusiastically into the promising new short-wave area, Hansell developed during 1925 a radically new transmitter for short-wave operation in daylight. The equipment produced an output of 7.5 kilowatts on a wavelength of only 15 meters—a record never before achieved and an achievement which, according to Beverage, ‘‘enabled RCA to lead the world by handling short-wave traffic in daylight for the first time.”

The development was economically as well as technically significant. As Hansell put it later:

“At one time at Rocky Point, $3 million worth of long-wave transmitter equipment was used to provide 450 kilowatts into an antenna system three miles long, supported on towers 410 feet high. This . . . failed to provide communication with South America. About three years later, nearly all daytime traffic from Europe and (p. 21) North America (to South America) was passing through a Rocky Point transmitter that had cost only a few thousand dollars and provided 7.5 kilowatts at 20 megacycles into an antenna consisting of 25 feet of No. 10 wire held up by clothesline.”

The reference to clothesline is perfectly serious. While the communications research program of 1925 had left the tent far behind, physical facilities and equipment remained ridiculously inadequate by comparison with today’s elaborate standards. Hansell’s first 15-meter transmitter employed not only clothesline, but also 5-and-10-cent store pie tins supported on broomsticks. Furthermore, he had scoured eastern Long Island to secure obsolete carbon lamps for use in fashioning non-inductive resistances needed in the system. This is evidence not of any corporate unwillingness to spend money on research, but of the degree to which much of the early work lent itself to improvisation on a scale that became impossible with the increasing sophistication of electronic research in later years.

A final key element in the short-wave system was the design of new antennas for the most effective transmission of signals to their particular destination. From 1927 through 1930, Lindenblad and Carter achieved major advances in this area with the development of directive antennas which provided a highly attractive combination of low cost and high efficiency. The first of these, Lindenblad’s Model A, was put into commercial service in 1927, directed to Germany but useful for communication to other points in Europe. Used in combination with Hansell’s Model A transmitter, (p. 22) it helped to establish a record for handling long-distance traffic by operating at speeds up to the limit of the best available terminal office equipment.

The sum of RCA’s communications research during the first decade of corporate life was an impressive advance in long-distance, short-wave radio service. One result was the establishment of firm RCA leadership in commercial wireless communications. Another result was the building of a strong foundation for major progress in the next decade. From the various contributions in frequency control, antenna design, relay techniques and propagation studies, would come important progress in television and microwave relay, in facsimile, and on other advanced communication techniques.

These advances will appear in due course in this account. It is enough at this point to observe that the productive work of the communications research group during the 1920’s has been matched in each of the succeeding decades by the ever-growing activity in many areas of electronics by the larger RCA research organization of which the communications group was the pioneering forerunner.

From Wireless to Broadcast Radio

The growth of international wireless communication during the first ten years of RCA's corporate life will inevitably be overshadowed in the history books by the even more dramatic parallel (p. 23) development of radio as a broadcast service for the public. This other aspect of radio became immensely important to RCA in the commercial sense. It also generated peripheral activities bearing directly upon the further growth of RCA research.

By 1921, David Sarnoff's "radio music box" was proceeding swiftly from prediction to reality with the awakening of public interest in broadcasts from a few pioneer stations. The cross-license agreement of that year among RCA, General Electric, and Westinghouse paved the way for the three companies to develop, manufacture and sell broadcast radio equipment. Just prior to the start of broadcasting, RCA had contemplated the sale of transmitting and receiving equipment to radio amateurs. With the new service showing greater commercial promise, this line of amateur apparatus was expanded to include home broadcast receivers manufactured by General Electric and Westinghouse.

Thus, for the first decade of its life, RCA was in the broadcast radio business largely as a selling agency for equipment made by the two manufacturing companies. Home receivers were produced by General Electric at Schenectady, N.Y., and by Westinghouse at East Pittsburgh, Pennsylvania, and Springfield, Massachusetts. Receiving tubes were engineered by the two companies at Schenectady and East Pittsburgh, and manufactured in General Electric plants at Cleveland, Ohio, and Harrison, New Jersey, and (p. 24) Indianapolis [Indiana]. Both of the manufacturing companies had their own research and engineering staffs to carry on tube and receiver development, but neither had a merchandising department for handling radio sales to the public. This was left to RCA. (p. 24)

As the merchandising agency, RCA alone was in the position to gauge the requirements of the market and to determine whether the apparatus provided by the two other companies would meet these requirements. This called for engineering judgment, based on tests of the new radio models. At the start, RCA contracted for this service with the electrical engineering laboratory of the City College of the City of New York, under Alfred N. Goldsmith. The sheer volume of work soon overtaxed the available facilities, however, and in 1924 RCA set up its own Technical and Test Department, employing Goldsmith and his associates from the college to staff the new establishment.

The new department was installed in a specially constructed building on the south edge of Van Cortlandt Park, in uptown New York City. It was charged with several responsibilities. These included the maintenance of necessary liaison between production and sales, the study and review of technical developments in the radio field, and a certain amount of original work aimed at the improvement of radio apparatus and the investigation of possible new products.

While the last of these responsibilities stood relatively low on the list, the opportunities were apparent for a respectable amount of applied research and advanced development. For one thing, Goldsmith was directly responsible to David Sarnoff, whose interest in research was as lively then as later. For another, the staff of the department included a number of enterprising individuals whose talents, first exercised on behalf of RCA at (p. 25)

Van Cortlandt Park, have carried them on to key positions in the corporation's research, engineering and marketing activities.

A partial list of the Van Cortlandt Park staff in mid-career includes Theodore A. Smith, now Executive Vice-President, RCA Corporate Planning; Irving Wolff, who recently retired as Vice-President, Research, of RCA Laboratories; Barton Kreuzer, who heads RCA's Space Activities as Division Vice-President and General Manager of the RCA Astro-Electronics Division; and Harry F. Olson, pioneer in acoustics and now Director, Acoustical and Electromechanical Research Laboratory, RCA Laboratories.

In response to the requirements of broadcast radio, the new department was organized into two principal areas of activity. These were a radio testing and development group under Arthur Van Dyck, and an

advanced development group under Julius Weinberger. In addition to the main activity of testing and modifying tfighthe radio equipment produced by General Electric and Westinghouse, the staff occupied itself with such matters as acoustical studies, the investigation of circuit problems, the development of sound motion picture equipment, and, during the late 1920s, with television.

During the six-year life of the Technical and Test Department, these varied activities employed a staff of seventy engineers, technicians, mechanics, carpenters, and administrative and service personnel. The total output encompassed a broad range of improvements (p.26) and modifications in home radio receivers, including such famed items as the first Radiola, and the first Radiola-phonograph combination. A nostalgic review of the department's work in the February, 1930, issue of the RCA magazine *Wireless Age* refers to the Van Cortlandt Park operation as "at once a queer combination of the academic and the practical under one roof, working side by side, yet joined in the common cause of better radio."

The "academic" presumably refers to certain aspects of the original work not directly associated with the improvements of radio receivers. An outstanding example, and one that ranks today as a major advance in acoustics, was the development by Olson of the velocity microphone. Until this advance was achieved, the standard broadcast microphone functioned on the basis of changes in air pressure caused by sound waves. This technique was effective enough in picking up sound and translating it into electrical signals, but the pressure microphone had no particular directional characteristics.

Olson's unique contribution was a new type of microphone that responded to the velocity of air particles rather than to changes in air pressure. Since particle velocity has direction, this tech-nique offered for the first time a pickup device that could respond to sounds coming from certain directions and discriminate against those originating front other directions. Moreover, this directional characteristic remained the same at practically all audio frequencies. (p. 27)

As the first pickup device to possess these advantages, the velocity microphone revolutionized sound pickup techniques in radio and sound motion pictures. Of particular interest to the movie makers was the fact that the new device could be used nearly twice as far away from the sound source as could any previous microphone. The effectiveness of Olson's basic design is attested by the fact that the velocity microphone remained virtually unchanged in form during almost thirty years of subsequent large-scale manufacture and use.

A further development of significance by the acoustical group was a compact and inexpensive loudspeaker for radios. A major advance in speaker design had been achieved in 1926 by Rice and Kellogg at General Electric with the development of the dynamic loudspeaker, in which electrical impulses from the amplifier were converted to motion by a magnetic coil. These motions were then converted to sound waves by means of a paper cone. The advent of the dynamic speaker set a new high standard in home listening, and its principles have been employed in most speakers produced since that time. The Van Cortlandt Park contribution, coming in 1927 from Wolff and his associates in the acoustical group, was a magnetic armature type of speaker with a structure considerably more compact than that of the original Rice-Kellogg dynamic speaker. Coming at a moment when home radio receivers were selling in large quantities, the new RCA speaker, known as the 100A, became a major sales item for the next few years. (p. 28)

The acoustical group also busied itself during the late 1920s with theater sound systems, a field into which RCA entered commercially in 1928 with the organization of the RCA Photophone Company. Working first at Van Cortlandt Park and subsequently at the Photophone plant on 24th Street in New York, the group developed a directional sound system for theaters, employing a cone-type speaker connected to a horn.

While the major accomplishments of RCA in television awaited the changes in organization that were to come with the end of the decade, the engineers of the radio group in the Technical and Test Department applied their considerable talents during 1927-29 to the development of an experimental television system

employing mechanical scanning and a 60-line picture reproduction technique. The work advanced to the stage of experimental broadcasting during 1928 over what later became the National Broadcasting Company television station W2XBS in New York. A further development by the group was a theater television system employing a fairly large screen upon which images were projected in a successful demonstration.

During this period, television was under investigation also at both General Electric and Westinghouse. But eventually, as we shall see, it was the advent of a single program aimed at achieve-ment of a complete system that led ultimately to a successful commercial television service after another decade. (p. 29)

In spite of the achievement of the Technical and Test Department in bridging the gap between production and marketing, the problems of coordination among the manufacturing companies and RCA presented many difficulties. As a marketing organization, RCA found it highly desirable to offer a uniform line of apparatus, regardless of manufacture. Tubes, which were not included initially in the sets that were sold, had to be uniform so that they could be interchangeable in any receiver. In an effort to solve these problems, General Electric and Westinghouse had established committees comprising specialists in the receiver and tube lines, and these committees had further relations with the RCA group at Van Cortlandt Park. Engstrom, working at General Electric during this period, has testified to the awkwardness of the arrangement.

As a member of the receiver committee, commuting over a long period between Schenectady and Pittsburgh, he found that it required a monumental effort to bring about coordinated design with the differing mechanical standards, differing manufacturing procedures and differing points of view in those early days. However, the coordination arrangement remained until new major changes in organization came to pass.

In the face of swiftly developing competition in the radio receiver market, this, method became increasingly ineffective. Numerous independent companies appeared able to move more rapidly in meeting the demands of the public. Many of these, incidentally, were drawing benefits by the late 1920s from licensing arrangements (p. 30) which provided them with rights to use radio inventions of RCA, General Electric, and Westinghouse. This process of sharing the fruits of research and development became an important feature of RCA corporate policy, contributing substantially through the subsequent years to the rapid growth of radio and television.

By the late 1920s, however, the difficulties of coordination pointed to the need for a basic change in the existing pattern of manufacturing by General Electric and Westinghouse for RCA as a marketing agency. The most logical solution appeared to be the acquisition by RCA of its own manufacturing facilities. The decision that resulted opened a great new chapter in the history of the corporation and in the course of its research program. (p. 31)