THE AWA REVIEW

Arthur Atwater Kent 1873-1949

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THE A.W.A. REVIEW

THE COVER

Arthur Atwater Kent, one of the giants of American industry during the 20th century, and the subject of our lead article by Ralph Williams. This photograph is a reproduction of the portrait in the collections of the Atwater Kent Museum in Philadelphia. The portrait was painted by F. C. von Hausen in 1940 and was presented to the Museum by Mr. Kent in that year.

The Atwater Kent Museum is the History Museum of Philadelphia. It was founded by Mr. Kent in 1938.

(Photo courtesy of the Atwater Kent Museum)

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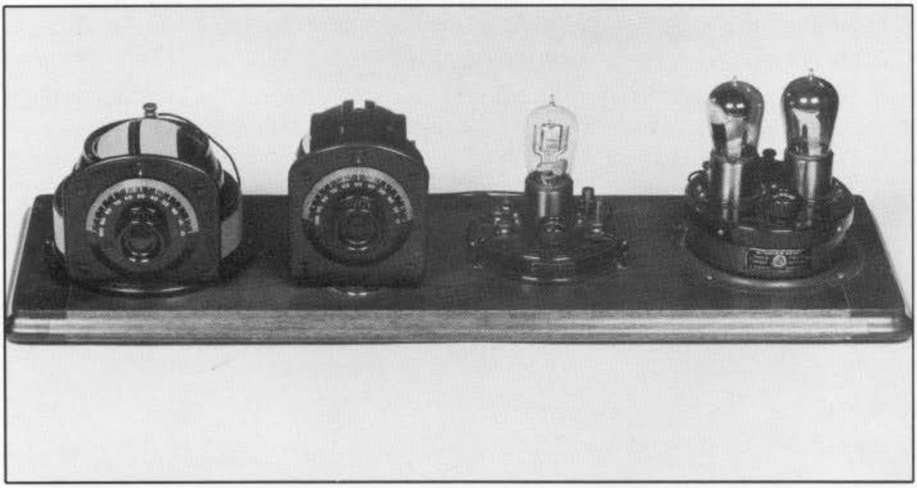
☆ CONTENTS ☆

Two of the early Atwater Kent Manufacturing Company breadboard receiving sets. The Part No. 3945, above, was introduced in November, 1922. The circuit was the detector-two stage amplifier. Below is shown No. 3955, introduced very shortly thereafter. The variometer, added after purchase to skirt around the Armstrong license for regeneration, is in the middle on both sets. Both are described in more detail in the AWA Review, Vol. 1.



FOREWORD

The Antique Wireless Association takes pride in presenting Volume 10 of the *AWA REVIEW*, a compilation of six papers describing historical events in the field of wireless and radio communications. Supplemented by some 190 illustrations, and written by noted authors and historians, these authoritative and well-documented presentations are also highly entertaining reading.

The lead paper, by noted AK authority Ralph Williams, presents the person Atwater Kent as a master in the art of marketing. While many of the AK products are described and pictured, the emphasis is on Kent's remarkable expertise in discerning his markets and taking the necessary, correct and timely actions required to build one of the major manufacturing companies of the early 20th century.

Mike Adams, an expert on pioneer broadcaster Charles Herrold, has extended his research into the realm of the development of radio-telephone, with an extensive and well-illustrated landmark article on the five key individuals and the technology which made it happen. The article and its illustrations gives the reader a view of the world and its perceptions of communications at the turn of the century, and the events, a race, which culminated in a system of practical "radio," still in use today.

The third paper, by author Chris Bacon, tells the story of RCA's Radio Central, the huge radio-transmission facility at Rocky Point on Long Island, which was so prominent in world affairs and appeared as a shining example of American expertise and industry for over six decades.

Al Jones and Hank Olson, historians and tube experts, have written the story of Heinz and Kaufman, pioneers in tube development and manufacture, their legal battle with Sarnoff and the Radio Trust, and the strategy used to attain victory over the giants. H & K products are described in detail, supplemented with a series of unusual photos.

Parker Heinemann, long interested in Collins Radio products, describes the formation and the early years of the Collins Radio Company, and includes some superb photos of early and rare Collins transmitters.

Finally, long-time contributor and noted historian Floyd Paul describes the early years of the Gilfillan Radio Company. His article, researched from the actual corporate records, also includes pictures of some desirable Gilfillan collectibles.

Taken together, the ten volumes of the *AWA REVIEW* constitute a valuable reference work on the history of early radio and wireless.

The Editor

Atwater Kent seated at his desk. On his right is the one-millionth radio produced in his factories, and on the desk are other AK products. Below is a close-up shot of the name plate on the commemorative Model 35.

ATWATER KENT — MASTER OF MARKETING

Ralph O. Williams, N3VT

Orient, N.Y.

INTRODUCTION

Almost all of today's radio collectors are familiar with Atwater Kent radio receivers. Because some of the sets, particularly the later breadboards, are dramatic contributions to a collection they are held in especially high regard. The name Atwater Kent has come to signify something above and beyond ordinary, collectible receivers. But what are the reasons for the character of the breadboards? Or the style of the metal boxes of the 40 series? When Atwater Kent introduced these unique styles, was he only responding to the novelty of radio?

Beyond the radios is a much broader story. It tells of a man who was hugely successful in the automobile industry before entertainment radio was conceived. It tells about a developing young man who ultimately climbed to the highest reaches of American enterprise. This man was the very best kind of "do-it-yourselfer," building the largest radio manufacturing company without outside stockholders, without interlocking corporate structures and without the unethical practices that marked too many contemporaries.

Examining Atwater Kent the executive, and the functions that he implemented in his several businesses, cannot be done unless a trove of documents about him is uncovered. What can be done is to review his products and, by comparing their technical sophistication to the times in which they appeared, postulate something of the man who made them happen.

Other authors have done exemplary work in describing Kent's radios. To focus more directly on Kent, this article looks at the relationships he maintained between the users of his products and the means by which they were produced. The name of the relationship is "marketing."

Marketing, as the term is used in the last part of the twentieth century, has come to have two separate but related meanings. The first meaning concerns doing something in a place where commodities are bought and sold. A phrase with the first meaning might be, "I'm marketing radios," by which is meant "I'm selling radios in the market." The second meaning is used in industry and commerce. It refers to an analytical function that compares the requirements of customers to the capabilities of a supplier within the limits of his business goals. This is the meaning of the term, marketing, as it is used in this article.

How did Atwater Kent respond within the broader concept of marketing? Was Kent's customary approach one in which the demands of his customers were related to his manufacturing capability? Conversely, did he, as part of his business strategy, alter his manufacturing facilities to meet his customer's demands? How effective was his influence on customers and their choices? How successfully did he modify his factory to profitably fulfill their demands?

When we propose that Atwater Kent was a master marketer, we suggest that he used far-beyond-ordinary skills in discovering the wishes and intentions of his potential customers and altering his factory to supply those demands. At the same time, we observe that he met his business goal of profitable operation.

As we move through Atwater Kent's business life we review each product's effectiveness. Near the end of each section of this paper, we comment on his apparent marketing effectiveness for the products discussed. In the conclusion of the article we comment on some of the earlier analyses with the intent of extending them to a broader evaluation of Kent as an executive.

If it were possible, our method would include the classic technique: interviewing the subject and comparing his responses to contemporaneous facts and opinions. Instead, our primary method was to obtain pertinent material about his products and then to evaluate them in the light of their own times. A large part of the data that we used is 1920's production information that was given to us by his son Atwater Kent, Jr. who said that it was all that was left of the factory records.

To better perceive Atwater Kent himself, we looked briefly at the state of American technology shortly before and during Kent's active business life. This made it possible to project the influence of the environment on his growth to maturity. Then, to obtain a broader evaluation of Kent as an active entrepreneur, we reviewed published material about him and his products. We have tried to leaven the whole with information from interviews with those who knew him.

INVENTION AND IMPROVEMENT

The evaluation of Atwater Kent's products requires a brief explanation of some terms as well as the context in which we use them. American technology throughout our history has been the result of two major creative activities: invention and improvement. While the results may seem greatly different, the processes by which both come about are largely the same. Only the bases upon which the processes work are different. For invention, the base is largely an idea, a mental concept. For improvement, the base is usually an existing device, an embodiment that can be touched or seen.

Creativity is the common element of invention and improvement. By creativity we mean that mental activity where concepts or ideas that do not have an initially obvious relationship are considered together, yielding a novel relationship which may or nay not have an immediate practical application. Although some question or problem stimulates creativity which then generates an improvement or an invention ("Necessity is the mother of Invention"), the creative process can occur unbidden.

Both invention and improvement involve experimentation. The experimentation may be conceptual (as Einstein sometimes cerebrated) or it may involve physical change to an embodiment. The form of the experiment differs between invention and improvement, but its function is the same in both cases; postulate novelty and consider effectiveness.

THE SWEEP OF TECHNOLOGY

The main body of this article is an evaluation of Atwater Kent's several product lines: electrical, ignition, military and radio. Kent's first offerings were electric motors. They were sophisticated devices in their own time and would have been far beyond a person with no technical skills. His first motors might have been direct copies of earlier motors or they might have resulted directly from Kent's background, the results of his earlier experience in studying and experimenting as he grew to maturity.

What was his background? While we don't have records of Kent's life we can review the technical world into which Atwater Kent was born. We look at it from two perspectives: one is the state of its body of knowledge, both conceptual and implemented. The other is the potential it has for developing an ambitious young man.

Technical understanding has a relatively short history compared to art or the classics. It amounts to little more than four centuries. The history of art, religion, politics and language is more than ten times as long. The history of the replacement of animal power with mechanical power (engines of all sorts) spans only two centuries. The technology of radio, with which we associate Kent, is now only one hundred years old. We have selected three periods to describe: Today, Kent's time, and the beginning of the nineteenth century. This makes it possible to see how the sweep of technology might have formed the persona that we ascribe to him.

Looking back in time from the end of the twentieth century the pace of technological growth seems staggering and, to some people, even fearful. One part of the impression is generated by the breadth of our developments, ranging from the sub-microscopic alteration of DNA to reckoning the age of the universe by using data from observations of waves radiated across the cosmos. Another part of the impression comes from examining the depth of knowledge that has resulted from the hypothesis, investigation, experiment and verification in our expanse of technology.

TECHNOLOGY TODAY AND YESTERDAY

The successful technical person of today, at the end of the twentieth century, grows up in a moderately comfortable family, with strongly interested parents and good schooling. Early in life this person is encouraged to study math, science and computer technology. Although he may have worked on machinery or electronics, he has concentrated on concepts and theory. In the last half-century, the technologies that he might have learned-by-doing have matured to the place where only primitive experiments can be performed. He sees devices as things completed rather than challenges for improvement. The potential for growth of a young person at the end of the twentieth century is limitless. Achieved growth depends only on human capacity, no longer on material means.

Going back almost two hundred years, to the beginning of the nineteenth century, a very different picture of technology is seen. The first part of the nineteenth century was a period of great creativity but most of the implements, both large and small, were made primarily of wood. All sorts of improved tools and devices were conceived, produced and improved by mechanics, farmers and entrepreneurs. The era of invention was at hand. The reaper, the cotton gin and a multitude of agricultural machines reflected the growth of mechanical technology. Iron bridges and the steam locomotive were major inventions in related fields.

Electricity was known but was only emerging from its experimental stage. Near the middle of the nineteenth century, the telegraph was reduced to practice and it thereby established two other areas of increasing breadth: coded electricity and the transmission of data. Little more than a century later these became basic necessities of modern life. Underlying all these inventions and improvements was the rapidly deepening understanding of what they really were and how they worked. This growing theory clearly resulted from innovative successes but, to a much greater extent, the knowledge was gained from the many unsuccessful attempts that preceded each final, useful achievement.

At a time in this period, such as 1820, a young man of high technical initiative would have been sent to a local school where he would have learned to read and to do arithmetic. He would also have learned classics at home with his mother or father. Because of his inclination toward technology, he would have gained much experience with tools and agricultural implements and very possibly been apprenticed to learn a trade. He would have been very fortunate if his apprenticeship included working with metal, particularly iron.

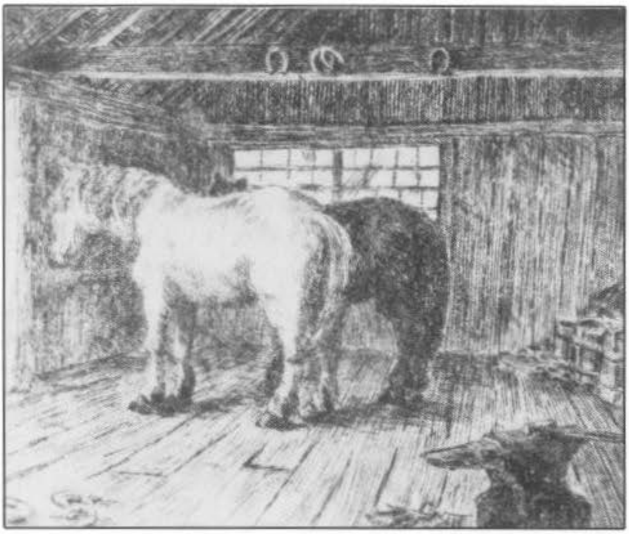


Figure 1. *The local blacksmith shop, the technology center of the 1800s.*

The local blacksmith shop, Figure 1, was the technology center of the early 1800s. Not only did the smith shoe horses and fashion simple tools but it was the place where the metal devices that were being developed for farms and small factories were invented and modified. An apprenticeship in the blacksmith shop would have exposed the young man to horses and oxen, since they were the main sources of portable power, but at the same time it would have offered him superior training in the most advanced technology in his area.

Had he been interested in medicine or teaching he might have gone to college. There he would have learned nearly no technology, because in the first part of the nineteenth century the inclusion of science and engineering in regular college curricula had not yet taken place. The potential for the young man of this time was dependent on both materials and theory but was nevertheless open to whatever growth his personal creative spirit could sustain.

TECHNOLOGY IN KENT'S TIME

Between these two major periods in the history of technology, specifically the last quarter of the nineteenth century, innovation accelerated; power obtained from animals or humans was being rapidly replaced by mechanical power. Steam power became ubiquitous. The gasoline engine, invented by Otto in 1864 and perfected by Charter in 1884, was well on the way to supplementing steam, especially for small applications and for the automobile. Some other inventions that strongly advanced technology in the late nineteenth century and probably influenced the youth of that period were; Brush's dynamo and arc lights in 1876, the practical typewriter brought out by Remington in 1874, and the mechanical typesetter, introduced by Merganthaler in 1878 and upgraded to the Linotype in 1885. The pace in other fields was equally rapid. Bell filed for a telephone patent in 1874, only days before Gray. In 1877 Edison added carbon granules to the Bell transmitter thereby making it a practical instrument. With the further improvements made since then it is still in use. Isaacs invented a multiple camera system to make pictures of the motion of a running horse. Muybridge altered the system in 1882 to use a single camera. Eastman, in cooperation with Edison, produced a 50-foot roll of film which became a true motion picture after multiple exposures in Edison's camera. In 1887 the system became the Kinetoscope. Perhaps the most obvious sign of sweeping technology in the late nineteenth century was the perfection of the incandescent lamp and of the electrical generating and distribution systems that provided its power.

The body of technical knowledge grew so rapidly that new academic disciplines had to be introduced into the curricula of technical schools and universities. Only by extensive dissemination could students interested in innovation share in using and extending it. The pattern of scientific and engineering education that is in place today had its start in the last part of the nineteenth century. Although schools taught concepts and technical practice, learning from experiment and experience was still the significant part of the development process. A young man could become very proficient in improvement and invention without a formal education.

To understand the particular young man who started building and selling the first Kent products, we must add details about his immediate home and family and consider the time and situation of his youthful development.

ARTHUR ATWATER KENT

Arthur Atwater Kent was born December 3, 1873, into a comfortable family of moderate means. His mother and father recognized the value of formal education, but when Arthur was small they had not become so modern as to preclude the value of learning by experiment. Kent's father, Prentiss J. Kent, born 1834, earned a living as a machinist and had taught school in the middle of the nineteenth century. Before the civil war he became a doctor and later was appointed a surgeon in the NY 174th Volunteers, staying in the service until 1864. Upon his return to Burlington, VT he married Elizabeth Atwater. The Kents moved to Worcester, MA in 1869 where he was involved in medicine, pharmacy and a vestige of his machinist days, invention.

The family returned to Burlington, where Arthur was born, and later moved back to Worcester. The is no clear record that says how strongly Prentiss Kent maintained his interest in machine work in Worcester but there is evidence that he had a machine shop there in 1889. From what we see of Atwater Kent's first motors, he must have been very strongly encouraged by his father to become proficient with machine tools. Kent's mother also encouraged him, in part because he was her only son, but in greater part because of his initiative and independence.

Later interest and effectiveness in the technical world suggest that young Arthur, as he was known at home, was strongly influenced by the both the technology and the culture of the last quarter of the nineteenth century. His father's experience and his mother's teaching provided him with the opportunities he used to become an entrepreneur while still in his teens. At the same time Kent benefited greatly from the cultural influences of his home life. Our interviews with Atwater Kent, Jr., his son, who preferred to be called Atty, left strong impressions of the richness of his fathers personality.

Atwater Kent's youth was the time when the steam engine, one of the very few complex machines of its time, had reached a stable level of perfection. Other examples are: the telegraph and the engine lathe. One story of Arthur's experimental bent and his family's "encouragement" was told by his son, Atty, nearly one hundred years later. It seems that Arthur had some serious thoughts about the steam engine in the family launch and how it could be improved. Figure 2 pictures such a launch. Out on the lake one day during a summer holiday, he put his ideas into action. The unanticipated result was disaster. The launch burned to the ground (water). As Atty told the story, Arthur's punishment had the flavor of restitution; perhaps it even enhanced Kent's further technological growth.

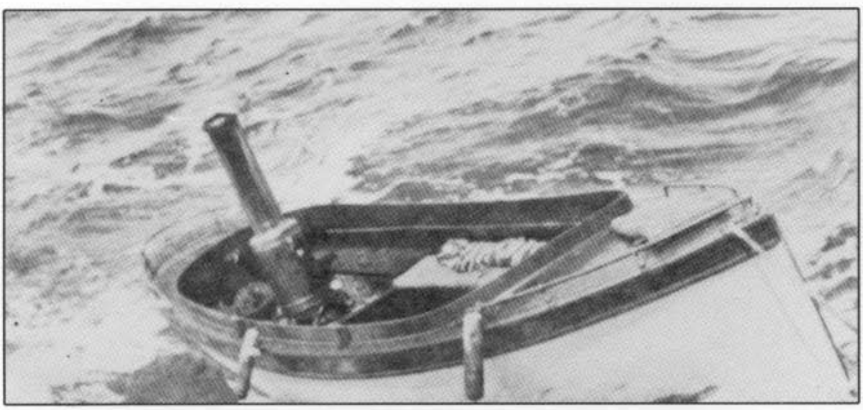


Figure 2. *An early steam launch, of the style that Kent worked with.*

The Kent Alternating Current Sewing Machine Motor

FREQUENCIES.
16000
7200

VOLTAGES.
52
104

THE KENT alternating current Sewing Machine Motor overcomes the difficulties encountered by alternating current motors, namely, the small starting torque and the nonvariable speed. It is started without a load when the operator sits down to the machine and runs at a uniform speed. The belt is then tightened by means of a lever connected to the treadle.

Any desired speed may be maintained by tightening or slackening the belt. In this way even more perfect regulation can be obtained than by direct current, as the speed can be changed in an instant, and the break which is automatically applied to the circumference of the balance wheel, stops the machine almost instantly. In ordering, state voltage and frequency, and whether for family or factory use.

Price $20.00.

Figure 3. *Data sheet from the Kent Electric Manufacturing Co., 1896.*

THE YOUNG MACHINIST

The few records that have come to light about young Atwater Kent let us look at him shortly after he turned twenty. One record shows that he entered Worcester Polytechnic Institute in 1895 as a member of the class of 1899. The other is a notice in an 1896 issue of the publication *Electrical Engineer* announcing a sewing machine motor made by the Kent Electric Manufacturing Company. Figure 3, reproduced from a data sheet issued at that time, describes the motor.

Figure 4 illustrates a fan that used the same motor that was used for the sewing machine. The written copy on its data sheet states "putting our fans on the market for the season of "96." Since in Massachusetts the fan season is summer, both the fan and the sewing machine motor must have been manufactured early in 1896. Considering the time that it would have taken to obtain materials and to make parts for the motor suggests that the motor was manufactured in late 1895 and early 1896. This work appears to have been going on at the same time as Kent's attendance at WPI.

The coincidence of Kent going to college at the same time as his latest motor was introduced was an intriguing idea to the author. What inferences could be drawn from this idea in the light of other information that was available about Kent? First, the documents from which the sewing machine and fan motor illustrations in this article were made were given to us by Atty, Atwater Kent's son, for historic preservation. We were ecstatic that he gave us the documents but more important, that he shared his pride in his father's invention of the devices.

A second inference is built on several other motors. Figure 5 reproduces the data sheet issued by his Kent Electric Manufacturing Company for the No. 2 Motor. Its design and description suggest strongly that it was

Figure 4. *Kent alternating current fan, 1896.*

similar to the sewing machine motor particularly in the design of its single rotor bearing. Figure 6 shows the No. 3 Dynamo Motor. Both of these motors are low-voltage direct-current machines that would have been produced before the sewing machine motor which had been upgraded to use line voltage alternating current.

Mention is made in the No. 2 data sheet of two more motors: "The No. 4 is the sewing machine size. The No. 5 is about 1-8 H.P." There were also direct-current fans produced in two configurations, one where the customer could buy the motor and the fan blade, the other where the fan was complete and contained its own pedestal. Figure 7 shows that fan.

Since all these direct current motors including the fan and their very mature, business-like data sheets predate the alternating current motor, there can be little doubt that Atwater Kent and his father, who would be nearing 60, were together in the Kent Electric Manufacturing Company. The design of the motors, their quality and their range of application show significant investment in time and money. The financial support would have come from Prentiss and the aggressive technical approach would have come from Arthur.

At the time of Kent's entry into college, his line of motors was in production and being distributed. His father may very well have supervised their employees in the shop and done the billing while Arthur attended school. That work would have been a very light demand on Arthur's time. Our second inference is that Kent kept in touch with the factory while he went to college.

Figure 5. *Kent No. 2 motor, 1896.*

Figure 6. *Kent No. 3 dynamo or motor, about 1895.*

Figure 7. *Kent "96" battery fan data sheet.*

KENT TRIES COLLEGE

There is a third inference to be considered. It relates to Kent's age at this time, 22 years in December, 1895. He was older than most of the students with whom he enrolled and he had a very different background. Kent had completed the designs of the several electric motors well before he started college, and would certainly have experimented with everything that interested him, especially electric motors. He probably would have built many in an effort to produce an improvement over those that he would have seen. He had used the time before college to learn technical invention. When the factory reached the production state, he was able to apply his time to the new experience, learning concepts and theory. His analytical capabilities would have been keen.

At the end of the 19th century engineering was still the province of the technician. The experience of constructing and reconstructing pieces of machinery was more pertinent to creating improvements than was design from concepts, principles and handbook data. (At the time of the author's return to college after WWII he was embarrassed to have the head of the electrical engineering department tell him that he brought far more knowledge about radar to class than was known in the school. The author needed field theory so he quietly continued his studies.) Our third inference is that Kent

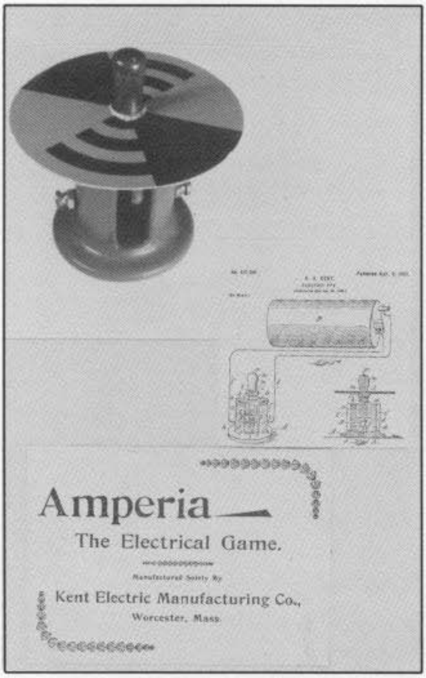


Figure 8. *Ken's electrical game, Amperia.*

used his time before college to create improvement and make inventions based on practice instead of theory.

The fourth inference concerns leaving college during the first year, reentering the next year and again leaving before finishing. While this might suggest that Kent was not a good student or that he couldn't meet academic requirements, such a characterization does not fit any of the qualities that typify Kent. Several years after this time he attacked and succeeded in solving ignition problems that required a great deal of hard head-scratching to overcome. Our inference is the more consistent view that he was so good a craftsman and inventor that he found the basic college courses divergent from his goals and that he chose to go his own way.

Kent was very familiar with small electric motors and he was also very familiar with the tools that were needed to manufacture small lots of electrical devices. He had grown up with the facilities and materials to devise improvements to any small machine on which he chose to experiment. No better way could have been found to create improvements and inventions than to couple teen-age curiosity with that kind of opportunity.

AMPERIA

One more Kent motor is pictured in Figure 8. It is the basis of a game called Amperia. The motor tells much more than the simple fact that it has only two poles and is spun by connection to a single cell battery through a key operated by the players in the game. The Amperia motor appears to be Kent's first product.

The data sheet for the No. 2 motor makes much of the improvement of its six-pole armature over the three-pole armatures used in competitive machines. Three-pole motors were significantly better than two-pole motor because, although they vibrated, they started. Sometimes when a two-pole motor is stopped its armature is in such a position that it won't restart unless moved a little by hand.

The Amperia motor must have been Kent's first try at a salable product. Although the finish work on the motor and its parts shows a reasonable level of quality, its operation does not. The motor was offered as a bonus for selling magazine subscriptions, indicating a novelty application. It was also used to demonstrate interesting optical phenomena such as color blending by spinning several primary hues and having the eye blend them. If a little magnetism was retained by the iron in the rotor or stator, the motor won't stop randomly so its value as a game was lost. Kent must have learned much from this foray into the business world.

Perhaps he brought too much experience and too little patience for the staff at WPI. Though his stay was limited his relationship with Worcester Polytech was always cordial. Nearly thirty years after this time he was awarded an honorary doctorate and, by way of his will, he endowed the Atwater Kent Laboratories at WPI. Taken together, the story so far indicates that young Atwater Kent was very bright, had gained much hands-on experience with machine tools, had very high initiative, was familiar with selling to customers, had chosen electrical applications as a way to go and was well on his way.

THE IGNITER

By about the turn of the nineteenth century, internal combustion engines using gasoline for fuel had started to displace steam engines. One form was used as the motive power for automobiles. Another form was the stationary engine, used to drive pumps and generators, rigged in boats for propulsion, and mounted on wagons and platforms to provide portable shaft power. One continuing problem with early engines was carburetion, getting the fuel to mix with air so that it could be exploded in the cylinder of the engine. The other problem was igniting the fuel-air mixture.

The present day method of igniting fuel in gasoline engines is to provide a high-voltage electric discharge across the points of a spark plug mounted somewhere on the walls or top of the cylinder. In the century since Atwater Kent first became interested in ignition the system has become so standard and so reliable that it is no longer a problem. In Kent's

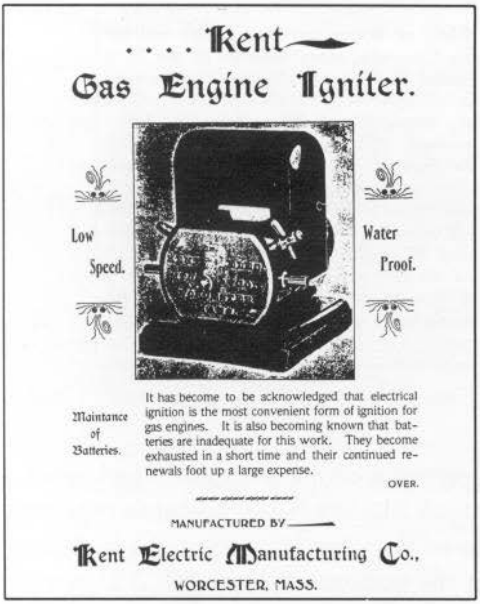


Figure 9. *Kent's gas engine igniter, 1899.*

time it was the most difficult problem with engines, even considering carburetion.

The means of generating a high voltage was known in laboratories. Ruhmkorff coils were used for experiments and demonstrations. Marconi was using the coils for his wireless development but they were not available to the ordinary users of gasoline engines. The systems used for ignition operated at low voltage by connecting a source to a pair of contacts inside the cylinder, and then mechanically separating the contacts.

With voltages higher than 12 volts the system would produce a feeble spark and could ignite the gasoline-air mixture in the cylinder under favorable conditions. If a battery was used to provide the electricity, the depletion rate was excessive since the points were closed more than they were open. By shaping the drive mechanism to modify the timing of the contact operator, the contacts could be left open for the larger part of the engine rotation. Then, near the end of the compression stroke, the contacts could be closed and opened, thereby conserving the battery energy.

With the invention and availability of small generators similar to those that were produced by The Kent Electric Manufacturing Company (described earlier) a higher voltage could be produced for the igniter to operate with. The generator was usually mounted on the engine with a belt to drive it, with its output wired directly to the igniter contacts. Because the points closed across the generator output, its windings had to tolerate the near-short circuit. Figure 9 shows the Atwater Kent's Igniter, a dynamo or generator built for stationary-engine service. An announcement in *Electrical World and Engineer* dates the availability of the Igniter to 1899.

> **KENDRICK & DAVIS.**—Mr. A. Kent, of Worcester, Mass., who was the manager and owner of the Kent Electric Company, manufacturers of the Kent motors, has moved his business to Lebanon, N. H., and will hereafter be associated with Kendrick & Davis, the latter having absorbed the Kent Electric Company. Kendrick & Davis have for years manufactured the well known Porter motors, one of the pioneer battery motors. The firm has extensive manufacturing facilities and operate their factory, the year around, by water power, being located on the Nashua River, at Lebanon, N. H., where water is abundant. This company, besides manufacturing battery fan motors of all kinds as well as small motors for various other purposes, manufacture voltmeters, ammeters, medical batteries, coils and many other electrical novelties. They are also soon to place on the market an entirely new gas engine igniter, which will embody many new features from any of those on the market at the present time. Mr. Kendrick states that they are shipping large quantities of goods to China, London, Paris and Cuba.

Figure 10. *Kent joins K&D, from Electrical World and Engineer, 1900.*

Although the illustration does not permit accurate analysis of the Igniter's construction, it appears to be very much like the No. 3 Dynamo mounted upside down. The field coil seems to be the topmost part of the Igniter in the illustration instead of being near the bottom as in the No. 3 Dynamo. The nameplate on the Igniter hid (and protected) the brush structure. The drive pulleys on both machines were on the side opposite the brushes.

The presence of the Igniter in the Kent Electric Manufacturing Company line of machines shows the expanding interests that Atwater Kent brought to his chosen field. With an expanding business based on customer acceptance of his products, his marketing analysis would have directed an increase in production capability. The foregoing review seems to indicate that The Kent Electric Manufacturing Company was an in-family business that would have required total restructuring to expand further.

KENDRICK and DAVIS

Figure 10 is a copy of an announcement in the *Electrical World and Engineer* for May 5, 1900. The announcement says several things of great interest to our look at Atwater Kent as a master-marketer. It says that Kent moved his business to Lebanon, NH. and that he will be associated with Kendrick and Davis. It further says that they absorbed Kent's business.

Kendrick and Davis were in the small electric motor business and no doubt benefited by getting Kent's designs, customers and, best of all, Kent himself. They announced that they made Porter motors and did not mention Kent's motors. The most startling part of the announcement is near the end when it says "They are also soon to place on the market an entirely new gas engine igniter, which will embody many new features from [sic] any of those on the market at the present time."

The result of Kent's marketing analysis was to involve another company. Whether this was the best outcome for his business is hard to

comes from a country life

Worcester May 25 1900
Dear Arthur
I at last got the book but it took some time, - his father had it locked up in his trunk.
I found one of those old motors, one of the first that was made to sell, - no projections on the bottom to fasten it to the base, I have got it to run very well and I would like to preserve it, but there is no suitable base here, it is a small one and the old bases here are too large, one a size smaller than the No. 3 would be right, do you have them there? if so, can't you send or bring one down?
P.J.K

Mr Arthur A Kent
Lebanon
N.Y.

Figure 11. *Prentiss Kent writes to his son, Atwater.*

ascertain with as little data as is available. Some personal feelings shared by Arthur and his family must have been part of the decision to change, because less than two years later Kent moved again. To provide a basis for evaluating Kent's home life Figure 11 reproduces a letter sent to him in Lebanon by his father in 1900. Each reader will make his own judgment of the closeness of the family. The fact that Arthur's father, Prentiss Kent, was saving and restoring one of their first motors is a strong indication of the Kent family values.

When Kent went to work for K&D, he brought his motor designs and his ideas. One of the motors was Amperia which Kent had not patented. As a result of being at K&D a patent was applied for and when issued was shared equally by Kent and the Company. The motor was altered slightly to eliminate the binding posts and marketed under a new name, the Electric Top (Figure 12).

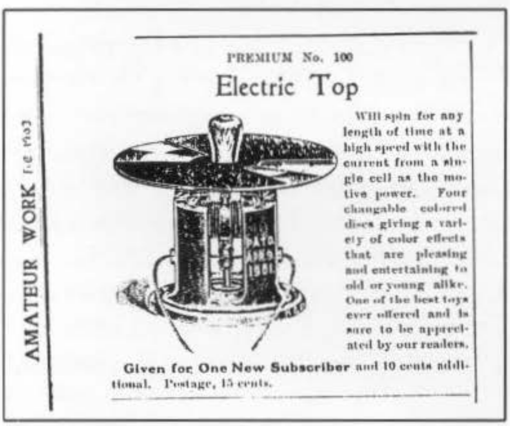


Figure 12. *The K&D Electric Top, 1900.*

PHILADELPHIA

Kendrick and Davis and Lebanon could not have held Atwater Kent's interest for long. He had sold his designs to them as a part of the expansion process and had joined the company to assure continued growth. They didn't appear to have his initiative or ambition so after getting the Igniter and the motors into production he moved on to customer cultivation and sales. Inside the bright ambitious young man there was also a budding executive who needed more challenge.

Kent looked at places where he could start another business. He had realized that the medium-size cities in New England did not suit his purpose. Boston, New York and Philadelphia were good choices for locating his new business, and of these Philadelphia was the best choice. It had a pool of technical skill, excellent educational facilities, competent labor, good transportation and easy access to materials, markets and manufacturing. In 1902 Kent started his new company, The Atwater Kent Manufacturing Works, in Philadelphia to continue making electrical products.

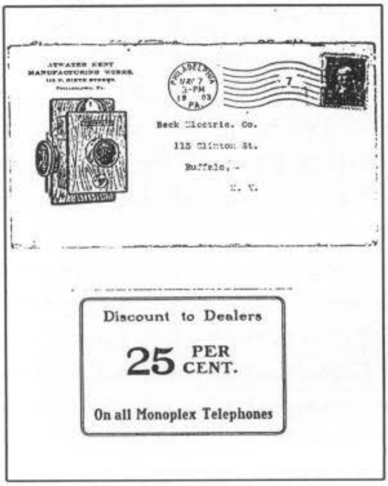


Figure 13. *The Monoplex telephone, illustrated on an AK Co. envelope, with dealer discount.*

The first product produced by the new company was a telephone for use in residences and businesses. One model is shown in Figure 13. Kent was ever mindful of the need to meet his customers' expectations, so for this product he coined the name "Monoplex." At its introduction the Monoplex was a basic telephone in an oak wall box, with a watchcase earphone, a carbon granule transmitter, a ringer, and a button to signal another similar instrument. In the initial system they were used in pairs to talk between two locations in a house, much like an inter-com is used today. Sales must have been satisfactory because extensions of the service using additional instruments were made available shortly after the Monoplex was introduced.

Monoplex Intercommunicating Telephones.

The Atwater-Kent Manufacturing Works, of Philadelphia, are bringing out intercommunicating instruments similar to their two-communicating system that would give equal satisfaction, led th concern soon after these instruments came out to give the matte their attention, with the present result. They made a careful stud of the requirements of systems for various uses and developed then by installing them in a large number of places that have give a severe test of their reliability and convenience. The "monoplex' instruments used on these systems are as simple as it is possible t make them.

The systems are designed so that they are simple to install, an the diagrams, as shown here, are plain and complete.

Their No. 2 system is an all-around intercommunicating an selective ringing system. The instruments are of the switchless typ so that they are perfectly automatic and need no adjustment in an way when the receiver is hung up. This instrument has many ad vantages, it is asserted, over the switch type. It saves consulting key to find the number of the station that one wishes to call, the

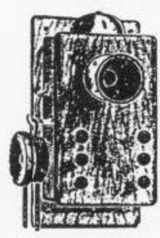


FIG. 1.—MONOPLEX TELEPHONE.

turning the switch to that point and pressing the button. Pressi the button beside the name of the station to be called is all th is necessary with the switchless type.

Another prominent feature is that it can be used for a finder to g a man immediately, no matter where he is in the building. Tl is done by a code of signals, which are rung on all of the bells

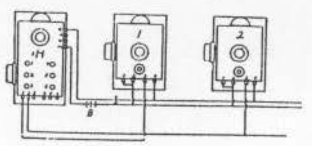


FIG. 2.—DIAGRAM OF CIRCUITS.

one time. The person then, on hearing his signal, goes to the nea telephone. The number of wires required on this system are th plus the number of instruments. Hence, a system of say five stati would require three plus five, or eight wires.

Only one central battery is needed for both ringing and talk circuit, and for the ordinary system, three dry cells or four wet c

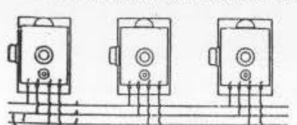


FIG. 3.—DIAGRAM OF CIRCUITS.

are sufficient. The impedance coil necessary with this system

Figure 14. *Trade literature description of the monoplex telephone.*

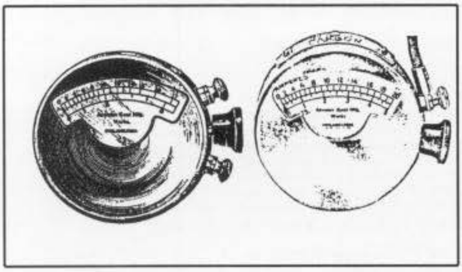


Figure 15. *Atwater Kent pocket volt-ammeters, 1903.*

System Number 2 introduced another form of the Monoplex, this instrument having not one but six signaling or calling buttons. Figure 14 shows the selective signaling Monoplex. Kent went on to offer further extended circuits to use his Monoplex telephones. They were announced and advertised in early 1903. Kent recognized the value of advertising, but he directed his messages to the trade rather than to the end user. He had not yet become aware of marketing (not selling) as a way of expanding his business. The apparent reason was that he was struggling to just establish a product line. He had left the small motor business with Kendrick and Davis. He tried the inter-phone line but it did not have great potential. He needed a new line and he found it in the automobile business.

KENT STRIKES A SPARK

Radio collectors may find it difficult to keep in mind (especially when the Monoplex telephone is considered) the fact that Atwater Kent was as interested in internal combustion engines as he was in electrical motors, and had been from his early teens. In 1898 he saw an opportunity to combine both interests and produced his Igniter, a fundamental internal-combustion engine auxiliary. In 1901 he acquired his first automobile and found out for himself the difficulties that came from discarding horses. After Kent established himself in Philadelphia he went to work on auto/electric devices in an effort to establish a new line.

In 1903 Atwater Kent introduced a voltmeter-ammeter for testing the batteries used with internal combustion engines in automobiles. Two of these instruments are shown in Figure 15. The push button on the side of the instrument switched the internal coils, to provide a voltmeter function with the button out and an ammeter function when the button was depressed. The movement of the voltmeter-ammeter was a simple moving vane whose deflection aligned with the resultant field generated by a fixed horseshoe magnet and the electromagnet produced by the current to be measured flowing through its coil. Several versions of the instrument were offered between 1903 and 1906. The left instrument in the figure came first. The two binding posts were for positive (marked C) and for return or ground (marked Z). The later version used a single binding post for ground and a serrated plate on the side of the instrument marked CARBON for the positive terminal.

This instrument could not be said to be an invention since there was prior art, but it could be classed as a patentable improvement. The advantages that it had over many other similar instruments was portability and ease of use. They must have been good sellers because their survival rate is moderate to high. Again no evidence of marketing analysis attaches to this product. Rather, it seems to repeat the story of the Monoplex telephone, a means of establishing a stable business, perhaps even a means of survival.

ELECTRICAL IGNITION

Igniting the fuel-air mixture in the cylinder of an internal combustion engine had been a problem for engine makers and users from the beginning of practical engines in the last quarter of the nineteenth century. On very early engines a hot tube that had a port directly into the cylinder was used but a direct electric spark was found to work much more effectively. The ignition took place by the simple opening of a contact located inside the cylinder and connected across a battery. Because the spark had to expend significant energy to assure igniting the compressed fuel mixture, reliable ignition could not be achieved by the low voltage spark. This difficulty led to the igniter, a higher voltage source that provided more energy in the spark discharge. Although the igniter was better, it was still limited in spark energy.

By 1903 one solution that was satisfactory (and with maintenance was reliable) was the vibrator-excited spark coil. This was a transformer whose primary was connected through a set of timer points and a vibrating contact to a battery. The points were operated by the cam shaft of the engine so that as the piston neared top-dead-center on the compression stroke the points closed. The vibrator then chopped the battery current through the primary of the coil and induced a high voltage in the secondary. The high voltage was connected directly to a spark plug and produced a series of sparks when the points closed and the vibrator buzzed.

The usual system had one spark coil for each cylinder. Distributing the low tension energy from several sets of points in a shaft-connected timer was much more reliable than distributing the high tension from one coil. But two problems were characteristic of the vibrator-coil system. At low engine speeds the multiple sparks produced by the vibrator wasted valuable battery energy. At high engine speeds the time lag of generating a spark resulted in late firing and reduced available power. The advantage of using a single coil with high-tension distribution was known but that

Mechanical Sparker for Gas Engines.

The accompanying illustrations show a new type of spark generators for gas engines, which does away with the usual commutator and magnetic vibrator. In the mechanical vibrato

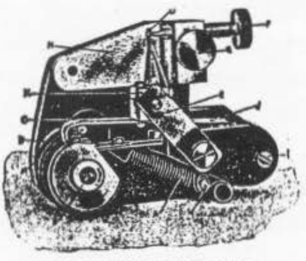


FIG. I.—MECHANICAL VIBRATOR.

(Fig. 1), which is the principal feature of the generator, there are two platinum contacts, one at *D* and the other on the end of the screw *F*.

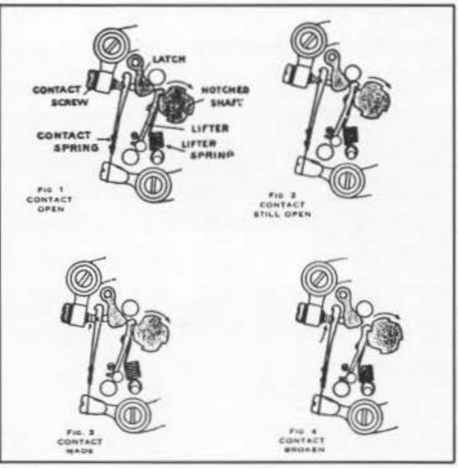


Figure 16. *The patented Kent Electrical Contact Device for gasoline engines.*

Figure 17. *Operation of the electrical contact device.*

method had not been reduced to reliable practice in 1905. Operating the coil by using the points in the timer to break the current was neither practical nor reliable.

THE UNISPARKER

Atwater Kent understood the single coil method of spark ignition. He set about solving the problems of the multiple sparks and the variable time of ignition. His work resulted in the Electric Contact Device shown in Figure 16. The sketch in Figure 17 shows the critical elements of the device. The action is based on the lifter which is pulled away from its rest position by the projections or teeth on the notched shaft. When a tooth on the shaft rotates far enough, the lifter is released and is pulled back toward its rest position by the lifter spring (second sketch). As the lifter travels back it is lifted up onto the tooth and away from its rest position (third sketch). The moving lifter pushes on the latch, which pushes the contact spring, which moves the contact on its upper side and closes the circuit. Further motion of the lifter separates it from the latch, which through the contact spring lets the contact open. The cycle ends when the last motion of the lifter and a few more degrees of rotation of the shaft permit the hooked tip of the lifter to drop into the space behind the tooth on the shaft, with the lifter returned to its rest position (fourth sketch). The lifter remains quiet until the next tooth engages its tip, at which time the cycle repeats.

Kent's contact device was connected between the battery and the primary of a transformer (ignition coil). The contact mechanism was mounted

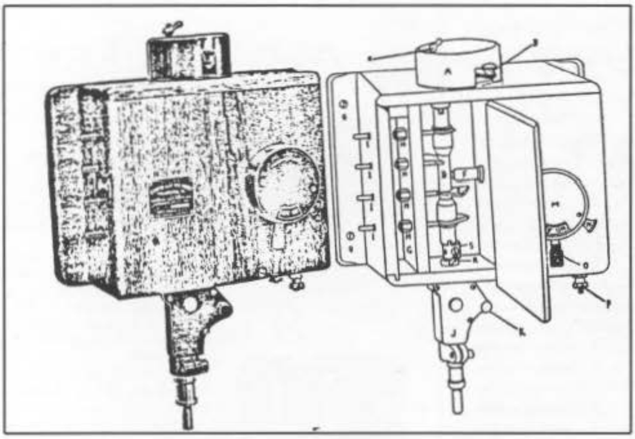


Figure 18. *The Kent Unisparker automobile ignition system, 1906.*

on an engine so as to engage the cam shaft and to be adjustable in angular position. Internal adjustments on the device controlled the contacts so that the time of closing and duration of current flow were adjusted to precisely what the engine required. The duration of contact closure was controlled by the rate of motion of the lifter actuated by the spring, and was not a function of the engine speed. That meant that the spark energy was delivered in single pulses that were not influenced by the sparking rate.

The contact device was a true invention. Kent applied for a patent in 1905 and was granted his patent in 1915. Because of the importance of the device in the automobile industry, there must have been many difficulties in establishing its claims. The patent was the basis of Kent's participation as a major factor in the automobile business and was the source of his first fortune.

As with the success of the name Monoplex for his telephone, Kent coined a name for the ignition system that incorporated his contact device. It was UNISPARKER. The first embodiment of the whole system was produced in 1906. It is pictured in Figure 18. The door covers the high-tension distributor. The contact device is shown on top. The entire unit was fastened to the dashboard of an automobile with the wires for the spark plugs fed forward through holes in the dash. The angle drive was used to connect the Unisparker to the cam shaft of the engine.

Atwater Kent built his ignition business over the period that his patent ran. He supplied equipment to original manufacturers listed in Figure 19 and made his systems available to retrofit automobiles like the Packard as well. Some examples of his products are shown in Figure 20. Several coils mounted in oak boxes along with a Unisparker distributor and a switch that was used with them are shown. In Figure 21, a Ford retrofit with its original box and its later distributor are shown.

Atwater Kent Type K-2 Ignition System is used as Standard Equipment on the Cars Listed Below

NAME OF CAR	YEAR	MODEL	TYPE OF ATWATER KENT IGNITION USED
Arbenz	1915	25	4 cyl. K-2 standard coupling
Chalmers	1914-15-16	26-30-32 B	6 cyl. K-2 standard coupling
Enger	1915-16	Six	6 cyl. K-2 standard coupling
Enger	1916	Twelve	12 cyl. K-2 standard coupling
Fischer	1914		4 cyl. K-2 standard coupling
Flagler	1914	Four	4 cyl. K-2 standard coupling
Franklin	1916-17-18	Series 9	6 cyl. K-2 male shaft
Grant	1914	Four	4 cyl. K-2 on magneto base
Grant	1914	Four	4 cyl. K-2 standard coupling
Grant	1915-16	Six	6 cyl. K-2 standard coupling
Hall Motor	1914		4 cyl. K-2 standard coupling
Harvard	1917-18	Four	4 cyl. K-2 standard coupling
Hollier	1916-17-18	Eight	8 cyl. K-2 standard coupling
Homer Laughlin	1918	Eight	8 cyl. K-2 standard coupling
Howard	Late 1915	Six	6 cyl. K-2 standard coupling
Hupmobile	1915-16	Four	4 cyl. K-2 standard coupling
Imperial	1914-15	Four & Six	4 & 6 cyl. K-2 standard coupl'g
King	1914	Four	4 cyl. K-2 on magneto base
King	1915	Four	4 cyl. K-2 male shaft
King	1915	Eight	8 cyl. K-2 male shaft
King	1916-17	Eight	8 cyl. K-2 standard coupling
Lexington	1914-15-16	Four	4 cyl. K-2 on magneto base
Los Angeles	1914	Four	4 cyl. K-2 standard coupling
Majestic	1917	Six	6 cyl. K-2 standard coupling
Meteor	1916	Six	6 cyl. K-2 standard coupling
Monarch	1914-15-16	Six	6 cyl. K-2 long male shaft
New Era (Elgin)	1916-17	Four	4 cyl. K-2 standard coupling
Norwalk	1916-17	Six	6 cyl. K-2 standard coupling
Paige	1914-15		4 cyl. K-2 standard coupling
Peerless	1915	Four	4 cyl. K-2 standard coupling
Peerless	1916	Six	6 cyl. K-2 standard coupling
Peerless	1917	Eight	8 cyl. K-2 standard coupling
Pratt	1915	6-50	6 cyl. K-2 standard coupling
Regal	1914-15	Four	4 cyl. K-2 long male shaft
Regal	1916-17	Eight	8 cyl. K-2 long male shaft
Remington	1916	Four	4 cyl. K-2 standard coupling
Ross	1915-16-17	A-B-C	8 cyl. K-2 standard coupling
Saxon	1914-15	A-B	4 cyl. K-2 standard coupling
Saxon	1915-16	Six	6 cyl. K-2 standard coupling
Saxon	1916	Four	4 cyl. K-2 standard coupling
Scripps-Booth	1915	Four	4 cyl. K-2 standard coupling
Thomas	1915	Six	6 cyl. K-2 standard coupling
Vixon	1915	Four	4 cyl. K-2 standard coupling
Westcott	1914	Four	4 cyl. K-2 standard coupling
Woods	1915	Four	4 cyl. K-2 standard coupling
Woods	1916-17-18	Four	4 cyl. K-2 on magneto base

Figure 19. *Users of the K-2 ignition system.*

ATWATER KENT

Fig. 13
Plate Switch Coil
Price $10.75

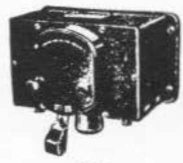


Fig. 14
Kick Switch Coil
Price $12.75

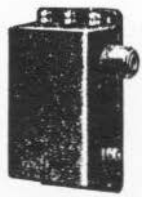


Fig. 15
Underhood Coil
Price $9.50

Fig. 16
Contact Reversing Ignition Switch
Price $3.25

Coil

The Atwater Kent coil is furnished in three different forms, any of which can be used with either Type "H" or "K-2" Unisparker. Plate Switch coil is made only for 6 volt circuit. Kick Switch coil and Underhood type are made for either 6 or 12 volt circuits. The designated voltage is marked on the bottom edge of each coil.

Fig. 13 shows the coil with simple Plate Switch, Fig. 14 the same coil with the addition of a more elaborate and heavier Kick Switch, Fig. 15 Underhood coil with separate switch. Both Plate and Kick Switches are provided with push button for producing extra hot starting sparks.

The Underhood coil is the one commonly used by manufacturers as regular equipment. It is intended to be mounted under the hood of the car, and while it is built to stand the high temperatures incidental to this location, it should be placed in as cool a position as possible.

Switch

The Atwater Kent Ignition Switch is arranged to reverse the direction of the current flowing through the contact points each time it is turned "on," thus minimizing any tendency of the contact points to pit or build up unevenly.

The Atwater Kent Switch is installed by cutting a hole $3\frac{1}{16}$" in diameter in the dash and setting in switch flush, fastening it with the three flat-headed screws furnished with the switch.

Figure 20. *Kent automotive ignition coils and switch.*

In doing the research and the reviews to elicit findings that paint a picture of Atwater Kent, one pauses because so much of the information is favorable. Perhaps the author's bias outweighs the facts. One important event removes much subjectivity and permits open admiration for the man. That event was the Award by the City of Philadelphia, on the recommendation of the Franklin Institute, of the John Scott Medal -"to the Most Deserving" - to Arthur Atwater Kent in 1914 for the Unisparker, Figure 22.

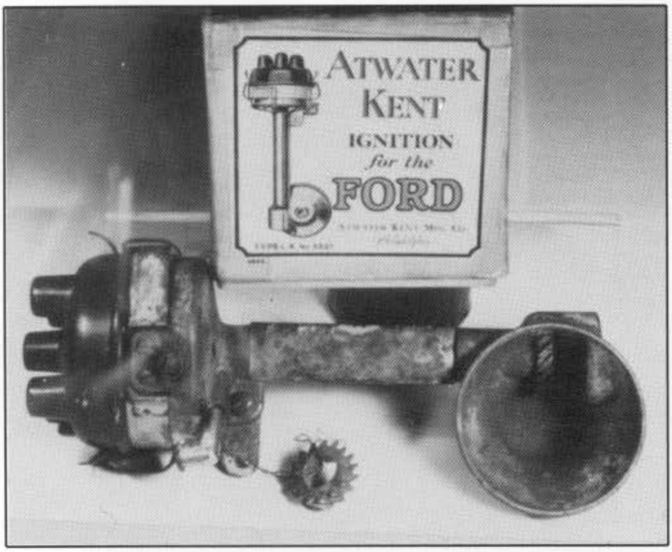


Figure 21. *A retrofit ignition system for a Ford.*

EXPANSION

One other product which reinforces the idea that Kent looked over a wide range of automotive products to find a profitable line is the horn shown in Figure 23, and the first sheet of the patent for it, Figure 24. Until experience had proven the superiority of his precisely-timed ignition system, he had to devote a lot of his attention to devising products that would keep him in business. After the ignition-product line was established and the licensing of his patent was accepted as a resource by the automobile manufacturers, he could spend his time improving his business efficiency and his customer relations.

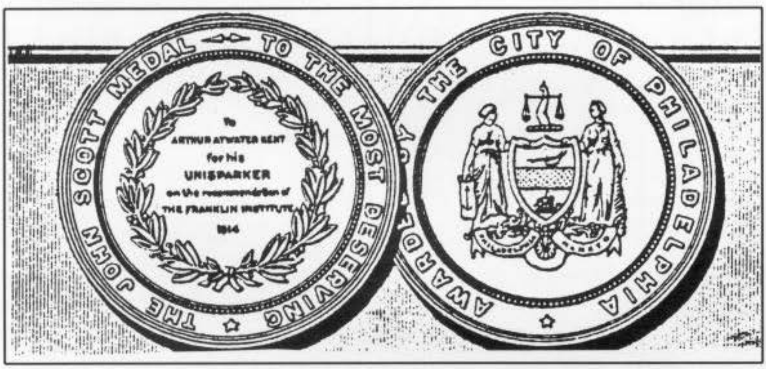


Figure 22. *The Philadelphia John Scott Legacy Medal given to Atwater Kent, 1914.*

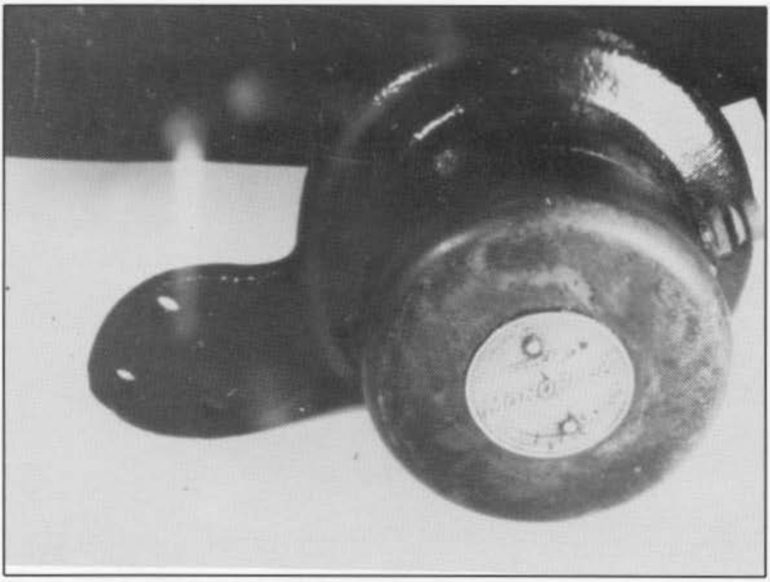


Figure 23. *The Kent Company Monoplex horn.*

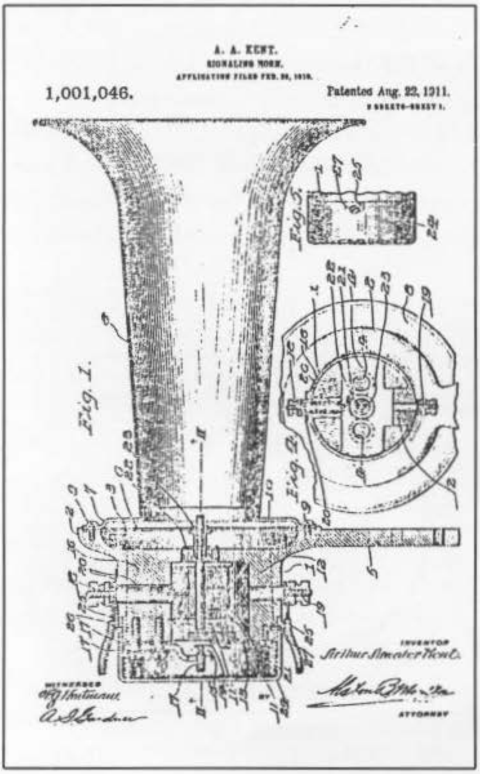


Figure 24. *The Patent for the Monoplex horn, issued 1911.*

Not all automobiles were equipped with full electrical systems. Kent realized that he could expand his ignition business into lighting, battery charging and starting. He was familiar with the concepts involved so the expansion was to add manufacturing capability and where necessary, licensing. By World War I he had established a full auto-electrical capability for supply and service. His customers were predominantly end-users instead of other manufacturers.

One important way Kent enhanced his company reputation was by assuring satisfactory operation of his products by the end-users. He established Atwater Kent Official Repair Stations across the United States and Canada. In 1919, there were 117 stations in the US and six more in Canada. Kent issued descriptive brochures for his products and made sure that they appealed to his customers by their appearance and by their quality of explanation. The experience that was to serve so well when he produced radios was initiated in this phase of his automobile business. Kent's marketing ability is demonstrated by his recognition of end-users as his customer base and by the modification of his factory to produce what they wanted to buy. To identify him at this point in his business career as a master-marketer is premature. To suggest that he had the potential to earn that title is perhaps an underestimation.

WORLD WAR I

When World War I drew the United States into the conflict, Atwater Kent had an active factory making electrical equipment for automobiles. The equipment was adapted to trucks for the military but more production for the war effort was needed. Kent was asked to design and manufacture some support equipment for gun-control.

One product that he made was the clinometer, pictured in Figure 25. It was similar in principle to a sextant but was simpler and less difficult to use. It was used for two functions. One was setting the elevation of a rifle using the bubble level and the elevation scale of the instrument. The other was determining the elevation angle of a distant hill by aiming the crosshair in the barrel at the hill and adjusting the bubble to level. The elevation was then read off the scale.

Another product that Kent produced was the theodolite, shown in Figure 26. It was used by gunners to determine both elevation and azimuth angles and to train weapons. The instrument was clamped to a platform and leveled. The pertinent readings could be made directly from scales in the instrument. Another device called the fuse-setter was produced for the military. It was a set of movable rings that engaged adjusters on the nose of a shell thereby permitting the gunner to set the time-to-go or altitude of detonation immediately prior to loading the shell.

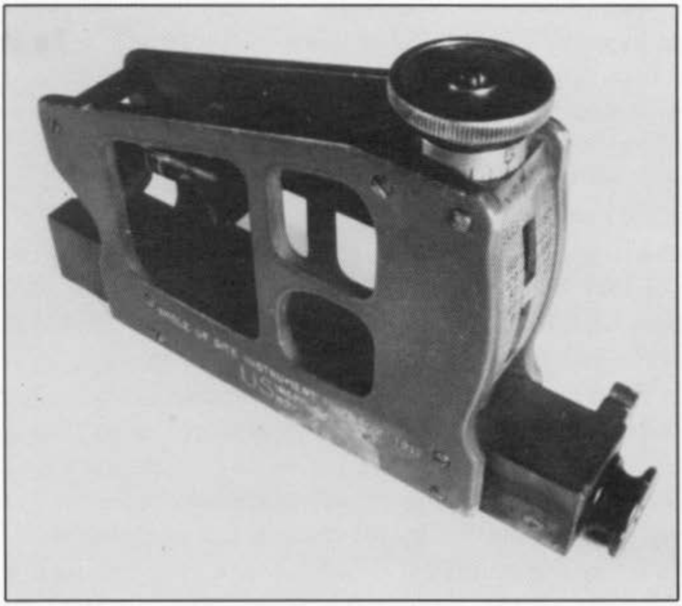


Figure 25. *The AK clinometer used by the military during WWI.*

With the end of WW 1, Atwater Kent's military support terminated. He had expanded his factory to accommodate the production of military instruments and he had continued production of auxiliary electrical equipment for use in military vehicles. Kent returned to the civilian automobile market with complete electrical systems for many makes of cars. His capacity was greater than his reduced market could absorb, and worse, the market was not subject to major expansion. Many of the earlier marques had disappeared and others were consolidating. Kent needed new products and cast about for effective use of his facilities. He needed a new direction for his factory.

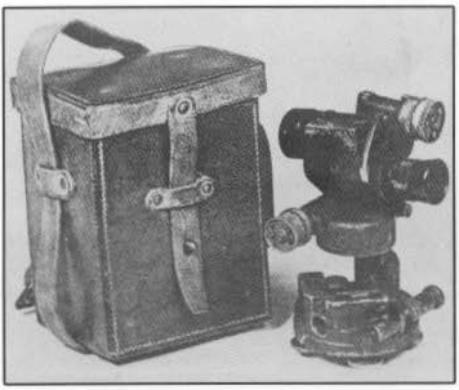


Figure 26. *The AK theodolite used by the military.*

THE BEGINNING OF RADIO PRODUCTION

The year 1919 saw the opening of a new field of national interest. Wireless had provided the knowledge and interest in a means of transferring knowledge beyond the imaginations of ordinary folks. Amateurs and returned military operators stirred the interest of the public in those invisible, inaudible disturbances of the ether. 1920 saw that interest turn into a new concept, public entertainment. In 1921 Kent joined this new excitement called Radio. It looked like the near-ideal market for his kind of product.

A marketing review might have gone like this: A new electrical market seems to be developing. Marine and military uses of radio have established a number of communications stations and an unofficial but interested body of listeners. Some experimenters and amateurs are showing that radio can serve a bigger purpose, informing and entertaining the general public. If the experimenters are right, a large market for general use radios could develop.

The second part of the Kent's marketing review might have considered his capability to enter such a market. He had the production facilities for electrical devices. His factory had experience in winding condensers and coils, his engineering staff was skilled with high-voltage devices and were very familiar with insulation suitable for making motors and ignition apparatus. His mechanical facility included the capabilities of forming small, high-quality, sheet metal containers, of casting superb phenolic (Bakelite) structural and appearance shapes, and of making and finishing the small boxes used for ignition equipment.

By 1920 several radio manufacturers had entered the developing market. Examples are Grebe, Kennedy and Westinghouse. Their initial offerings were reapplied military production. Then, after the Radio Corporation and its owners, General Electric, Westinghouse and American Tel. & Tel. entered the domestic market, the new opportunity became very apparent to potential manufacturers all over the country.

Kent would have put aside all doubts.

More importantly, Kent had a nationwide network of auto-electric dealers and a reputation for producing very fine equipment. Because some of his electrical systems were retrofitted to the automobiles of individual owners, his service organization was experienced in satisfying his direct users, who would become his radio set buyers. Altogether, he was in an optimum position to sample the new market without having to invest heavily in new facilities and without having to start at the beginning in merchandising a new product line.

To follow what seems to be the trail of new radio parts offered to potential Kent customers, we are going to assume that Kent's factory, particularly his engineering record-keeping function, followed standard practice. This means that Drawing Numbers were assigned as new parts and pieces were committed for design, specification, and manufacture or purchase. Each new part received a unique number which was abandoned if the part was not to be added to the production process. Using the part numbers the order of the appearance of different parts can be determined quite accurately, and even more pointedly, the time of introduction and initial use of the part can be established.

When Atwater Kent introduced the Open Sets (breadboards), what was he doing? Interested collectors have come up with several explanations, some of which are: "He was simply following a standard experimental practice," and "He had earlier produced table instruments and had to use them up," or "He liked that style of radio construction and pushed it onto the market." These explanations are valid but they are incomplete. For example, consider the first one, experimental use.

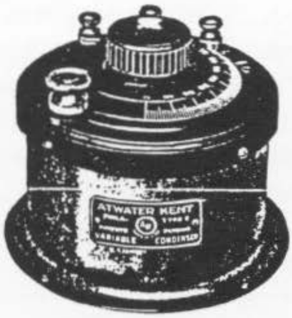
Up to the time of micro-electronic implementation of radio circuitry (almost today), engineers have used breadboards to build and try their first circuit configurations. Now the computer has become the breadboard and on-screen graphics have replaced the physical attachment of parts. But, Atwater Kent's engineers would have used the breadboard technique to evaluate his initial line of instruments in actual circuits.

Evidence of the use of breadboards to support product evaluation may be found in several ways. Figure 27 shows the earliest tuning condenser, No. 4117, which was built with a circular base for mounting on a horizontal, flat, circuit board. The first mounting board has a much earlier number. It was No. 3601, and was 18 ½" by 8 ½". Almost all the other early instruments have similar base-mounting arrangements. With so many clues pointing toward production using the horizontal board style, the simple explanation of experimental use doesn't explain the breadth of its application.

The second explanation of having the instruments in the table-mounting configuration and pushing them off to the public, is more an effect than a cause. Why did he have so many instruments of this style? Perhaps the reason is to be found in a standard style of construction used at the beginning of entertainment radio. There, the tuning instruments and rheostats were mounted on a vertical panel and the transformers and tube sockets were mounted on a horizontal shelf that was fastened to the bottom edge of the panel. Kent produced the instruments for horizontal mounting because that was the early standard and he made a lot of them because they were popular and sold well.

ATWATER KENT

Variable Condensers



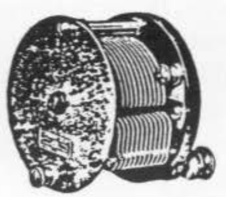
No. 4117. TABLE MOUNTING, TOP CONTROL . . $8.00

THE ATWATER KENT VARIABLE CONDENSER has been designed for the purpose of obtaining the greatest possible degree of accuracy in tuning, which is of vital importance in broadcast reception.

The remarkable degree of precision in adjustment of this condenser is obtained through the extreme smoothness of operation together with a friction type of Vernier. An accurately ground steel shaft and self-aligning bronze cone bearings are used.

The workmanship and material throughout is of the highest possible grade. It is ruggedly built to give permanent satisfaction. Electrical losses have been reduced to a minimum.

No. 4270
TABLE MOUNTING, FRONT CONTROL, $8.00



No. 4165
PANEL MOUNTING, $7.00

Figure 27. *Data sheet showing the earliest AK radio tuning condenser, the No. 4117.*

THE OPEN SETS

Ascribing to Kent the perception that the Open Sets were the style of the future in 1921, when he first started designing radio instruments for production, seems inconsistent with his being a manufacturer of great marketing skill. The first approaches to the new market do not show a great burst of creativity. The table-mount variable condenser does not differ enough from the Murdock condenser to justify describing it as an innovation. The Type F low-boy audio transformer No. 3509 was similar to others, differing only in the orientation of the core, horizontal instead of vertical. He also produced some early instruments that were used only for panel mounting. These are the panel-mount tuning condenser No. 4164, the rheostat No. 3530 and the potentiometer No. 4095.

A better explanation would be that he initiated manufacture of instruments of both styles so as to capture shares of both markets. The early inductive instruments tell an interesting story of aiming at both styles. The first variometer was No. 3488. It was described as "unmounted," meaning no dress panel. The mounted variometer was No. 3822 brown or No. 3824, black. The more than three-hundred number difference in the part numbers indicates an early application to panel construction and a later use on breadboards where the dress panel provided the background for the dial. This is another indication that Kent looked at both styles.

Less than a year later the first assembled radio device was produced. It was a panel and box assembly containing a detector and two stages of audio amplification. It was No. 3590, introduced on May 26, 1922. Note that its number, and that of the panel-mounted rheostat and the two audio transformers are in the earliest radio part number series. Since there were no more assemblies of that style and no more panel instruments, it appears that Kent had chosen the Open Set style as being his best market opportunity. The indicated approach to both construction styles is a strong reason to believe that Atwater Kent showed the sensitivity to his market that is a characteristic of an expert.

Even if the discussion above points to Kent's decision to go with the Open Sets, the larger question is: Why did Kent continue producing breadboards for three years? During an interview with Atwater Kent, Jr. the subject of his father's preferences came up, and we learned that the Open Sets were definitely Kent's favorite. Possibly, the reason was prescience, but another explanation is that they were very profitable and therefore allowed him to move away from the ignition and auto-electrical business. This was necessary because his 1907 ignition system patent would run out in 1924.

THE "THREE-DIALERS"

When the entire line of Open Sets is analyzed for circuit development and mechanical configuration, some findings stand out as important marketing decisions. At the time that Kent started assembling complete radios (the 3900 series in late 1922), he might have arranged to get a license for regeneration but he didn't. One of the reasons might have been that Kent had some kind of self-image that kept him from accepting someone else's work. This is not likely since he knew the value of the ignition patents and had benefited greatly from them. Another reason might have been that he couldn't obtain a license from Armstrong. This may well be true, but if he had another way to go the reason is moot. Still another and perhaps very likely reason might have been that he had to see a pay-back for the investment in license fees and that was unlikely unless he wanted to make regenerators his main radio product.

The radios in the 3900 series were detector-amplifier receivers, not regenerators. They were not good home companions because their audio output was too small to properly drive a loud speaker. The benefit of regeneration was that it would increase the overall amplification enough for speaker operation, but that feature was accompanied by an unwelcome characteristic in the receiver. Unless it was very carefully controlled by the user, the regenerator spilled over and became an oscillator. Interference in the neighborhood was not a good sales feature.

Kent's market analysis made it clear that the overall amplification of his receivers had to increase. Even though his customers wanted loudspeaker operation, he would not go to regeneration. However, he did make the variometer available for those who wanted more overall amplification and were willing to accept the liability of spillover with sets in the 3900 series.

Kent's way around the limited output problem was to increase the number of tubes and to use radio-frequency amplifiers to build up the signal level at the detector. In this approach, we see the picture of a marketing person controlling manufacturing so as to secure an overall increase in business growth. Looking back and noting how the radio field expanded, we see that Kent was right in going to five-tube receivers, and he was also right in avoiding regenerators. Whether this choice came because of his marketing acumen or from bending in the face of the inevitable must remain undetermined until more factual evidence is uncovered by radio historians. Taken with the other situations discussed in this article, the suggestion is strong that Atwater Kent was an acute marketing man.

When Atwater Kent produced his first five-tube receiver, No. 4066, tuned-radio-frequency amplification had not yet come into general use. He had his engineering staff devise fix-tuned radio-frequency transformers, Part Nos. 3802 & 3972, to be used in the 4000 series. The fix-tuned r-f transformers of the 4000 series did nearly nothing to discriminate against an adjacent channel. They were designed to be quite broad (low Q) and were tuned to make the radio-frequency amplification of the receiver relatively non-selective. The set, when it was introduced in January of 1923, was satisfactory because there were only two frequencies in use and they were nearly 100 kilocycles apart.

The Department of Commerce changed the situation later in the same year when it redefined the broadcast band and assigned channels ten kilocycles per second (kHz) apart. Because of the 10-kHz channel spacing, the capability to discriminate became more important than sensitivity or enough power for the loud speaker. The single tuner of the 3900 and 4000 series did little to eliminate interference from adjacent stations because its purpose was to adjust the antenna impedance to the input amplifier. The radios in Atwater Kent's first two series became obsolete.

However, they were still usable in some situations. For a listener in a small city there was usually only one station and consequently interference didn't exist. Stations in big cities were assigned with five-channel spacing (50 kHz) so local interference was tolerable.

But in the winter time, when stations from great distances came in almost as well as local stations, the problem with adjacent channels grew severe.

The solution for the adjacent channel discrimination problem was the "three-dialer." Atwater Kent produced his first three-dialer, No. 4340, in September of 1923. In keeping with Kent's awareness of the value of a name, it was initially identified as the RADIODYNE and shortly afterward as the Model 10. The rate at which the Kent factory updated its production is staggering, especially when the parts ordering and assembly modifications are considered. From the release of the Model 1, No. 3925 to the release of the Model 10, No. 4340, less than eleven months had elapsed. This sequence shows how strongly the market drove production. The production rate of the Model 10 is another significant indicator of the demand Kent's customers made on the factory. It exceeded three thousand sets per month, more than 150 breadboards per day. All of Kent's experience was necessary to reach that rate. Not only did he have to be a market analyst, but he had to be a production planner, a factory manager, a dealer negotiator, a transportation specialist and a banker. The experience of the ignition days and the demands of the military in WW 1 served him well. He did not hesitate to put the best talent on his staff, whether they were technical, commercial, production or sales. Among other qualities, he was an excellent executive. The increasing growth of his business, its customer base and its manufacturing capability is another cogent reason to recognize Atwater Kent as a master marketer.

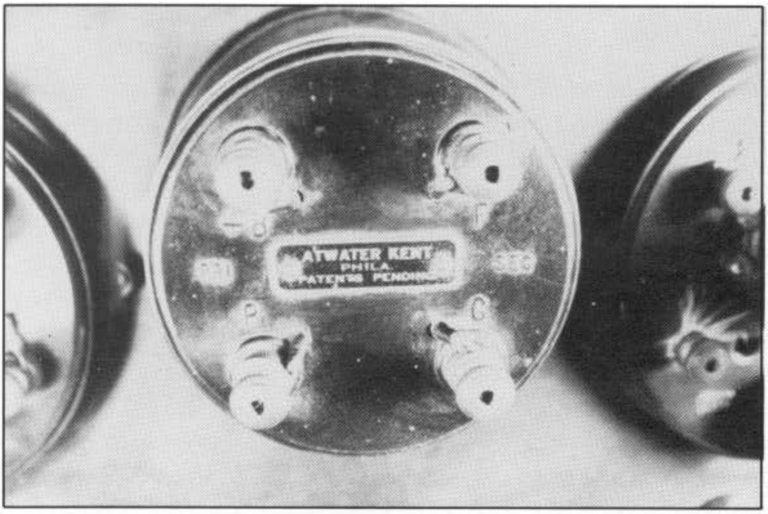


Figure 28. *The interim nameplate on the Radiodyne coil.*

RADIODYNE

When Western Coil Company of Racine, Wisconsin, notified Atwater Kent about their priority of the name Radiodyne, Atwater Kent immediately stopped shipping radios with that name on the coil (r-f transformer) nameplates. It is interesting to contemplate how long it was before he shipped the first set with new nameplates. The date of the change is not known but it might have been in November of 1923. This would have been the time when the dealers were getting ready for the holiday season with a radio set that was a best seller. To cut off the supply would have been almost unthinkable, certainly intolerable.

Kent's action was very direct. Neither circuit nor assembly had to be changed. All that the new set needed was a new nameplate for the coils on which "Model 10" was substituted for "Radiodyne". To do his, the original artwork had to be cut, pasted and re-photographed for new etching masks. The new plates had to be etched, polished and painted and then attached to the coils. It is interesting to guess how long all of this would have taken: A week? Two days? One shift? The way Kent ran his factory suggests the last estimate.

But what happened meanwhile? Kent had someone go back into the stockroom where the surplus nameplates that had been used on tube sockets, potentiometers and tuners were kept. Enough of those old nameplates were retrieved to complete all the coils that were no longer to be part of the Radiodyne. Those nameplates made it possible to continue uninterrupted production until the first Model 10 was assembled. Figure 28 shows one of the coils on the interim set.

THE BOX SETS

Atwater Kent would have liked to continue production of the Open Sets but his marketing awareness signaled a change. Customer response to the open sets was less enthusiastic than it had been. Why? One reason was that their style, a very esoteric look, was no longer greatly appealing. Another reason was that, in many homes, radio sets had become part of the general furniture and the Open Set did not conform to the more traditional styles that were familiar to Kent's potential customers. A third reason was the impracticality of dusting and cleaning the exposed instruments on the Open Set and the attendant risk of damaging the tubes. Kent realized that he had to go to enclosed (box) sets. Here again, the marketing function ties the customer to the producer, this time affecting parts of the factory.

The differences, from the manufacturing standpoint, between the Model 20 (the first box set, No. 4640) and the Model 10C (the last Open Set, No. 4700) were extensive. First, there was the box with its hinged cover, which substantially expanded the wood-fabrication part of the factory from what was necessary to build boards for the Open Sets. Then there was a new function, the stamping, welding and painting of the front panel and its attached chassis. This expanded the metal processing shop but did not require any new fabrication techniques. Finally, there was a necessary repackaging of all the components. While the functions and internal materials of the piece-parts did not change, components like the tuning condensers and the audio transformers were given new external forms.

For the new sets, the electrical circuits did not change. However, the mechanical repackaging did alter the electrical performance of the radio. The different couplings between coils and the new, unshielded tuning condensers required some electrical engineering to assure the dependable performance that characterized the Open Sets. The pressure to get ready to release the Model 20 in April of 1924 must have been very high, especially with the factory still in full production on Model 10C.

The first few Model 20 radios were not the same as subsequent sets. They looked the same, and to the listener, performed the same. The differences were two: One was that the coils were larger than the standard coils of the 20 series. The other was that the nameplate on the inside of the lid was the one that had been used on the Model 5. An explanation for the larger coils is that Kent foresaw the next model series as smaller in physical size and, in the not-too-distant future, the single-dial receiver. To meet those future needs, new coils had to be designed, coils that were smaller in physical size and more uniform in their electrical characteristics.

The redesign of the coils did not get done in time to meet the release date for Model 20, so special coils were fabricated in the model-shop and installed in the first sets. The coils were the same size as the ones used on

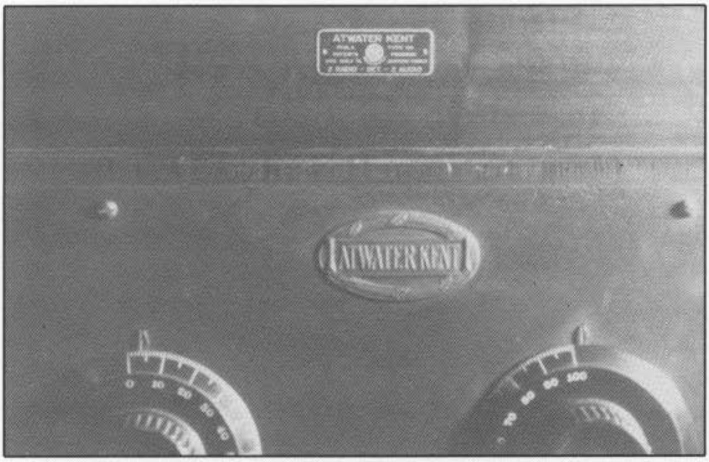


Figure 29. *The obsolete Model 5 nameplate on the transition Model 20.*

the Model 10, but were different because they used treated cardboard forms instead of the bakelite castings used on the breadboards.

Kent felt that the sets with the non-production coils had to be identified separately. Therefore, instead of etching a nameplate different from those already in hand, he used the obsolete Model 5 plate shown in Figure 29. The customer would not have been bothered by the substitution. The normal business functions such as shipping, billing and warranty service functions were able to properly handle the set because it was adequately identified.

THE COMPACT MODEL 20

Kent's continuing analysis of the radio business in 1924, and the expected market of 1925, indicated that table model sets had to get smaller. This finding was in accord with his own views even though his reasons were different from those of his customers. The customers no longer wanted large, showy table models because the novelty and status of having a radio had diminished. A radio had became a customary part of American life. Now the old-fashioned large table-model receiver was taking space away from the decorative household items preferred by the homemaker.

Kent's response was the Model 20 Compact, No. 7570. From the factory's standpoint the changes to produce it were small. The set was only the big Model 20 reduced in physical volume by removing the unused, empty space inside the cabinet. The parts and the circuit were identical in the two sets. Later the bias scheme in the Compact was changed to enable higher loudspeaker output. From the customers' viewpoint the set was very popular, and Kent had hit the market correctly again. Production of the Compact Model 20 exceeded 750 sets a day and continued for two years.

Consoles had come on the scene to fill the need for big showy receivers, but Atwater Kent did not want to get into the furniture business. He resisted making consoles, or even having them made for him. But he knew there was a customer base for the larger sets. To meet the demand for consoles, he arranged with furniture manufacturers to provide the receiver that would be sold as part of the console radio by the furniture company.

Two examples of the arrangement are Pooley and Red Lion, both Philadelphia companies.

During an early interview with Atwater Kent Jr., he told us that his father liked the solid mahogany woodwork of the Open Sets and the cabinets that characterized the 20 and the 30 series. He said, further, that Kent rejected the use of plywood and veneer as cabinet materials.

In the arrangement Kent made with these furniture makers to sell his radios in their cabinets, we see the marketing function of relating the customer requirements to the production capability fulfilled in another way. Here the production part of the requirement is not met by altering the factory but by supplementing it with a contracted, not capitalized, service. It should be noted that even when a console was made by a different company, the Atwater Kent identification was retained. This was especially apparent in the advertising. The furniture supplier benefited greatly by the use of the Atwater Kent name.

THE R & S POWER SUPPLIES

Until about 1926 most home radios were powered from batteries. The energy to heat the filaments on sets like those three-dialers that Atwater Kent sold came from a 6-volt wet cell called the "A" battery. Providing the plate voltages required with 201A tubes was the function of the "B" battery. This was usually a block of 1½ volt cells connected in series to supply output voltages from 22½ volts to 135 volts. Batteries were not big favorites with the homemakers of the time.

The wet cells of the A-battery were dirty, exuded acid fumes, and had to be recharged as often as weekly. Their operating cost was between one and two cents per hour. B-batteries were cleaner but the cost of their use (replacement after depletion) was high. The B battery cost more than five times as much as the A-battery; as much as ten cents per hour to operate a three-dialer with the speaker at moderate volume.

In homes where electric power was available for lighting and utilities the set user could recharge his A-battery conveniently and cheaply with a simple charger. The dry-cell B-batteries remained the big expense of radio operation because they could not be recharged. This resulted in a big market for "B Eliminators." These were devices that converted line power, usually supplied as 110V. A.C., into the voltages and currents usually obtained from the B-batteries.

Atwater Kent produced two B-battery eliminators, Type R, No. 8800 for 60 -cycle A.C. and Type S, No. 9000 for 25-cycle A.C. service. The part numbers indicate they were designed about the same time as the Model 30 radio, possibly as early as the end of 1925. In terms of the potential market for B-eliminators they were late. Both the 10- and the 20 series needed them. Why were they late? Were there some marketing considerations that explain the late introduction or was there a technical problem?

One very interesting early technical limitation concerns the rectifier that had to be incorporated in a B-eliminator. The hot-filament rectifier designed for receiver service, the Type 213, was made available by RCA in 1925. Before then, cold-gas rectifiers such as the Raytheon B were tried. Kent did extensive experimental work on his own tube, an argon-discharge rectifier, and therefore did not use the Type 213 or the Type B.

Kent preferred to use his rectifier, No.607. Looking back at the introduction of the Atwater Kent B-eliminator suggests that the development of this tube delayed the production of the eliminator and resulted in a missed market. (In trying the tube and the eliminator fifty years later, the author concluded that the product was not up to Kent's quality.)

Another consideration is that Kent's marketing evaluation for the B-eliminator found a strong market but a weak factory capability. He may have decided that the eliminator was not profitable as a product, or perhaps the Type R and Type S power supplies were not in the mainstream of his planned products. It appears that little or no emphasis was given to development of the B-eliminator. When they were finally introduced, the Types R and S were late and did not have a high sales potential.

The story does not end on this note, however. One analysis of the Types R and S eliminators indicates that they were really fall-outs from the development of the power supplies to be used in the A.C. sets. Development work done on Types R & S was part of the work on the whole line of A.C. power supplies. More is said about this in looking at the Model 36.

THE SINGLE DIAL – MODEL 30 AND 30-A

Three-dial receivers, compared to their predecessors, were much more docile and useful in the family. They might be described as house-broken. They made it possible for ordinary folk to listen to programs without having to cope with a technology that took the fun out of entertainment and the pleasure out of culture. They were suitably sensitive, offered loudspeaker volume, presented a good appearance in the home and were stable. Still they had one characteristic which made them not friendly. They were not easy to tune. If you knew the individual dial settings for your favorite station, you could bring it in without much trouble. If, however, you wanted to change stations, perhaps to hear another program, you had to remember the new settings for each of the three dials, tune them and then tweak the set for the volume level you wanted. As listeners became familiar with their three-dialers, the preference for an easier way to tune, such as using only one dial, resulted in an increasingly high demand from radio listeners.

Kent was aware of this when he went from the Open Sets to the 20 series (both three-dial sets). He didn't have the technology to go directly to a single dial because the production controls on the components and on the amplifier tubes were not tight enough to assure the proper resonance for a common dial setting on all three tuners. Much progress toward that end was made in going to the Model 20 Compact receivers. Manufacturing tolerances tightened enough so that the dial settings for two of the stages were the same over the broadcast band. The remaining problem was with the first stage tuner, caused by the antenna effects.

An antenna has some of the properties of a tuned circuit and it therefore affected the tuning of the first amplifier stage of an uncompensated receiver. If every listener had the same antenna as the others, the first amplifier of a receiver on a multi-stage radio like the ordinary three-dialer could be compensated by the manufacturer to make its dial setting track the other dials. In the middle 1920s most radio listeners had long-wire antennas of as many different sizes and locations as there were listeners, and the first stage of their receivers usually needed different dial settings.

Kent's engineers developed ways to get around the problem and consequently produced a single-dial set that significantly improved the ease of operating the radio. One way was by using an untuned amplifier before the first tuner. This additional stage isolated the antenna from the tuning system. Model 30, No. 8000, was the first of the series to get the isolator stage. It was a big step forward in the progress of the Atwater Kent product line.

The extra stage added only moderate cost to the radio. When Type 201A tubes were first used in Atwater Kent radios they were priced at six dollars each. The extra cost of the isolator stage would have been a doubtful trade for the convenience of single-dial tuning, but when the price of tubes dropped to half of that, the overall price of the tubes in the six tube set was less than it had been with five expensive tubes and the three-dialer became obsolete.

Model 30 was, in many ways, identical to the Model 20 Compact. It used the same mahogany box so it looked very similar. It used the same power and operated the same speaker. There were some differences; most important, it was user-friendly.

The other major difference was condenser ganging. The tuning condensers and coils in the first Model 30 were the same as those in the Model 20 Compact, but they could not be supported by the front panel for esthetic reasons. Their mounting screws would not have been hidden by dials as on the Model 20. A sub-panel, in itself a separate chassis, was installed to mount the condensers and the bakelite panels that contained the tube sockets.

The improved receiver was identified as Model 30-A, No. 8000-A. It differed from the earlier set in the mechanical details of the tuning condensers and their supporting chassis. Up to the time of the Model 30-A the tuning condenser used bakelite end-plates to support the rotor, to insulate the stator and to mount the condenser to a panel. With the Model 30-A the factory went to a metal end-plate for the condenser. It carried the rotor bearing, incorporated insulating plates for the stator and was fastened directly to a newly designed chassis. This new design was used later on the Model 33 and the Model 35.

In operating a single-dial receiver, the listener is not at all interested in how the motion of the dial causes the condensers to rotate as long as they track (stay in tune). However, the factory was strongly interested in this mechanism. Atwater Kent devised a method of connecting a pulley on each condenser to the others by means of a flexible, phosphor-bronze belt. Turning the middle condenser shaft with the dial resulted in moving all the tuning condensers exactly the same angular amount.

Another way to accomplish the same function was to fasten all of the condensers onto a single shaft, under the patent of J.V.L. Hogan. Atwater Kent did not license the patent, preferring his way until several years later when the complexity of the radios he was building precluded use of the pulley-and-belt system. This occurred in the 60 series. (Sometimes the author wishes he had worked for Kent and could have learned the background reasons, not just the results).

Almost 100,000 of the first configuration of the Model 30 were sold in 1926. Before the end of the run in 1927 another 20,000 sets of the improved version of this single-dialer were sold.

THE FOUR -TUNERS – MODEL 33

The standard broadcast receiver of the early tuned r-f amplifier days had five stages; two radio frequency, two audio frequency and a detector. The Atwater Kent line had been established with that line-up in the days of the Open Set Model 7, No. 4066. Its difference with subsequent five-tube sets was the lack of tuning in the r-f stages. All the versions of Model 10 were five-tube sets of the two r-f, two a-f, detector configuration. Because they used three tuning circuits in the r-f stages they were called three-dialers. Atwater Kent understood that variations had to be made available to those who wanted something more or something less. For the something-else customers he brought out Model 9, an abridged Model 10. Later he brought out the Model 19, an abridged Model 20.

For the something-more people of the breadboard days he brought out Model 12. It had three a-f stages and was also a three-dialer. Collectors don't usually identify it as a three dialer even though its r-f-stages are identical to those on the corresponding Model 10. When the 20 series was introduced, Kent made Model 22, No. 4930 available. (The author has not seen a Model 22 but believes it to be the big Model 20 with an extra audio tube located in the empty space behind the regular audio tubes.)

When the series 30 was introduced, the something-more customers wanted a radio that was better than the ordinary Model 30. It had to have more than the five tubes that was the earlier standard. But the sixth tube in the Model 30 didn't fulfill their expectations for two reasons. First, the extra tube didn't count since it was an isolater and not a tuned amplifier. The other reason was that the set did not offer to the something-mores an appearance that was up-scale enough. The set had to look bigger and more important than the Model 20 Compact and the Model 30.

To satisfy these customers Kent brought out Model 32, No. 8270. He incorporated the isolater tube to make the set friendly but he also built in another radio amplifier for a total of seven tubes. With four tuners instead of the standard three, the set sold very well. Model 32 had the same construction as the first Model 30s. It used the bakelite end-plates on its tuning condensers and individual tube sockets for the radio amplifiers.

When the Model 30 was upgraded to Model 30-A another variation of the 30 series was produced, Model 33, No. 8930. This was a six-tube set but like Model 32 had four tuning condensers. The circuitry that had been used with the isolator in Model 30 was combined with the first tuned r-f amplifier to reduce the tube count from seven in Model 32 to six in Model 33.

The variation in antennas that was still a problem for listeners when Model 33 was introduced was solved by adding two conveniences; separate connections for a long antenna, or for a short antenna, and a trimmer to provide finer compensation. Model 33 used the same design for the internal chassis that characterized Model 30-A but it was longer because of the extra tuner. The style of condensers used on Model 30-A was repeated on Model 33 but there were four instead of three. Its cabinet was very nearly the same as that used for the Model 32. The eye appeal of the Model 32 was maintained even though the circuit had been simplified.

Model 33 is an interesting set from a marketing standpoint. The customer analysis part of marketing said there would be good sales and that analysis was correct. Model 33 was one of the big selling receivers. The factory analysis part of the marketing evaluation was much more complex. The new-style chassis construction was available from Model 30-A and from Model 35 with only a small change to accommodate the greater length. The circuit changes were minimal. The factor that may have obscured all of the factory availability analysis was the on-coming requirement to manufacture an A.C. receiver, and to do it immediately. Model 33 was to become Model 36.

A.C. FILAMENTS – MODEL 36

The marketing analysis suggesting that the B-eliminators were not substantial product investments may well have indicated several other important considerations. The B-battery eliminator only solved half of the problem of using direct current tubes in circuits powered with alternating current. It took care of making plate current available but did nothing to solve the tube-heating current problem. A-Battery eliminators were available to solve the filament heating problem but they were not well received because they were expensive, and with their wet-cell rectifiers, were as messy as wet-cell batteries. What was needed to advance the radio art were new vacuum tubes with filaments that could be operated directly by alternating current.

The Radio Corporation, together with Westinghouse and General Electric, had been working on the redesign of battery-powered vacuum tubes almost from the time that Atwater Kent had started radio production. It was able to release replacements for the Type 201-A in 1926 and 1927. They were the Types 226, 227 and 171. As soon as samples were available, Atwater Kent's engineers started redesign work to get a set on the market without delay.

Kent's market analysis also would have directed the redesign of a radio that assured immediate customer acceptance, the use of an existing set to reduce factory changes, and doing everything that was needed to maintain the Atwater Kent reputation. This would not have been the time for sweeping change. Getting the A.C. set into the customer's hands was more important than creating a new image. The new radio was Model 36, No. 9390

For easy redesign, the best radio was Model 33, No. 8930. It had good customer acceptance as a full-function, high-end set with all the operating features that the A.C. receiver needed. It was the best choice for conversion to Model 36 for another reason. The Model 33 chassis had the latest technical features and projected the longest manufacturing run. It had binocular coils, four tuning condensers, an antenna peaker and the metal subchassis.

Converting Model 33 to A.C. operation did not involve extensive rework. The only requirements were a new bakelite sub-panel for the new detector and audio-frequency amplifier tubes (the Type 227 detector had five pins instead of the four pins used for the Model 33 detector), a new cable to connect the chassis to the power supply, a new volume control unit, substitution of Type 226 tubes for amplifiers, substituting a Type 171 tube for the power output tube, and minor bypassing.

Model 36 required a full A.C. power supply. Here the work on the Type R and the Type S power supplies paid dividends. With a simple change to add filament windings on the power transformer, a change to the output terminal board, and the substitution of the Type 280 vacuum rectifier for the Type 607 gas rectifier, the new power supply, Type Y, was ready.

Production numbers for the Model 36, No. 9390, show that it was a success. It came out in late 1927 and more than 36,000 were sold. The marketing analysis had paid off handsomely.

THE METAL BOXES – MODEL 35

In the middle 1920s a very important change took place in the use of steel for the fabrication of sheet metal stampings. By the addition of manganese to a smelter batch of iron containing a small amount of carbon, the ductility of the resulting steel was remarkably extended. Shapes hitherto beyond forming with presses because of wrinkles and tears became standard production. The pressure on the steel companies to improve their iron metallurgy came from automobile manufacturers who wanted to produce major body components and other large sheet-metal parts in single units, instead of having to limit their sizes or fabricate them by assembling smaller pieces.

One result of the availability of this new steel was its use in another industry, the manufacture of major household appliances. An example was the manufacture of domestic-service refrigerators to replace ice-boxes. General Motors produced the first Frigidaire in 1926 and General Electric made its first Monitor Top in 1927. Atwater Kent, through his continuing friendships in the automobile industry, was able to follow the progress of metal forming, not only for automobiles but in the other industries where it expanded the product applications.

Kent could easily conceive of a metal container that might be used to enclose a radio. He didn't lack interest or experience. His ignition coils were assembled in deep-drawn steel cups, and the TA amplifiers were contained in shallow steel pots. The Model 5 had extended this concept, and the Model 20 panel-and-shelf utilized larger but simpler stampings. Kent's marketing sense also indicated a very strong change in his customer's interests. America would fall in love with stamped steel. The automobile companies were ready to advertise their new steel vehicles, the appliance companies had new products (electric servants) to be introduced and the novelty of steel appliances was in the air. Atwater Kent could see that his radios should be in the wave.

This time the marketing analysis not only indicated the new and potentially very large customer demand, but it also indicated a major expansion in the capital equipment of the factory. He had to replace his wood shops and minor metal-fabricating facilities with a major metal-forming capability. Kent knew that he had get a new radio on the market in the least possible time.

He could not make all the design improvements that would be desirable in a single model change, so he wrapped the upgraded Model 30-A, No. 8000-A, in a decorated metal enclosure and created Model 35, No. 8100. He did not use Model 33 for the upgrade and he did not include the A.C. power supply even though it was available from Model 36. He was right again; Model 35 was the next record seller for Atwater Kent.

MODEL 37

The success of Atwater Kent's first metal box receiver, the Model 35, confirmed his evaluation of the market. He had found a very strong customer interest in a new style. His problem was how to combine several vital forces that could result in a stable product line. One of the forces was based on production, the use of stamped steel for the container. Kent knew that by increasing the production rate and reducing the cost of the materials, an improved radio in a shaped metal case was not only possible but the way he wanted to go.

Another force came from the market. Home makers wanted and were willing to buy a radio with a new style. The new receiver had to have a modern look but, at the same time, it could not depart very far from the traditional look of radios. Several characteristic elements could be carried over from the box-and-panel sets of the previous period. The table model continued to be popular and its size had been well accepted. The width and height of the new style did not have to be substantially larger or smaller than the 30-series battery receivers. The depth had to grow to accommodate the internal power unit but on a living room table the depth would go unnoticed.

The new radio did not have to present a new tuning dial. The general public had not yet come to relate favorite stations with frequency or wavelength. A dial number or position was satisfactory. The new style did not require its container to incorporate a loud speaker. Listeners were comfortable with separate speakers, especially those that could be moved away from the radio to the easy chair.

Still another market force was the use of A.C. filaments and the incorporation of the B eliminator. The use of batteries was no longer acceptable except where house power was not yet available. All the electrical parts except the antenna and the loud speaker had to be put into the cabinet of the radio.

Combining the best elements of the radios and power units that he had produced and sold was the way Kent maximized the appeal of his new line while minimizing his investment in its production. He used the chassis of Model 35 (almost without change), the power unit from Model 36 (Model Y redesigned), and a new stamped steel container to make the new set, Model 37. However, part of the new factory had to be equipped with large punch presses if the new line was to be produced economically.

THE FACTORY STORY

When Atwater Kent started his new business, The Atwater Kent Manufacturing Works, in Philadelphia, he located his offices at 112 N. Sixth Street in the old Franklin Institute building. His manufacturing operations were done in nearby rental facilities. Kent was very creative, as evidenced by his many patents, but his capability to innovate was not limited to the products he put on the market.

He showed a strong interest in the means by which his production took place. He was actively concerned with the manufacturing process and its facility. As his business grew Kent found that downtown Philadelphia was not as good for expansion as a place on the outskirts of the city. One of the communities he looked at was Germantown, a suburb only about six miles from the center of Philadelphia.

Germantown was founded by settlers who came to Pennsylvania in the seventeenth century, not long after William Penn. It became a part of Philadelphia in 1854 and, like other districts in the city, was the home of a hard-working, skilled labor force, ideal for the production of the ignition equipment that earned Atwater Kent his public recognition.

In about 1912 Kent opened a small factory on Stenton Avenue in Germantown, not far from the railroad. He gathered his scattered manufacturing operations and consolidated them in that plant. The ignition business continued to grow because Kent's system, using the precise Unisparker, had shown its superiority over the trembler and the fixed-magneto systems. He was able to expand his operations and fill the Stenton Avenue factory. With the advent of World War I, and Kent's manufacture of precision equipment for the military, he further expanded his factory on Stenton Avenue by moving into a new, larger building at the end of the street.

The end of the war saw Kent with more factory capability than his business needed. His tools included small presses, screw machinery, Bakelite casting equipment, wire and coil winding machines and a competent woodworking shop. He needed another product line. Making instruments for the new fad, radio, was a possibility.

In 1919, the radio business was a combination of recovering communications companies and a new breed of radio amateurs, some licensed, some not, many of whom had been military operators. These new fans were fascinated by what they heard listening to ships, commercial stations and experimenters. All of this interest led to a new use of radio waves, entertainment. This new idea caught the public fancy (like today's Internet) and resulted in an almost uncontrolled growth of listeners, amateurs and commercial experimenters who were trying to establish the viability of making broadcasts. Constructing and showing a receiver, however simple, became a popular activity for technically interested hobbyists.

In 1920 Kent decided to enter the radio business. In many ways he was well equipped for the new venture. He had the factory, and his nationwide service organization. Most important was his native ability to recognize the marketing potential. During the next year Kent started making radio instruments in the facilities at Stenton Avenue. Based on the enthusiastic response of the radio market to his instruments he added the assembly of Open Sets. In 1922 he was manufacturing Bakelite castings and metal stampings for the radio instruments that home-built set constructors wanted, and he was making similar instruments for the factory assembly of the first Open Sets. At the same time he continued the production of auto-electrical systems.

By the time the Radiodyne was introduced in 1923 Kent again needed more factory space. But this time he was severely limited by the lack of suitable property on Stenton Avenue. The direction that the radio business had gone, and was going, convinced Kent that a very much larger plant than the entire Stenton Avenue factory would be required. It was because of this need to expand and the limitation of Stenton Avenue that we get a chance to see another side of Kent's interests. He had to select another location, build a new plant and, in effect, start a new business. To do this he felt strongly that he had to conceive and define the new plant and all its elements, i.e., function, location, appearance, design, and operation. Kent wanted a factory that not only built his radios but also enhanced his image as a major entrepreneur in the American business scene.

WISSAHICKON AVENUE

Based on the production rates of the Open Sets, the continuing automobile-electrical system business, and the limitations of Stenton Avenue, Kent decided that a new plant of about half-a-million square feet in total area, located in the same general part of Philadelphia, would accommodate all his needs. He bought a 20+ acre plot on Wissahickon Avenue and engaged the Ballinger Company, architects and engineers, to design and supervise the construction of what turned out to be one of the most advanced radio-manufacturing plants of its time.

The new facility included his engineering development staff with its laboratories, the commercial offices and most important, his headquarters. Kent felt that the building had to reflect his views of technical progress and architectural excellence. The first part of the new plant construction was triangular in shape and enclosed about one tenth of the fifteen acres that would finally comprise the factory building. Its dominant feature was the entrance. It was faced in limestone colored terra-cotta to match the brick facing of the rest of the building and its echoed Renaissance design with heavy columns setting off both sides of the arched doorway. It presented a fine appearance for Atwater Kent's new factory and continued to enhance Philadelphia's industrial image long after the property was sold.

The initial, triangular part of the building was completed in 1923. It was immediately tooled up to make Model 10 Open Sets and roughly doubled Kent's manufacturing capability. Because casting Bakelite was a limiting process in producing the instruments for the Open Sets, a new casting department was installed at the new plant. One evidence of the duplicate casting departments may be seen in the radio transformer coil forms. The older ones had bosses on top, a vestige of the days when binding posts were used. The newer forms, made at Wissahickon Avenue, had a decorative ring on the top of the form instead of the bosses. Both the Stenton Avenue and the Wissahickon Avenue production lines continued to make Model 10 Open Sets until they were replaced by Model 20.

Work on enlarging the Wissahickon Avenue plant continued at such a pace that in 1924 the second section, which enclosed more than half of that building's floor area, was ready for service. Since this was the time of the 20 series there must have been a greatly enlarged wood working department put into operation in the new section. The next year the third section, which filled out the main body of the building, was completed. In 1926 the last part, a two-story extension, was added to the corner of the first building, diagonally opposite the entrance.

Atwater Kent had much to be proud of in this bright new factory. One of the most important features was the skylight roof. The saw-toothed panels faced north providing light for the operators that was almost free of glare and never cast shadows. The entire roof, nearly fifteen acres, was the light source. The roof construction took advantage of the saw-tooth nature of the skylights by adding strength members at the top of the saws to form trusses.

Another feature was the arrangement of the vertical columns that supported the roof. Because of the design of the trussed roof these columns were located 40 feet apart in both directions, leaving very large areas on the floor (1600 sq. ft.) that were free of all encumbrances. The open floor space was ideal for shifting operations as the need to add new functions or to abandon old ones had to be met. The Superintendent of Plants, Harold Ashworth, in writing about Kent's modern factory said in part:

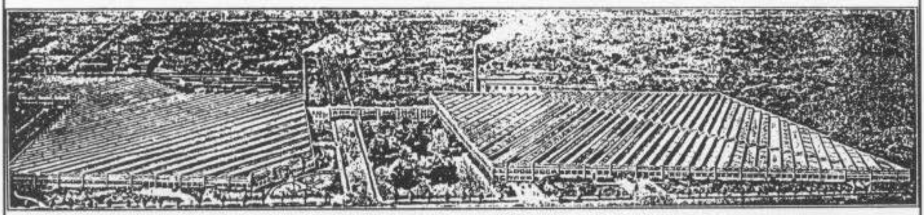
> "—it is no uncommon thing for a whole department to be removed to a new location between a Saturday closing hour and Monday morning, while another department expands with equal speed to occupy the space thus vacated."

The picture of Atwater Kent clears a little more. He had emphatically influenced the design of the new factory and continued active in defining what and where the many operations were performed. Perhaps it is not inaccurate to say that the Wissahickon Avenue factory was his image as well as his invention.

When the third section of the plant was put into service it might have been planned and set up for the assembly of Model 30. This would have been good manufacturing practice since any disturbance of the very profitable Model 20 lines would have been out of character with Kent's direct concern with his manufacturing efficiency. In 1925 a few more than 350,000 radios were produced, almost all in the 20 series. There were also about 25,000 from the 10 series but a large part of those were probably made at Stenton Avenue.

The next year saw the full change-over to the 30 series. The whole plant produced about 450,000 sets of which about 80,000 were in the 20 series. In the first part of 1926 the wooden-box 30 series were predominant, but by the end of the year almost 200,000 Model 35, metal-box sets had been manufactured. When the big presses that were to be used for drawing the Model 35 steel enclosures were delivered, they were probably installed in the fourth section of the plant. By putting them in that area, only minor alterations in the assembly area traffic patterns would have been made. Handling the raw stock for stamping and finishing would not have conflicted with circuit assembly.

The floor space and the assembly lines in the factory were sufficient for planned production rates for the entire 30 series based on the battery sets in wooden boxes. Substitution of the metal enclosures for the earlier wooden boxes did not result in extra demands for factory space, beyond that planned for the new punch press area in the fourth section of the building. But the demand for the sets with the metal enclosure, Model 35, was far higher than had been projected by Kent's earlier marketing estimates. Another factor that had to be considered was that the required fabrication floor space for Model 35 production was somewhat more than that given by sets that were no longer being made. It was poor factory practice to replace the wood shop with the big hydraulic presses while some wooden-box sets



The Complete Atwater Kent Factories in Philadelphia, Including the New Sixteen and a Half Acre Addition

Figure 30. *The 16½ acre addition to the Wissahickon Avenue plant, 1929.*

were still in production. Together, these factors made it clear that the factory would be pressed to meet the increased customer response.

MODEL 37 AND THE SECOND BUILDING

The problem was even more serious because the next set to be released was Model 37. It required greatly enlarged floor space to stamp, punch, draw and bend the new cabinets and to assemble the internal power supplies. Moreover, the demand for Model 35 was based on appearance, not convenience (it was a battery set) so the conversion to socket power for the new radio, the 37, would have forced still higher demand estimates. To meet the demand a new building was started on the western edge of the Wissahickon Avenue site. It would double the factory size to about 32 acres (Figure 30).

The production of Model 37 was started in 1927 using the first factory building, which had just been enlarged. In that year only 12,000 sets were produced but they served to confirm Kent's upgraded estimates of what floor space was required in the immediate future. The 40 series was the next group of receivers to be produced. They did not require any revision in the layout and equipment of the factory but they were a substantial load for the first building because they were popular. By the time the second building was up and running, the next series, the 55s, was ready for production. The second building was tooled up for them.

Some of the statistics about the Wissahickon Avenue facility are interesting. Together, the east and west buildings extended nearly half-a-mile along Wissahickon Avenue. To walk around the entire plant was a trip of about 1 1/2 miles, but to go from one building to the other the bridge over Abbottsford road was used. Inside the factory assembly and material movement used about six miles of conveyors — belt, chain and roller, Figure 31. But for radio collectors, the most interesting feature of the new building was (and still is) its cornerstone.

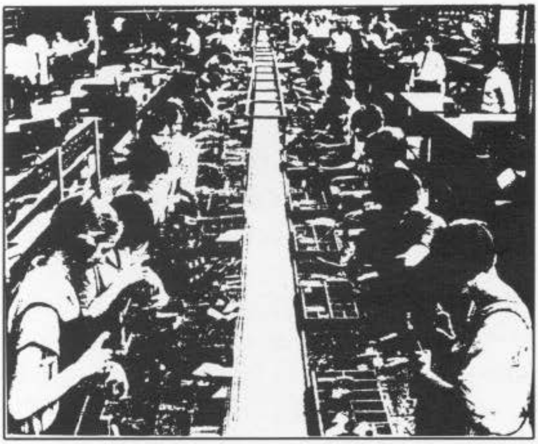


Figure 31. *Conveyor belt for assembling sets, inside the factory.*

When the building was dedicated in 1929, a current model radio was sealed in the cornerstone. Figure 32 shows the ceremony on May 21 with Atwater Kent standing behind the Model 55. (It could be a 60 but May 1929 is very early for that Model, and Kent would not have used an engineering sample.) In his dedication speech Kent told much of himself and his view of the future of radio. In part he said:

> "My own feeling about the present and future of radio is presented to you in the form of this big new factory. Great as the success of radio has been in the past, I feel more confident than ever today that the greatest development still lies in the future and I have shown that confidence by the construction of the plant which we have met here to dedicate.—"
>
> "—the radio business is something which is constantly changing and constantly moving forward. To me this is inspiring and stimulating. I could not be happy doing the same thing every day in the same way; cut and dried to order. I like a game which puts me on my mettle, which makes me keep my wits about me, which forces me to meet and beat new problems."

A. Atwater Kent, With Many National Celebrities, Placing His Latest Receiver in the Date Stone at Dedication of New Plant

Figure 32. *Sealing a Model 55 set inside the cornerstone at the dedication, May 21, 1929.*

MODEL 55 AND THE CHASSIS PRESSES

The receivers in the 55 group continued Kent's enthusiastic customer response. They were available as table models in several colors and highlights. To meet the demand of families that wanted their radio to be furniture, they were made available as consoles. All the sets were of the same basic design, the difference between the table model and the console being only the metal-box enclosure.

The earlier metal-box sets, the 40 series, and Models 37 and 38 used a sub-chassis to carry the radio parts and a separate enclosure for the power supply. In all those sets, the radio sub-chassis was fastened to the enclosure by means of two brackets, one on each end of the sub-chassis. The power-supply enclosure was bolted to the flat bottom of the metal box. To supply these sets as consoles, the entire metal box was simply placed on an internal shelf in the body of the console. The dial, volume control, switches and monogram were made available through trimmed cut-outs in a decorative panel which hid the metal box from the listener.

The mechanical design of the Model 55 and subsequent sets was different. All the parts, both radio and power supply, were mounted on a full-sized metal chassis. This change in design permitted a consolidation of the manufacturing processes. With the full chassis only one manufacturing sequence was required because the power supply components were no longer assembled in a separate unit. The sequence was duplicated on as many production lines as the volume of sales justified.

The Model 55 set was cased either in the metal-box enclosure that was Kent's image or in a console without the metal-box. For the console sets the full chassis was built with a small front panel exposed by an opening in the face of the cabinet. For the metal-box sets the chassis was fastened to the bottom edges of the enclosure. Both styles used a flat metal cover fastened to the bottom of the chassis to protect against dust and interference.

Model 55 (and all of Model 60s except the last design) used a vertical panel fastened to the main chassis to mount the tuning condensers. Kent retained the band-and-drum system for ganging the condensers, and on all but the very first Model 55s mounted a vernier tuning mechanism panel and windowed the front of the enclosure to reveal the dial. The first 55 did not have the window but used the same dial as the 40 series, Figure 33.

The change to a single large chassis was a savings in so far as assembly was concerned, but it also incurred an expense. New presses were required to stamp out the new chassis. The factory had to be equipped with larger presses than those that shaped the metal box enclosures used for the 55 and the earlier receivers. The reason for the bigger presses was the size of the 55 chassis. It was a 10" by 21" medium-draw stamping with turned

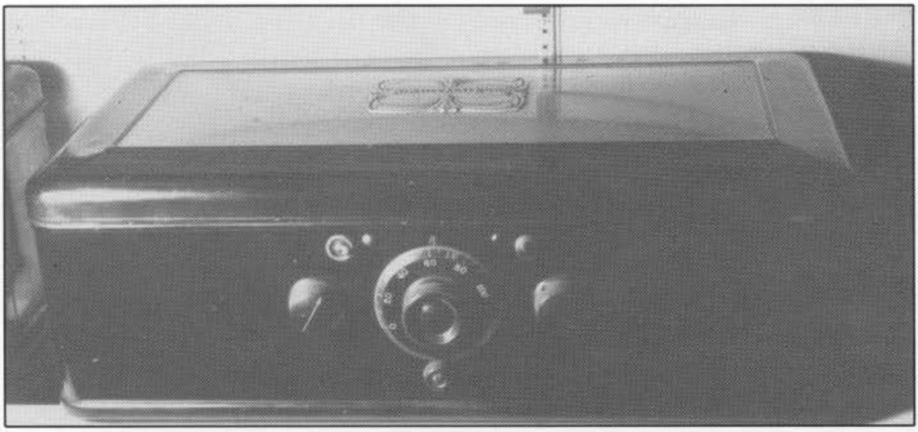


Figure 33. *An unusual AK Model 55 without the dial window.*

edges. With the big presses Kent did not have to reinvest to stamp out all the rest of the console sets that he produced. Figure 34 shows what the big presses looked like.

Sometime between the start of production of the Model 55s and the end of production of the Model 70s, Kent's production rate peaked. This was probably late in 1930 or early in 1931. At the same time three very significant changes took place in the business of manufacturing radios. One of these was a change caused by the ever-present cycle of styles. The metal box radio no longer spoke to the public of technological progress. High style had to reflect an exotic influence and it had to be done in wood.

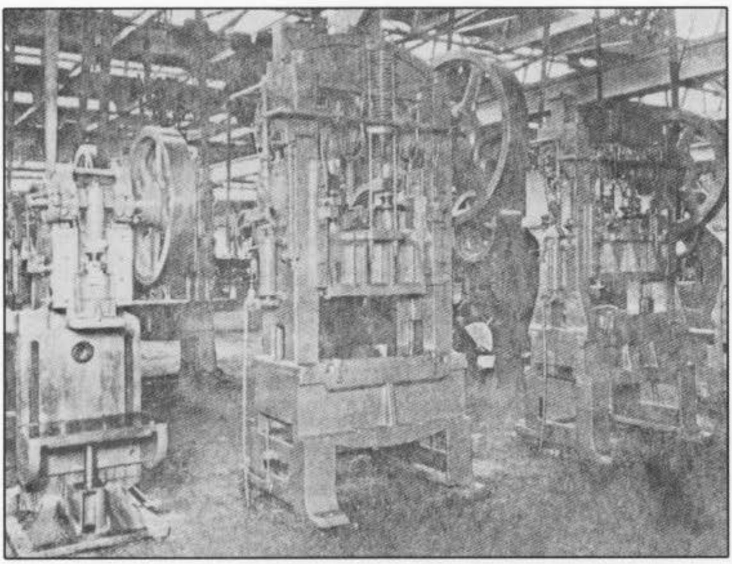


Figure 34. *One of the large flywheel presses for forming chassis.*

Another change was generated by the licensing of the superheterodyne patent to all comers. The day of the large tuned-radio-frequency set and a separate loud speaker was done. Although Kent's first superhet, Model 72 with its H circuit, was assembled on the big chassis, the compact style exemplified by the 80 series with their small chassis and incorporated speakers took over. The third change was in the pocketbook of the nation. No longer was the middle of the market able to afford the prices attached to the big chassis sets even if they were enclosed in economical metal boxes.

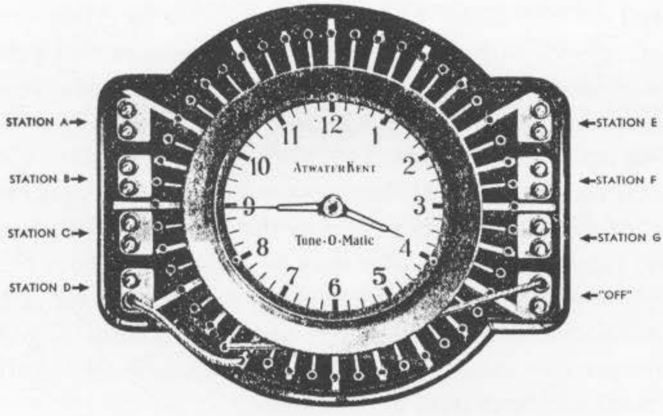
The winning combination was exemplified by a six-tube superhet with an 8" speaker in an art-noveau-inspired, veneered, round-topped box for less than $50.00 complete. Kent recognized this new market. His marketing analysis indicated that expanded factory performance was no longer the key factor. The capability of finishing big chassis had to be replaced by reductions in size, complexity and cost. Continuing business efficiency meant expanded customer contact, but the market had changed. Reaching the customer called for a new sales approach; discount stores were displacing department store merchandising. Kent tried to bridge the chasm.

Kent produced a line of compact radios that appealed to the new customer demands. He also continued to develop and modify his line of consoles. He made some very good receivers such as the Model 812 and the Model 511 (Figure 35), but he also produced a line of less expensive consoles. They used the same chassis as one of the table models, e.g., Models 286 and 356.

To maintain the business positive changes had to be made on the customer side, and more particularly in influencing the potential customer to buy a new Atwater Kent Receiver. This was no novelty for Kent; he had effectively pursued his automotive and radio customers for more than three decades.

KENT INFLUENCES HIS CUSTOMERS

In any business that maintains a stable performance over several cycles of product replacement, the marketing function continually relates two aspects of the on-going business processes, Making and Using. "Making" is a way of referring to manufacturing and all its elements, such as the factory with its machines and its people. "Using" is a way of referring to all the customer activities up to and including the actual operation of the product itself by the end user. Our marketing analysis of Kent's business has been based on a major assumption: that there was a durable product. The product had to be capable of being produced and it also had to be useful. Its cost and price had to be contained within the standards set by customer acceptance and business practice. All of Kent's products, with the possible exception of Amperia, met that test.



Illustrating the simplest case of automatic tuning: Station "D" will be tuned in automatically at 7 o'clock and automatically shut off at 7:15. If the "off" load is inserted in some other jack, say for 10 o'clock, station "D" will continue in operation until 10 o'clock.

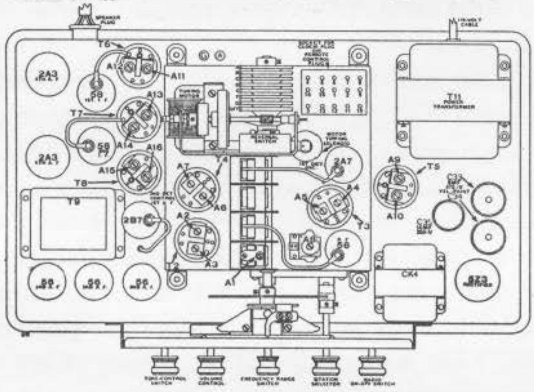


Figure 35. *The Model 511 remote receiver and tuner*

Up to this point our analysis of Atwater Kent as a master of marketing has looked predominantly at the Making function. Four decades of his products and the effects they had on his production facilities were reviewed. We have observed, without analysis, that his success was a direct reflection of his perception of his customers' potential needs, coupled to his management of technical and production operations.

Now we try to analyze how well Kent applied his marketing capabilities to the Using process of his business, which has two major factors. The first factor of the Using process is how the customer utilizes the product. The second factor is how the user may be influenced about the product or about an improved product. Because Kent's customers ranged from automobile manufacturers to homemakers and his products ranged from little motors to expensive radios, his customer relations included all the ways a producer communicates with his audience.

Customer relations range from a minimum of just supplying a distribution agent with product information to a maximum of doing business directly with the end user. Included in customer relations are all the activities related to:

- informing potential purchasers (advertising the product)
- informing the general public (institutional advertising)
- backing the product (warranty and factory service)
- providing maintenance service (dealers and factory service)
- agency sales (salesmen, distributors, dealers)
- providing product data (descriptions, service procedures)
- customer enticements (discounts, turn-ins, prizes, agreements).

At the end of the nineteenth century, when Kent started making electric motors, he seemed to be following his own interest (and skill) in the choice of products to make. There were customers for his motors but Kent seemed more inclined to make what he could than to alter his Making process to fit customer needs. His products were not the kind that were sold directly to the final user. The motors and the ignitor were sold inside the trade so his customers were the next-level manufacturers of end products. An example is the maker of a stationary engine such as Fairbanks Morse, to whom Kent wanted to sell his ignitor. Kent had to make his products known to that customer so he used the accepted method of that day, the trade journal, Figure 36. He also produced descriptive literature in the form of flyers and pamphlets that were sent to potential customers or passed out by sales agents.

Although Kent did not advertise directly to the end user of his motors, he was interested in their satisfactory use. This is evidenced by the treatise that he wrote while he was employed by Kendrick and Davis. It is shown in Figure 37. In this 32-page booklet Kent takes a student through enough

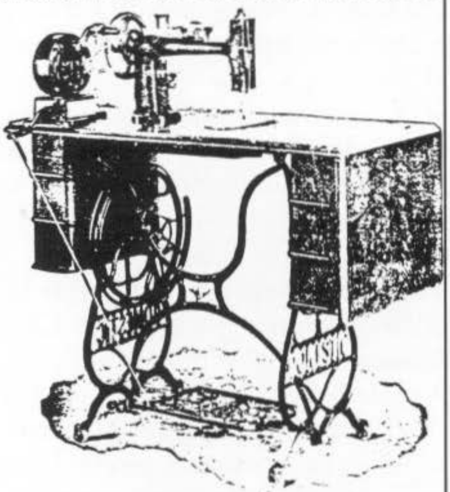
THE ELECTRICAL ENGINEER.

December 9, 1896]

THE KENT ALTERNATING SEWING MACHINE MOTOR.

THE extended use of the alternating system of electric lighting has created a large demand for small power specialties for such circuits. The Kent Electric Manufacturing Company, of Worcester, Mass., have lately been bending their energies in this direction, and one of their results is a sewing machine motor illustrated in the accompanying engraving.

The great difficulties encountered in this work are the small starting torque, and the non-variable speed of these motors. Both of these obstacles are overcome in the device shown. The motor, which is of the induction type, is mounted on a base, to move with a lever, connected to the treadle of the machine, and the speed regulation is obtained by tightening and slackening the belt. By this method, any desired speed may



THE KENT ALTERNATING SEWING MACHINE MOTOR.

be maintained. In this way even more perfect regulation can be obtained than by direct current, as the speed can be changed in an instant, and the brake which touches on the circumference of the balance wheel stops the machine instantly.

A switch located on the base is turned on when the operator sits down to the machine. The motor is thus started without a load, and is running constantly while the machine is in use. It is compact, and neat in appearance.

The company also manufacture a variety of other apparatus such as battery fan outfits, alternating current fans, and small machines which can be run either as a dynamo or a motor, capable of lighting from one to four 8 candle-power lamps, or of running a 6-inch fan. The voltage

Figure 36. *The Kent sewing machine motor, as depicted in a trade journal.*

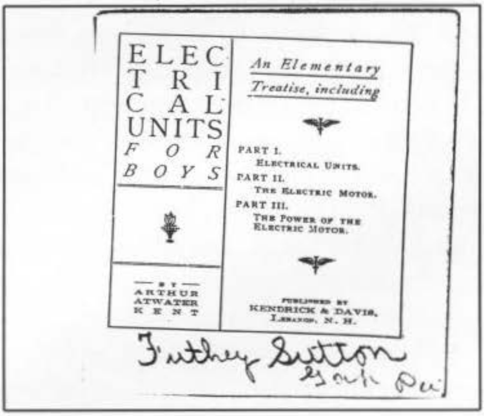


Figure 37. *An elementary treatise on electricity, written by Kent around 1900.*

basic electricity to enable him to calculate the input current required by a small electric motor. This publication and the instruction pamphlet that he wrote for the Amperia game were Kent's first direct contacts with his end users. They appear to have been good first steps in his marketing experience, but they were not as effective as the influences of other manufacturers or even of Kent himself in subsequent product lines.

The impression that Kent was more interested in Making than in Using is borne out by the transfer of himself and his business to Kendrick and Davis in 1900. There he could take advantage of their marketing process, even though it was little better than Kent's. He stayed with K&D for only a short time before he wanted to strike out again. The author feels that he was searching for the customer interface and he did not find it at K&D. He chose Philadelphia because its population included many craftsmen with high levels of technical skill. This says indirectly that Kent was still looking at the Making process. Nowhere does any available history of this phase of his career suggest that he went to Philadelphia because of its markets. He was not yet skilled in the Using process of marketing.

Kent's products in the beginning of his Philadelphia activity were indications of his looking for customers different from those of his pre K&D employment. The telephone and the Voltmeter were new products for him. They involved electricity but were not made by techniques that Kent had used in making his little motors. Here we see the beginning of the analytical marketing function: The Making process for these two instruments being directly controlled by the Using process, in this case the actual end-users.

The telephone and another early product, the horn, further reveal Kent's growing awareness of the need to influence his customers. He chose a catchy name for the instruments: Monoplex. The first half of the name means one or single. The second means part or piece. The name comes out as one-part, or unitary, a very good way to suggest cohesiveness. For the telephone installed in a business or in an extensive home the idea was effective. The customer was trying to enhance his cohesiveness by the use of the new communication capability offered by the Monoplex. He chose well. For the horn the idea of oneness accorded directly with the purpose of the horn, to warn with a single-tone, a loud signal.

Kent's next product, the contact maker, seems to tell a different story. It is with this product that Kent's marketing capability starts to show. The device was a major technical improvement over previous current interrupters. Kent had taken his experience, from all the way back to the burned launch of his teens, and added his technical ability at problem definition and mechanical design to invent the contact maker. Here he showed that he understood one factor of Using; the application of the device.

The customers in the ignition business were a far more complex problem than the product users Kent had experienced with his earlier devices.

Of particular difficulty were the relations with the end-user, the automobile or stationary engine owner. Internal engines in the period before World War I were at best balky and, more often than not, unreliable. One of the common difficulties was ignition, the function on which Kent had done his best technical work. (The Ignitor did nothing to remove the difficulties with unreliable ignition.)

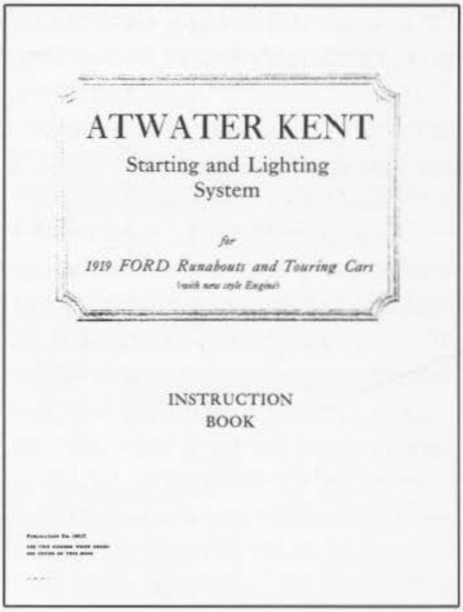
Kent's system was capable of providing reliable, trouble-free performance but it had mechanical adjustments to accurately set initial performance and to compensate for its wear and aging. Adjustments were a mixed blessing. They compensated for the minor but cumulative manufacturing tolerances and customer special conditions that were exorbitantly expensive to eliminate, and they kept down the cost of using the complex ignition system, but they were also an open invitation to the tinkerer whose experimenting usually resulted in undesired (faulty) ignition performance.

Any supplier of equipment as complicated as an ignition system had to provide a user-support service to keep his system in working order after delivery to the customer. Kent did this by appointing and training service stations throughout the country. They, in turn, trained local servicemen who worked directly on the customers' automobiles. From the beginning of Kent's national service capability through the 1920s, auto-electrical work on cars tended to be done by specialists who operated their own shops and garages. These service businesses were not exclusively tied to Atwater Kent systems. They handled all the current electrical systems and in many cases made and sold storage batteries. Their work ranged from turning commutators to burning the lead that inter-connected plates and cells in lead-acid storage batteries.

Kent put out instruction books and pamphlets for the use of those who installed or worked on his equipment. The Atwater Kent Instruction Book for the 1919 Ford Runabout is shown in Figure 38. The last page lists the Official Service Stations then in operation, 117 stations in 40 states plus six in Canada. Kent had learned the vital nature of customer service for his business reputation. For the detailed procedures that were necessary to assure effective automobile engine performance, the need for adequate service had become a mandatory part of Kent's business. To support his products he had to provide a factory technical group whose purpose was customer satisfaction and whose backing was all of Kent's engineering, sales and manufacturing organization.

The era of direct advertising to his final customers had not yet become a part of the Kent's necessary business practice about the kind of equipment that he made. Car manufacturers themselves had become very skillful at appealing directly to buyers through extensive advertising. Tire manufacturers, who sold replacement tires directly to end-users, had also learned how to use advertising in magazines and other periodicals. Kent, through

Figure 38. *The instruction book for the AK Starting and Lighting System, 1919.*



ATWATER KENT

Starting and Lighting System

for

1919 FORD Runabouts and Touring Cars

(with new style Engine)

INSTRUCTION BOOK

his close association with the automobile industry, had become very cognizant of the power of direct advertising.

Because of the nature of his offerings, direct advertising was of limited use to him in the auto-electrical business. However, he was very aware of the continuing need to evaluate his customers' interests and was quick to find ways that he could modify their demands, especially through his service stations. The lessons of customer evaluation and direct advertising would pay off handsomely later when he went into radio.

THE RADIO CUSTOMERS

In 1920 Atwater Kent started in the radio business. His marketing analysis might have gone like this: There is a new product appearing on the scene. It comes from the possibility of receiving programs of value through the air. To receive these programs, a customer must have a receiver, a device made up of electrical parts (the product) that are related to the ignition equipment that we have manufactured for more than a decade. These parts can be sold through the same dealer network that sells our electrical systems.

The factory can manufacture these parts with only minor changes in its equipment. We will need some engineering for design of the parts and for changes to the factory, but they are only a small expense. Our reputation has been built over the years and is now associated with outstanding equipment. We will have to produce the same quality in this new field of radio (Making).

We can stay in contact with our customers using the same methods we have used in the past. We can easily produce instruction booklets, specifications and attractive packages for our products. Through our service stations and their clients, the direct servicemen, we can reach the experimenters, amateurs and radio fans who should become profitable customers (Using).

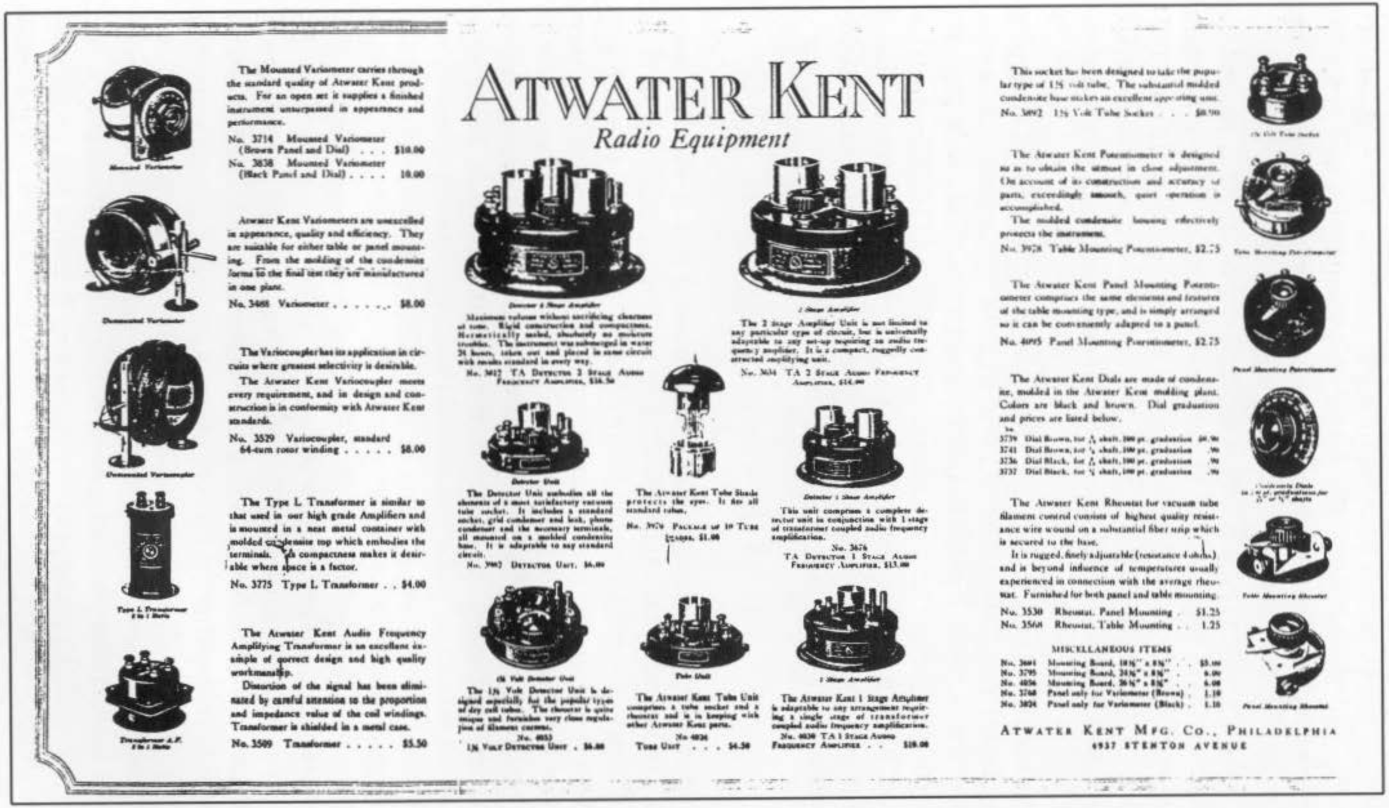
This analysis was very positive. On the basis of it, Kent started the engineering that was required for the new radio parts and the procedural changes that would be needed in the factory so that by the middle of 1921 he had parts to ship to his dealers, repair stations and servicemen. In effect Kent was expanding his product line without changing his approach to his customers.

The enthusiasm for radio was so strong in the country that a supplier could successfully put out a line of parts without announcing and extensively advertising them. Kent was able to benefit especially well from the intense customer interest because in every town that had an auto-electrical serviceman he had a radio parts salesman. He made his parts available through the servicemen and built an excellent reputation for high-quality instruments.

PARTS OR RECEIVERS ?

It is interesting to conjecture about how the next step in Kent's expansion in the radio business came about. Did he foresee the need to build radios and plan to do that immediately after he introduced his line of parts? Or, was there a strong customer response to the sales agencies telling them that many of their customers would prefer to buy a complete radio than to assemble one from parts? The first two Atwater Kent receiver models suggest the latter question to be closer to the way things went. Since Kent considered the boards as parts and sold them along with the instruments, the only sign of factory engineering in those first sets was in the instruction sheets packed with the parts, Figure 39.

In either case, before the end of 1922 Kent had recognized his customer and started to meet end-user instead of dealer demands. As an example he sold Model 3 in two configurations, one with only the detector, No. 3960, and the other, No. 3955, with the detector and another instrument, the two-tube amplifier. At about this time, Kent started directly contacting his customers about radio receivers. He used catalogs put out by appliance sales companies and electrical supply houses and he included extensive data folders in the radio parts packages, but he did not yet employ direct advertising. The Using process of the marketing function had so far only considered the customer's use of Kent's products. The factor of influencing the customer about the products was an extensive and interesting part of Kent's business, but he had not yet started to use it.



ATWATER KENT
Radio Equipment

The Mounted Variometer carries through the standard quality of Atwater Kent products. For an open set it supplies a finished instrument unsurpassed in appearance and performance.

No. 3714 Mounted Variometer (Brown Panel and Dial) . . . $10.00
No. 3838 Mounted Variometer (Black Panel and Dial) 10.00

Atwater Kent Variometers are unexcelled in appearance, quality and efficiency. They are suitable for either table or panel mounting. From the molding of the condensite forms to the final test they are manufactured in one plant.

No. 3468 Variometer $8.00

The Variocoupler has its application in circuits where greatest selectivity is desirable.

The Atwater Kent Variocoupler meets every requirement, and in design and construction is in conformity with Atwater Kent standards.

No. 3529 Variocoupler, standard 64-turn rotor winding $8.00

The Type L Transformer is similar to that used in our high grade Amplifiers and is mounted in a neat metal container with molded condensite top which embodies the terminals. Its compactness makes it desirable where space is a factor.

No. 3775 Type L Transformer . . $4.00

The Atwater Kent Audio Frequency Amplifying Transformer is an excellent example of correct design and high quality workmanship.

Distortion of the signal has been eliminated by careful attention to the proportion and impedance value of the coil windings. Transformer is shielded in a metal case.

No. 3509 Transformer $5.50

Detector 2 Stage Amplifier

Maximum volume without sacrificing clearness of tone. Rigid construction and compactness. Hermetically sealed, absolutely no moisture troubles. The instrument was submerged in water 24 hours, taken out and placed in same circuit with results standard in every way.

No. 3612 TA Detector 2 Stage Audio Frequency Amplifier, $16.50

2 Stage Amplifier

The 2 stage Amplifier Unit is not limited to any particular type of circuit, but is universally adaptable to any set-up requiring an audio frequency amplifier. It is a compact, ruggedly constructed amplifying unit.

No. 3634 TA 2 Stage Audio Frequency Amplifier, $14.00

Detector Unit

The Detector Unit embodies all the elements of a most satisfactory vacuum tube socket. It includes a standard socket, grid condenser and leak, phone condenser and the necessary terminals, all mounted on a molded condensite base. It is adaptable to any standard circuit.

No. 3962 Detector Unit, $6.00

The Atwater Kent Tube Shade protects the eyes. It fits all standard tubes.

No. 3976 Package of 10 Tube Shades, $1.00

Detector 1 Stage Amplifier

This unit comprises a complete detector unit in conjunction with 1 stage of transformer coupled audio frequency amplification.

No. 3676 TA Detector 1 Stage Audio Frequency Amplifier, $13.00

1½ Volt Detector Unit

The 1½ Volt Detector Unit is designed especially for the popular types of dry cell tubes. The rheostat is quite unique and furnishes very close regulation of filament current.

No. 4053 1½ Volt Detector Unit . $6.00

Tube Unit

The Atwater Kent Tube Unit comprises a tube socket and a rheostat and is in keeping with other Atwater Kent parts.

No. 4036 Tube Unit . . . $4.50

1 Stage Amplifier

The Atwater Kent 1 Stage Amplifier is adaptable to any arrangement requiring a single stage of transformer coupled audio frequency amplification.

No. 4030 TA 1 Stage Audio Frequency Amplifier . . $10.00

This socket has been designed to take the popular type of 1½ volt tube. The substantial molded condensite base makes an excellent appearing unit.

No. 3892 1½ Volt Tube Socket . . . $0.90

The Atwater Kent Potentiometer is designed so as to obtain the utmost in close adjustment. On account of its construction and accuracy of parts, exceedingly smooth, quiet operation is accomplished.

The molded condensite housing effectively protects the instrument.

No. 3978 Table Mounting Potentiometer, $2.75

Table Mounting Potentiometer

The Atwater Kent Panel Mounting Potentiometer comprises the same elements and features of the table mounting type, and is simply arranged so it can be conveniently adapted to a panel.

No. 4095 Panel Mounting Potentiometer, $2.75

Panel Mounting Potentiometer

The Atwater Kent Dials are made of condensite, molded in the Atwater Kent molding plant. Colors are black and brown. Dial graduation and prices are listed below.

No.		
3739	Dial Brown, for $\frac{3}{16}$ shaft, 100 pt. graduation	$0.90
3741	Dial Brown, for ¼ shaft, 100 pt. graduation	.90
3736	Dial Black, for $\frac{3}{16}$ shaft, 100 pt. graduation	.90
3737	Dial Black, for ¼ shaft, 100 pt. graduation	.90

The Atwater Kent Rheostat for vacuum tube filament control consists of highest quality resistance wire wound on a substantial fiber strip which is secured to the base.

It is rugged, finely adjustable (resistance 4 ohms) and is beyond influence of temperatures usually experienced in connection with the average rheostat. Furnished for both panel and table mounting.

No. 3530 Rheostat, Panel Mounting . $1.25
No. 3568 Rheostat, Table Mounting . . 1.25

Table Mounting Rheostat

MISCELLANEOUS ITEMS

No. 3601	Mounting Board, 18⅝" x 8⅝" . .	$5.00
No. 3795	Mounting Board, 20⅝" x 8⅝" .	6.00
No. 4056	Mounting Board, 26⅝" x 8⅝" . .	6.00
No. 3760	Panel only for Variometer (Brown) .	1.10
No. 3824	Panel only for Variometer (Black) .	1.10

Panel Mounting Rheostat

ATWATER KENT MFG. CO., PHILADELPHIA
4937 STENTON AVENUE

Figure 39. *Early AK radio parts catalog sheet detailing boards and parts.*

ATWATER KENT MANUFACTURING COMPANY

SCIENTIFIC AUTOMOTIVE EQUIPMENT

A. ATWATER KENT
President and Treasurer
W. J. LITTLE
Vice-President

4937 STENTON AVENUE
Philadelphia

March 15, 1923.

TO DEALERS SELLING ATWATER KENT RADIO EQUIPMENT.

Thru the courtesy of your jobber we are getting acquainted with you direct in the hope that we will be able to help in the sale of ATWATER KENT Radio equipment. There is no question but what you are having a busy season in radio and we hope it is proving to be a profitable one.

This letter conveys to you only a spirit of cooperation and a request that you use our organization for any information or sales helps needed. We will send such literature as you actually need. Any technical information we can give you will be gladly furnished without charge. In other words just tell us your problems and we will give you the best advice at our disposal.

ATWATER KENT Radio equipment has almost become a household word thruout the country and we feel that you have surely done your part in making it so. We appreciate your efforts and want you to feel that we are backing you up at every turn of the road. The enclosed magazine reprint is just one evidence.

Sell your customers Atwater Kent and you'll be safe.

Very truly yours,

ATWATER KENT MFG. COMPANY.

Figure 40. *AK 1923 letter to prospective dealers. Note the letterhead and the absence of the word Radio.*

1923 was a year of significant change in customer relations for Atwater Kent. Figure 40 reproduces a part of a letter to prospective dealers suggesting their affiliation with the Company. Notice in the heading of the letter that there is no mention of radio apparatus. Later in the year the words RADIO APPARATUS were inserted above the address. 1923 was also the year that Kent's radios stabilized with the Model 10 design. This enabled him to increase factory efficiency and at the same time consider the use of magazine advertising to inform the public about his radios. He had advertised in trade journals and through jobbers and sales agencies over the country, even to the point of providing print aids and blocked plates, Figure 41.

Using advertising to directly influence public opinion was a major change in the way Kent had done business. Prior to the introduction of the Model 10, he had not realized the importance of the national attitude toward the acceptance of his products. He also did not realize his role in influencing that attitude. That part of his marketing mastery was the necessary last phase of his business maturity. In 1925, when Atwater Kent went into

Figure 41. *Advertising aids; an electroplate and the printed image.*

print advertising directed to his potential customers, he chose national magazines with large circulations targeted to the middle-class homes of the country. The liberal use of color and contemporary art in full-page ads suggested that Kent's products were top-of-the-line.

Kent had become aware that for radio manufacturers, particularly, broadcasting was the other powerful means of influencing customers. He started using radio ads to supplement his print advertising in 1925, at the time that the networks were connected. Kent was very particular about the programs that he wanted. They had to offer classical music and be presented by recognized artists. His interest was greater than the simple engagement of musical-program creators. He had to participate in the selection of numbers to be programmed and in selecting the artists who performed. In this participation, Kent revealed an unfulfilled interest in the classics that had been deflected by his extraordinary attention to his business. This interest again emerged after Kent retired to live in Bel Air.

DEALER SUPPORT

The following year Kent initiated an internal Radio Bulletin Service for his dealers. Its purposes were to offer sales information about the products and to provide service support, and dealer bulletins were issued whenever something of interest occurred. They were continued through 1927. Number 109 of that year announced the millionth set and illustrated the ceremony that took place in the factory.

Starting in 1924 Frank Atlee, K2PI, went to work in the technical publications function at Kent's plant on Stenton Avenue. Frank left Atwater Kent when the Wissahickon Avenue plant closed in 1936 and went to work for RCA in Camden. When the author and his wife moved to the Philadelphia area in 1965 and joined AWA we also went to New Jersey to become acquainted with Frank and Margaret Atlee. We became good friends and through Frank's guidance the author initiated his studies of Atwater Kent. Part of the material in this article is based on Frank's recollections and on his articles in the Bulletin and in *Popular Electronics.*

In 1925 the technical service function started issuing the Service Manual. It was reissued each year until 1928 and then again in 1931. The Manual described the receivers from an operating and servicing standpoint but it did not give the values of the components on the diagrams or in the descriptions. For the values the serviceman used another manual, Electrical Values. If the repair required a part that had to be bought from a distributor or from the factory, another manual was needed. This was the numerical Parts List. To find the price of the replacement part, the serviceman went to the fourth manual, the Parts Price.

Collectors who don't have easy access to these manuals find trouble shooting and repair of an Atwater Kent receiver a frustrating experience. They usually obtain a copy of the required diagram from the Rider's Manuals where the values have been annotated for the convenience of the general serviceman. This practice is not very different from the situation for servicemen in the middle 1930s. Kent's manuals were supplemented through 1936 but only to subscribers. Rider's manuals appeared in 1932 and covered nearly all the radios that a general serviceman would encounter. The relatively common Rider's manuals, compared to the Kent manuals that have become collector's items, indicates that after the 1931 issue, very few servicemen entered new subscriptions.

After the Open Sets became popular and Kent had started to actively involve his dealers and his factory service organization in building sales, Kent set up a Dealer Helps function. He issued a catalog of merchandise that the dealer could buy to furnish his store with eye-catching displays. Figure 42 shows a part of one page from the 1927-28 catalog, along with a page from the 1929-30 catalog. Part of two pages from the 1929 Retail

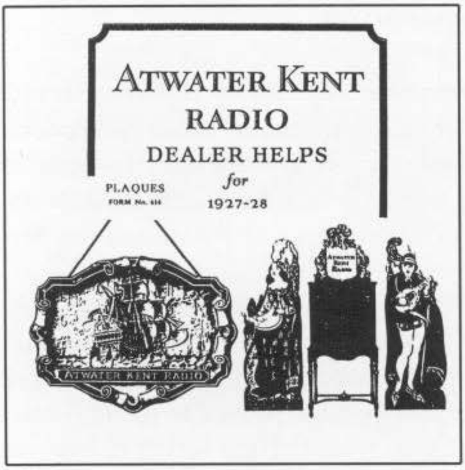


Figure 42. *Some of the many AK radio dealer support items, 1927-18.*

Sales Promotion Plan is shown in Figure 43. With this kind of material and with his institutional advertising campaign using print and broadcasting, Kent influenced potential customers as strongly as any other radio manufacturer of that time.

KENT SNAPS THE LOCK

The time has come to ask," Was Atwater Kent really a master marketer?" We established the concepts by which the question could be answered. There had to be a useful product and Kent certainly had demonstrated his capability in both factors of the Making process. He kept himself constantly aware of what his factory could do and how efficiently it ran. He showed many times how he could improve his manufacturing ability by adding new buildings, new machines and new practices. At the peak of Atwater Kent's success in building radios, after the three millionth set in 1931, he made completely clear his understanding and success with the Using process. From the ignition days he made his decisions based on his customers' uses for his products. That recognition stayed through the entire radio production. When Kent understood the effectiveness of changing his customer's expectations about radio in favor of his products, he showed that all the factors of the marketing function were in place and he was applying them effectively to control his business. He was indeed a master marketer.

Leaving the analysis at the peak of Atwater Kent's production only considers the up-side of the business as the base for the assessment. There was also a down-side, all the time from 1932 until he closed in 1936. New conditions altered the factors in the marketing function. The factors in the Making process were altered by the superheterodyne circuit and changing styles. The results were smaller mechanical radios that provided very

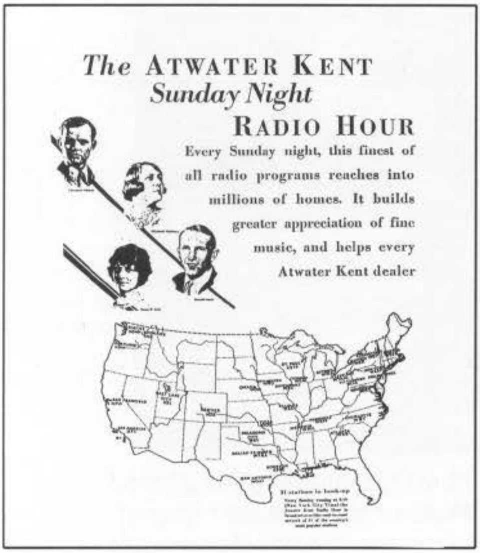


Figure 43. *Sales promotion of the AK Sunday night Radio Hour.*

acceptable performance at a price more in line with what the customer in the 1930s could pay. That impacted the factory two ways; the production procedures had to change, and the costs had to go down.

The investment in the big presses and the big chassis handling equipment no longer paid off since that part of the factory had to be idled. Customers' taste for cabinetry changed to compact sets that had to compete with the offerings of other manufacturers. Unfortunately, there was nearly no margin for profit when the cabinet suppliers' costs were paid.

Kent understood these new factors in the Using and the Making processes. His customers were being pressed by their own economic situations and were therefore increasingly buying for price rather than for brand-name. The total dollar volume was reduced by both the price changes caused by the smaller sets and by the tendency to keep older sets in service instead of replacing them. There was little Kent could do to influence potential customers to buy his line of radios beyond what he had been doing since he started extensive print and radio advertising. After the peak years, Kent's marketing analysis pointed only to negative changes on both the Making and Using processes.

Kent was not alone in this dismal analysis. All the big manufacturers were being forced to the same conclusions. Some saw their future as bleak and retrenched. Some hung on with the hope that things would get better. Some manufacturers were pushed out of the market. One company sharpened its approach and succeeded even through the worst of the depression. That company was not Atwater Kent; it was Philco.

During the early thirties, Atwater Kent tried to continue but several forces were working against him. His marketing function said he could

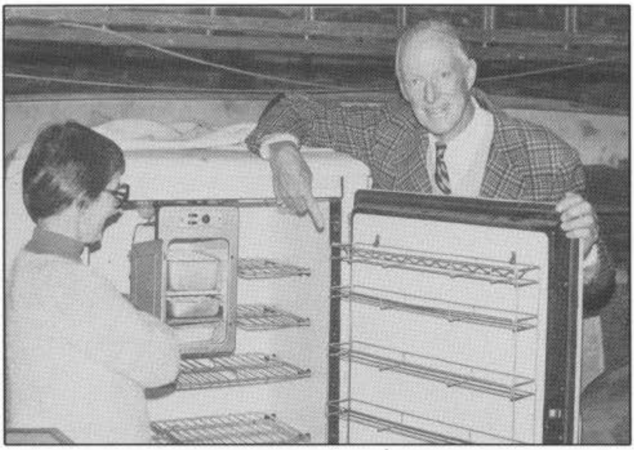


Figure 44. *Selling an AK refrigerator. In this photo, taken about 1979, Elinor Williams is shown with Atwater Kent, Jr.*

not expect a different future unless he used a totally different approach. In 1934 he decided on a new approach and entered the major appliance business by producing a refrigerator. From the Making process standpoint it was a good choice since the factory could make the panels and frames of the refrigerators using the big presses. They were idle most of the time since they were used for only a few of the big sets that were still being made. The compressor with its condenser and piping was not a difficult engineering or manufacturing task. Refrigerating machines had become standard products by 1935.

The Using process analysis was not favorable. While Kent could easily discern the customers' ways of using household refrigerators he could not easily assess how the average customer could pay for the machine. Worse, there were other manufacturers who had already staked out large portions of the total market. General Electric and General Motors were formidable and Crosley was almost as powerful.

The refrigerator itself was competitive, especially since it used shelves in the door, probably licensed from Crosley who owned the name Shelvador. Figure 44 shows the top Atwater Kent salesman trying to sell one of the refrigerators to a very interested customer. To help you identify the actors in the play, the initials are AAK and ELW. Needless to say, the addition of refrigeration to the radio line did not alter the basic marketing situation.

While changing the entire business approach to radio manufacturing was within Kent's capability as a business man (the example of Philco showed that a different approach was possible), he had to balance the revision of the business and the new demands on his life-style against the payoff. He was a millionaire many times over; therefore money had little appeal. Power as an entrepreneur offered no new satisfaction.

The challenge of the new business was not nearly as attractive this time as those challenges that he had met before, the ignition invention and its success, and becoming the world's largest radio manufacturer. Beyond these negatives was his distaste for the way a business had to be run in the New Deal Era. Kent was a typical American capitalist, rugged, self-centered and unsympathetic to the deplorable conditions of the world in the thirties. He was also nearing the time in his life when he wanted to enjoy the pleasures of retirement instead of the driving achievements of business.

For all these reasons, Kent's personal marketing analysis said that it was time to go. As his son, Atty, told it to us, his dad brought him to the factory, told him to sell the fixtures and the plant, and snapped the lock.

❖ ❖ ❖ ❖

AN APPRECIATION

In the initial process of analyzing the Atwater Kent radios in the Voice of the Twenties collection, and in responding to questions about their circuits and styles, Elinor and I came to realize that we were studying a person as much as we were fitting together the story of his radios.

Technical details were easy to extract from the radios and from written material, particularly factory publications. Much harder was the gathering of information about Atwater Kent himself. Examination of newspaper and magazine articles amplified the history of the company but told little of the man behind its growth. Our understanding of Atwater Kent has come from people who knew him directly and from historians who studied him.

We take this opportunity to identify and thank the critical sources of the material in the article:

Atwater Kent Jr. When we lived in King of Prussia, PA, Atwater Kent Jr. (Atty) learned that we had a museum that featured AK radios and related artifacts. He visited us and was fascinated by the idea that his father was famous for his radios. We became good friends and Atty shared with us his memories of his father and the few pieces of graphic history that he had kept.

Peter Kent, Atty's son. Peter's interest in his grandfather was strong, so when we arranged a visit to the remnant of the Stenton Avenue factory

Peter recorded our adventure and shared his family recollections, particularly as they related to his grandfather's automobiles.

Franklin and Margaret Atlee. We met the Atlees shortly after we moved to Pennsylvania (and joined AWA). From them we got a strong understanding of Kent's attitude toward his customers and their satisfaction with his products. Frank gave us some of our first breadboard instruments.

Alan Douglas. Over the years we have shared our friendship with Alan and we have been the grateful beneficiaries of his extensive analysis of early radio contemporary publications. Alone that would not have sufficiently characterized AK, but Alan's correspondence and personal contacts with Atwater Kent Jr. and with members of the manufacturing company staff have enriched our understanding of the human side of Kent's career.

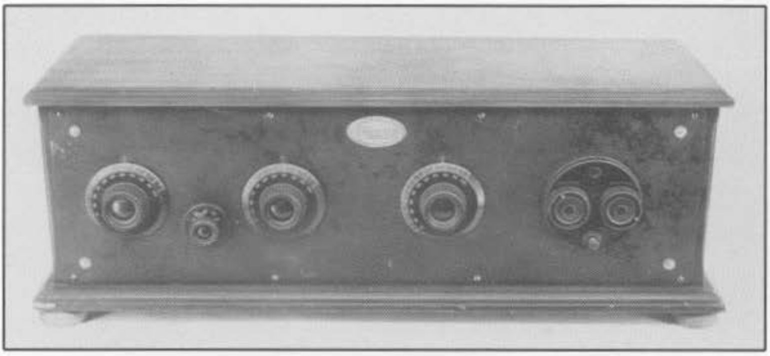
John Wolkonowitz. Almost from the beginning of our interest in AK we have exchanged ideas and analysis with John about AK, his factories and his radios. John's insistence on accuracy and consistency has significantly amplified and clarified our work. Particularly important was his (and Alan's) participation in the day-long visit with Atty and Peter to the early factory facilities.

David Kenig. About 1970, when we first opened the Voice of the Twenties museum, Dave was an interested visitor. He was doing research for a thesis and had chosen early radio as his subject, with the emphasis on Philadelphia manufacturers. A small change in emphasis resulted in his diligent research of the AK growth and success story. His research was both an early guide and a later fact-filled source for our museum and our work on AK history.

Jeffrey Ray. The proximity of Philadelphia and our friendship with Atty led to our strong interest in the Atwater Kent Museum and its role in preserving the city's history. We were introduced to Jeff who welcomed us to the museum, its history and its mission. Like so many others we were disappointed to learn that the museum did not feature AK radios. For our purpose of getting to know Kent himself, Jeff's experience and his friendship were excellent sources of information about Kent's support of the public good.

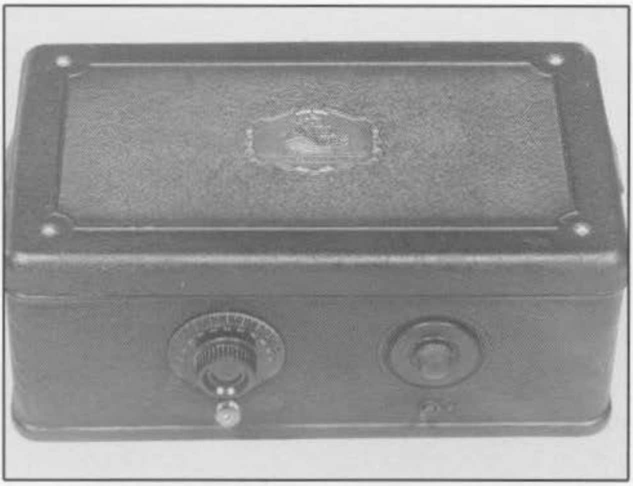
Ralph O. Williams

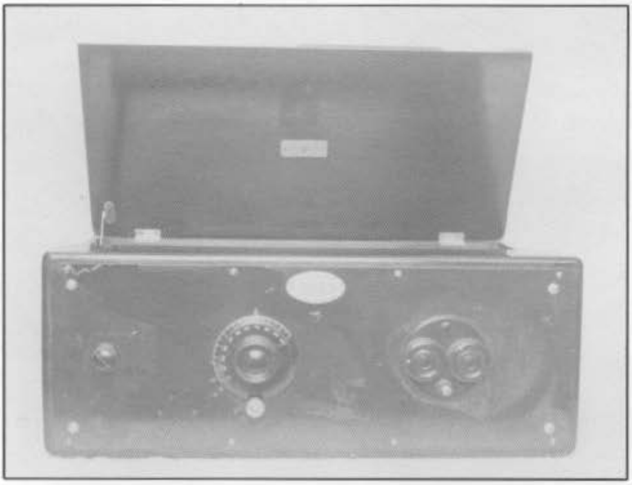
SOME ATWATER KENT RADIOS



Model 24

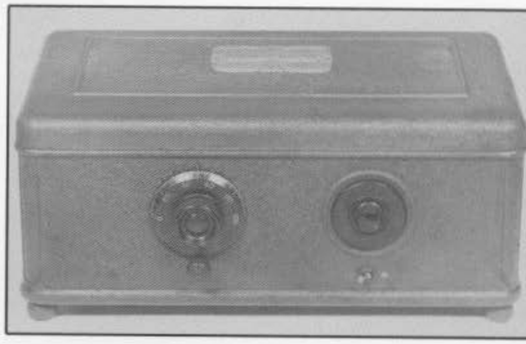
Model 37



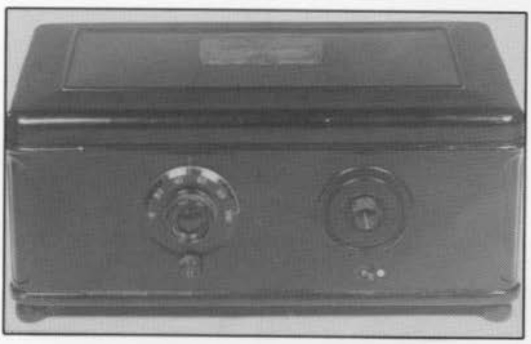


Model 33

Model 38



Model 43



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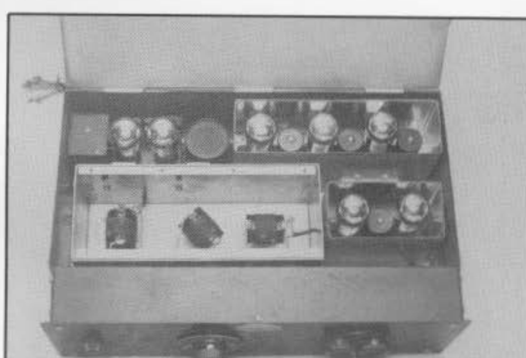


Model 50

RALPH O. WILLIAMS
N3VT

Born in November, 1920, coincident with KDKA's first broadcast, Ralph attended high school in NJ, followed by Cooper Union College. When WWII intervened, he studied radar and after serving as a radar officer in China, he completed college at Northeastern University in Boston. After graduating in 1947, he joined General Electric and worked in various aspects of radio engineering. He developed an interest in the history of the radio art, and after a 1965 move to Philadelphia, he concentrated his efforts on the historical material of RCA and Atwater Kent.

He joined the AWA, and through association and with the encouragement of other collectors he rapidly built a collection of Atwater Kent radio artifacts. He obtained his master's degree in engineering science; his thesis was on the information-processing efficiency of the Morse telegraph code. Over the years he has been a steady contributor to the various programs and other activities of the AWA. His series of landmark articles on Atwater Kent radio receivers in the first three volumes of the AWA REVIEW, unfortunately now out of print, are considered prime information sources for collectors.

After retiring from GE in 1980, Ralph moved to Orient, NY on the northeastern end of Long Island, where he and Elinor and his excellent collection of Atwater Kent material reside in an historic house more than 300 years old.

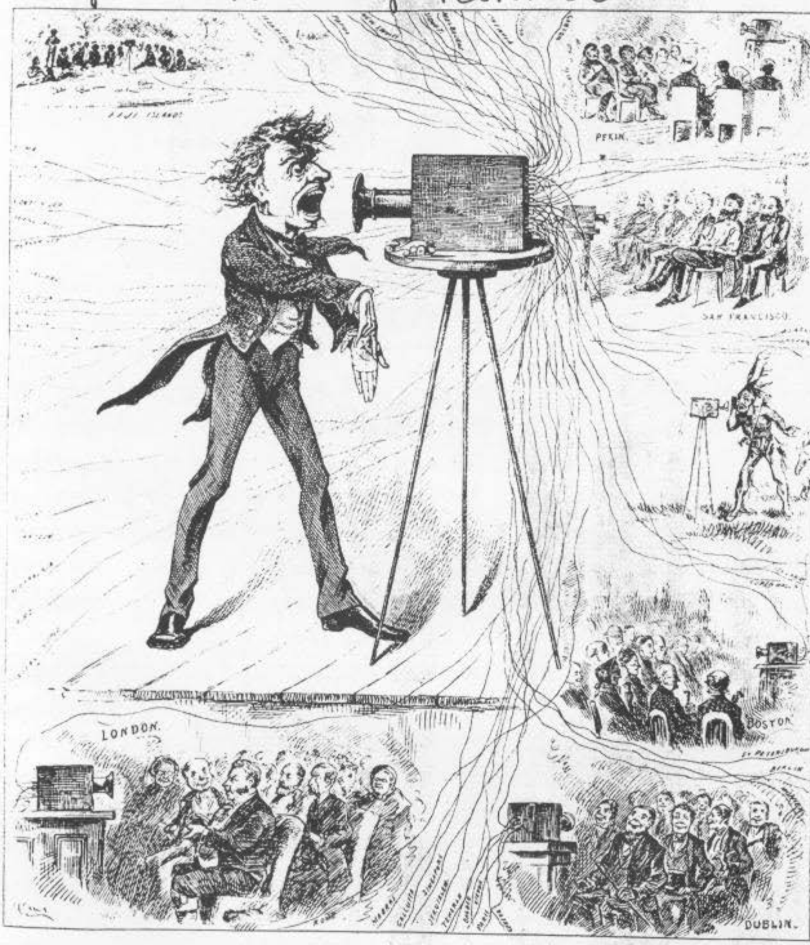
THE DAILY GRAPHIC

An Illustrated Evening Newspaper

39 & 41 PARK PLACE

VOL. VIII. All the News, Four Editions Daily. | NEW YORK, THURSDAY, MARCH 15, 1877. | $12 Per Year in Advance, Single Copies, Five Cents. NO. 1246

Rockefeller Center weekly Feb. 27 '36



TERRORS OF THE TELEPHONE—THE ORATOR OF THE FUTURE.

From the collection of Culver Service

The National Broadcasting Company, Radio Corporation of America, Bell Telephone Laboratories in the New York Museum of Science and Industry in the RCA Building, and you and you and you will be interested to note that way back in 1877, when the telephone was new, this artist didn't miss the 1936 radio broadcasting idea very far.

Figure 1. *"Terrors of the Telephone" from the Daily Graphic, March 15, 1877. (Clark Collection)*

THE RACE FOR RADIOTELEPHONE: 1900-1920

Mike Adams
112 Crescent Court
Scotts Valley, CA 95066

INTRODUCTION

Imagine a race for which there is no clear prize or finish line, a contest of which most participants didn't even realize they were a part. Years later the race would be viewed as one of finding the right technology and a greater social purpose for the talking wireless, one resulting in an electronic mass media totally different from its original prototype, the telephone and the telegraph. Before this race ended, before the finish line had been reached, some of the contestants would have dropped out, the Federal Government would finally get involved, and world events would alter its outcome. Major industries, corporations and fortunes would be established and their power would be felt for decades. Both the race and the prize would have lasting influence.

There was such a race for the radiotelephone. It took place between 1900 and 1920, the years when the radiotelephone came of age, twenty years in which we saw this device evolve from an original emphasis on two-way wireless telephone communication experimentation into broadcasting for an audience. Within these two important decades the transmitting technologies of spark, arc, alternator and vacuum tube were tried, improved, discarded or embraced. This important transition period will be explored through the work of five individuals, most of whom began as scientists and inventors, but later some became businessmen and promoters. The five are Reginald Fessenden, Valdemar Poulsen, Lee de Forest, Charles Herrold and Frank Conrad.

This article evolved out of a larger research and writing project. I started out looking for supplementary material for an in-progress biography on early broadcaster Charles Herrold and I ended up with this story of five men whom I believe were primarily responsible for either the discovery, the invention or the realization of the broad uses of a talking wireless. I found that more than any others, it was probably this group of five who led the early race for the radiotelephone. And while the evidence suggests that it began for all of them as a quest for a wireless replacement for the wired telephone, it ended with the broadcasting of entertainment programming for an audience. Of course, this is my list based on my unique research experiences. Important technical and business contributors like Edwin

Armstrong and David Sarnoff are missing from the list because the purpose of this story is to focus narrowly on the invention and the public uses of early radiotelephone transmitting technology between 1900 and 1920.

PRELUDE AND PERSPECTIVE

Early rumblings of the possibility of what radio might become sounded several decades before Marconi's wireless became part of the lexicon of the Twentieth Century. Books like Edward Bellamy's *Looking Backward: 1887-2000,* and other political and social satire in the form of editorial cartoons, encouraged public discussion of what might result if a system of sending a speech or the music of a live orchestra simultaneously to a number of receivers were to be developed. Some editorial writers thought it would be an intrusion, others believed it would destroy society as it kept people out the concert halls and away from the orator's public soapboxes and isolated them in their homes. Nevertheless, from time to time there was speculation about such a system, and in several European countries, such music and news subscription systems actually existed for a time. Of course those fictional and real systems all used connecting wires. Their precedents were the existing communication systems of the era; the telephone, the telegraph and the transatlantic cable.

There were also a handful of pre-wireless inventors who constructed and even patented voice transmission systems using modulated light, ground conductivity or magnetic inductance. Some of these individuals, such as Alexander Graham Bell, were already well known for other inventions. Others, like Nathan Stubblefield, went to their graves believing they had been foiled by unknown conspirators, or that if they could have found one more financial backer, or the time and money with which to make one more improvement, their system would be the one in use today. Before Heinrich Hertz, Oliver Lodge and Guglielmo Marconi experimented with the sending of small signals from a spark gap from one side of a room to another, there were the theories and writings of James Clerk Maxwell and others that at least suggested that a better system, perhaps a wireless one, was waiting to be discovered and exploited.

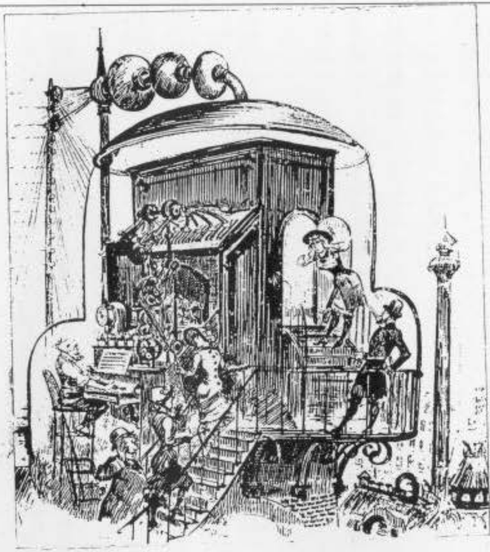
Compared with the wired systems of speculative fiction, compared to the very limited range of the modulated light and inductance methods, the wireless telegraph popularized by Marconi was to be the base on which was launched every new system of sending voice and music to an audience of more than one. The issues raised by this new electro-magnetic method of long-distance communication changed forever the thrust of the invention that would ultimately lead to radio broadcasting. The important work leading to a practical radiotelephone began with the arc systems of

Poulsen and Duddel, the spark and alternator voice experiments of Reginald Fessenden, and the early arc and later vacuum tube work by Lee de Forest. It was from this basic work, most of it in the first decade of the century, that inventor Charles Herrold entered the picture. Herrold's significance was twofold: He made Poulsen's arc work well enough and long enough to be a dependable carrier of voice and music, and before anyone else he used this technology to start and maintain the first radio station. Finally, as these two decades ended, engineer Frank Conrad found himself in a position to set the stage for the ultimate practical use of the radiotelephone. As the RCA agreements clarified ownership of the technology, the broadcasting of entertainment and information into homes by radio became a reality.

THE NINETEENTH CENTURY IMAGINATION

Before the radiotelephone experimenters introduced their competing wireless systems, there already had been some discussion in the newspapers and periodicals about how the technology of sending music into homes might be accomplished. More than talk, there actually were a couple of systems in place that today might be categorized as "subscription music services," Nineteenth Century versions of the current TV cable-delivered *DMX, Digital Music Express*. Likely influenced by the Bell telephone, all of those systems, whether actual or imagined, used wires for distribution. The significance of those early non-Hertzian systems to this story is that for the first time they introduced into the public debate a possible family entertainment service that was closer to what radio would become than the then in-home fare of books, magazines, stereo-opticon cards, and the piano. What those few non-wireless systems attempted were certainly ahead of their time, perhaps unknowingly awaiting a successful wireless telephone.

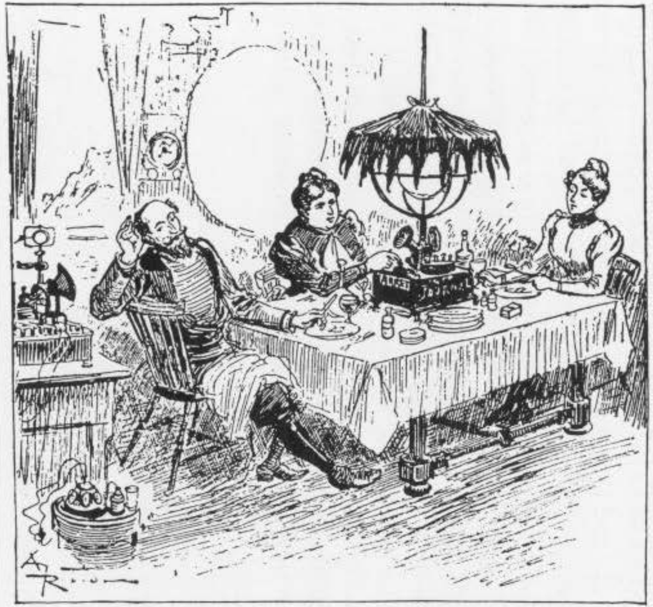
In Bellamy's best-selling 1887 novel *Looking Backwards*, its discussion of the wired music system of the future and its influence on the public cannot be minimized. As one of the most exciting, most read stories of speculative fiction, it placed a system of musical entertainment in every home in the context of a utopian, albeit benevolent socialist society in the year 2000. There was no poverty and everyone had a job and a home. Within each home there was a future version of the radio: "They have devised an arrangement for providing everybody with music in their homes, perfect in quality, unlimited in quantity . . . you can hear by merely pressing a button." (1) But even before Bellamy's ideas went into print, there was a prophetic cartoon on the front page of the March, 1877 issue of the



Radio Broadcasting station,.
1882
Lithograph by Albert Robida
Radio Journal,Feb. 1943
(SRM 14 265)

Note the wires leading up to the pole, and thense outward to subscribers. Note also the large "spark gap" above the station. This may have been a combined wired-wireless and radio broadcasting station!

Figure 2. *Albert Robida's 1882 lithograph re-titled "Radio Broadcasting Station, 1882" by George Clark in Radio Journal, February 1943. (Clark Collection)*



Historia Mondiale

AN ANTICIPATION OF THE WIRELESS RECEIVER

A futuristic sketch, by Albert Robida in 1883, of a telephonic installation by which newspaper reports are to be transmitted. The apparatus is constructed in the table lamp and is marked "Journal" and "Stop (Arrêt)." On the neighbouring table is another apparatus which transmits information

Figure 3. *Albert Robida, 1883 lithograph, re-later titled "An Anticipation of the Wireless Receiver."(Clark Collection)*

New York Daily Graphic. Captioned, "Terrors of the Telephone," it depicted an angry-looking orator yelling into a floor-mounted oversized telephone microphone. From the back of the device are hundreds of tiny wires connected to large receivers in a dozen places; London, New York, Dublin, Boston, San Francisco, Peking, and curiously, a lone Indian, outdoors, on the American prairie. With the exception of the Indian, all of these receivers are in public halls, none in a living room setting. (2) (Figure 1)

That same year a similar idea had been advanced in the form of a song. Written by Thomas P. Westendorf, *The Wondrous Telephone* predicted lyrically that: "You stay at home and listen to the lecture in the hall or hear the strains of music from a fashionable ball" (3) Then there was Albert Robida, a political cartoonist and lithographer who in 1882-83 did a series of lithographic drawings depicting broadcasting, but this time aimed at a home listener rather than an audience in a public hall. At the "transmitting" or originating end, a musician played what appeared to be a combination organ-steam calliope, its sound somehow gathered and connected to many wires. The late George Clark, RCA Historian in the 1920s and 1930s, added a note to the bottom of the cartoon calling it "Radio Broadcasting Station, 1882." In Clark's words, "Note the wires leading up to the pole, and then outward to subscribers." (4) In Robida's 1883 lithograph a home receiving setup was portrayed, with the husband, wife and daughter sitting around a table listening in rapt attention to several telephone loudspeakers. It's described by Robida as: "a telephonic installation by which newspaper reports are to be transmitted." (5) (Figs. 2, 3)

If the systems described in the books and editorial cartoons of the day seemed more like science fiction than reality, consider the actual working systems. In an operating demonstration system patented in 1881 by French inventor Clemen-Agnes Ader, microphones were installed next to the footlights of a stage, connected to listeners by wires. According to Ader's patent, "The telephone allows us to convey songs, music and the spoken word to distant places." (6) Apparently, the existence of wired systems was more commonplace than realized: "European capitals had a service of wired broadcasts via the telephone system. Paris naturally had such a system. London telephone subscribers could participate in the two-tier tariff *Electrophone* service at five or ten pounds per year, and eavesdrop on concerts, music halls, theatres or church services. The London system ran from 1899 until radio finally killed it in 1925." (7) And, "In 1893 the *Telephon-Hirmondo* in Budapest was transmitting news, weather reports, market quotations, lectures and music over the telephone from 8am to 11pm for a large number of subscribers." (8) Wouldn't those systems and the publics they served have benefitted from a successful wireless telephone? Could the transition have been made from a reliance on wires to a technology less onerous? Were those early attempts simply "radio" waiting to happen?

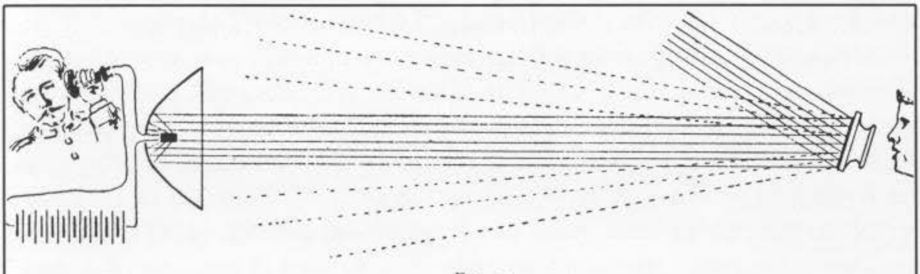


FIG. 1.
Bell's Original Photophone.

AT+T 1904 E
St Louis Expo

The Radiophone.

How It Is Possible to Talk Over A Light Ray Miles in Length.

The radiophone, which forms a part of the exhibit of the Bell Telephone Companies at the Louisiana Purchase Exposition, is the only practicable method of telephoning without the use of wires yet discovered. By its means the blinding rays of a searchlight may be made the path for human speech and other sounds. The rays of light will carry for miles every tone and inflection of the voice, the delicate shading and varying effects of orchestral music, every note and cadence of a song. With the help of the radiophone electric lights may be made to talk or be transformed into musical instruments. The radiophone is the embodiment of much that is wonderful in the transmission of sound, and it suggests the marvelous possibilities hidden in articles of common use. A bit of the black worsted which a woman uses in knitting, a tiny fragment torn from a silk dress, particles of rubber scraped with a pen knife from an old overshoe, these and many other substances may be made to repeat words flashed to them from an electric light miles away. So may the fine hairs found on the milkweed and the thistle-down which is the sport of the summer's breeze.

Alexander Graham Bell, the inventor of the telephone, also discovered the means by which wireless telephony has been made possible, and constructed the first apparatus to which the name of the radiophone was given. This was later perfected by an officer of the Bell Telephone system, and the wonderful results now attained are due to the scientific knowledge and skill of American inventors and engineers. In the experiments which led to the making of the radiophone Mr. Charles Sumner Taintor was associated with Professor Bell. They found that a great many substances could be made to give out sounds under the action of the heat car-

1

***Figure 4**. Bell's Photophone: "How it is Possible to Talk Over a Light Ray Miles in Length," 1904, unidentified article. (Clark Collection)*

EARLY RADIOTELEPHONE SCIENCE

Early on, there were a number of individuals who apparently saw a need for a non-wired voice communication system. Much of this activity, if not all of it, happened prior to and around the time of Marconi's wireless telegraph introduction. Before the successes of Fessenden, Poulsen, de Forest and others, most early experimenters had based their devices on non-Hertzian principles. Whether over land or water, most of the early attempts to send voice without wires fell into one of two categories of technology: modulated light or inductance. There were systems that used a bright, focused light source modulated or made to "flicker" analogous to the varying currents caused by speaking into a carbon button telephone in series with a DC voltage. The receiver used a light sensitive element, selenium, in combination with batteries and earphones. The flickering of the received light falling on the selenium created tiny currents representative of the voice transmitted which could be heard in a telephone receiver. The range was limited to a few miles, and depended on the atmospheric conditions and the brightness of the light. The most successful of those limited devices was known as the "Photophone." Originally introduced by Alexander Graham Bell in 1878, this light telephony system had been improved by 1904 where it was demonstrated at the Louisiana Purchase Exposition in St Louis. Bell called it the "Radiophone," and while it may have attracted attention it never found practical use. (9) (Figure 4)

How did the press greet Bell's discovery? The word "radio" was used in a 1904 report: "The radiophone, which forms a part of the exhibit of the Bell Telephone Companies at the Louisiana Purchase Exposition, is the only practicable method of telephoning without the use of wires yet discovered. By its means the blinding rays of a searchlight may be made the path for human speech and other sounds. The rays of light will carry for miles every tone and inflection of the voice, the delicate shading and varying effects of orchestral music, every note and cadence of a song. With the help of the radiophone electric lights may be made to talk or be transformed into musical instruments. The radiophone is the embodiment of much that is wonderful in the transmission of sound, and it suggests the marvelous possibilities hidden in articles of common use." (10) While Bell clearly saw and marketed his device as a wireless accessory for his wired telephone, at least one member of the press was beginning to look at the future.

Other less well-known scientists were also working on variations of modulated light voice transmission using an arc as a light source. Moving closer to the Poulsen system of wireless arc transmission, in 1897 Professor H.T. Simon discovered that a DC arc would give out tones and speech by superimposing telephone currents on an arc used for a line-of-sight transmitter. This may have convinced Bell to use an arc for his Photophone. Around this same time the German inventor Ernst Ruhmer equipped several naval vessels with his version of a light telephone device. Distance limitations and the soon-to-be-invented wireless telephones would rapidly doom all development of this and other line-of-sight devices.

Then there was the strange case of Nathan B. Stubblefield, 1860-1928. His two radiotelephone systems, one based on ground conductivity and the other induction, both caused quite a stir in his native Kentucky. He claimed to have sent the first non-wired voice transmission over land as early as 1892. In an attempt to free the telephone from its wires, Stubblefield

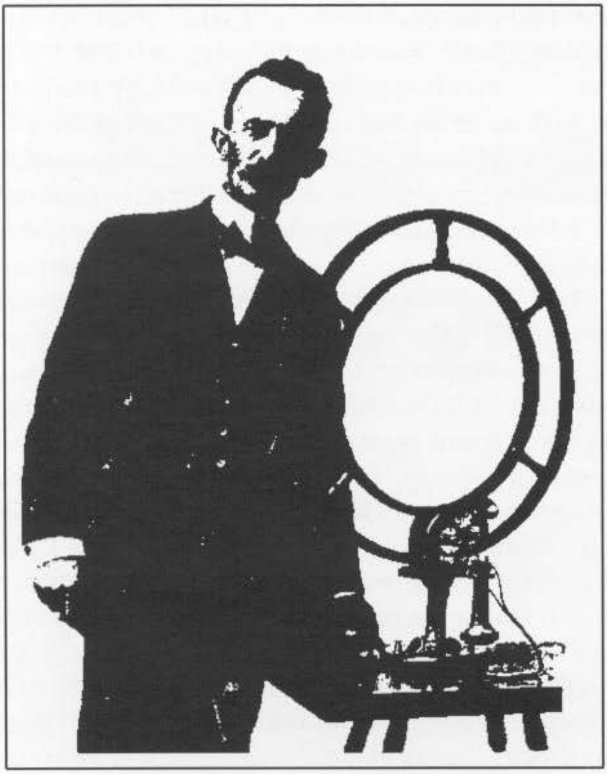


Figure 5. *Stubblefield and his induction device. (Murray State College, KY)*

did not use true wireless methods, but rather, two non-radio systems. The first of his systems used the conductive characteristics of moist ground, and featured a carbon telephone transmitter, many batteries in series, and long rods stuck in the wet earth. It was big news by 1902: "Nathan Stubblefield, a Kentucky truck farmer, claims to have discovered telephoning without wires. At a public exhibition in Murray, Calloway County, Ky., on Jan. 1, he convinced a thousand people of the truth of his claim. . . Stubblefield placed his transmitter in the courthouse square and ran two wires from it into the ground. He established five 'listening stations' in various parts of the town, the furthest six blocks from the transmitter. Then Mr. Stubblefield's son took his place at the transmitter and talked, whispered, whistled and played a harmonica. Simultaneously everyone at the receivers heard him with remarkable distinctness." (11)

The importance of this demonstration was not in the technology employed for it was primitive and limited. Its significance was in the sending of voice and music without wires to more than one receiver in a public, non-message application. This demonstration, organized by the Wireless Telephone Company of America, also preceded their purchase of the rights to 500,000 shares of stock in the Stubblefield inventions. For a while it looked as if Stubblefield might become rich: "The company also organized an experiment in Central Park, New York City, in June, 1902. This event, however, was nearly a total failure, due primarily to the rocky soil in the park which would not conduct electricity. Company executives suggested that Stubblefield surreptitiously run a wire underground to connect the rods. Nathan became immediately suspicious and, upon further investigation, discovered that the company was nothing but a stock fraud. He returned to Murray and urged all his friends who had invested to demand their money back. The company collapsed and the swindlers involved eventually went to prison." (12) (Figure 5)

Perhaps influenced by Sir William H. Preece who in 1899 used telephones and a parallel-wire induction system to transmit voice three miles (13), Stubblefield's second system was based on magnetic induction, a technology similar to modern day systems that connect to a hi-fi receiver which allow a music listener to walk around a room wearing headphones but with no connecting wires. He received a patent in May, 1908 for his magnetic induction system, which, unlike the Preece system, used a telephone and a battery fed into large inductance coils, like the primary of a giant air core transformer. The secondary coil was connected to a telephone receiver. After his earlier experience with ground conductivity Stubblefield refused to show his induction system to potential investors for fear that they would steal it from him. He used the induction system for a while but later gave it up, having unsuccessfully spent four years trying to raise the money needed to develop it. Its range was probably limited to less than half a mile. In the March, 1930 issue of *Kentucky Progress* Magazine, an article, "Murray Kentucky, the Birthplace of Radio" tells of the plaque placed on March 28, 1930, at Murray State Teachers College to honor Stubblefield as, "The first man to broadcast and receive the human voice without wires. Although he undoubtedly gave the world its greatest invention, the radio, he failed to get the honor due him." (14)

MARCONI'S IMPORTANCE

But then around 1900, there was publicity surrounding a true technical revolution, actual wireless as we now know it. The first stories to appear in the national press were about Guglielmo Marconi, a young boy with an Italian father and British mother. When the Italian government would not support his work, he took his inventions to the British. From sending Hertzian waves across a room as early as 1894 to the highly publicized transmission of the letter "S" from Poldhu, England to Newfoundland, Canada in December, 1901, Marconi's system made obsolete all non-Hertzian systems of wireless communication. Today some believe Marconi's success was mostly because he was a "systems man," the first to successfully combine the relevant practical and theoretical wireless ideas and experiments of others into a business. Said historian Hugh Aitken: "What differentiated Marconi from his contemporary rivals was not his scientific knowledge nor, initially, the distinctive excellence of his technology. It was his sense of the market, of where a demand for this new technology existed or could be created." (15) And Marconi had little interest in wireless beyond dependable two-way commercial communication and the safety of ships at sea. Contrary to broadcasting by voice, Marconi believed messages should remain private.

By 1902 Marconi's wireless telegraph was an established fact. It was in that context that a new group of experimenters began to look at better ways of sending voice through the air. After all, the light and induction systems were limited to a few miles and never would be taken seriously, especially if a voice transmission system with the range of Marconi's wireless telegraph could be found. So in the future invention history of radio, wireless by Hertzian waves was where all the action was going to be centered. And between the time of Marconi's wireless in 1900 and the broadcasting decade of the 1920s, systems based on spark, alternator, arc, and the vacuum tube quickly overshadowed all earlier non-Hertzian systems as a carrier of voice. Determining which one was best would consume the first two decades of the new century. Scientists and inventors like Poulsen, Fessenden and de Forest led the way. While none of the participants knew it at the time, it would be a race for the radiotelephone.

Another limiting technology that for a time delayed the transition from modulated light systems to a wireless-based radiotelephone was that of the receiver. For translating the dots and dashes of spark, the major device used in the Marconi system was a variant of Branley's Coherer, a small tube containing iron filings which closed like a switch when receiving the electromagnetic pulses of the Morse code. It both looked and worked like a Rube Goldberg creation: Each time the filings "cohered," or caused the circuit to close, current from an in-series battery flowed and a buzzer sounded or a telephone receiver clicked or an inking device recorded a coded symbolic component of the message, a dot or dash. Then a small hammer would "tap" the filings apart, and the entire process began again in order to detect the next dot or dash. In addition to being extremely slow, the mechanical coherer could not receive sound which we know to be audio frequency. A coherer did not allow a receiver to "hear" audio, obviously a serious technical impediment to the development of the wireless telephone. New systems of detecting like Fessenden's "Liquid Barretter" and Picard's "galena" had to be discovered before an operator could "hear" a human voice using a headphone. A new generation of detectors which converted or "rectified" RF, radio frequency, into AF, or audio frequency really opened the door for the Hertzian-based radiotelephone.

THE NEW RADIOTELEPHONE PIONEERS

So in the first few years of the new century, the stage was likely set for a practical radiotelephone system or systems based on Marconi's success with the Hertzian principles. In the beginning, some of the five pioneers profiled here only wanted to discover and reap the financial rewards from finding a replacement for the wired Bell telephone, just like Marconi had done with the land-based telegraph. Fessenden and de Forest were serious scientists, and Herrold a wireless tinkerer, but all three tried to invent and profit from a practical system. And perhaps accidentally, these three began to discover that they had small audiences listening to their experimental transmissions of voice and music. Poulsen's importance was that his arc system was the major transmitting technology used between 1907 and 1916, a technology which was brought from Denmark to the Bay Area of California by a Stanford engineering graduate. It was the Poulsen arc transmitter and the wireless company built around it that became the basis for the development of the modern electronics industry and Silicon Valley. Conrad became important toward the end of the two decades. By then he and others saw a potential for a mass entertainment system out of the finally perfected radiotelephone. The result was that the 1920s would become broadcasting's defining decade.

REGINALD FESSENDEN AND THE FIRST BROADCAST

Reginald Aubrey Fessenden was born in Bolton, Quebec, Canada in October 1866. As the son of a minister, he was educated in New York and Canada, and "at an early date manifested a particular liking for mathematical and scientific subjects." (16) Between 1887 and 1890 Fessenden worked for Thomas Edison, then as a professor of electrical engineering at Purdue University and at Western University of Pennsylvania, 1892-93, and finally at the US Weather Bureau, 1900. Described by colleagues as a hard working, hard driving intellectual, by 1902 Fessenden had 13 wireless patents issued in his name. He was an early primary contributor to the science of wireless and radio; in 1902 his inventions covered "improvements in construction of antennas, means of amplifying received signals, wireless telephone." (17) Probably his most important early contribution was the 1903 invention of the Liquid Barretter, "an electrode-electrolytic

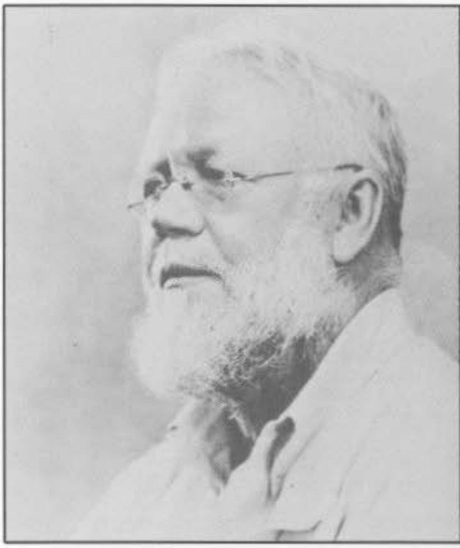


Figure 6. *Reginald Fessenden. (Communications Research Centre, Canada)*

Figure 7. *Fessenden in his lab. (CRC, Canada)*

interface rectifier which was used for both radio-telegraphy and radiotelephony – initially for reception of synchronized rotary spark gap transmissions, another one of his inventions, and later for reception of amplitude-modulated wireless signals." (18) In simpler terms, Fessenden invented the first audio receiving device that made the hearing of wireless voice transmissions possible! (Figure 6)

The Liquid Barretter was no small accomplishment since, unlike all the previous mechanical detectors like the above mentioned coherer, audio could finally be heard with it over headphones. Using it, Fessenden had listened to the various musical notes of the spark stations and noticing their distinct audio sounds believed that if he could put a voice over the air, it too could be "heard" by the Barretter. And Fessenden was probably the first to send and have received a voice transmission using Hertzian waves, this as early as 1900. Writing in *Scientific American*, Fessenden in 1907 describes his work with all three systems: spark, arc, alternator. About his early spark experiments during his employment by a wireless company, The National Electric Signaling Company (NESCO), he wrote how he, "transmitted speech wirelessly for the first time in the summer of 1900 by the method disclosed in US patent 706,747. While the speech transmission could be understood, there was a great deal of extraneous noise in the telephone, and various devices were devised for eliminating this." (19)

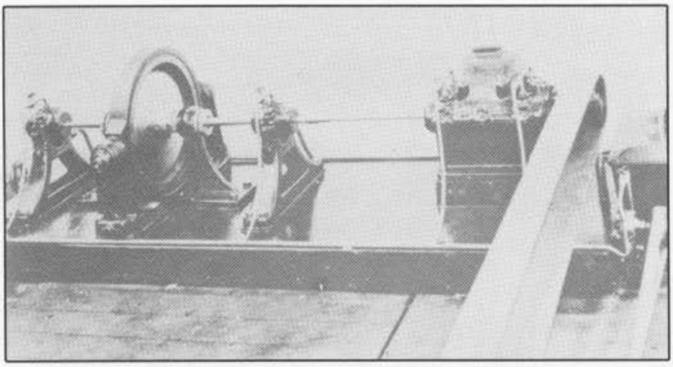


Figure 8. *The Alexanderson/GE built alternator used for the 1906 broadcast. (CRC, Canada)*

Next, he turned to an arc with "an improvement on the original Thomson singing arc method, recently discovered by Poulsen and others, but which was used by the National Electric Signaling Company in 1901 and patented in 1902." (20) Fessenden also described his work with General Electric engineer Ernst Alexanderson in developing his alternator for NESCO: "During this test not only speech but phonographic talking records and music were transmitted, all being received with perfect clearness and distinctness, the wireless telephone being in this respect markedly an advance over the regular wire lines." (21) (Figure 8)

As an eccentric genius, he was reported to be tough on his staff: "Fessenden and Alexanderson worked well together, although that was not the case for many others who fell into Fessenden's orbit. His assistants, for example, grumbled about his high-handed ways with them. 'Don't try to think - you haven't the brains for it!' was one of the kinder ways he addressed them. Alexanderson recalled that Fessenden was domineering and bombastic with people he thought were beneath him. When something went wrong, he sometimes would fire everyone only to rehire them the next day." (22) While he continued to work with Alexanderson on the design of a super-alternator for radiotelephone communication, he continued to intimidate his staff: "As Fessenden's prowess in wireless grew, so did his eccentricities. He experienced growing paranoia that any number of people were out to steal his inventions. His Brant Rock, Massachusetts laboratory became a top-secret outpost, where information and apparatus were kept under lock and key at all times. His visions of industrial espionage were not entirely imaginary. A casual visit by de Forest to one of Fessenden's workshops in 1903 resulted in a round of court battles regarding de Forest's theft of the Barretter receiver design." (23) After three court appearances, he finally received an injunction against de Forest for patent infringement. It cost Fessenden over $100,000 and increased his paranoia.

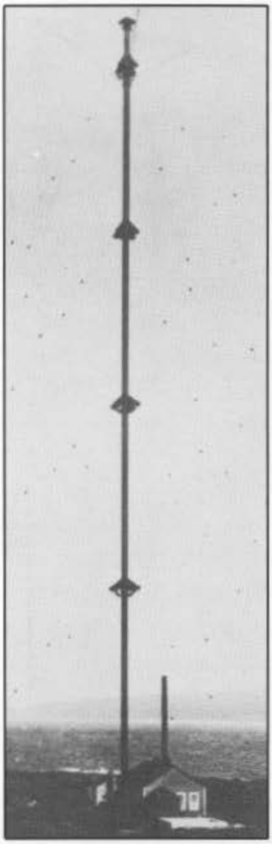


Figure 9. *Brant Rock antenna. (CRC, Canada)*

Fessenden's longest lasting and most public claim was his 1906 Christmas Eve broadcast from Brant Rock, a small Atlantic coastal village north of Cape Cod Bay. In a letter he wrote to Westinghouse Vice-President S. M. Kintner in 1932, he reflected on this event: "This broadcast was advertised and notified three days in advance of Christmas, the word being telegraphed to the ships of the U.S. Navy and the United Fruit Co., which were equipped with our apparatus that we intended broadcasting speech, music and singing on Christmas Eve and New Years Eve. The program on Christmas Eve was as follows: first a short speech by me saying what we were going to do, then some phonograph music, Handel's Largo. Then came a violin solo by me, being a composition by Gounod called 'O, Holy Night,'' and ending up with the words 'Adore and be Still' which I sang one verse of, in addition to playing on the violin, though the singing, of course, was not very good. Then came the bible text, 'Glory to God in the highest and on earth peace to men of good will,' and we finally wound up by wishing them a Merry Christmas and then saying that we proposed to broadcast again New Years Eve." (24) (Figure 10)

While today many historians categorize the 1906 Brant Rock musical program as a "broadcast," Fessenden's stated goal was simply to build a radiotelephone for commercial purposes. He was a musician by avocation, as evidenced by his performances on the 1906-07 Brant Rock transmissions, and he admitted sending phonograph music many times to "rest my voice," but other than Brant Rock, he never made any claim to being a broadcaster. His two most important contributions to actual broadcasting were in the technology, not the art. The Alexanderson Alternator used in the 1906 Brant Rock broadcasts demonstrated early that clear speech and music could be transmitted. And most important, his earlier invention of the Liquid Barretter detector forever changed the receiver from its earlier mechanical roots. It was, "the first device to enable operators to receive signals 'by ear." (25)

Reginald Fessenden was truly an original thinker. But that he was also an eccentric caused his early undoing, and by 1910 his backers, NESCO,

Figure 10. *Fessenden in lab, Brant rock, 1906. (CRC, Canada)*

fired him and removed his equipment. According to a witness, "He needed a bathtub of especial size to accommodate his huge frame, and had one installed at Brant Rock, covering it by a requisition as 'Blueprint Washing Machine.' Fessenden had just returned from a voyage to Europe and had turned in a prodigious expense account, which the backers would not pay. So he was fired. The workers chose sides. The order came to dismantle the plant, and especially to get the records packed in boxes and sent to Pittsburgh. Up came a van with large packing boxes, into which the papers were hastily stowed. Then arose a battle between the ins and outs, and the upshot was that the pro-Fessendenites sat on the box covers all night to prevent them being taken away by the renegades. The matter was settled amiably and the records put back." (26) But after that insult, and with a divided staff and little or no money with which to continue, Fessenden got out of the radiotelephone business. Others like Lee de Forest and Charles Herrold learned from his work, his successes and his failures, and continued to find new ways to use the talking wireless.

VALDEMAR POULSEN, THE DANISH EDISON

Another early and important influence on radiotelephony was Valdemar Poulsen, who was later known by the complimentary title, the Danish Edison. For most of the first two decades of the Twentieth Century his DC arc-based system of transmission was the model on which most inventors based their devices. Poulsen, who had earlier discovered the fundamentals of

Figure 11. *Early Poulsen magnetic recorder. (Ampex Museum)*

magnetic recording used today, improved on the theories of others to develop a system of arc telephony. Just as Marconi built on the work of Hertz and Maxwell, Poulsen based his arc system on "William Duddell's discovery of the singing arc. The principle of this discovery was that when an arc lamp, fed by a direct current of about two-hundred and fifty volts, is shunted with a suitable capacity, and an inductance, alternating currents of a frequency of 40,000 per second were established." (27) Poulsen discovered that when the singing arc was placed into an atmosphere of hydrogen or other gas, the frequency of the oscillations increased to almost 500,000 cycles per second, putting it in the radio frequency range where it could be detected as audio. He was also the first to introduce the use of "six arc lights in series as generators of an oscillating current of high frequency." (28) The Poulsen-Duddell system was introduced in 1903. For the transmission of voice most inventors used and attempted to legally improve upon Poulsen's technology.

In 1903 Poulsen patented, "an improved arc oscillation generator using a hydrocarbon atmosphere and a magnetic field." (29) The modifications of the Poulsen-Duddell discovery continued with Telefunken. Their arc telephone system in 1906 covered 25 miles: "The arcs used by the Telefunken Company were burned either six in series on 220 volts direct current, twelve in series on 440 volts, or twenty-four in series on 880 volts." (30) Then there was the problem of the microphone: Every Poulsen-based arc radiotelephone system required a microphone capable of handling high-current, the most popular of which used a carbon microphone with some form of circulating liquid to keep the element from overheating. In 1906 the Italian Count Majorana used a variant of the Poulsen arc system but

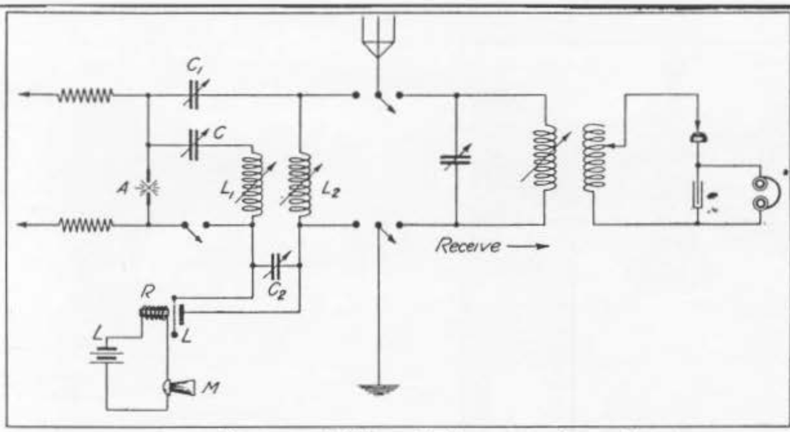


Figure 34—Dubilier radiophone transmitter and receiver

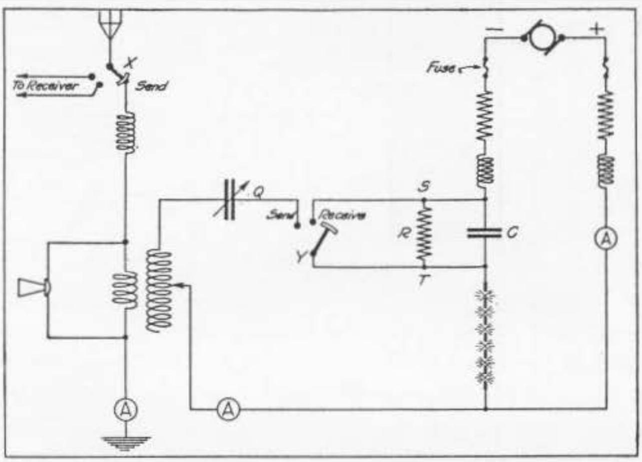


Figure 27—Telefunken series arc radio transmitter

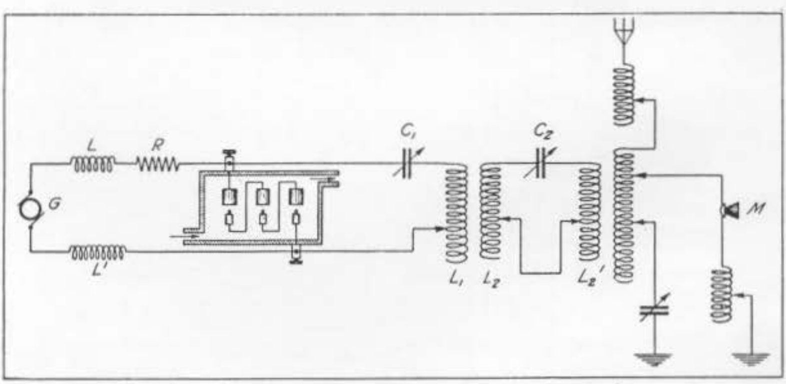


Figure 28—Colin and Jeance radiophone transmitter

Figures 12, 13, 14. *Three schematics of arc systems based on Poulsen principles: Dublier, Telefunken and Colin & Jeance. (Clark)*

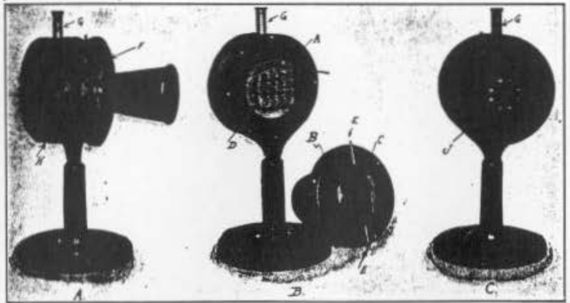


Figure 131—Egner-Holström high current microphone

Figures 15, 16, 17, 18. *Four views of carbon microphones necessary for the high current requirements of the arc radiotelephone system. Most were cooled by liquid. (Clark)*

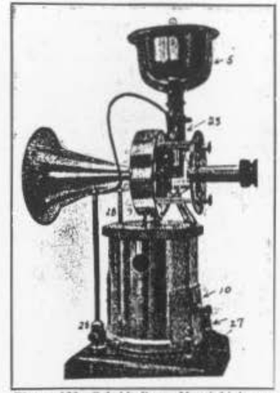


Figure 133—Scheidt-Boon Marzi high current microphone transmitter (relay type)

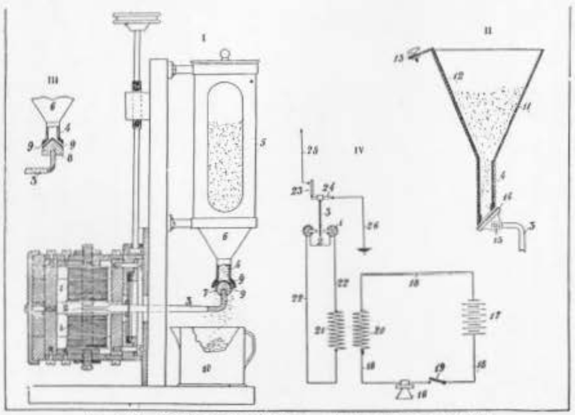


Figure 134—Details of Marzi high current microphones and relays

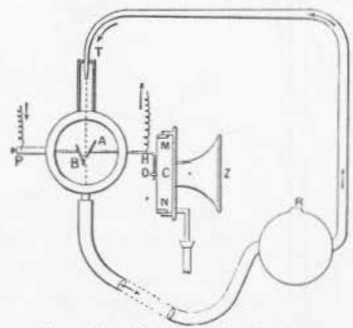


Figure 136—Vanni's liquid microphone

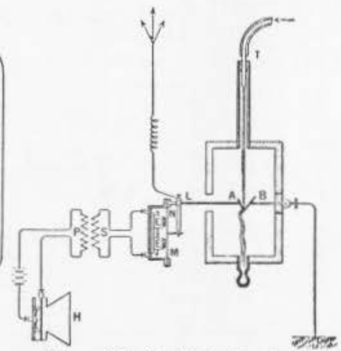
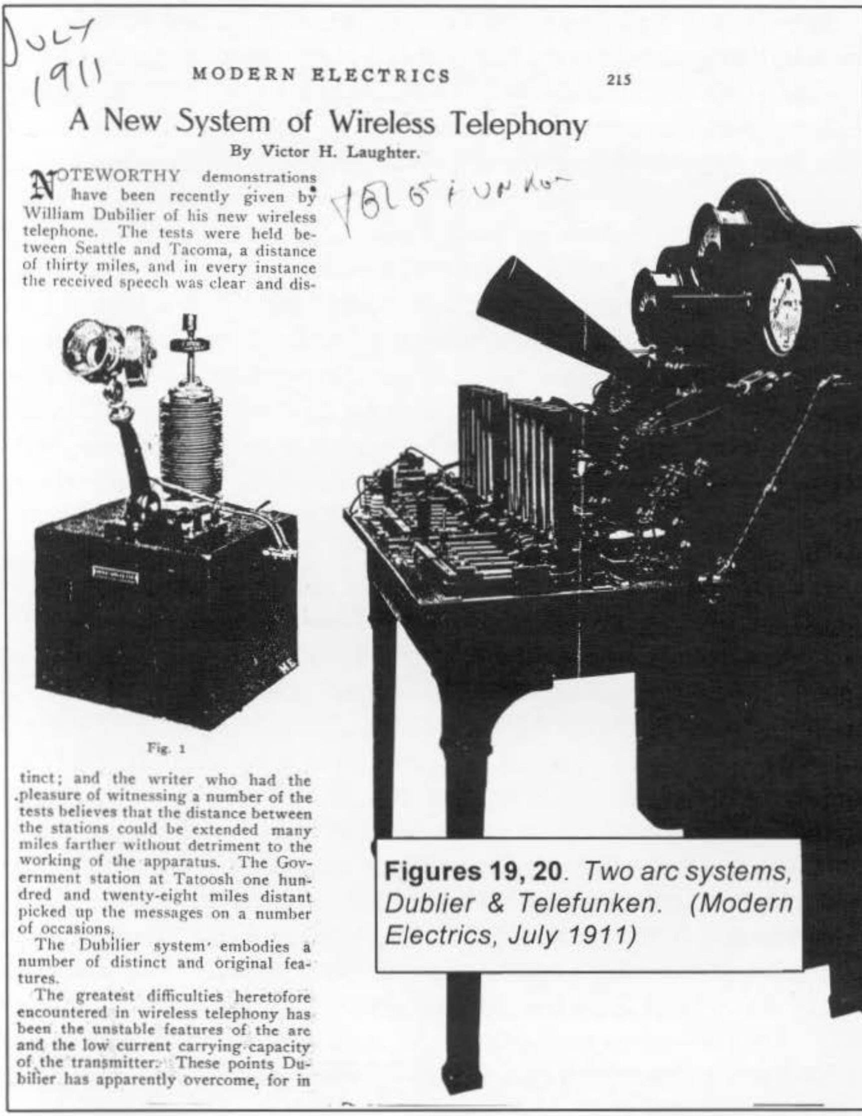


Figure 137—Vanni's liquid microphone relay



MODERN ELECTRICS 215

A New System of Wireless Telephony

By Victor H. Laughter.

NOTEWORTHY demonstrations have been recently given by William Dubilier of his new wireless telephone. The tests were held between Seattle and Tacoma, a distance of thirty miles, and in every instance the received speech was clear and distinct; and the writer who had the pleasure of witnessing a number of the tests believes that the distance between the stations could be extended many miles farther without detriment to the working of the apparatus. The Government station at Tatoosh one hundred and twenty-eight miles distant picked up the messages on a number of occasions.

The Dubilier system embodies a number of distinct and original features.

The greatest difficulties heretofore encountered in wireless telephony has been the unstable features of the arc and the low current carrying capacity of the transmitter. These points Dubilier has apparently overcome, for in

Fig. 1

Figures 19, 20. *Two arc systems, Dublier & Telefunken. (Modern Electrics, July 1911)*

added his own special invention, a "hydraulic microphone." Majorana's solution was based on the hydrodynamic principle: "Water is made a conductor by the presence of acid or salt and by continuous change so that even the heat produced by the current is removed from the set." (31). His microphone, based on earlier experiments by Chichister Bell, showed that a column of liquid responded to mechanical energy, and was not a carbon system but a liquid-filled microphone; water to which salt or acid is added is used to change electrical current when exposed to acoustic events. (32) (Figures 15, 16, 17, 18)

The obvious significance of Poulsen was that he had introduced the first wireless system that made possible a high quality clear transmission of voice using Hertzian waves. The realization of the vacuum tube as an oscillator was then more than a decade away, and so the Poulsen arc was really the only option for radiotelephone experimentation, even broadcasting, during much of the two important decades covered here. But the story of Valdemar Poulsen and his arc had a hidden significance, one that was important to the development of the modern electronics industry. It began with a young San Francisco wireless experimenter and a Stanford engineering graduate, and it's culmination was the formation of a unique company based in a now famous "garage" in what has become Silicon Valley. Even today, the Poulsen story remains significant because of its direct connection to Cyril Elwell and the Federal Telegraph Company, and the inventions that evolved out of this early association. It is an important but necessary digression, an interesting story in the radiotelephone saga. It was all part of the same race.

Francis McCarty was an early Bay Area radiotelephone experimenter. Using the Collins system of spark, in 1907 he sent music, according to an eyewitness, from a "transmitter erected on the Ferry at the foot of Market Street to the Ferry boats plying between San Francisco and Oakland. This was the system employed by A.F. Collins, consisting of a 1" induction coil, with very nicely adjusted vibrators, so that vibration frequencies or primary interruptions could be obtained up to about 1500 cycles. The oscillating circuit spark gap was composed of two silver discs, spaced from .0005 inch to 3/16" when the microphones were good. There were three to eight telephone type microphones placed in parallel, these in series with a six volt battery in the primary." (33) The fidelity of this spark coil system was limited; Fessenden's earlier experiments with similar technology had already proved that spark transmissions were so overpowered by the noise artifacts of the system that it was next to impossible to hear clear audio. By McCarty's time spark as a carrier of voice and music was already a dead end technology.

Still, McCarty's experiments, unsatisfactory as they were, served as the catalyst for the formation of the Federal Telegraph Company a few years later. McCarty's financial backers, the Henshaw Brothers, approached a recent electrical engineering graduate, Cyril Elwell, to help them evaluate and perhaps improve the McCarty transmission system. In 1907 Elwell set up a transmitting station at Palo Alto and constructed McCarty's device based on the details in his patent. While it produced mostly unintelligible speech, Elwell found that when he closed the spark gaps to as narrow as possible, an arc developed and the voice quality improved. He told the Henshaws not to waste their money on the McCarty spark patents. Case Closed. But based on what he had learned from the McCarty failures and having read something about arc systems Elwell traveled to Denmark and negotiated the American rights to the arc transmission system of Poulsen. He brought several of the Poulsen transmitters back to Northern California in 1909 where he demonstrated them in Palo Alto for a group of Stanford professors.

The Poulsen Wireless Telephone and Telegraph Company was formed, and by 1910 stations were in operation in nearby Sacramento and Stockton. Earl Daniels worked for the Poulsen station in Sacramento, which used the same arc transmitter as did Stockton: "The microphones were in series with the ground lead, and were multiple, mounted on a disc in a circle, all in parallel. An old style Columbia phonograph of the morning glory horn type was played into this set of microphones. The Poulsen people were represented by Jensen, now with Magnavox. He brought the set from Denmark and installed it. His standard speech in testing was, 'Hello, hello, hello, Stockton. This is the Poulsen Wireless Telephone, invented by Valdemar Poulsen, of Copenhagen, Denmark. Mr. Poulsen has secured the rights to this phone in the U.S. of America. Hello, hello, hello, Stockton. I will play you another record now." (34)

Even though Elwell's goals centered around the two-way radiotelephone message business, not broadcasting, in later years he wrote in his autobiography about the early radiotelephone experiments in Palo Alto, 1909-10: "Little did I realize that we were laying the foundations of broadcasting..." (35) What Elwell accomplished was the formation of a radiotelephone business utilizing a series of high-powered wireless telegraph and telephone stations based on the Poulsen arc, but used to send messages across the country and the world. (The company evolved into Federal Telegraph and the Poulsen arc was used into the early 1930s for high-powered wireless telegraph transmission.) Elwell and his business contemporaries had no use for the "hams" and people like Charles Herrold who would clutter up the air with useless music and talk. Lee de Forest joined Elwell in Palo Alto in 1910, where in that famous garage near the Stanford campus he worked to improve his Audion, first as an amplifier for the telephone company, and later as the oscillator behind the final and successful version of the radiotelephone. And so the connection to the Bay Area of California and the invention and industry that evolved into Silicon Valley and the modern electronics industry remains an important Poulsen-related legacy.

LEE DE FOREST: IN A CLASS BY HIMSELF

The single most important individual in the twenty year evolution from two-way wireless telegraphy as a commercial business to the technical

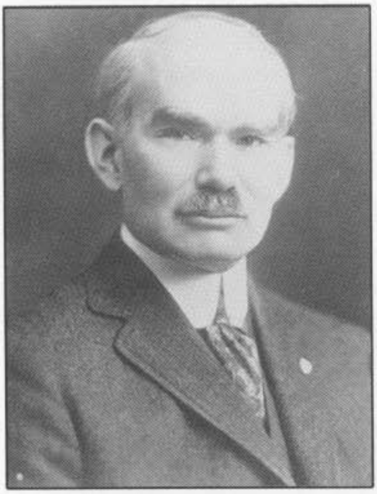


Figure 21. *Lee de Forest. (Perham Foundation)*

perfection and use of the radiotelephone for entertainment broadcasting was Lee de Forest. There were three major events that defined de Forest as a radiotelephone pioneer-cum-broadcaster; his equipping of the Navy Fleet in 1907, his publicized broadcasts of opera in New York City between 1907 and 1912, and his 1916-17 and 1919 broadcast demonstrations over stations in New York and San Francisco. Judging by this early performance, Lee de Forest should have won the race for the radiotelephone hands down.

Arguably, there was no wireless and radio inventor who was surrounded by more controversy than Lee de Forest. He fought for decades to convince the technical community that he deserved to be known as the "Father of Radio," and he spent millions in court battles trying to validate and re-validate his patents. Still, whether you fall into the two opposite camps, whether you love him or hate him, sanctify him or vilify him, (there seems to be no middle ground) the evidence strongly suggests that, more than any single individual, Lee de Forest was the first to want to use the wireless for more than two-way commercial message traffic. Throughout his early career he bordered on the edge of the activities of broadcasting, sending entertainment programs to a defined audience. In all the published reports, in all the historical analysis, it is the name of de Forest that is early and often associated with the sending of music and news using the radiotelephone. And while until 1919 he failed to establish a permanent station, failed to broadcast on a regular basis and therefore failed to gain a regular audience, his contribution to the art and science of radio is unprecedented. The evidence strongly suggests that Lee de Forest could rightfully claim to be what he struggled his entire life to be, the "Father of Radio." (36)

Lee de Forest was born in the Midwest but really grew up in the South. Shortly after his birth in Council Bluffs, Iowa in 1873 young Lee's father accepted a position as the President of a small black college (Talledega) in Alabama. But while de Forest grew up on that rural campus, his education was formal, upper class and thorough. After a local grammar school he went on to the Mt. Hermon School for Boys in Massachusetts, preparatory to his entrance into Yale University's Sheffield Scientific School. De Forest

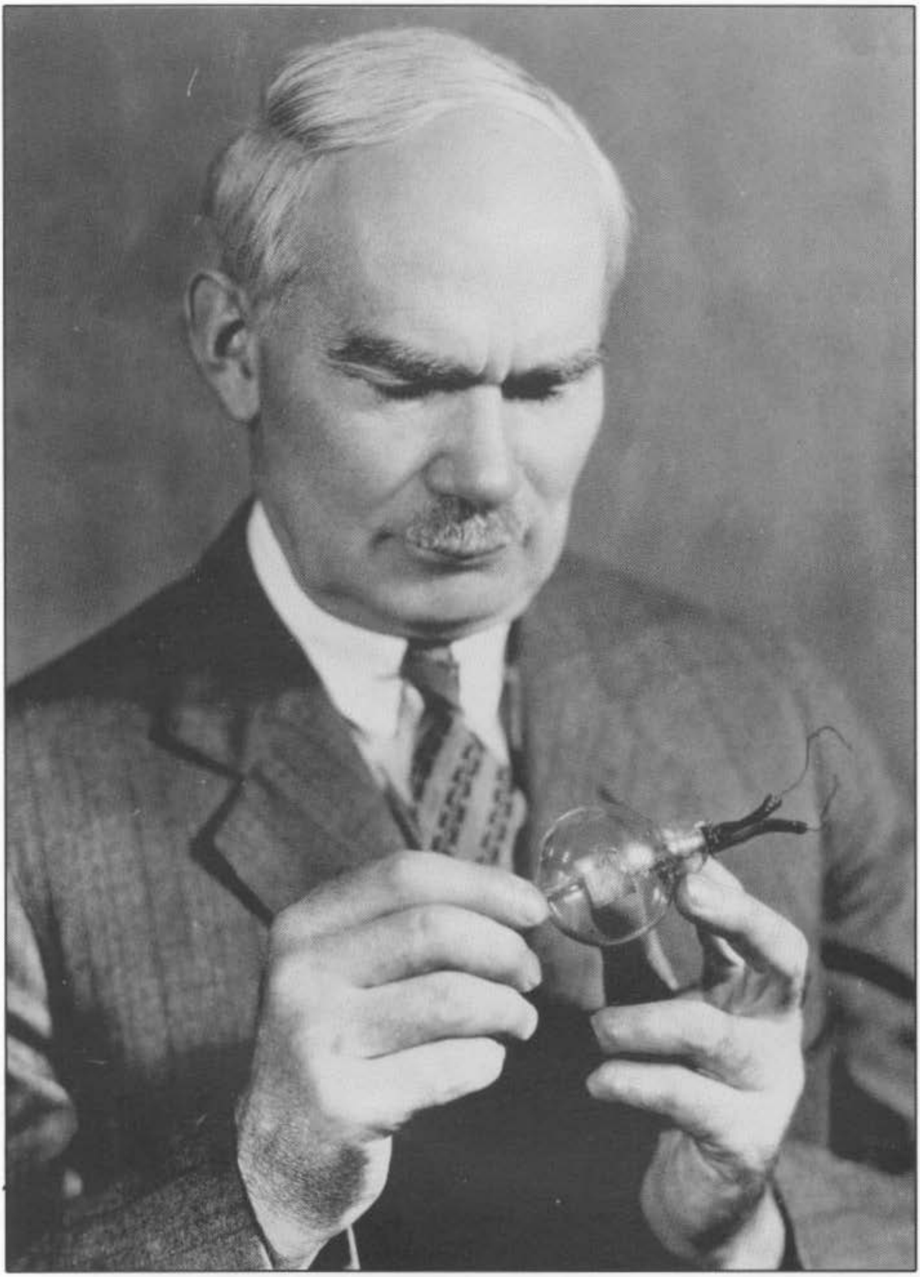


Figure 22. *De Forest with Audion. (Perham Foundation)*

completed his higher education and received the degree of Doctor of Philosophy. His 1898 dissertation was titled: "The Reflection of Hertzian Waves at the End of Parallel Wires." Well-educated, Lee de Forest as an engineering graduate worked for several Chicago companies, Western Electric among them. (37)

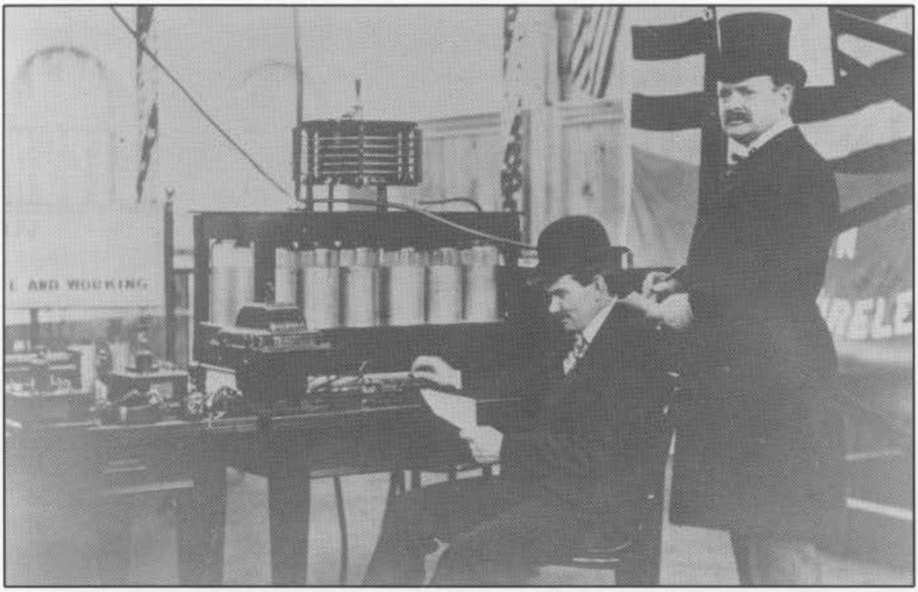
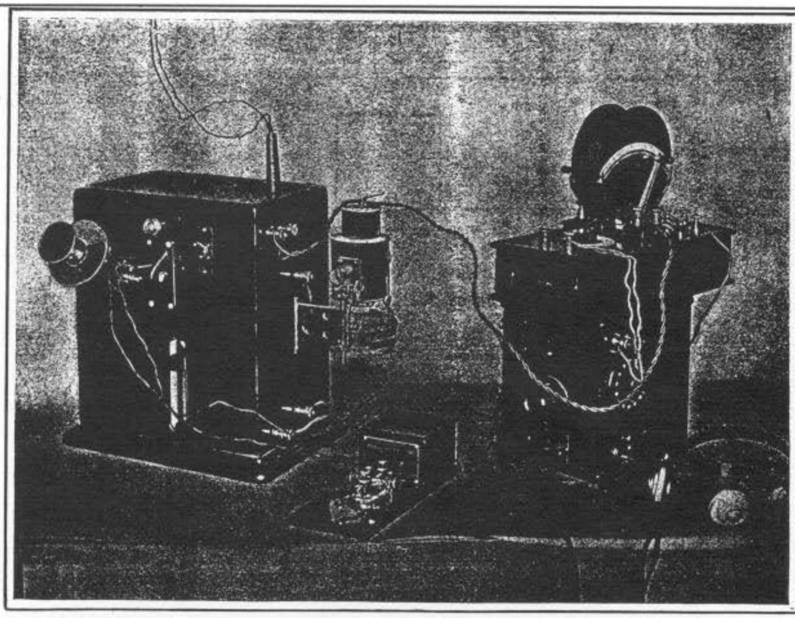


Figure 23. *De Forest at telegraph with wireless promoter White.*

Even though it is the purpose of this article to place de Forest into the context of the transition from radiotelephone to broadcasting, he is most known for his contributions and improvements to the basic invention of all radio and television, the vacuum tube. Thomas Edison's electric lamp earlier had been modified by the Englishman, Ambrose Fleming, who added a second element, a plate, and called it the Fleming Valve. By 1906 de Forest had modified Fleming's Valve by adding a grid (which amplified small signals) and called this device the Audion. (38) And while today it is believed that de Forest did not fully realize what he had invented, and while he battled Edwin Armstrong in court for decades over the regenerative or feedback principle of the Audion, it was really Lee de Forest's work in early radiotelephone experimentation and its broadcast-like applications that proved to be the most interesting of his career. In the beginning he seemed to have followed the work of Marconi, attempting to develop better communication between ships and shore stations. And like Fessenden and Charles Herrold, de Forest first tried spark and later a Poulsen arc in an attempt to give voice to his wireless.

The reality of the early radiotelephone development years did not include the broadcasting of music and information into homes using wireless. If you needed backers, if you wanted to sell stock certificates to raise money, it had to be for a wireless telephone for serious, profitable two-way communication purposes, an addition to the wired Bell telephone. And further, as de Forest and hundreds of inventors lamentably discovered, you had to be a promoter as well as an inventor, and that often meant



Complete Equipment of Transmitting and Receiving Instruments for One Station.

THE DE FOREST RADIO-TELEPHONE APPARATUS.

Figure 24. *The de Forest arc transmitter and audion receiver built for the US Navy. (Clark)*

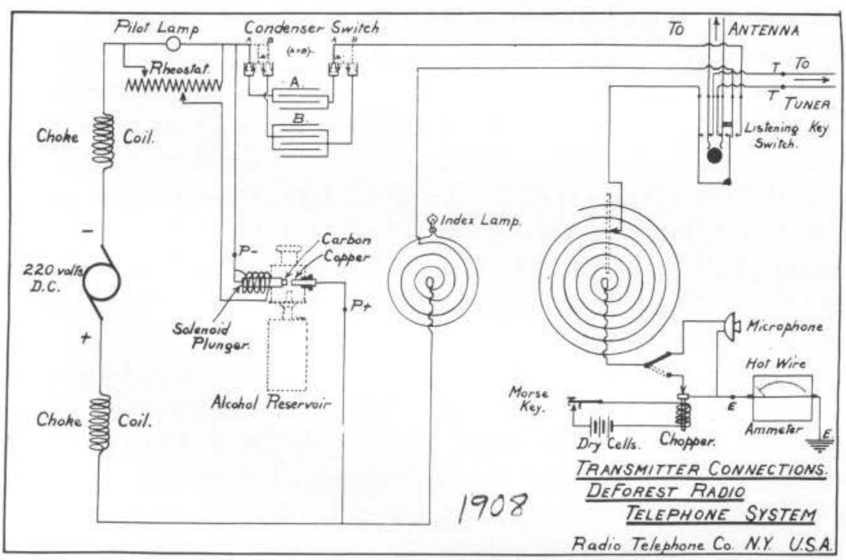


Figure 25. *De Forest Company radio-telephone arc transmitter schematic, 1908. (Clark)*

that you found yourself allied with an unsavory, easy money crowd. De Forest himself was accused, but acquitted of stock fraud, although his backers went to prison. Controversy notwithstanding, de Forest began early and often to find public uses for his version of a Poulsen-like arc radiotelephone transmitter: "In 1906 he devoted his entire energy to the problem of wireless telephony. His first invention of importance was the use of the microphone in the earth connection, where it has been used in practically all (arc) wireless telephone transmitters ever since." (39) That Lee de Forest was both a promoter and a music lover led him and his arc radiotelephone into two areas; one is practical, a demonstration for the Navy, the other reflected his penchant for bringing culture to the masses, the use of opera music to demonstrate his wireless telephone for newspaper reporters. (Figures 24, 25, 26, 27)

An early recipient of the de Forest arc radiotelephone system was the Navy: "In 1909 I was manufacturing wireless telephone sets for the US Navy; each set was tested by means of phonograph records. Much to my surprise, many wireless amateurs and professional operators intercepted and enjoyed these test transmissions. They came to look for these 'programs.' And quite naturally, the idea of mass communication occurred to me, whereby attractive music and interesting talks might be placed on the air, thus creating a profitable demand for wireless equipment by those desirous of listening in." (40) De Forest equipped the Navy Fleet's lead ship *Ohio* and others with his arc transmitter and a wind-up phonograph for the fleet's trip around the world between 1907 and 1908. This is a well-publicized event, and while on the West Coast, de Forest, aboard the *Ohio,* played music from the phonograph and communicated with Mare Island during June, 1908. Radio operator Herbert J. Meneratti of the *U.S.S. Ohio* documented these events well in correspondence with historian Clark in 1948: "We gave music regularly to the Mare Island Station. Our record shows that from June 1 to July 5 (1908) we did not miss a day in giving out music to the fleet in the Bay at the time." (41) Meneratti claims that on January 12, 1908, his ship, the *U.S.S. Ohio*, was sending out band tunes to other ships, even responding to requests, a "date he considers the beginning of broadcasting, although we didn't call it that." (42)

Another early claim of "broadcasting" by de Forest was connected to his love of opera. He had long admired this form of music, and while he realized it appealed to the upper classes who could afford the time and money with which to attend live performances, the evidence suggests that he believed that in the future even the less affluent would be exposed to opera using the wireless telephone: "It will soon be possible to distribute grand opera music from transmitters placed on the stage of the Metropolitan Opera House by a Radio Telephone station on the roof to almost any dwelling in Greater New York and vicinity. . . The same applies to large

Mazarin Sings by Wireless

"Carmen" Heard a Mile Off

Mme. Mazarin and diagram sketch showing how her songs from "Carmen" were transmitted by wireless.

2-25-1910

A. 39TH AND PARK AVE., WHERE MME MAZARIN SANG INTO WIRELESS

B. WIRELESS STATION METROPOLITAN BLDG. IN WHICH MME MAZARIN'S SONG WAS HEARD

Notes of Aria Carried Over Skyscrapers by Radio Sound Waves.

of this system of handbook manipulatio attaches has been gathered by The Am has been going on, an extensive trade, bookmakers, has been built up.

Exactly what the telephone employ

Reprinted from NEW YORK GLOBE and Commercial Advertiser, Jan. 8, 1910

GRAND OPERA BY TELEPHONE

The Metropolitan Will Send Music by Wireless, Beginning Next Wednesday

Grand Opera by wireless telephone from the Metropolitan Opera House will be ready within a few days. Already there is opera by the regular telephone, and during the performance of "Walküre" this afternoon telephones about town were connected with the opera house and some of the singing of Mme. Homer was heard miles away from the opera house.

That, however, was part of the wireless scheme. The apparatus for the wireless opera has already been installed back of and above the stage. For several days Lee de Forest and Mr. Turner have been at work putting in this plant, and they have about finished their work. Now there is nothing to do but to prepare the outside stations which shall receive the opera at a distance and make it possible to hear the music for miles away.

The connection will be made with several wireless stations of Mr. De Forest's system, and every performance at the Metropolitan may be heard far off. The first test will be made when on Wednesday Mme. Fremstadt sings "La Tosca."

Reprinted from NEW YORK COMMERCIAL January 14, 1910

HEAR OPERA BY WIRELESS

Novel Entertainment Feature of Dinner Aboard Royal Mail Ship Avon

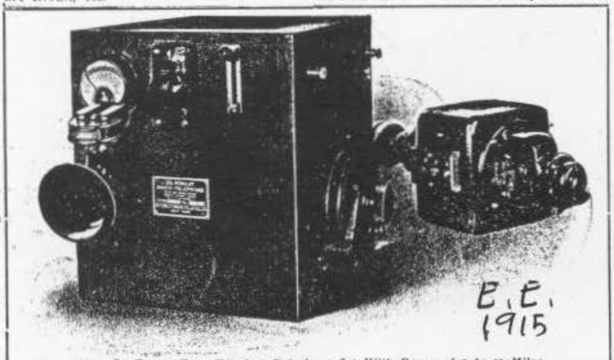
The 250 guests who attended the inspection and dinner on board the Royal Mail Steam Packet Avon last night, were entertained by the Metropolitan Opera House Co. by means of the ship's wireless apparatus and the radio telephone, during the dinner served in the main dining saloon. The guests could distinctly hear Caruso and Mme. Destinn singing on the Metropolitan Opera House stage. The opera was dispatched from the roof of the Metropolitan to the masthead of the Avon.

Figures 26, 27: *1910 newspaper headlines about de Forest's opera broadcasts. (Clark)*

WIRELESS DEPARTMENT

A New 100-Watt Wireless Telephone

One of the latest productions of the De Forest Radio Telephone & Telegraph Co. is a small-size w'reless telephone outfit of improved type, which b'ds fair to find extended commercial application. The illustration shows the complete transmitting equipment, wh'ch comprises a special form of arc gap, together with heavy current microphone, regulating apparatus for the arc circuit, etc.

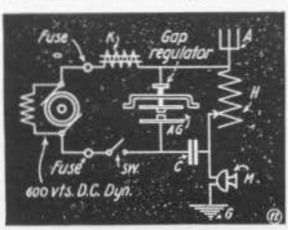


New De Forest Type Wireless Telephone Set With Range of 7 to 15 Miles.

The arc is operated from a small 600-volt D. C. dynamo, which is also shown in the illustration. This machine is driven by a gasoline engine or electric motor, whichever may be convenient.

Considerable tests have been made in the past few months of this radiophone transmitt'ng set around New York City, and it works very well indeed. It may be said that the principal feature is the arc, and this takes place between the two platinum buttons or electrodes of small size, which are mounted on two large copper or other good heat-conducting plates. These will be observed mounted on the right-hand side of the transm tter cabinet.

A schematic diagram is given, which shows the general arrangement of these new sets, and in some of the larger sets, supplied for ship service in transmitting undamped rad otelegraphic waves, the arc is started by momentarily short-circuiting the dynamo through a large choke coil and a switch. This new set, however, is claimed to be self-starting as regards the arc, and this can be managed in several



Schematic Diagram Showing Relation of New Radiophone Apparatus.

In the diagram here shown K is a large-size choke coil in the dynamo circuit, and a switch is indicated at S. The arc gap is placed at AG. An oscillatory c'rcuit, of course as usual, composed of a condenser C, with inductance or helix H, is shunted across the arc gap AG. A heavy current microphone into which the words are spoken may be connected in the ground wire at M or in some other part of the c'rcuit. Th's set will talk from seven to fifteen miles.

Figure 28. *A 1915 de Forest story introducing his latest arc radiotelephone.* (Electrical Experimenter, *1915)*

cities. Church music, lectures, etc., can be spread abroad by the Radio Telephone." (43) And so between 1907 and 1912 the press was invited to a half dozen of his opera experiments using his arc transmitter. Featuring the voices of the well-known divas Mazarin and Farrar, stories of these one time only promotional events were reported in all the major papers. (44)

Of course in later years, in the 1920s and 1930s when broadcasting was an established fact, all inventors, Charles Herrold and Lee de Forest included, reflected back on their radiotelephone work as broadcasting. But in those early years, their major purpose was to make a fortune either by finding a dependable wireless replacement for the wired telephone or an acceptable system that the Navy would use to equip their ships. Nevertheless, there is some evidence that in the early days de Forest, before the others, had ideas of how to use his radiotelephone for purposes other than two-way. Around the time of the Navy experiments, de Forest wrote, in an article about his radiotelephone, an early harbinger

Long Distant Broadcasts of Speech and Music, 1915,

by Bell System in cooperation with the Navy.

A newly developed vacuum tube transmitter installed at the Arlington, Va. Naval Radio Station was heard at: the Panama Canal Zone; Mare Island, Calif.; Pearl Harbor, Hawaii; and Paris, France. Here H.W.Everitt toots into microphone at Arlington. Phonograph in left background.

Figure 29. *De Forest's work in Palo Alto led to making his vacuum tube oscillate for this 1915 Bell System/Navy experiment in voice transmission. (Espencheid Papers)*

of what broadcasting might become: "still another feature of the invention . . . the supplying of music and other forms of entertainment to passengers traveling on the passenger vessels. A service of this kind, aided by a large receiver, so that all of the passengers gathered in a large salon could hear the music or operatic air. . . " (45)

The radiotelephone years, 1900-1920, were known more for the competing voice transmission technologies than for broadcasting. While spark was quickly rejected as too noisy and the alternator as too costly, it was the many permutations of the Poulsen arc that clearly dominated radiotelephone inventions and early broadcasting for an audience. Even today many people apparently believe that early radiotelephone science was dominated by de Forest's vacuum tube. The evidence suggests otherwise. De Forest himself was manufacturing, marketing and using an arc radiotelephone as late as 1915.(Figure 28) This was not an aberration; de Forest, Charles Herrold and all other radiotelephone inventors had between 1910 and 1916 spent countless dollars perfecting the arc as a carrier of voice and music. (Of course much of that money was spent on lawyers in attempts to somehow get around the basic Poulsen patents) It is ironic that the individual responsible for bringing the Poulsen system to America, Cyril Elwell, and the company he founded based on the Poulsen patents, Federal Telegraph, had long abandoned as impractical the use of the arc for voice and instead concentrated on high- power, long-distance arc telegraphy. Likely because of the high current demands of a microphone in an arc circuit, only low-power, limited- range arc radiotelephones were ever satisfactorily developed and employed.

By the beginning of 1916, de Forest had finally perfected his Audion for its most important task — that of an oscillator for the radiotelephone.

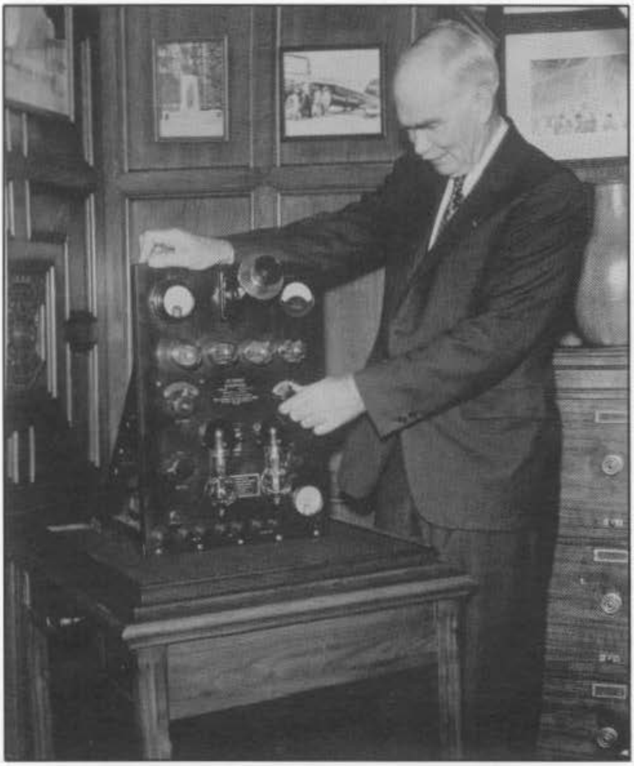


Figure 30. *An older Lee de Forest looks at an early version of his vacuum tube (Oscillion) radiotelephone. (Perham Foundation)*

Earlier in Palo Alto he had made his tube perform as an amplifier and sold it to the telephone company as an amplifier of transcontinental wired phone calls. —Returning to his home in New York City, by late 1916 de Forest had begun a series of experimental broadcasts from the Columbia Phonograph Laboratories on 38th Street, finally abandoning his version of the arc transmitter and using for one of the very first times his Audion as a transmitter of radio: "The radio telephone equipment consists of two large Oscillion tubes, used as generators of the high-frequency current." (46) One early broadcast received mixed reviews: "Columbia phonograph records played from the laboratory of the company at 102 West Thirty-Eighth Street were distinctly heard in the receiving room of the (Hotel) Astor, with the exception of a few interruptions by the powerful naval wireless apparatus at the Brooklyn Navy Yard, when the warning of a storm was heard intermittently with the music." (47) One month later, de Forest told a *New York Sun* reporter that he, using a 'wave length' of 800 meters, "will be setting another record by giving the first public concert by wireless in history." (48)

A few months later, de Forest moved his tube transmitter to High Bridge, New York, where one of the most publicized pre-WWI broadcasting events took place. Just like Pittsburgh's KDKA would attempt exactly four years later in 1920, de Forest used the most public of events for his broadcast.

650 THE ELECTRICAL EXPERIMENTER January, 1917

RADIO DEPARTMENT

Election Returns Flashed by Radio to 7,000 Amateurs

SEVEN thousand wireless telephone operators within a radius of 200 miles of New York City received election returns from the *New York American*. Three hundred and fifty moving-picture theaters; special bulletin boards in different parts of the city, and the principal hotels of Manhattan obtained the news from the above office,-as fast as it was received. Fifty extra telephone lines were run into the *American* office, the theaters were placed on lines that were in continuous operation, and while the news of the closest Presidential election in years was being given to the public thru these channels, the editorial staff compiled the returns without the slightest confusion.

When the returns came in, indicating the election of Hughes, and the first edition was prepared for press at 11 p.m., the heads and the reading matter inclined that way. Later there was a change, a doubt was cast, and then the tide drifted Wilsonward. It ebbed and flowed, from one candidate to the other, for several hours. Thru the clearing house all outlying district information was gathered, in an effort to sweep aside the uncertainty. Then the headings, which were studies in clarity and terseness, were altered, the introductions and summaries were changed, and Wilson was featured as the winner. The wireless-telephony feature was remarkable. The 7,000 amateur radio operators were all notified in advance, and the news was supplied in the most systematic manner, thru the circulation department, by an expert from the editorial rooms, who took his bulletins from the same source as the fifty operators who supplied the moving-picture shows, hotels, and bulletin-board operators.

Realizing that all men cannot grasp a spoken message alike, or in the same time, and because it was impossible to stop and answer questions, a black-board was erected, in view of all the operators. The bulletins were written on this and reading from it, the operators telephoned the news to the different points. In the picture theaters the messages were transmitted to slides and flashed on the screen.

The amateur wireless operators located in different towns about New York gave out the information, and allowed others to *listen in*. **They heard not only election returns, but music as well.**

Over their heads, reaching from that droning desk in the *New York American's* office to the white bulletin boards on which their eyes were fastened, a vast network of electrical waves were meshing and passing. On these unseen waves the news they sought was carried.

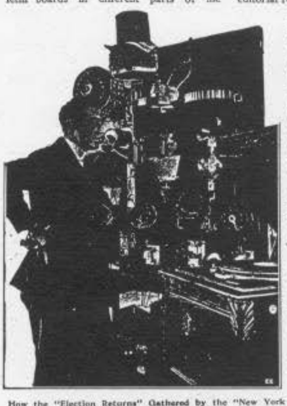
From the deep semi-circular desk the news had been flung by telephone to the de Forest Wireless Telephone Laboratories at Highbridge on the Harlem River. Up in the de Forest tower sat Walter Schare, an unassuming chap, who listened thru a receiver clamped to his ear.

At Schare's hand was the wireless telephone transmitter switch. As he heard the news from the seventh floor of the great red building near Brooklyn Bridge he snapt it forth to 7,000 anxious amateur wireless operators within that great 400-mile circle.

Between the bulletins, music was sent thru the clouds. The crowds heard "The Star Spangled Banner," "Dixie," "Columbia, the Gem of the Ocean," "America," "Maryland," "Yankee Doodle" and all the other anthems, songs and hymns that Americans love.

The radiophone equipment consists of two large Oscillion tubes, used as the generators of the high frequency current, which may be seen on the panel. They develop one-half kilowatt of energy and this charges the antenna. The high potential current is obtained fro[m] volt direct current generator, d[…] constant speed motor. This high te[…] rent is controlled by suitable rheostats and shunted with capacities so as to reduce the inductive reactance as much as possible in the oscillating current. The filaments are lighted by 110 volt direct current. The oscillating circuit comprises a number of capacities and inductances properly balanced in the circuit. The voice-current modulations are derived from a microphone, inductively coupled to the high frequency circuit. Another microphone connected in parallel with the first by a switch, is used in conjunction with a phonograph. The operator standing near the microphone is Charles Logwood, chief engineer to Dr. de Forest, and a great deal of credit is due him in the development of the radiophone employing the Oscillion tube as a generator of radio frequency currents.

Dr. Lee de Forest gave a demonstration of transmitting music by wireless at the Hotel Astor, New York, on the evening of […]



How the "Election Returns" Gathered by the "New York American" Were Spread Broadcast to 7,400 Waiting Amateurs by Wireless Telephone from the de Forest Laboratory Near New York.

AIR WILL BE FULL OF MUSIC TO-NIGHT

11-6-16

First of Series of Wireless Concerts to Be Given by Lee De Forest.

From Toots Paka on the west to Tschaikowsky on the east and from "Die Walkure" to the "Kangaroo Hop," the bull fiddles and the slip horns and the inevitable ukelele will throb to-night through the hot air which has settled over the Atlantic seaboard since the campaign began.

For to-night's the night that Lee De Forest, inventor, working hand in hand with the Columbia Graphophone Company, will begin a series of wireless telephone concerts with the aid of graphophone discs supplied by the Columbia firm and the wireless telephone apparatus invented by Dr. De Forest. Within a radius of 200 miles of Manhattan the 2,000—or 2,000,000,000, or whatever the number is—owners of amateur wireless plants may tune in and listen to the band and the singers tum-tee-tumming across the ether.

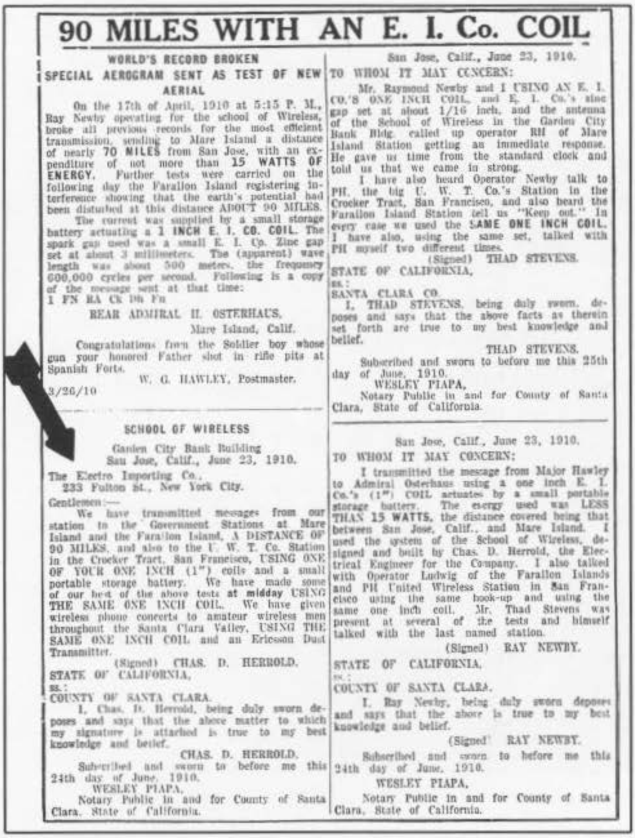
Dr. De Forest and the Columbia firm gave a wireless telephone concert at the Hotel Astor a week ago last Thursday, the music being sent by wireless from the roof of the Columbia firm's manufacturing plant in West Thirty-eighth street to telephone receivers in the Astor. That was the first wireless concert in history, but it was a semi-private affair. When Old Bill Bailey starts to twang his ukelele to-night, however, the ukelele—plus the bull fiddles and slip-horns and vocal hulaballooers—will be setting another record by giving the first public concert by wireless in history.

Figures 31, 32. *News stories of de Forest's High Bridge transmissions, 1916. (NY Times, November 6, 1916 and Electrical Experimenter, January 1917)*

This time it was the Hughes-Wilson presidential election of November, 1916: "The *New York American* installed a private wire and bulletins were sent out every hour." (49) This time the listener reports were more positive: "Seven thousand wireless telephone operators withing a radius of 200 miles of New York City received election returns from the *New York American*. They heard not only election returns, but music as well. Between the bulletins, music was sent thru the clouds. The crowds heard 'The Star-Spangled Banner,' 'Dixie,' 'Columbia, Gem of the Ocean,' 'America,' 'Maryland,' 'Yankee Doodle' and all the other anthems, songs and hymns that American's love." (50) Because it happened in New York, was listened to by a large audience, and received so much press attention, it was one of the single most important pre-World War I events in radio broadcasting. (Figures 31,32)

Years later, de Forest wrote to Charles Herrold about how he saw the art and science of broadcasting in 1916. He discussed both his and Herrold's early experiments in the context of the vacuum tube: "Until the 3-electrode tube had been developed sufficiently to serve as a reliable oscillator for radio telephone purposes, and the audion amplifier could be used at the receiver in connection with the detector, those early efforts at radio broadcasting were necessarily unsatisfactory. In 1916, after we had learned how to build 'Oscillion' tubes of 50 to 100 watts power, I began a regular nightly broadcasting service from my station at High Bridge, NY. This service was regularly maintained until the federal government caused a suspension of all non-military radio communications shortly before our nation entered the European War." (51) Were it not for the Great War and the closing down of all non essential, non defense uses of radio, de Forest, already exciting small audiences with interesting, entertaining and informing broadcasting, might have succeeded with this new service four years ahead of KDKA.

After the war Lee de Forest was anxious to return to the air. After his near-success in 1916, he was prepared to broadcast again. De Forest later told Herrold: "I resumed these operations in December, 1919, as soon as the governmental ban was lifted. The U.S. Federal Inspector in New York clamped down on me in February, 1920, however, acting on the technicality that I had voided my license by moving my station downtown without his authorization. Whereupon I promptly moved the High Bridge transmitter to San Francisco and installed it in the wings of the California Theatre, running my antenna up to the roof of the bank tower next door. This station was maintained in daily operation, broadcasting the orchestra music of the Weber Orchestra in the theater. In the fall of that year the station was moved over to Berkeley, where it was maintained in operation for perhaps a year." (52) In 1929 de Forest remembered the day that the radio inspector first shut down his post-war New York operation: "Then the Federal inspector (Arthur Batcheller) in New York, taking advantage of the technical fault that I had moved my station from High bridge downtown, peremptorily closed the service after a few weeks, with the definite statement that program broadcasting for entertainment had no place, no legitimate place, in the ether, and should be terminated, and he terminated it." (53) Beginning with his arc telephone experiments for the Navy and his transmissions of opera music, and ending with his radio stations at High Bridge in 1916 and San Francisco in 1920, the evidence strongly suggests that Lee de Forest, more than any other individual entered in the race for radiotelephone, saw a potential for voice transmission beyond just a wireless replacement for two-way communication.



90 MILES WITH AN E. I. Co. COIL

WORLD'S RECORD BROKEN

SPECIAL AEROGRAM SENT AS TEST OF NEW AERIAL

On the 17th of April, 1910 at 5:15 P. M., Ray Newby operating for the school of Wireless, broke all previous records for the most efficient transmission, sending to Mare Island a distance of nearly **70 MILES** from San Jose, with an expenditure of not more than **15 WATTS OF ENERGY**. Further tests were carried on the following day the Farallon Island registering interference showing that the earth's potential had been disturbed at this distance ABOUT 90 MILES.

The current was supplied by a small storage battery actuating a **1 INCH E. I. CO. COIL**. The spark gap used was a small E. I. Co. Zinc gap set at about 3 millimeters. The (apparent) wave length was about 500 meters, the frequency 600,000 cycles per second. Following is a copy of the message sent at that time:

1 FN RA Ck 19h Fn

REAR ADMIRAL H. OSTERHAUS,
Mare Island, Calif.

Congratulations from the Soldier boy whose gun your honored Father shot in rifle pits at Spanish Forts.

W. G. HAWLEY, Postmaster.

3/26/10

SCHOOL OF WIRELESS

Garden City Bank Building
San Jose, Calif., June 23, 1910.

The Electro Importing Co.,
233 Fulton St., New York City.

Gentlemen:—

We have transmitted messages from our station to the Government Stations at Mare Island and the Farallon Island, A DISTANCE OF 90 MILES, and also to the U. W. T. Co. Station in the Crocker Tract, San Francisco, USING ONE OF YOUR ONE INCH (1") coils and a small portable storage battery. We have made some of our best of the above tests **at midday** USING THE SAME ONE INCH COIL. We have given wireless phone concerts to amateur wireless men throughout the Santa Clara Valley, USING THE SAME ONE INCH COIL and an Ericsson Dust Transmitter.

(Signed) CHAS. D. HERROLD.

STATE OF CALIFORNIA,
ss.:
COUNTY OF SANTA CLARA.

I, Chas. D. Herrold, being duly sworn deposes and says that the above matter to which my signature is attached is true to my best knowledge and belief.

CHAS. D. HERROLD.

Subscribed and sworn to before me this 24th day of June, 1910.

WESLEY PIAPA,
Notary Public in and for County of Santa Clara, State of California.

San Jose, Calif., June 23, 1910.

TO WHOM IT MAY CONCERN:

Mr. Raymond Newby and I USING AN E. I. CO.'S ONE INCH COIL, and E. I. Co.'s zinc gap set at about 1/16 inch, and the antenna of the School of Wireless in the Garden City Bank Bldg. called up operator RH of Mare Island Station getting an immediate response. He gave us time from the standard clock and told us that we came in strong.

I have also heard Operator Newby talk to PH, the big U. W. T. Co.'s Station in the Crocker Tract, San Francisco, and also heard the Farallon Island Station tell us "Keep out." In every case we used the **SAME ONE INCH COIL**. I have also, using the same set, talked with PH myself two different times.

(Signed) THAD STEVENS.

STATE OF CALIFORNIA,
ss.:
SANTA CLARA CO.

I, THAD STEVENS, being duly sworn, deposes and says that the above facts as therein set forth are true to my best knowledge and belief.

THAD STEVENS.

Subscribed and sworn to before me this 25th day of June, 1910.

WESLEY PIAPA,
Notary Public in and for County of Santa Clara, State of California.

San Jose, Calif., June 23, 1910.

TO WHOM IT MAY CONCERN:

I transmitted the message from Major Hawley to Admiral Osterhaus using a one inch E. I. Co.'s (1") COIL actuated by a small portable storage battery. The energy used was LESS THAN **15 WATTS**, the distance covered being that between San Jose, Calif., and Mare Island. I used the system of the School of Wireless, designed and built by Chas. D. Herrold, the Electrical Engineer for the Company. I also talked with Operator Ludwig of the Farallon Islands and PH United Wireless Station in San Francisco using the same hook-up and using the same one inch coil. Mr. Thad Stevens was present at several of the tests and himself talked with the last named station.

(Signed) RAY NEWBY.

STATE OF CALIFORNIA,
ss.:
COUNTY OF SANTA CLARA.

I, Ray Newby, being duly sworn deposes and says that the above is true to my best knowledge and belief.

(Signed) RAY NEWBY.

Subscribed and sworn to before me this 24th day of June, 1910.

WESLEY PIAPA,
Notary Public in and for County of Santa Clara, State of California.

Figure 33. *Ad from Electro-Importing Catalogue, 1910 telling of Herrold's "wireless phone concerts for amateur men throught the Santa Clara Valley." (EI)*

CHARLES HERROLD BROADCASTS ENTERTAINMENT PROGRAMMING

"By modern broadcasting is understood a radio intelligence that is sent out at a certain pre-determined schedule or program," so wrote radio publications pioneer Hugo Gernsback in *Radio for All*. (54) Later, RCA historian George Clark suggested that in order to qualify as a broadcaster you had to have scheduled, pre-announced, publicly advertised programs, but you also had to reach a "citizen audience," which he defined as people who were not experimenters or hobbyists. (55) By 1912 Charles Herrold of San Jose, California was announcing his regularly-scheduled programs in the local newspapers and while important, these announcements were actually preceded by several years by one of the few very early printed

Figure 34. *Young Charles and his telescope. (Herrold Papers)*

references to the activities of broadcasting to an audience. Likely an important "smoking gun" of intentional broadcasting, it was this 1910 notarized statement by Herrold, "We have been giving wireless phonograph concerts to amateur men in the Santa Clara Valley" that appeared in an early 1910 New York publication of the Electro-Importing Company. (56) To this researcher, it qualifies as the earliest and most prophetic statement in the national public record descriptive of what broadcasting was to become. Not Fessenden, not de Forest, not anyone else engaged in wireless telephony was saying about their work anything close to what Herrold was saying. And while Herrold's 1910 listeners could hardly be considered a citizen audience, he changed all that when he broadcast daily to audiences at the 1915 San Francisco World's Fair. (Figure 33)

Charles Herrold's contributions to the technology of the radiotelephone years and the art of what was to be broadcasting were in the beginning derivative and accidental and finally, purposeful. As an inventor of a transmitting system he called an "arc fone," he spent years attempting to differentiate his system from that of Poulsen's. Herrold received a total of six U.S. patents for his devices, patents that certainly would have been challenged by the Poulsen people were it not for the fact that by 1917 the perfection of the vacuum tube as the basis of all future radiotelephones made such arc-based devices obsolete. Nevertheless, by 1912 Charles Herrold had established a radio station. He was programming information and entertainment for an audience on a regular schedule, often pre-announced in the newspapers. That he may have accidentally stumbled onto what was certainly radio broadcasting might have been a function of his role as the proprietor and headmaster of a wireless trade school. Given the responsibility of providing daily technical activities for hundreds of eager young boys, it is my belief that the broadcasting of the popular music of the day by his students to an audience of their friends, families and possible future students was the cauldron from which broadcasting emerged, Charles Herrold style.

Charles David Herrold was born in 1875 in Fulton, Illinois on the Mississippi River. In 1888 the family moved to rural San Jose, California where William Herrold became a successful farmer. Charles attended high school between 1891 and 1894 and it was there that he began to be recognized by his teachers and classmates for his superior grasp of mechanical and scientific subjects. He constructed telescopes and microscopes and excelled in photography. After graduation he attended Stanford University in nearby Palo Alto, but after three years he dropped out for unidentified health reasons. In 1900 Herrold set up an electrical manufacturing company in San Francisco, and when the 1906 Great Earthquake destroyed his work and possessions, he moved to the Central California town of Stockton to teach at a small college that specialized in electricity. (57) Both his work as an inventor and his experience with students led Herrold to return to his family in San Jose and open his own school. The Herrold College of Wireless and Engineering was to be a way to provide an income and at the same time provide him with the classroom and laboratory environment necessary to continue his inventing. This was in 1909 and Herrold was most interested in inventing a radiotelephone system that would make him rich and famous.

Published reports and interviews with former students indicate that beginning in 1909 there was music and voice coming from the Herrold College daily. As the earlier reference in the 1910 Electro Importing Catalogue suggests, "wireless concerts for amateur men" were an accomplished fact. By 1912 Charles Herrold was broadcasting to a sizeable audience: "It was a religion for 'Prof' Herrold to have his equipment ready every Wednesday night at nine o'clock. He would have his records ready, all laid out, and what he wanted to say. And the public or listeners, it became a habit for them to wait for it." (58) Herrold's assistant Ray Newby remembered what contemporary historians now believe to be the first regularly scheduled radio broadcasts of entertainment programming for an audience. (59, 60, 61, 62, 63) Said Newby, "We even had a San Jose music store that

IS WIRELESS TELEPHONY A FACT?

YOUTH again has outstripped age, and to two mere youths have come the laurels of success for which such men as Edison, Tesla and Marconi have unsuccessfully striven for years. Edison—that wizard of the wires—has been experimenting for years in an attempt to perfect a wireless telephone. Partial success has been his but never such as would warrant his exploiting it commercially. He has plodded on and from his workshop occasional rumors have filtered out concerning the progress of a wireless telephone, which, according to last accounts, was on the brink of perfection. And in the face of this has come the dispatch from New York that two boys, not yet of age, have discovered the secret for which Edison and other scientists have been toiling so long.

Experts who have tried the invention of these mere youths are most optimistic over its possibilities. From a small plant on the roof of a dwelling, where first as amateur wireless telegraph operators for the last six years they have been quietly developing their system, they have talked with battleships all along the Atlantic coast. Wireless operators at telegraph instruments along the coast reported hearing plainly-spoken words coming apparently from nowhere. Years ago it would probably have been looked upon as a voice from heaven, but in this materialistic age it was but another knot in nature to be unravelled. So the wireless operators began their wireless telegraph signals, and from the roof station the signal was answered and the seeming miracle explained.

According to the young inventors, whose untiring industry has met with such astonishing results, the apparatus is so simple that it may be used in connection with the ordinary telephone if the exchange were fitted with a wireless receiver, and in this way it would be possible to call up any exchange so equipped and have the wireless switched onto the home or office of any telephone subscriber.

But, if the invention is what is asserted, there is a far greater field of usefulness than its mere convenience as a readier means of communicating by land. The inventors claim that it would be possible with five wireless telephone stations, costing not more than $10,000 each, scattered along the Atlantic coast, to have telephonic communication with every ship within 1000 miles of the shore fitted with wireless telegraphy. Ships within 1000 miles of one another could talk instead of telegraph, and any telephone user could talk from his own telephone to any such ships, calling up any passenger desired. If this astounding discovery be indeed what is asserted, there need never again be such a disaster as shocked the world last April. Instead of a vague flash or the "S. O. S." whose direction could not be accurately determined, there will be the human voice to direct them to the rescue. Instead of a signal which in the confusion of accident may be mistaken or misconstrued, there will be a spoken message, details given, and intelligent succor may be rendered without loss of valuable time. Think of the inestimable value of wireless telephony either on land or sea; the innumerable uses to which it would be put. A field almost too vast to conceive of is opened at once, with future possibilities as yet undreamed—if only these young inventors have really solved the problem of which they seem so sure!

Paper Herald
City San Jose
Date JUL 22 1912 State Cal

CONCERT BY WIRELESS TELEPOHNE A SUCCESS

Several Signify That They Hear Music From Phonograph Distinctly.

Professor Charles D. Herrold of this city, assisted by his operator, E. A. Portal, successfully demonstrated yesterday afternoon that wireless telephony is a reality and a fact. For more than two hours they conducted a concert in Mr. Herrold's office in the Garden City Bank building, which was heard for many miles around. The music was played on a phonograph furnished by the Wiley B. Allen Music company.

Immediately after the first record was played numerous amateurs from various points in the valley notified Mr. Portal that they had heard the music distinctly. Mr. Portal gave the names of the records he had on hand, and asked those with whom he was communicating to signify their choice, saying that he would play any record they desired. One asked for "My Old Kentucky Home," which was furnished.

Mr. Portal has a similar outfit to that of Mr. Herrold at his home on Vine street. Mr. Herrold, in company with a Mercury reporter, went there and held a lengthy conversation over the wireless with Mr. Portal, who also played several selections on the phonograph. The articulation was heard as distinctly as over the ordinary telephone.

Mr. Herrold is developing the wireless telephone into a practical means of communication, and is now working on a scheme to do away with the spiral. He has already made successful experiments in that direction.

E. A. Portal, Mr. Herrold's assistant, is a local boy who is a very promising operator. He is only 16 years old, but he can already operate either the wireless telegraph or wireless telephone. He has developed several original ideas of his own in the line of telegraphy.

Figure 35. *A July 8, 1912 editorial from the* San Jose Mercury- Herald.
Figure 36. *A July 22, 1912 story from the* San Jose Mercury-Herald *"Concert by Wireless Telephone a Success" tells of a Herrold broadcast.*

supplied us records, of course free of charge, and I think we played them all. We would take the *Mercury*, I believe it was the *Mercury-Herald* in San Jose, and we would read headlines and discuss them a little bit, just something to yak about and make it interesting at the same time, to develop an audience, I would say." (64) The major significance of Herrold is that he, before anyone else, began the transmission of regularly scheduled programs of entertainment and information for an audience. He started a radio station.

But no one, not even Herrold, simply woke up one morning in 1912 and said: "Let's broadcast to the public." It happened much more gradually than that, so slowly that even a major San Jose newspaper failed to see its significance. The press, like most of the public, still saw the radiotelephone's importance as that of a replacement for the wired telephone. Two July, 1912 stories in the local *San Jose Mercury-Herald* illustrated both the public's confusion and perception of "broadcasting," and demonstrated why most at that time didn't see the future of the wireless telephone in the way that Charles Herrold did. In a July 8, 1912 editorial, the subject was the potential commercial use of the wireless telephone for two-way communication: "It would be possible with five wireless telephone stations, costing not more than $10,000 each, scattered along the Atlantic coast, to have telephone communication with every ship within 1000 miles of the shore. If this astounding discovery be indeed what is asserted, there need never again be such a disaster as shocked the world last April" (65) Obviously, it was the sinking of the *Titanic*, with its great loss of life, that set the immediate agenda for the new invention.

But it was in another article in the same daily paper two weeks later (66) where you can see that Charles Herrold saw his wireless telephone in a different light. Herrold and assistant Emil Portal demonstrated for the reporter: "For more than two hours they conducted a concert in Mr. Herrold's office in the Garden City Bank building, which was heard for many miles around. The music was played on a phonograph furnished by the Wiley B. Allen Music company. Immediately after the first record was played numerous amateurs from various points in the valley notified Mr. Portal that they had heard the music distinctly. Mr. Portal gave the names of the records he had on hand and asked those listening to signify their choice. One asked for 'My Old Kentucky Home,' which was furnished." (67) It was broadcasting, much in the same way Herrold had been describing it since 1910. Sure, there was no doubt that Herrold's main motive paralleled that described in the earlier editorial; to invent a successful system of two-way radiotelephony and thereby profit from its manufacture. As an inventor that was Herrold's business, and the regular broadcast of music and talk was a way to test his system. Years later, Herrold said that it was from those daily experiments that regular broadcasts designed to entertain rather than test evolved: "Broadcasting was an obsession with us and certainly, the entire Pacific Coast looked upon the radio broadcasts from San Jose as an established institution." (68)

Closer to the action was Ray Newby. Appearing as a guest on the 1950s television show, "What's My Line," he signed in as the "World's First Disc Jockey." Later he described for Herrold biographer Gordon

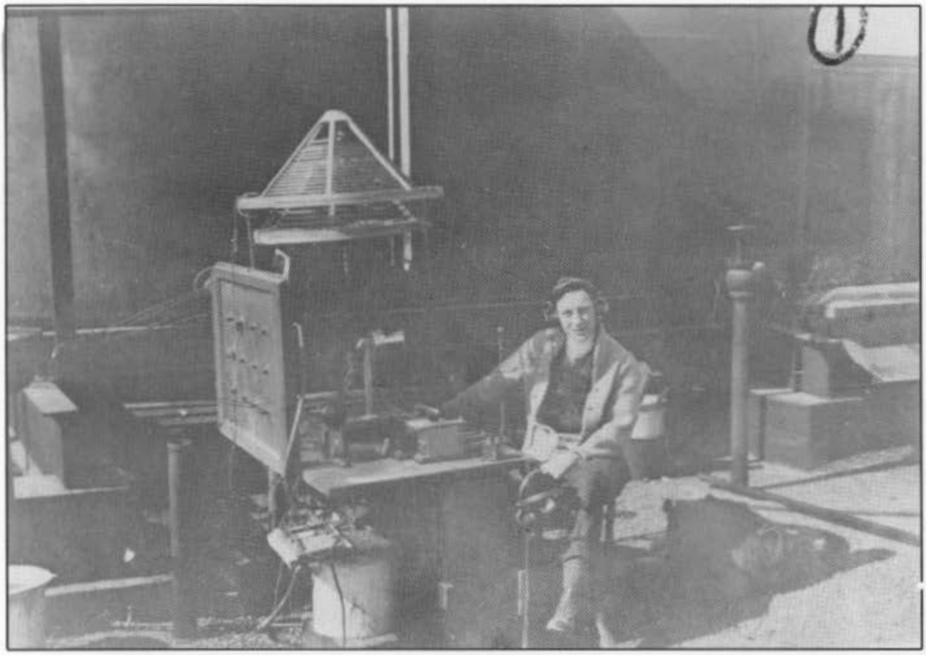


Figure 37. *Herrold assistant Emil Portal at an early arc radiotelephone at the Herrold College. (Perham Foundation)*

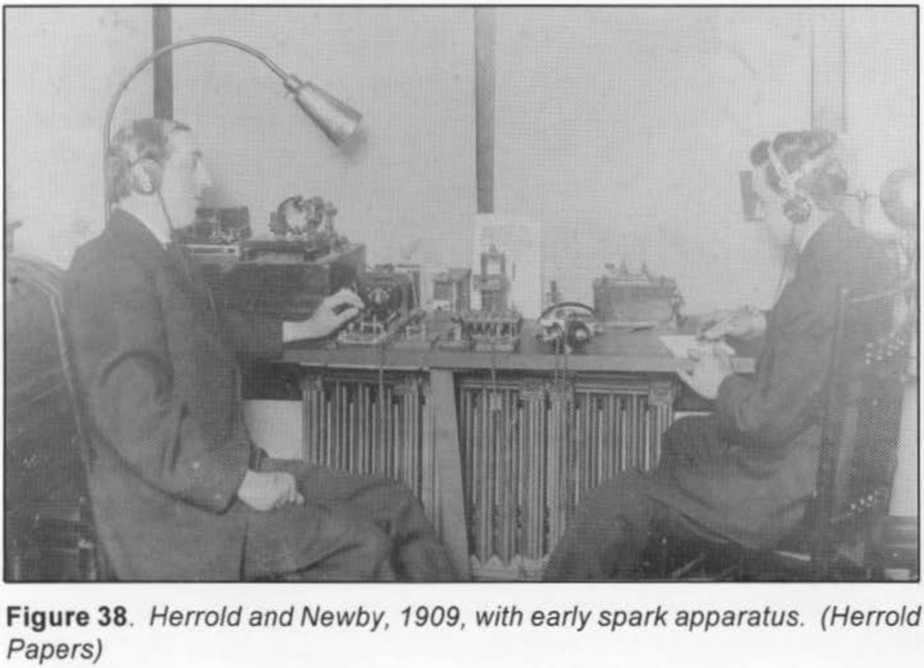


Figure 38. *Herrold and Newby, 1909, with early spark apparatus. (Herrold Papers)*

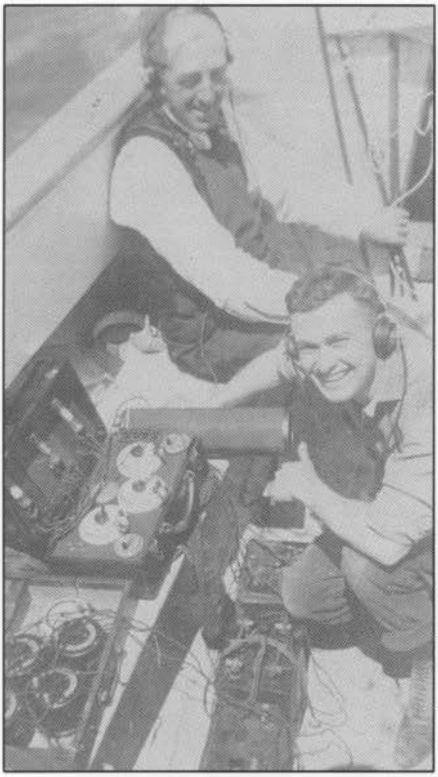


Figure 39. *Herrold and a student experiment with wireless, 1910.*

Greb a typical 1912 broadcast: "In general we would just ad lib and play a record like you would today, more or less. We would read the newspaper headlines and carry on with whatever came into the mind that you would think would be important. We had the old Caruso records. We did use an Edison once but it didn't have a hard needle. Many a time we'd sing with the records at the old bank building. We had musical instruments come in, such as a harp, we had a lady play a harp one time and she was a little disturbed by the proximity of the microphone. She was afraid of the thing." (69)

And who did Newby understand his early audience to be? "The listeners were all amateurs who had crystal detectors listening to ships or codes or whatever they could learn and read and find and they were startled to find music coming in on their ears. Oh, they'd call us right up and say put on such and such a record, or play it over and over, certain ones they liked better. And we had callers coming in from around San Jose, even as far as San Francisco. We had listeners within, I'd say, at that time, even in the earliest arc days, it was heard as far away as 900 miles but under very favorable conditions. We had listeners all over the Bay Area." (70)

Obscured by his broadcasting claims is the fact that Herrold received a half dozen patents for his arc transmitter. Like most radiotelephone inventors between 1910 and 1916, Herrold and his attorneys, in an attempt to get around the American Poulsen arc system patents, had designed a system just different enough to get government recognition. It is believed that if the arc had become the technology of the radiotelephone, Herrold and other arc experimenters would have certainly met the Poulsen forces in court. And lost. One area in Herrold's patent applications in which he was trying to differentiate his system from that of Poulsen was in the elimination of the magnetic field. Poulsen's arc needed to operate in such a field so that high-power, long-distance wireless telephone could be possible. Arc

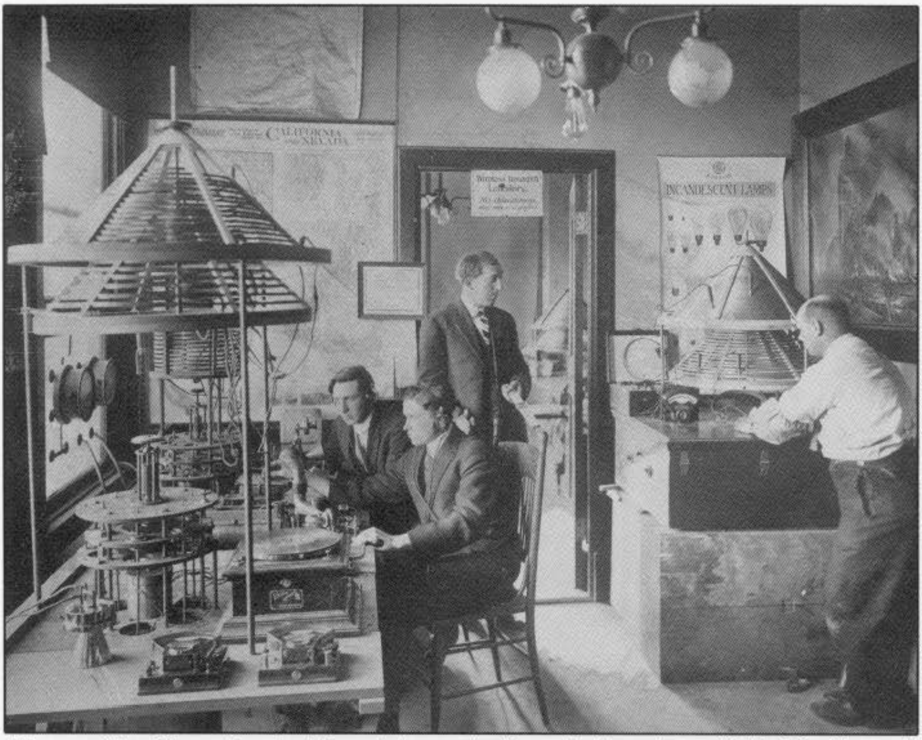


Figure 40. *The classic Herrold arc station photo, circa 1912-14; Herrold standing in the doorway; at right is "mechanician" Frank Schmidt; at microphone, left, Emil Portal; right, Ken Sanders. Portal and Sanders began as Herrold's students.*

technology expert William J. Byron was asked to examine Herrold patents and documents: "Herrold uses no magnetic field, but he does use alcohol in the arc chamber. They will operate at low powers (no more than 10 or 20 watts) without the field, and that's one of the reasons Herrold's arc worked . . . I suspect that Herrold was trying to avoid the difficulties of providing a field in the area of the arc – not to mention infringement of innumerable patents covering the field; the era virtually exploded with patent suits, involving everyone, including Marconi." (71) And the Herrold patent for his distinctively-shaped conical helix coils would have likely been in trouble: "If Herrold were to try to manufacture and sell his system he would have come face-to-face with Marconi's patent on the secondary coupling system; Herrold's 'Conical" coils. It was patented in 1898, British patent number 7777, hence the description 'the four-sevens patent.' The conical shape really had nothing to do with the physics of the device. Marconi's patent would have put him out of business." (72)

The Herrold technology is best seen rather than described. Both the patents and the pieces that made up his "arc fone" are presented here in this series of photographs and drawings. Nearly all radiotelephone inventors, de Forest included, used some form of an arc fired by 200-500 volts DC, in series with inductors. A water-cooled microphone was typically in the ground circuit of the secondary of the antenna coupling coils. Here is the entire Herrold system, the patents and the actual devices, a system representative of the type of arc systems used by practically every inventor during the two decades of radiotelephone development. (Figures 40-55)

Having invented, tested and improved his "arc fone" between 1912 and 1917, Herrold began to patent the various versions of the pieces that made up his system of radiotelephony.

Science and invention was not Herrold's legacy. It was the sending of regularly-scheduled entertainment programs designed specifically for a public audience that defined Herrold. There were two events, the 1912-1917 weekly "Little Hams Program," and the 1915 daily broadcasts to the public receiving stations at the Panama Pacific International Exhibition in San Francisco. According to former students, Herrold believed that after a week of hard work spent on invention and study, both the students and the audience were entitled to some fun: "Every Wednesday night at nine o'clock he would be on because he knew he had fifty or more listeners with crystal detectors to report to him. They'd call up on the phone and ask for records. They'd request or call in or ask what records we had and also we'd yakity yak and sing. I used to sing on it myself. (chuckle) And news. We'd give out news from the *Mercury-Herald*." (73) Eventually, Herrold, Newby and the students were joined by Herrold's young wife Sybil: "I really believe that I was the first woman to ever broadcast a program. We used to get cards from the little hams asking us to play after we started playing the records for their little programs on Wednesday nights. And I went to Sherman-Clay (a San Jose music store) and arranged to borrow records from them at no cost but just for the sake of advertising these records to these young operators with their little galena sets. And we would play the up-to-date young people's records and they would run down the next day and be sure to buy the one they heard on the radio the night before." (74) (Figure 56)

While the Wednesday night programs were true "local radio," with an audience of mostly young experimenters, it was at another event, known the world over, that the Herrold broadcasting apparatus was placed into service to entertain what probably was their largest audience ever. The 1915 Panama Pacific International Exhibition (PPIE), held in San Francisco, was designed to celebrate the opening of the Panama Canal. Billed as a "World's Fair," the PPIE featured the very latest technology. Newspapers from all over the country began announcing in 1914 some of the big names in wireless expected to attend and present at the event: "William Marconi, the wireless inventor, announced today that he had decided to participate in the Italian section of the Panama Pacific International

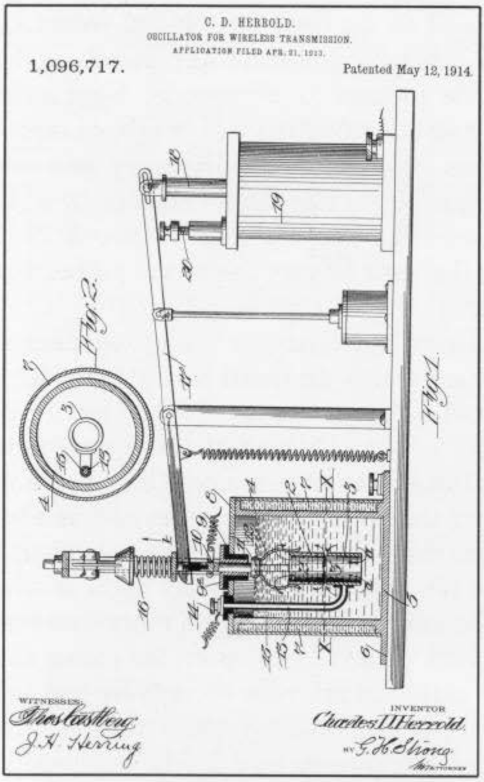
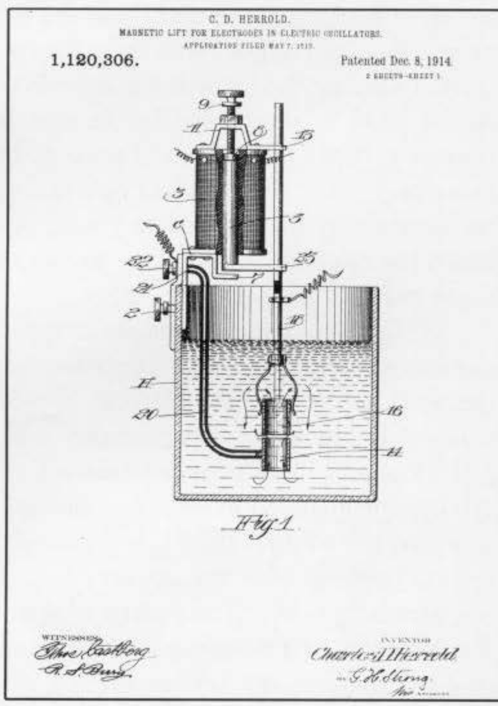


Figure 41. *"Oscillator for Wireless Telephone," filed April 1913, patented May 1914.*

Figure 42. *"Magnetic Lift for Electrodes in Electric Oscillators," filed May 1913, patented December 1914.*



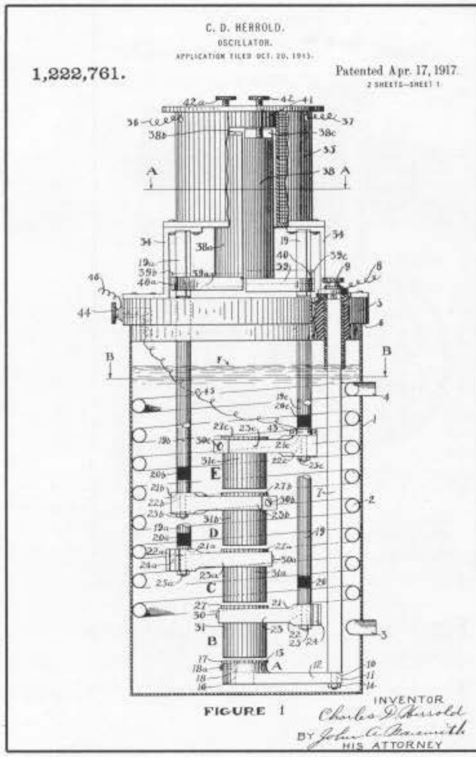


Figure 43. *"Oscillator," filed October 1915, patented April 1917.*

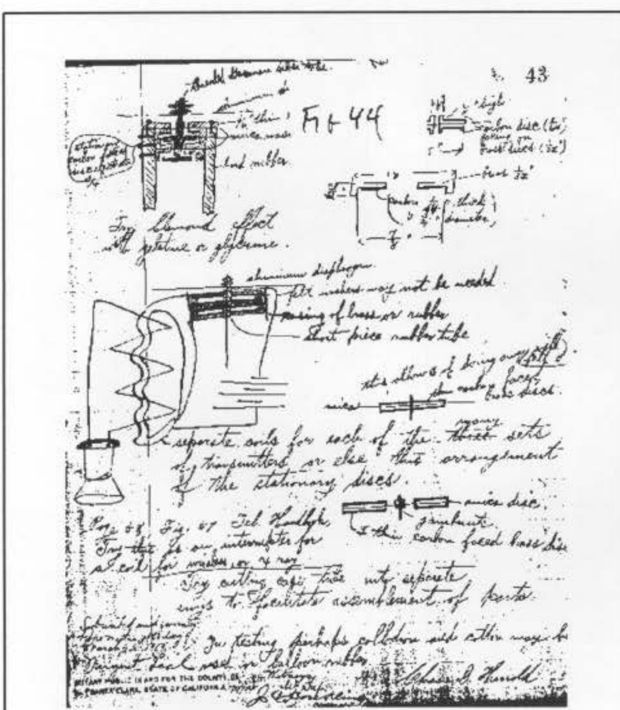
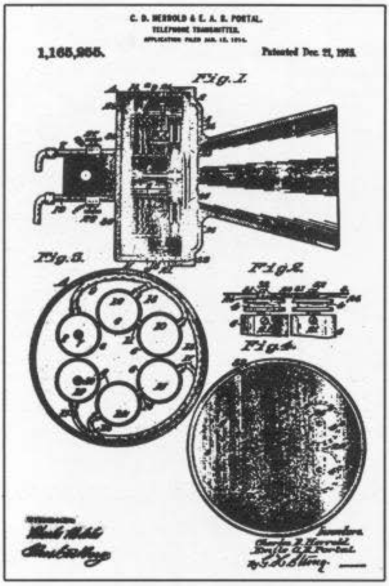


Figure 44. *Original notarized drawings for Herrold "Telephone Transmitter" microphone, 1913.*



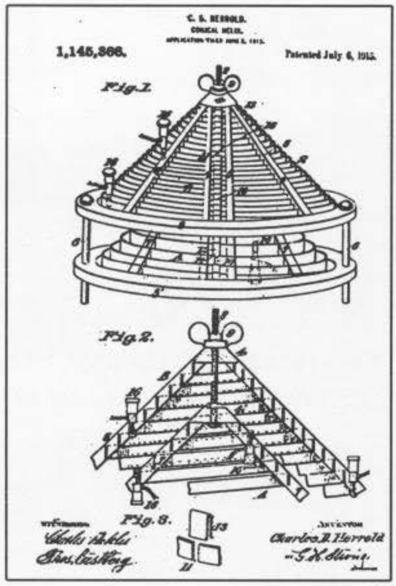
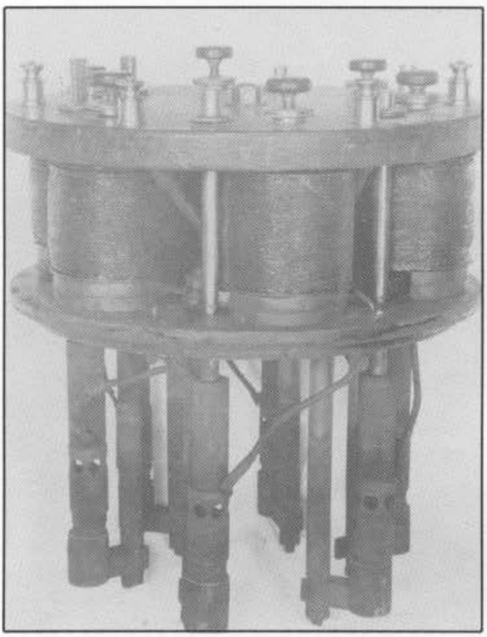


Figure 45. *"Telephone Transmitter," filed January 1914, patented December 1915.*
Figure 46. *"Conical Helix," filed June 1913, patented July 1915.*



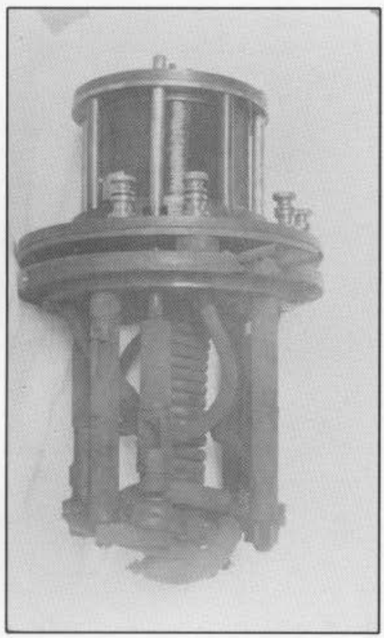
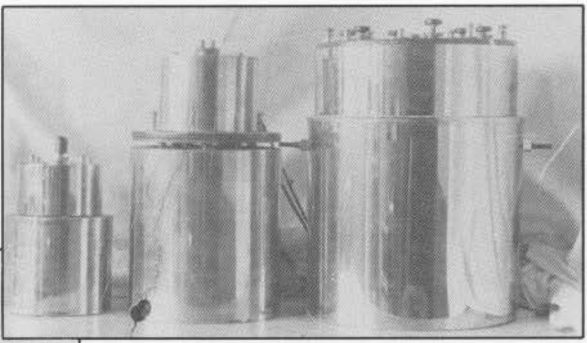


Figure 47. *Oscillator with six arcs and magnetic lift, version 1.*
Figure 48. *Oscillator with six arcs and magnetic lift, version 2.*



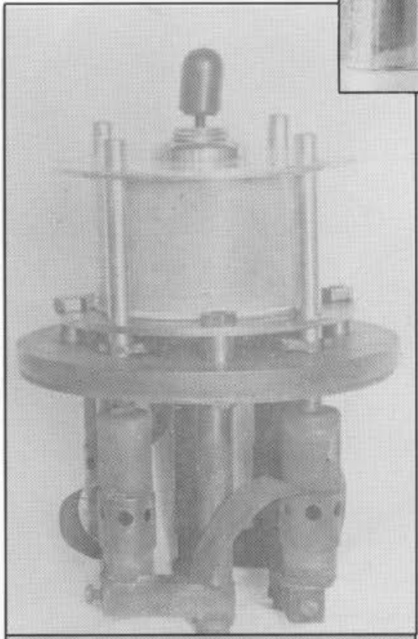


Figure 49. *(left) Oscillator with four arcs and magnetic lift.*
Figure 50. *(above) The above arcs in metal cans for submersion under alcohol, three sizes/versions.*

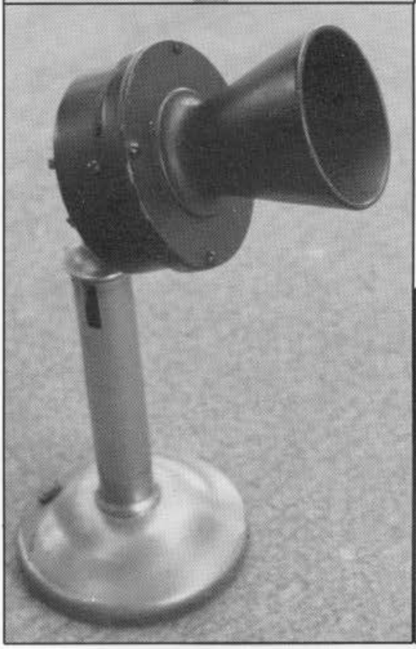
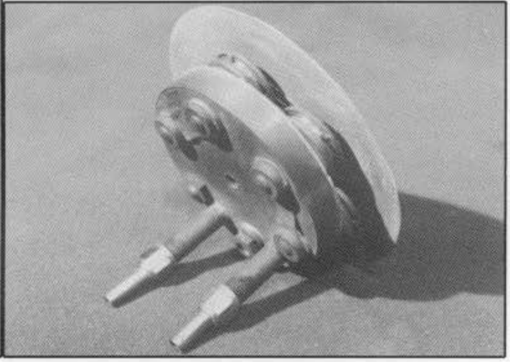
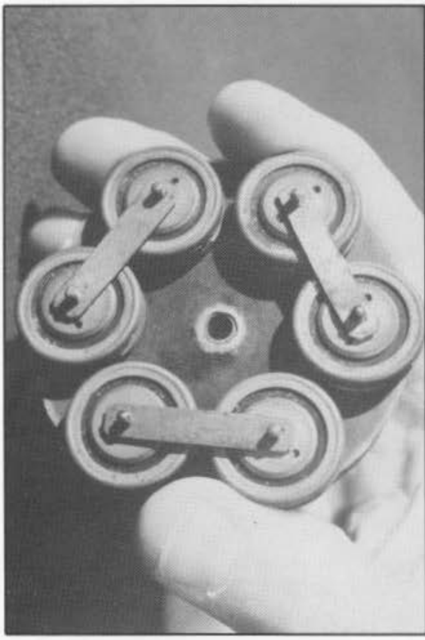


Figure 51. *(left) Water-cooled microphone mounted on telephone base.*
Figure 52. *(below) Water cooling chamber from microphone showing water connections.*





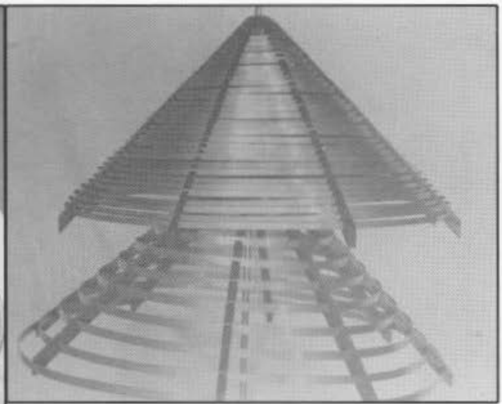
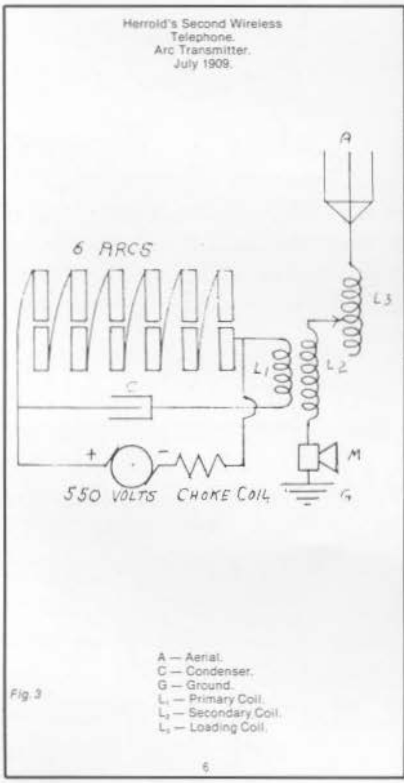


Figure 53. *(left) Attached to water cooling chamber are six carbon buttons in series.*

Figure 54. *(above) The Herrold conical helix.*



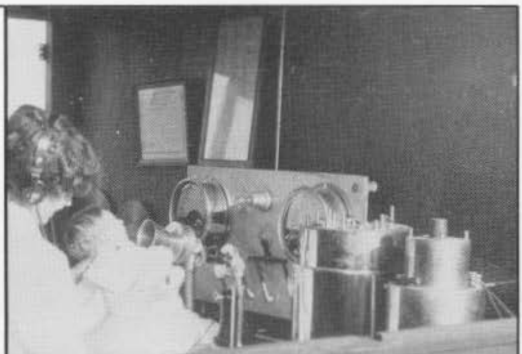


Figure 55. *(left) Possible schematic of basic Herrold arc system as drawn by Thorn Mayes.*

Figure 56. *(above) Sybil Herrold with son Robert, "on the air," 1913.*

Exhibition at San Francisco. He said he hoped to be able to communicate from the exposition by radio-telephony with all of the states and Canada." (75)

Another of the radiotelephone pioneers profiled in this article had also made plans for San Francisco. Lee de Forest, working nearby in Palo Alto, had an exhibit in the fair's Liberal Arts building, one dedicated to a major advance in long distance wired telephony. Sure, it had been rumored that he would also demonstrate at his booth how he had been able to make his audion oscillate at the radio frequencies necessary for the transmission of voice and music. The real purpose, however, of the de Forest exhibit had been to demonstrate the "de Forest Audion amplifier licensed to the American Telephone and Telegraph Company as a telephone relay that made the transcontinental service possible." (76) De Forest's audion transmitter failed to work and that allowed Herrold to participate as a broadcaster at the PPIE: "At the personal suggestion of Lieutenant Ellery Stone, U.S. Radio Inspector, I carried on a special daily schedule of radiocast music from 6 to 8 hours per day for the World's Fair at San Francisco, California, in 1915. This was received at the radio inspector's booth, also at that of Dr. Lee de Forest, in the Liberal Arts building." (77) That first PPIE broadcast was heard at the foot of the Tower of Jewels on the exposition grounds by Herrold and his wife: "I was at the fair with him when he received the programs that our station was putting on here in San Jose. He was anxious to see what the reception was like there. We'd been sending out these things but this was the one time when we got to hear it ourselves." (78)

Apart from that important year of daily broadcasting to the World's Fair, between 1912 and 1917 Herrold was continuously trying to build the most difficult part, the final piece of the radio puzzle. How do you create an audience? Herrold believed that the publicity surrounding the PPIE was one way to gain listeners. He knew that if he was on every day, more and more young men, even commercial operators would tune in. Wrote a former Herrold student: "A Marconi operator stated that he had danced to our 'wireless' music from San Jose on the deck of a trans-Pacific liner, using a long extension cord on his fones." (79) Later Herrold recalled his audience in a letter to Lee de Forest: "My audience was not always made up of amateur wireless telegraph operators. During the period of 1909 to 1917 I trained over 1200 students in the theory and practice of wireless telegraph and telephone. The interesting part is that these students built apparatus and installed sets with which people could listen to the telephone music. It was a beginning, and my students were building my audience, and incidentally they were publicizing my school." (80) He also told his story to the local newspapers: "If any boys in the neighborhood possess a wireless telegraph outfit ask them to permit you to listen any night between 9 and 9:30 o'clock and you can hear my station experiment with the wireless telephone. Phonograph concerts over the wireless telephone are not all uncommon. You can hear the phonograph as distinctly as if it were placed in the next room to you." (81)

Did Charles Herrold really understand the difference between broadcasting and what he termed narrowcasting? Years later in a radio interview he explained it this way to a reporter: "The word 'broadcast' is an old word used by the Marconi telegraph operators to designate a message 'to all ships and stations.' When Valdemar Poulsen talked from his laboratory at Lyngby, Denmark to a test receiving station, that was a narrowcast. Count Arco, Professor Slaby, and many other Europeans did the same thing. When Lee de Forest in this country had a singer from the Metropolitan Opera sing in his laboratory and he himself talked, this was intended for reception by a group of newspapermen located on a ship in the harbor equipped with receiving instruments. There is not the slightest evidence to show that Collins, McCarty, de Forest, Poulsen, or any of these early experimenters had in mind the use of their experimental radio telephones for entertainment purposes" (82) Conversely, he believed many of his own early transmissions to be true broadcasts: "Certainly the thousands of amateurs who made it a religion to listen every day to our dance music and the thousands of records we played, certainly the hundreds of homes who connected a dozen pairs of telephone receivers to their receiving sets and invited the neighbors to listen – certainly they knew what I was doing." (83)

FRANK CONRAD, THE FIRST LICENSED BROADCASTER

Frank Conrad was a Westinghouse engineer who has been widely credited with being the first person to receive an actual government broadcasting license. The station, of course, was KDKA. According to Conrad researcher David Kraeuter: "Born in Pittsburgh on May 4, 1874, by age 16 Frank Conrad had quit school to work as a bench hand with the Westinghouse Electric and Manufacturing Company, his life-long employer. Between 1898 and 1942 (the year after his death) Conrad received over 200 American, English and German Patents on mechanical and electrical devices such as grenades, refrigerators, carburetors, radio transmitters and receivers, televisions, clocks, arc lamps, gear shifts, air conditioners, insulators, vacuum tubes, and electric meters. His experimentation with radio transmitting in 1919 and earlier helped Westinghouse found pioneer radio station KDKA. In the 1920s Conrad also did pioneering work which helped establish worldwide communications via short wave." (84) A self-made man, in 1928 Conrad was awarded an honorary Doctor of Science from the University of Pittsburgh.

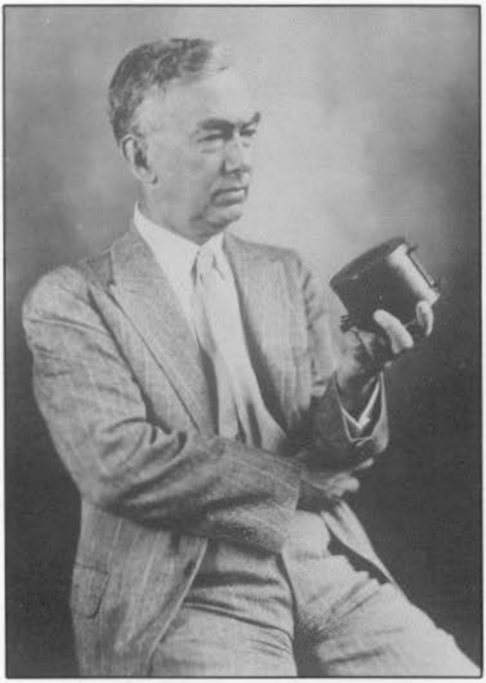


Figure 57. *Frank Conrad. (Westinghouse History Collection)*

Prior to Conrad and KDKA, amateurs and experimenters like Lee de Forest had just "gone on the air" with music and talk, often without any license. Charles Herrold, using the experimental radiotelephone call sign 6XE, had been allowed to "experiment" until the World War I ban beginning in April, 1917. And while de Forest, Herrold and others had probably been "broadcasting" as defined by their programming content and audiences, they were not official in the eyes of the government or the communications industry. To commercial operators they were misplaced, they interfered with legitimate "traffic," and even as late as 1920 there was hope in Federal Government circles that in the future all wireless would be controlled by the Navy. The historic metamorphoses of Conrad's experimental radiotelephone known as 8XK into KDKA almost did not happen!

Nevertheless, it was two years following the April, 1917 ban on amateur radio sending and receiving that stations were allowed to pick up where they left off, and so many continued with their earlier pre-war radiotelephone experimentation. In the June, 1921 publication by the Radio Service, Bureau of Navigation, Department of Commerce called *Commercial and Government Radio Stations of the United States*, a small group of radiotelephone stations were listed as "Special Land Stations, Alphabetically by Names of Stations [Additions to the List of Radio Stations of the United States, edition of June 15, 1919 only]." (85) These three were listed: "Pittsburgh, Pa, 8XK, variable wave length, Frank Conrad; Madison, Wi, 9XM, University of Wisconsin; San Jose, Ca, 6XE, Charles D.

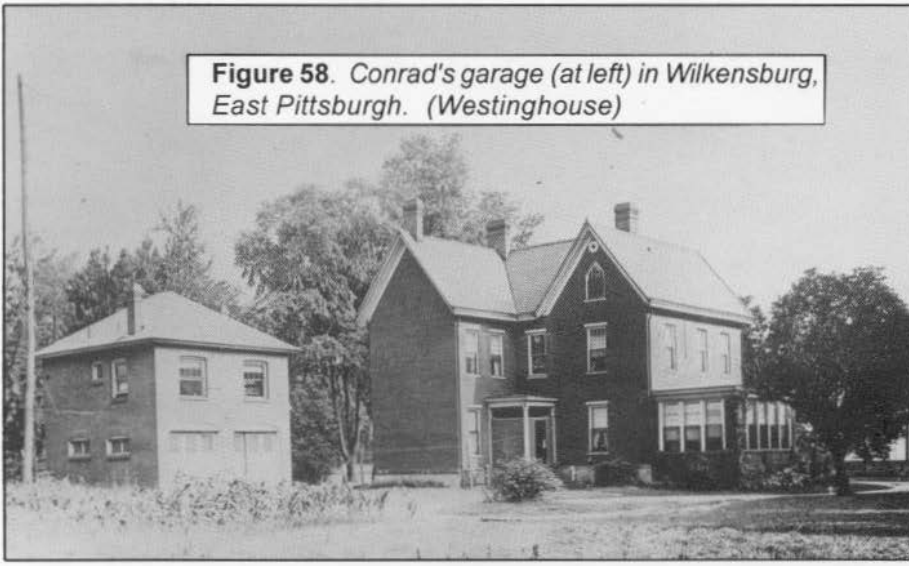


Figure 58. *Conrad's garage (at left) in Wilkensburg, East Pittsburgh. (Westinghouse)*

Herrold." Later each of those experimental radiotelephone licensees went on the air as broadcasters; Conrad in late 1920 became KDKA, the University of Wisconsin (Earle Terry) as WHA, and Herrold as KQW (now KCBS), both in 1921. All three stations operate today.

Unlike others during the war Conrad had been in a unique position, that of being allowed by the Signal Corps to experiment with a vacuum tube radiotelephone. Often he accomplished this by using his voice and a phonograph as an audio source: "During the War, the Navy gave him (Conrad) permission to carry on with his experimental work, for they wanted him to solve some problems, such as an airplane transmitter. His call then was 3WE, the "3" meant that the station was in the third Naval district." (86) After the war ended Conrad continued to experiment, and by mid-1920 his Saturday night phonograph concerts had caught on in an interesting way with a small audience in (Wilkensburg) East Pittsburgh, Pennsylvania. Said Conrad in 1940: "People within radio distance had bootleg receivers, and soon they began picking up (my) transmissions. Then they began to telephone and say, 'We have some friends in this evening. They do not believe us when we tell them that we can pick up music out of the air. Won't you please play some selections for them?" (87) This clandestine receiving and audience activity (Conrad's transmissions were legal) had been building during the wartime ban on amateur activity. After the ban was lifted he continued and he got the attention of his bosses.

Said S.M. Kintner of Westinghouse: "On account of the number of requests he received he agreed to undertake this broadcasting at regular intervals. So he agreed to do this every Wednesday and Saturday night at certain times. The number of requests kept growing, till by the summer of

Figure 59. QST, *September 1920.*

1920 some of the department stores of Pittsburgh were carrying radio receiving sets of approved type which were advertised as suitable for listening to Mr. Conrad's concerts." (88) And according to Leroy Williams, special patent counsel to Westinghouse: "As a result of the publicity that Conrad got with his sending out radiotelephone signals, Joseph Horne and Co., a department store of Pittsburgh advertised in September, 1920, that they would sell receiving sets that would pick up Conrad's music. H.P. Davis (Westinghouse president) saw this ad and saw the possibilities of radio broadcasting. He thought it was time for the company to take over the work of Conrad." (89) It was the corporate spin on the work of an inventor who incidentally spent his entire working life at Westinghouse. Was Conrad bitter in later years that his idea had been usurped and the credit taken by boss Davis? The evidence suggests that he never publicly raised the issue. Conrad was a good soldier.

There was national publicity as well. Concurrently with Westinghouse's awareness of the potential of Conrad's work, his experimental station was featured in a cover story in a major national amateur publication. In the September, 1920 issue of QST, Conrad's 8XK was written up in great detail. (90) With photos and descriptions of his low-power tube transmitter with its microphone aimed at the horn of a wind-up phonograph, it was the first up-close look at the technology that several months later in that same year would be licensed as KDKA, just in time for its broadcast of the Harding-Cox presidential election. And unlike the de Forest Wilson-Hughes presidential broadcast of four years earlier, that time the public was more ready for radio. Thanks to the ongoing RCA negotiations and their effect on the supply of legal radio parts, a few ordinary citizens were able to buy receivers with which to hear the KDKA broadcasts. In fact, one of the major benefits hoped for out of the highly publicized Conrad broadcasts was to profit by selling simple consumer versions of the Westinghouse/RCA RA DA tuner-receiver, a device originally worked on by Conrad and manufactured for the war. (91)

But it was not simply an overnight transition from Conrad's garage experiments to KDKA as a broadcast station. According to Conrad, the whole idea began as a plan for a two-way service: "(S.M. Kintner of Westinghouse) planned a city service or rather cities service, placing stations at Pittsburgh, Newark, and Cleveland, for code communication, with radiotelephone working as a sideline. These point to point stations were installed. It was for code operation in these stations, incidentally, that the RC receivers were designed. I went to H.P. Davis, big boss of Westinghouse and said, 'Why have this just a point to point affair? Why not let the station talk to everyone, not just to each other?' This was June or July of 1920." (92) Davis agreed and KDKA evolved out of that group of Westinghouse stations originally designed for this commercial operation: "It went on the air, for the first time, on Election Day, 1920. Permission to use the station for broadcasting on that night was granted, the call to be 8ZZ. A few days after the election, permission to add broadcasting to KDKA's license was granted . . . [I] used the calls 8ZZ and KDKA more or less interchangeably during the night." (93)

Frank Conrad described the famous November, 1920 election eve broadcast in a 1937 letter to RCA historian George Clark: "The broadcast was carried out in cooperation with the Pittsburgh Post and the publicity was entirely confined to the Pittsburgh Post circulation. The broadcast was primarily to announce the election returns and the first returns were received about 8pm; however, some preliminary matters, such as talks and music were transmitted from about 6:30pm. The content of the broadcast, other than the news bulletins of the election, consisted of short talks explaining how the broadcast was carried out and interspersed with musical selections. These selections were almost entirely phonograph reproductions. My recollection is that the weather was clear on that day. We had carried out enough preliminary tests to assure ourselves that the service would be reasonably reliable; however, to guard against any general breakdown, such as power or lines, arrangements were made so that (my) private station in the garage (8XK) could be used in place of the station at East Pittsburgh – line facilities being arranged for from the *Pittsburgh Post* building to (my) home. Certain information on the results were known soon after the broadcast started by telephone calls from receiving stations, which previously had been instructed to report on the success of receiving the returns. The broadcast in general was handled by the personnel of our publicity department and the radio engineering department. It would be somewhat difficult to give a complete list of the names of the people taking part in the program. However, so far as the listening audience was concerned, it is probable that only one name appeared, that of L.H. Rosenberg, who did the announcing." (94)

Unlike Lee de Forest and Charles Herrold, Frank Conrad had excellent timing. The nation had put the war behind, the technology had mostly been sorted out and the patent issues were being resolved. Radio had arrived and people were beginning to embrace its possibilities. And most important, there was big-time corporate support behind the fledgling service.

SOME CONCLUSIONS ABOUT THE RADIOTELEPHONE DECADES

So which of these individuals won this imaginary race for the radiotelephone? Can you now visualize the finish line, the prize? You probably have your own opinions. Before I give you mine I want to summarize the importance of the years 1900 to 1920 to the invention, realization and perfection of the radiotelephone from its communications beginnings into broadcasting for an audience. I offer the following five broad conclusions:

1. BROADCASTING WAS AN ACCIDENTAL BY-PRODUCT OF INVENTION

The first radiotelephone experimenters and inventors probably became broadcasters by accident; they discovered that they had small groups of listeners or audiences in the course of trying to invent a wired replacement for the Bell telephone. Fessenden was a musician, de Forest an opera lover and promoter, Herrold the headmaster of a wireless trade school with a large number of young boys to keep occupied. Conrad used the phonograph as an audio source for his Signal Corps experiments. As you'll read later on in these conclusions, it would be several years into the 1920s before a clear direction for broadcasting was finally realized. (Figure 60)

Figure 60. *The young boys who were the first radio audience.*

2. PUBLIC AWARENESS OF THE POSSIBILITIES OF THE RADIO TELEPHONE BEGAN AS EARLY AS 1912

The years between 1912 and 1915 were important to the future perception of the radiotelephone because they were the first years in which the latest inventing news made its way from the hobby periodicals to the daily newspapers. Beginning in 1912 the general public finally began to hear about the inventors and their experiments, and therefore the editorial comments surrounding that new medium. Those were also the years in which several unrelated events convinced the youth of the day that any place related to wireless was an exciting place to be. Perhaps it began with the publication of exciting reading material aimed at the high school boy. The 1911 book, *Tom Swift and his Wireless Message* (95), was all the impetus many boys needed to sell their parents on the idea that a little "higher education" at a wireless school could translate into a living wage. Certainly the popularity of wireless in general was further helped by the major event of 1912, the sinking of the *Titanic*, the news of which came in the form of a wireless message: "We have struck an iceberg. Badly damaged. Rush aid." According to its survivors: "Seaward and landward, J.G. Phillips, the *Titanic's* wireless man, had hurled the appeal for help. By fits and starts for the wireless was working unevenly and bluringly Phillips reached out to the world, crying the *Titanic's* peril." (96) To many newspaper readers, the value of wireless had been solidified. (The loss of White Star's *Republic* in 1909 was a significant event in wireless history although it did not have the same public exposure as the *Titanic*.) (Figures 61-63)

Meanwhile, from coast to coast the work of the radiotelephone inventor was being reported in the nation's newspapers. (97) In what were four of the most important years in the slow transition from experimental radiotelephone development to actual programming for an audience, the years between 1912 and 1915 marked the introduction of the radiotelephone to the public. No longer confined to the technical and wireless hobby publications, the radiotelephone was now being discussed on Main Street. As the newspaper stories indicate, dozens of inventors, having constructed their own radiotelephone systems, began working on the next steps: promotion and publicity and marketing and sales. Newspaper reporters during those years seem to be interested in two things: how these inventors planned to replace the wired telephone and the type of audio content they were using to promote, test and demonstrate it. Often it was the inventor himself shouting, "Hello, can you hear me?" Sometimes it was music from a phonograph. Always, the goals were to both augment the wired

MAY TALK SOON FROM EUROPE TO AMERICA

Moretti's Wireless Telephony Already Brings Rome and Tripoli Together.

PERFECTS WIRELESS TELEPHONE SYSTEM

Elman B. Myers Hopes He Will Soon Talk, With London.

HOLDS DISTANCE RECORD.

Can Pick Out and Shut Off Any Station.

HUMAN VOICE HEARD 700 MILES BY WIRELESS PHONE

The wireless telephone has come, for they are talking daily now between Rome and Tripoli, which is 700 miles away. The inventor is Dr. Riccardo Moretti, a modest man, 35 years old, and a Roman by birth.

Wireless Telephony Here, Though Its Promoters Still Talk Through Their Hats

By Frederick W. Ford

TALKING across the Atlantic Ocean, from Neustadtam-Rubenberge, Germany, to New Jersey, a distance of four thousand miles, was accomplished by wireless telephony on October 27, according to Rear Admiral Georg August Emsmann.

Figure 61. *Montage of newspaper stories about radiotelephone, 1912-1914.*

telephone for two-way personal conversation and add a voice to the message handling work of the wireless telegraph business. With the exception of a few speculative editorials, the content of broadcasting was rarely discussed.

3. BROADCASTING WAS READY FOR THE PUBLIC BY 1916

Some members of the public were even ready for broadcasting. That much was obvious from the news reports. The technology and mass manufacturing, however, had not quite caught up. The situation in 1916 was that all the various inventors of the pieces that would make up radio transmitters and receivers had up to this time refused to put their pieces together and so a complete system was legally impossible. Then there was the war. As a result of our entry into WWI in 1917, the holders of various radiotelephone patents were forced to pool their inventions for national security, but it took until after the war for the patents to finally be sorted out and cross-licensed through the 1919 RCA agreements. The manufacture and marketing of radio receivers specifically for the consumer began


Wireless Talk Across the Atlantic

1913

Wireless Telephony Here, Though Its Promoters Still Talk Through Their Hats

By Frederick W. Ford

TALKING across the Atlantic Ocean, from Neustadtam - Roesbenberge, Germany, to New Jersey, a distance of four thousand miles, was accomplished by wireless telephony on October 27, according to Rear Admiral Georg August Ensmann. The message was sent and received in the middle of the afternoon, in spite of the daytime being most unfavorable for wireless

[redacted]

Youths Make Phone Calls by Wireless

Work to Perfect Scheme They Stumbled Onto

C. L. Sears, Son of Expert Marksman, Is Reticent About Discovery.

Wireless Telephony an Established Fact

BY GARRETT P. SERVISS.

There is no longer the slightest doubt that the time is coming, and perhaps close at hand, when we shall habitually talk to one another at distances of hundreds, or even, thousands, of miles without the intervention of any wires connecting the speaker with the hearer. Wireless telephony is an established fact, but the apparatus still needs development before it can come into general everyday use and displace the existing telephonic system.

There is something weirdly impressive in the thought of transferring the feeble human voice over mountains and seas, and making it virtually encircle the earth. Man speaks and his planet hears! At his command a little electric demon transforms his voice into waves that traverse the ether with the speed of light, carrying the voice with them, locked up in their undulations. In less than one second and a third they could bear it to the moon. In about three minutes they could carry it to the planet Mars.

WIRELESS TELEPHONE NOW.

An Italian Scientist Says He Has Solved the Great Problem.

Dr. Riccardo Moretti of Rome claims to have solved the problem of wireless telephony owing to a special generator of electric oscillations of his invention, which has been successfully experimented with between Rome and Tripoli. This apparatus consists of two poles fixed vertically a small distance apart and through one of which a thin continuous jet of water flows.

The water is evaporated by an electric spark between the ends of the poles, and an alternating current of extraordinary rapidity is consequently generated since the oscillations thus produced are calculated at several hundred thousands every second. As the oscillations exceed in number and rapidity the vocal vibrations by means of this generator it is possible to transmit the voice over long distances.

Dr. Moretti has experimented with his invention in connection with the naval wireless installations with the addition of ordinary telephone receivers and transmitters, but he is now working on a hydraulic transmitter, particulars of which are still undivulged, as ...

... a large number of patents as least as important, if not more so, than the patents which he has taken out in the past. This forecast focussed the attention of commercial men on the vast business possibilities of a system of speaking across space without wires. Such an invention, it is obvious, will be of great international importance.

But the Marconi Company was not alone ...

... years old, and with whom he works in his electrical activities. They have been able to speak and he has heard sounds of a whistle and a mouth organ.

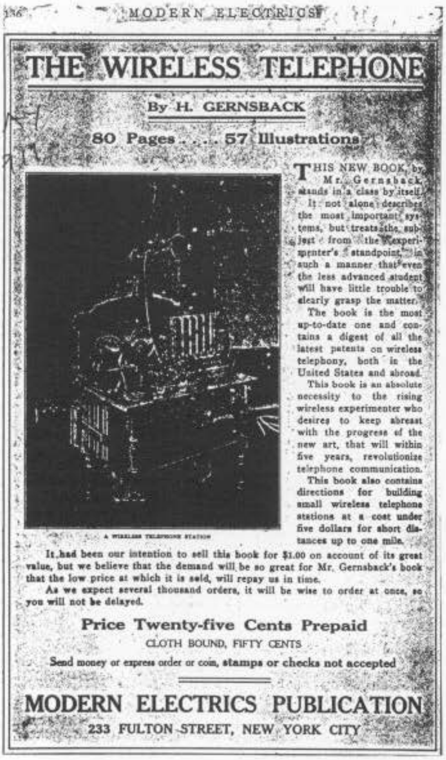
Constructed Most of Plant.

Sears has attended Manual Training School, but in telegraphy he is entirely self-taught. With the exception of the motor and the receivers, he has made the whole of his complicated plant. ...

Figure 62. *Another montage of the same.*

around 1920. Nevertheless, you can tell from some of the newspaper stories in 1916 that the public was beginning to embrace radio. Most important were the earlier mentioned High Bridge, New York broadcasts by de Forest. (98) Less well known were the 1916 efforts of Charles Herrold. The public record of one such Herrold broadcast illustrated what the public was being told about a new use for the radiotelephone:

First, the broadcast was pre-announced on December 22, 1916: "An extremely novel form of musical entertainment is planned for Christmas morning at 11 o'clock. The place will be anywhere that wireless waves can reach. Ships at sea as well as commercial and government stations within a radius of 1000 miles will be listening to catch the first strains of the opening numbers of the program. Professor Charles Herrold, the well-known radio and electrical engineer, assisted by Emile Portal, well known in wireless circles, will have charge of the concert. A modern talking machine will be placed in front of the transmitter through which flows a stream of cold water to protect against the powerful currents used. This system of wireless voice transmission has been subjected to the severest tests during the past three years and represents the highest development of the art." (99) (Figure 64)



136 MODERN ELECTRICS

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Figure 63. *This Advertisement appeared in the May 1911* Modern Electrics *for a new Gernsback book called* The Wireless Telephone.

News of the concert's apparent success was reported on December 26: "Edward Bellamy's prophecy in '*Looking Backward*' that some day people would turn on a button and listen to music from a central plant came true yesterday in San Jose when the wireless operators of the city and beyond within a radius of 1000 miles listened to a program of Christmas music in their homes. It was made possible by connecting their own wireless apparatuses with the central apparatus of the Herrold-Portal aerial system of telephony." (100) Even the papers didn't really get it, or at least they didn't get it right. There was no connection between the "central plant" and homes. That was the point. Later in the article, a listener gave his impressions: "It was as clear and sweet and beautiful as if it had been played and sung in the next room. The sounds came in distinctly. There was no disturbing noise and we listened to the whole program, which lasted about 20 minutes, without the slightest difficulty." (101) (Figure 65)

And what about the public? What about those in that very early small audience who would wonder themselves about what it all means? A San Jose newspaper editorialized the day of the Christmas morning broadcast. They compared it to other media forms of the day; film, records and the player piano. They were thoughtful. They were impressed. They counseled caution. The entire 1916 editorial is re-printed as an early indicator

Concert by Wireless Heard by 300 People

Music Clear and Distinct, States Man Who Was on "Wireless."

Edward . Bellamy's prophecy in "Looking Backward" that some day people would turn on a button and listen to music played and sung at a central plant, came true yesterday in San Jose when the wireless operators of the city and beyond within a radius of almost 1000 miles listened to a program of Christmas music while sitting in their homes. It was made possible by connecting their own wireless apparatuses with the central apparatus of the Herrold-Portal aerial system of telephony.

One of the local families which had the benefit of listening to this program was that of Mr. J. O. Heatwood, 239 Sixth street.

Mr. Heatwood said in speaking of the program, which was heard through the wireless apparatus of his son, James G. Heatwood. "It was as clear and sweet and beautiful as if it had been played and sung in the next room. The sounds came in distinctly. There was no disturbing noise and we listened to the whole of the program, which lasted about 20 minutes, without the slightest difficulty." Mr. James Heatwood has been working with wireless apparatus for the past five or six years.

Prof. Charles Herrold, who has perfected the system to its present most efficient state, said last night that there were about 300 owners of wireless apparatus within the radius reached by his machine. One of the great advantages of his system as explained by Prof. Herrold was the fact that operators could break into the middle of the word and start again without disarranging the sentences in a tenth of a second. With other systems it takes from two to five minutes to be "on" and "off."

12-16

A Newspaper of Quality | EDITORIAL PA(

EMBER 25, 1916.

A WIRELESS CONCERT.

SO NOW WE CAN HAVE a whole concert repertory shot through the air—a Christmas hymn, a Sousa march, an effable "Perfect Day," intermission and all complete—and science careers on to bankrupt space and link up those it divides. For this morning radio and electrical engineers in this city will transmit from records a musical selection that all with proper receivers within 1000 miles radius will hear—they say—and so the message of Christmas morn and a variety of other things will go out from San Jose, to Salt Lake City on the east and the storm-tossed sailor on the west.

What will it all lead to? Here we have Paderewski drawing divinity from a piano; an impress is taken and unrolled on mechanical pianos, and so the master's touch is duplicated ad infinitum. Melba sings once, and the song is heard a million times by machinery. Bernhardt acts, and her gestures are thrown on the screens of all the world. And soon one transmission will entertain the Esquimaux, the Maori and the Basutos at one and the same time with complete symphonic concert.

Here is the making of a revolution in human nature that needs to be watched and studied. It means that in the general process of centralization where mankind finds efficiency in government, industry and trade, something very similar is taking place in the realm of art. It is no longer necessary for artists to be present in the flesh when the busy, bustling public have half an hour to spare for musical or dramatic relaxation. For at a trifling cost the scientist will reproduce their skill with his machines, and the fruits of their labor are distributed, to order, with more or less precision.

But one cannot afford to ignore the dangers that arise from this organized distribution of art. For art refuses to be governed by the ordinary laws that pertain to efficiency. The greatest achievements of science could never make the Jew dance in the bramble-bush or rid the town of rats. In its mechanical reproduction it loses all that subtlety and magnetism that the artist himself can give; it loses that mysterious force that touches the very soul of those who listen. It is all the difference between a Rembrandt and the copy of a Rembrandt, between the thunder of Jove and the thunder of the "flies." In other words, it is an imitation which, however faithful, cannot shed all the inherent defects of an imitation.

And if we hear none but reproductions and imitations, whether by wire, needle or air, we may raise our standard of taste somewhat if these be good, but we shall inevitably dull the keenness of our appreciation of art through lack of human magnetism and soul.

The scientist then will do wonders yet undreamed of; he will make the world so small that he will long for other worlds to conquer; but the singer and the player of ancient history will always be abreast of modern times and will defy the efforts of science and machinery to place him in harness.

Figure 64. *An announcement of the success of the December 1916 Herrold broadcast,* San Jose Mercury-Herald, *December 26, 1916.*
Figure 65. *Editorial from the December 1916* San Jose Mercury-Herald *about the Christmas Day, 1916 Herrold broadcast.*

of what radio would become and how the audience might come to view this revolutionary use of the radiotelephone:

"So now we can have a whole concert repertory shot through the air - a Christmas hymn, a Sousa march, an affable 'Perfect Day,' intermission and all complete and science careens on to bankrupt space and link up those it divides. For this morning radio and electrical engineers in this city will transmit from records a musical selection that all with proper receivers within 1000 miles radius will hear they say and so the message of Christmas morn and a variety of other things will go out from San Jose, to Salt Lake City on the east and the storm-tossed sailor on the west.

"What will it all lead to? Here we have Paderewski drawing divinity from a piano; an impress is taken and unrolled on mechanical pianos, and so the master's touch is duplicated ad infinitum. Melba sings once, and the song is heard a million times by machinery. Bernhardt acts, and her gestures are thrown on the screens of all the world. And soon one transmission will entertain the Esquimaux, the Maori and the Basutos at one and the same time with complete symphonic concert.

"Here is the making of a revolution in human nature that needs to be watched and studied. It means that in the general process of centralization where mankind finds efficiency in government, industry and trade, something very similar is taking place in the realm of art. It is no longer necessary for artists to be present in the flesh when the busy, bustling public have half an hour to spare for musical or dramatic relaxation. For at a trifling cost the scientists will reproduce their skill with his machines, and the fruits of their labor are distributed, to order, with more or less precision.

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"And if we hear none but reproductions and imitations, whether by wire, needle or air, we may raise our standard of taste somewhat if these be good, but we shall inevitably dull our keenness of our appreciation of art through the lack of human magnetism and soul.

"The soloist then will do wonders yet undreamed of; will make the world so small that he will long for other worlds to conquer; but the singer and player of ancient history will always be abreast of modern times and will defy the efforts of science and machinery to place him in harness" (102)

Who were the other broadcasters of 1916? By 1917 an inventor named Earl Hanson was broadcasting to his small audience in Los Angeles. According to Hansen: "Municipal wireless phonograph concerts may also soon be a reality. For these a single centrally located sending station would be necessary, the waves from this having a radius of the entire city." (103) And in a Pittsburgh newspaper story from 1915, "Wireless Talkfest Planned," historian George Clark related a story about a Professor Van Dyke of the

Carnegie Institute of Technology who planned and pre-announced a wireless "talk" about general news, politics, etc., aimed at "every amateur wireless operator in the county." Another isolated event, "the test was for the benefit of amateurs within a radius of ten miles." (104) And while impossible to prove but fascinating to think about, consider that another Pittsburgh resident, KDKA's Frank Conrad, might have been in that 1915 Van Dyke audience, and thereupon got an idea or two. Still another local event was happening in New Rochelle, New York: "Station 2ZK, operated by George C. Cannon and Charles V. Logwood, broadcast music between 9 and 10pm daily except Sunday in November, 1916." (105) Logwood earlier had worked in Palo Alto with Lee de Forest during his days at the Federal Telegraph Company. Another set of influences, another connection. Broadcasting, 1916 style. So why didn't it happen? Why would it take four more years to catch on?

It was the Great War. It was in April, 1917 that all licensed amateurs received this letter from the Department of Commerce and the US Navy District Communication Superintendent: "To all Radio Experimenters, Sirs: By virtue of the authority given the President of the United States by an Act of Congress, approved August, 13, 1912, entitled, 'An Act to Regulate Radio Communication,' and of all other authority vested in him, and in pursuance of an order issued by the President of the United States, I hereby direct the immediate closing of all stations for radio communications, both transmitting and receiving, owned or operated by you. In order to fully carry this order into effect, I direct that the antennae and all aerial wires be immediately lowered to the ground, and that all radio apparatus both for transmitting and receiving be disconnected from both the antennae and ground circuits and that it otherwise be rendered inoperative both for transmitting and receiving and radio messages or signals, and so remain until this order is revoked. Immediate compliance with this order is insisted upon and will be strictly enforced. Please report on the enclosed blank your compliance with this order; a failure to return such blanks will lead to a rigid investigation." (106)

Never again would such a sweeping ban on not only transmitting but receiving radio signals be implemented. That was a historic decision. And even more onerous, emboldened by this shut down and with the belief that amateurs have no place in the future of radio communication, the Padgett Bill, known as HR 2773, was introduced on April 9, 1917. It proposed that all American radio communication be turned over to the Navy, forever. And while the bill did not become law, America's involvement in the Great War did portend an uncertain future for wireless and radio.

4. THE SUCCESS OF LICENSED BROADCASTING IN 1920 WAS GREATLY ENHANCED BY THE RCA AGREEMENTS

Licensed broadcasting started in 1920 with KDKA, but it took several years to get off the ground. In a survey of all issues of the periodical *Pacific Radio News* between 1920 and 1923, I noticed how a gradual transition occurred from an audience of mostly amateurs building sets and listening to radio to a non-technical public being able to buy easy-to-tune receivers. As late as 1923, the radio magazines were still using the term, "radiophone concerts." (107) In those three years, programming was being developed, advertising was not yet legally allowed, and all stations were sharing the same frequency (360 meters), with each on for a hour or so a day. It would take a few more years for both audience and government to take broadcasting seriously enough for regulation. That would finally happen in 1927 and by 1930 the radio industry was fully formed. Advertising was its financial basis, networks were formed, programming was in place, the AM broadcast band had been separated into local, regional and clear channels, the public was hooked.

Why did broadcasting catch on in the 1920s in way that it couldn't and didn't in 1916? One answer was the war. On a social level it could be argued that the public, having been freed from the weight of war, death and sacrifice, was ready for some fun, some good times. It was in this context that a device, the radio, was introduced that could bring music into the home, something you didn't have to learn to play like a piano. As believed in 1920 (an almost exact paraphrase of Bellamy's 1888 book): "By using channels of different frequencies, different classes of aural amusement would be simultaneously transmitted, permitting the subscriber to select at will his own type of amusement merely by pushing the proper button which controls the selective circuit employed . . . The amusement might come from stored sources, as from phonograph devices, or might be given directly by a speaker, or a concert." (108)

The other, more objectively explained outcome of the war was the negotiation of a collection of hard-fought technology agreements that made the radio possible. The Radio Corporation of America began forming in 1919 with two companies, GE and AT&T. General Electric had the patents to the Alexanderson Alternator, and AT&T/Western Electric held the all-important de Forest tube patents. Initially, these were the most important companies to sign on to the RCA agreements. Although author Banning (an employee of AT&T during the RCA negotiations with that company) seemed to have viewed the agreements as a way for the telephone company to retain its position in vacuum tube technology, it was really the specter of British control of the Alexanderson Alternator by the Marconi company that added urgency to the formation of RCA and propelled it toward its conclusion. After the war had ended, many in government and industry had wondered hypothetically what could happen in a future war if the means of international and national communications within our borders were controlled by a hostile power. "Thus in 1919 was created a corporation which, in power, financial and otherwise, was able to cope with any other in existence. General James G. Harbord, a recently returned war hero, representing government influence, was elected president, and a young man of twenty-eight named David Sarnoff, whose first job, nearly fifteen years before, had been that of telegraph messenger boy, was made commercial manager." (109)

Later, Westinghouse, a company that originally believed itself strong enough to go it alone, reluctantly signed with the Radio Corporation. They had obtained the International Radio Telegraph Company and important patents held by Fessenden and Armstrong. So while not a part of the original RCA group, Westinghouse had already owned or quickly obtained enough important exclusives to finally get in. As the final player in the RCA group, Westinghouse signed on June, 30, 1921. The Radio Corporation was now complete. The threat of Navy control, of Government ownership of radio, very real at the conclusion of the Great War, was stopped thanks to the RCA agreements, worked out by a combination of government officials and private companies, but with the control resting with the private companies. RCA was born as a government-sanctioned telecommunications monopoly. It is a truly fascinating and complex story, the most complete and accurate details of which can be found in Hugh Aitken's *The Continuous Wave: Technology and American Radio, 1900-1932*. (110)

RCA was originally formed for commercial communications purposes, not entertainment radio. So how did the RCA agreements affect broadcasting throughout the 1920s? Here is the simple version: Westinghouse and General Electric were allowed to manufacture radio receivers, to be sold to consumers under their name and that of the RCA label. The so-called "telephone companies," Bell, AT&T and Western Electric, were given exclusive rights to manufacture broadcast transmitters. Practically every radio station in the 1920s used a version of the Western Electric transmitter. More important initially, this latter group of companies, because of its ownership of the wired telephone system, were also given the exclusive RCA franchise in two other untried and untested areas: Toll Broadcasting, or the right to charge advertisers money to have their names mentioned on the air as a program sponsor, and Chain Broadcasting, the ability to "network" more than one station to ensure a larger regional or national audience for a single program. And while the AT&T group through station WEAF in New York was the first to try "Toll" and "Chain" broadcasts, they were not really interested in the further exploitation of these RCA granted exclusives. By the mid-1920s networks began to form and advertising became the basis of support for radio broadcasters.

5. ALWAYS QUESTION HOW HISTORY IS MADE AND PERCEIVED

I have also looked seriously at how the history of the radiotelephone and its transition into broadcasting was created. When, why and by whom was the agenda really set for what we now believe as "the history of broadcasting?" Many of the historians of the 1940s and 1950s had based their knowledge on one important source, Gleason Archer's 1938 book, *History of Radio to 1928*. Archer based some of his work on the collected documents of RCA historian George Clark. Beginning in the early 1920s and continuing until his death in the 1940s, Clark argued for his criteria for what was broadcasting and what was not. According to Clark, to qualify as broadcasting the transmission had to be expressly to entertain, it had to be advertised ahead of time, or pre-announced to the public, it had to adhere to a regular schedule, and it had to be heard by a citizen audience, not just a group of "hams" or professional operators. It was this last criteria that left out Herrold and de Forest. Finally, but no less important, from the late 1930s until the early 1950s, there were published a plethora of popularized broadcast history books, mostly anecdotal in nature. And while many of these books were not accurate or thoughtful, and even written by those with an unspecified commercial or political agenda, their influence lasted far too long. The real story is surely more complex and is always being revised. Always seek primary sources, evaluate carefully and ask plenty of questions.

THE FINISH LINE

And who won my race for radiotelephone? Of the five, some won more than they deserved, some have probably already been given an accurate place in history, while others are still being re-evaluated by scholars. If there is a prize for being remembered as a serious inventor and prestigious scientist of the radiotelephone era, then Valdemar Poulsen and Reginald Fessenden share the honors for their thoughtful technical contributions to the very early technology of the radiotelephone transmitter and receiver. Were it not for the early inventions of the arc radiotelephone and the liquid detector, later experimenters would not have considered wireless as a carrier for voice and music as early as they did. So for most of this century Fessenden and Poulsen have enjoyed a solid, secure place in history. Lee de Forest gets the prize for being the first and most tenacious in his pursuit of the radiotelephone as a device for bringing culture into the homes. Ironically, most of de Forest's early and most important work in this area was carried out using his version of Poulsen's arc transmitter. It was only later, in 1916, that de Forest used his own invention of the oscillating vacuum tube to broadcast.

Charles Herrold was included in the race for two reasons. First, there is no question that however accidentally, between 1912 and 1917 he started and maintained a radio station designed to entertain an audience of hobbyists, experimenters and friends. And second, Herrold is symbolic, a good example of one of the dozen "every men" in the pre-WWI race toward broadcasting. He began like dozens of others, using arc technology, and while trying to find a replacement for the wired telephone, he affiliated with a company for the purpose of obtaining capital. When license broadcasting began in the 1920s, Herrold set up a station, and like hundreds of others, lost it. The difference between Herrold and the many other minor players, pre-1920, is that he stayed on the air, was reinforced by an audience and received publicity for what he was doing, and therefore was early in the promotion and experimentation of the non-two-way communication uses of wireless telephone transmitting technology. Because of the war Herrold did not finish the race.

Frank Conrad started the race late but finished. He wins the prize for being in the right place at the right time, and for possessing the good sense not to question the wisdom of his employers at Westinghouse. While his radiotelephone experiments were not significantly different, content wise, from those of Herrold or de Forest a decade earlier, Conrad had the right technology, the right company behind him, and most important, the right audience, an American public freed of the darkness of war and ready to be entertained. Unlike the others, Conrad had arrived at the same time and place as his audience. Five individuals all racing toward an imaginary finish line in the race for radiotelephone.

ACKNOWLEDGMENTS

I wish to thank a large group of individuals and organizations for their cooperation during my five year research effort into the pre-history of broadcasting. Beginning initially as a narrow search into the life and work of Charles Herrold and evolving into a need to put the Herrold story into the larger context of the invention of the radiotelephone, I have traveled and interviewed and photocopied and written and concluded, and at times been both excited and baffled by the early history of the radio. First, and most important to this effort has been friend and fellow San Jose State scholar Gordon Greb, whose early research into Charles Herrold inspired my 1995 PBS video production: *Broadcasting's Forgotten Father: The Charles Herrold Story,* as well as a book, *The Accidental Broadcaster*, we are writing on the subject. And in addition to the help provided by several dozen researchers and biographers of the principles of this article, I have long been helped in my efforts by scholars and broadcast historians Christopher Sterling and John Michael Kittross, whose time and interest on the video and with the book manuscript have been significant. Thanks also to Bruce Kelley who opened the Antique Wireless Association archive and his home to me, to Jim and Felicia Kreuzer who allowed me to search their private library, and Elliot Sivowitch who coordinated my activities at the Smithsonian Institution where along with Gordon Greb I spent a week with the Clark Papers. This *Review* article was reviewed by Gordon Greb, Christopher Sterling of George Washington University, by Barry Mishkind of the valuable Internet broadcast history archive, <www.oldradio.com> and by Donna Halper of Emerson College. And, as always, my sincere thanks to the Perham Foundation for its generous support of my research and publication.

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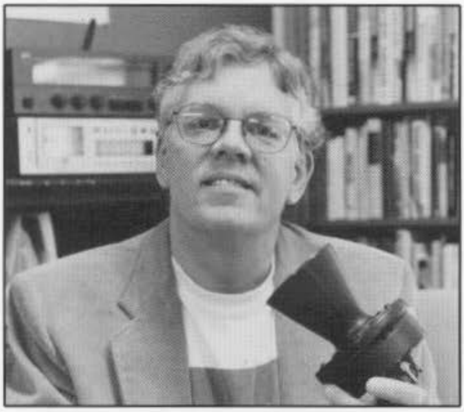
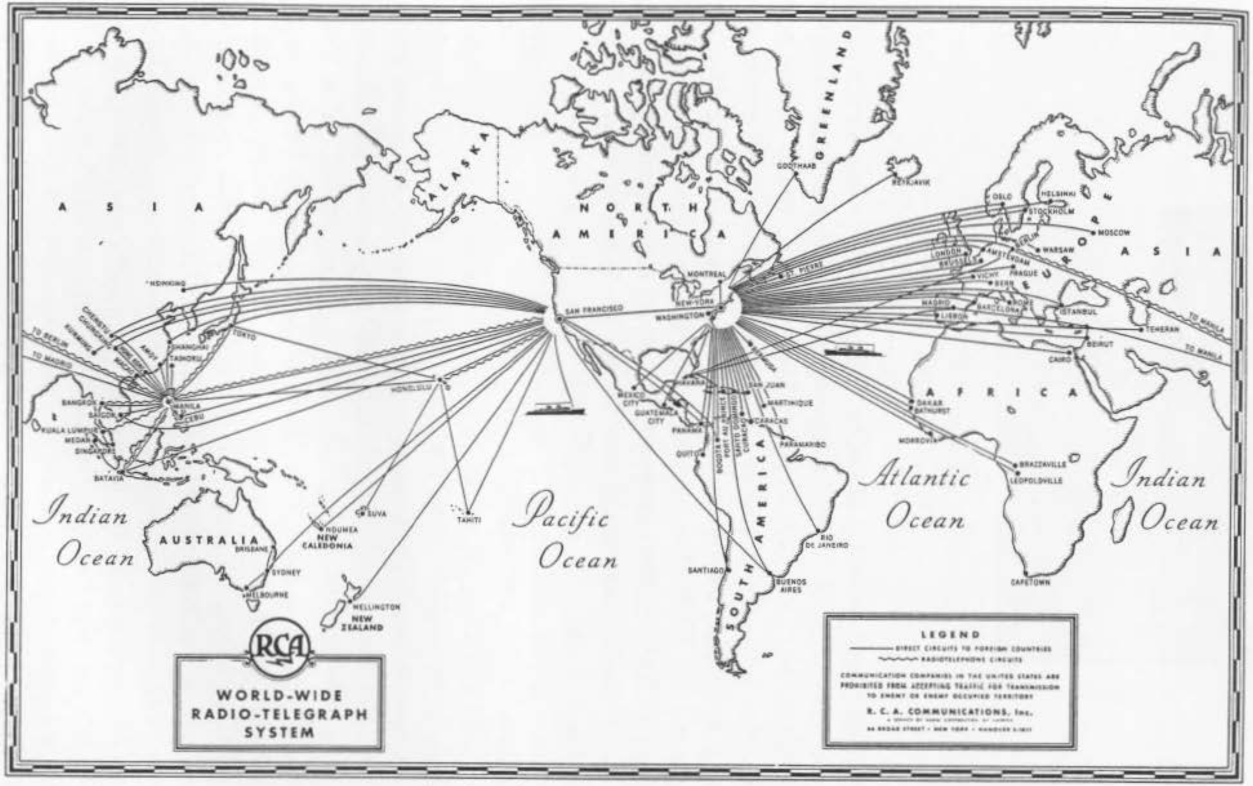


Mike Adams

Mike Adams remembers a defining moment in his childhood when he first discovered radio. As a young listener, Adams began to poke around behind the little box in an effort to discover where "radio" came from. During his high school years he built several pirate transmitters and entertained his neighbors with music and talk. More than anything, he wanted to be on the air. In 1960 Mike went to Ohio University in Athens where he got involved with the college radio station as an announcer and news reporter. For spending too much time at the station and too little at the books, he flunked out. He spent the rest of the 1960s working in radio where he found modest success as a "top-40" disc jockey during the "golden age" of rock and roll AM radio.

Bored with commercial radio he returned to college and completed his graduate work at Ohio State University. He moved to Los Angeles in the 1970s where he made documentary films and taught at several universities. Currently, he is professor of radio and television at San Jose State University where he is also the coordinator of the radio-TV-film degree program. And yes, he is back in college radio, this time as faculty advisor to the student-run FM station, KSJS. He has authored numerous articles for historical radio journals and periodicals, two books on radio and television production, and a video series for PBS called <u>*Radio Collector*</u>*. Adams is a former president of the Southern California Antique Radio Society, SCARS, and is currently on the boards of the California Historical Radio Society, CHRS, and the Perham Foundation Electronics Museum. His latest works are a book and a television documentary on what else radio broadcasting history. Look for* <u>*Broadcasting's Forgotten Father: the Charles Herrold Story*</u> *on PBS. And look for the Herrold book, The Accidental Broadcaster, coming soon. You can learn more about Mike Adams on the World Wide Web. His page is at <http://www.ksjs.org/adams>*



RCA radiotelegraph circuits help to make the United States the communication center of the world.

Map of RCA Communications System ca. 1944.

COMMEMORATING THE 75TH ANNIVERSARY OF RADIO CENTRAL

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SUMMARY

November 5, 1996 marks the 75th anniversary of the inauguration of Radio Central, the hub of a vast worldwide communications network that was owned and operated by the Radio Corporation of America. This hub consisted of the 6,400-acre Radio Central transmitting site on the north shore of Long Island at Rocky Point, and a companion 2,000-acre receiving station at Riverhead, about 16 miles southeast. Aside from the role these stations played in the creation of the global economy and America's rise to leadership of it, the facilities at Riverhead and Rocky Point also included laboratories in which a number of important communications concepts were first developed and put into practice. RCA's buildings and antennas are gone from Rocky Point and Riverhead today, but their technological and historic legacy remains.

INTRODUCTION

Today, there is nothing unusual about somebody in an office in America teleconferencing with others in Europe or the Far East. Fax machines vie with humans for telephone circuits that reach literally anywhere over cellular networks, while computers on the Internet freely pass data to other computers around the world instantly. Along with the data and telephone service, geosynchronous satellites relay thousands of radio and television programs every day. While much of this technology came to fruition in just the last 25 years or so, the present day will seem rather slow-paced as innovations now unfolding further combine computers, video, and telephone systems with satellites and fiber optic cable.

This map (opposite) from a 1944 brochure shows the RCA Communications system as it was at the outbreak of World War II. Note the disclaimer against accepting messages for transmission to enemy territory!

Seventy-five years ago this November, in the village of Rocky Point, Long Island, a huge long wave radio transmission facility known as Radio Central (1), and a companion receiving station at Riverhead, 16 miles southeast, were inaugurated. Fully developed as the hub of a vast worldwide radio network, the services they offered bore a remarkable similarity to many of those we think of as high-tech today. Aside from those services, many concepts that are fundamental to today's communications technology were pioneered there. It is also worth remembering Radio Central on this anniversary because it was built for nationalistic reasons, and was for many years regarded with pride as a prime example of American know-how. Radio Central fully lived up to the hopes and expectations of its builders as it helped usher in the world economy, and America's leadership thereof.

The organization that built and operated Radio Central was the Radio Corporation of America. Not quite two years old in November, 1921, RCA had been brought into existence to provide the United States with a transoceanic wireless system second to none. For the next 66 years, it set the pace for innovation in its field, advanced American business interests worldwide, and served the American government and people in peace and war. While it may be early to tally the most important developments of the 20th century, it is probable that modern international communications, with all their impact on world economics and politics, will be counted among the most significant. In this regard, the accomplishments of Radio Central, and the system it was part of, will undoubtedly be considered among RCA's finest and most lasting.

A QUICK OVERVIEW

In the seven decades RCA was in the communications business, four stages of development are evident. Starting with its origins in the old American Marconi Company, from 1920 until about 1930, it was primarily a wireless telegraph service that offered both international and shipboard communication. Towards the end of the decade it began offering frequency measurement and program relay services to broadcasters which were available to all networks and radio stations, not just NBC and its affiliates. The first radio facsimile service, similar to the "wirephoto" systems that were used by news organizations, was offered to the public in 1924. Regular transatlantic radiotelephone service was inaugurated in 1927 by AT&T using antennas and transmitter space at Radio Central, leased from RCA.

In those early years, communications provided much of the income at RCA, allowing it to develop other businesses such as manufacturing and broadcasting. Unlike Marconi, which kept its shipboard and international operations under the same corporate umbrella, a separate subsidiary, known as the Radiomarine Corporation of America (RMCA), was established in 1927 for RCA's maritime activities. By 1929, RCA had gotten too big for centralized management, so the corporation was reorganized into divisions, and the international wireless network became RCA Communications, Incorporated (RCAC). During the first years of the Great Depression, RCA's entertainment and manufacturing divisions were deep in red ink and the corporation might have joined so many others in bankruptcy court had it not been for the solidly profitable performance of RCAC and RMCA.

The second period, from 1930 until 1953, was one in which the basic concepts on which the business was founded underwent upheaval, despite the Great Depression and World War II. Electromechanical long-wave transmitters gave way to vacuum tubes as operations moved to the short-wave bands. Along with the introduction of time-division multiplexing, leased channel services were made available to corporate and government users who purchased or leased their own terminal equipment. The replacement of Morse code and human operators with Teletype machines, begun in the late 1930s, was greatly accelerated afterwards by expertise gained developing teleprinter networks for the Army during the war.

From 1954, when the long waves were finally abandoned, to the first satellite communications offered to business users in 1964, the third period was one of even faster change. The introduction of undersea telephone cables in 1954 pushed much of RCA's traditional message service aside, but this was more than offset by a greater demand for automated business-oriented services like leased channels, dial-up Telex and computerized data handling. Sophisticated multiplexing and single-sideband modulation techniques were used to greatly increase the capacity of circuits where demand warranted it.

In the last period, 1964-1986, all operations were shifted to satellites and coaxial cable. In keeping with the space-age image the organization wanted to portray, the name was changed to RCA Global Communications, Incorporated, in 1969. It continued to grow and diversify in the telecommunications business to the point where it was reorganized again in 1981. To signify this restructuring, the 1929 name was reinstated. In 1986, RCA was reacquired by General Electric and the end of RCA Communications as an entity came the following year when it was sold to Microwave Communications Incorporated (MCI).

The list of special events RCA Communications was involved with is much too long to fully detail in these pages. Just a few of the highlights include relaying Paul Goddard's reports from England during the ARRL amateur transatlantic short wave tests in 1921; the first American broadcast of the sound of Big Ben in February, 1924 (the transmission originated from

London on long wave, was received at Belfast, Maine and relayed to Riverhead by short wave, and finally broadcast in New York by WJZ); receiving Admiral Richard Byrd's radio transmissions from the South Pole at Riverhead and relaying them to the American public via NBC in 1929; and receiving the first, and perhaps only transatlantic short-wave television signals from Alexandra Palace, England, in 1938, also at Riverhead. Limited operations continued during World War II, but messages intended for enemy or enemy-held destinations were banned, and all international traffic was subject to U.S. censorship regulations. The restrictions on normal operations did not slow things down, however, because RCAC was "drafted" into the Armed Forces. Military and government messages were given full right-of-way over the network, and RCAC engineers lent their expertise to innumerable projects. These included special long-wave facilities for the navy, entire stations built and operated in war zones for the army, and managing D-Day communications for SHAEF. The original "hot line" between Washington and Moscow, installed at the height of the Cold War to prevent an accidental nuclear war, was not the red telephone everybody imagined, but a dedicated RCAC teleprinter circuit. During NASA's early days, certain of its critical tracking stations were linked to Mission Control through the system. The organization even provided equipment and technical assistance to Hollywood for the 1971 sci-fi movie "The Andromeda Strain." The film could not have been a source of satisfaction to RCA's advertising department, however. In it, one of RCA's teleprinters prevents a terrible mistake that would have killed nearly everybody on earth, but only because it malfunctioned!

Over the decades, RCA and RCAC functioned as goodwill ambassadors around the world. Social barriers were broken down as circuits were extended to nations of differing ideology, language, and custom. In some countries, foreigners were not allowed to own radio stations. To get those countries into the network, RCA built the stations, sold them to the appropriate government authorities, then leased the facilities back. RCA also had to deal with numerous government-controlled telegraph and telephone systems, many of which had their own ideas of what could be sent and who was going to do the operating. So RCA Communications helped pave the way for today's modern multinational corporations, and greater cooperation between nations on the problems of standardization and information exchange.

TECHNOLOGICAL LEGACY OF RADIO CENTRAL

From the outset, Radio Central, Riverhead, and the Central Office, which was located in New York City, supported research that resulted in major contributions to radio technology. Starting in a tent in the winter of 1919-1920, a laboratory for receivers and receiving antennas was opened in Riverhead; labs for transmitters and associated equipment, and for terminal equipment (telegraph, telephone, teleprinter, and facsimile) were established in Rocky Point and New York, respectively, when those facilities were built in 1921. The communications labs functioned alongside the regular operations and were independent of the rest of the company until RCA Laboratories, Incorporated, was formally organized in 1942.

Just a few of the many important concepts developed in these facilities during the 1920s were the Wave Antenna (also known as the Beverage Wire), frequency-shift keying, diversity reception, precision radio-frequency measurement techniques, and radiophoto (facsimile). RCA's first radiophoto was a picture of Charles Evans Hughes, transmitted to London on July 6, 1924, where the signal was relayed back to New York and recorded. Single-sideband radio got its first airing in an experimental one-way conversation from Radio Central to England in 1923. This was done by AT&T using antennas and space leased from RCA, with the RCA engineers looking over the shoulders of their Western Electric colleagues.

In the 1930s extensive propagation studies were conducted, not just for the short-wave bands, but also for higher frequencies. These studies led directly to practical applications such as VHF and UHF relay links, and also served as the starting point for other things such as television broadcasting. Teletype equipment was introduced, along with time-division multiplexers that allowed up to four different messages to be carried on a single channel. With multiplexing, leased channel services became cost-effective for many users for the first time. This became a significant factor in RCAC's growth in later years.

Before all activities were dedicated to the war effort, the 1940s saw one of the first automatic message error detecting systems put into operation. At Riverhead FM was given perhaps its first real trial outside of Edwin Howard Armstrong's labs. It received highly favorable reports.

In the early 1950s, it was realized that techniques which had been developed for encoding and decoding multiplexed teleprinter signals were the key to an all-electronic color television system that would be compatible with existing black-and-white TV receivers. Two engineers from Radio Central who developed teleprinter encoding systems, and two from Riverhead who worked on the matching decoders were sent to RCA Laboratories in Princeton, New Jersey, where they developed the basic color encoding and decoding schemes of the NTSC and PAL television systems used in most of the color TVs operating in the world today. Other technical highlights of the decade include an early application of phase-locked loop oscillators for receivers, the first radio-Telex service, and fully automatic message error correction.

RCAC offered satellite communications to business users for the first time in the 1960s, and computers were applied to message handling. With the gradual shifting of operations away from short-wave radio that occurred at the close of the decade, the bulk of the research work moved elsewhere, but until the end, experiments were still being done at Radio Central and Riverhead, and new things were being learned.

EVENTS LEADING TO THE START OF RCA

In the first years of the 20th century, wireless was a new frontier for inventors, experimenters, and investors. Promoters in England, France, Germany, and the United States envisioned vast globe-spanning systems. But at the low frequencies then in vogue, costly high power transmitters and huge antennas were required to send messages any distance. To paraphrase comedian W.C. Fields, with the long wire antennas at a typical station of the day, it was hard to see why anybody called it "wireless." But it was indeed free of the wires and undersea cables of conventional telegraphy, and that was significant. During the previous century, England had arranged matters so that most undersea cables passed through, or terminated on Empire territory, an obvious advantage for dominating the field. Yet, perhaps due to their familiarity with wire-based telegraphy, the only way investors could initially be attracted to wireless was to operate it on the same basis as the wire telegraph services, carrying messages for hire from one party to another. Guglielmo Marconi was the leading proponent of this form of radio, and as we shall see shortly, he can be considered at least indirectly responsible for the creation of RCA and RCA Communications.

In order to determine whether or not radio waves had characteristics similar to light, Henrich Hertz had deliberately chosen very short wavelengths for his experiments. Others, including Sir Oliver Lodge, duplicated Hertz' work without questioning the choice of wavelength. Given the nature of signals we would call VHF today and the equipment available a century ago, it is no surprise that the consensus was that wireless would never be anything but a laboratory curiosity. Marconi was among the first to notice something quite unexpected at the time: as the wavelength was increased, the distance the waves traveled appeared to increase as well. Although it was later realized that the relationship is by no means so simple, Marconi reasoned that if he lowered his wavelengths enough, radio communications should be possible over hundreds or thousands of miles, thereby turning the laboratory toy into something of great utility. He then carried on innumerable experiments to find the most sensitive detectors and the most suitable antennas for putting his plans into effect.

By 1895, his experiments had grown beyond his finances to continue. The Italian government did not see any future in wireless and declined to assist him. But perhaps with the idea that it might make an excellent adjunct to cable telegraphy, Britain offered Marconi the backing to continue. Continue he did, until he successfully transmitted the single letter "s" across the Atlantic Ocean on December 12, 1901. This was the only letter that was sent; to obtain maximum power and ensure the best chances of hearing the signal, the transmitter in his station at Poldhu, Cornwall, England was restricted to sending only dots! But within a few months, whole wireless messages were sent and received across the Atlantic on a test basis.

It is not completely accurate to say that Marconi invented wireless; James Clerk Maxwell had shown, mathematically, the existence of electromagnetic waves in 1873, and Hertz demonstrated their physical existence 15 years later. Nikola Tesla used them to convey a form of intelligence in 1892. Tesla saw and wrote of the potential the waves had not only for messages and broadcasting, but also for remote control of machinery and carrying power. Early in 1900 he began construction of a huge worldwide transmitter on Long Island at Shoreham, then called Wardenclyffe. The name was for James Warden, a local real estate developer who gave Tesla several acres of land in the hopes of selling homes to the station's employees when it became operational.

Sadly, that never happened because Tesla alienated his backers. Had he been able to complete the station, a lot of 20th century history might have turned out very differently. Things were going well until Tesla revealed that Wardenclyffe was going to communicate with the world by using the ionosphere high above the earth, and the earth itself as a planetary resonant circuit (2). It could just as easily transmit power as messages, Tesla said, and he was planning a second, larger station at Niagara Falls specifically for the transmission of power generated by the falls. While the communications part of the plan had been appealing to Tesla's financiers, the power aspect was not. If it worked, anybody could erect an antenna and a tuning circuit and have free power. There would no longer be any way to cut off people who didn't pay, so the existing power industry would be decimated. J. Pierpont Morgan, who had a large part of his fortune invested in electric utilities, and who had supported Wardenclyffe initially, came to believe that if he was to save his financial empire, Tesla's project had to be terminated before even the communications station proved workable, and Tesla had to be personally discredited.

This proved easy to do. Very conveniently for Morgan, Marconi had just spanned the Atlantic with equipment that cost a fraction of what had been spent on Wardenclyffe, which had yet to span a mile! Doubts were raised about Tesla's sanity. Wardenclyffe looked like a white elephant. The House of Morgan called in its loans to Tesla, who couldn't pay, and other investors sensed that something was up and refused to give Tesla any more funds. Its equipment repossessed, the station building was abandoned in 1905, and the massive wooden antenna tower was dynamited in 1917. Legend has it that the American government destroyed the tower because World War I German spies were climbing it for an excellent view of the munitions ships on Long Island Sound. Actually, one of Tesla's creditors, the Waldorf Astoria Hotel, had the antenna brought down in the hopes of recovering what it could from the scrap. Three years after Tesla's tower sagged to the ground, twelve new antenna towers were under construction in Rocky Point, just a few miles away.

Marconi succeeded where Tesla did not because he performed working demonstrations that convinced investors of the worth of his visions. Although his system might have been seen as competition by the established telegraph interests, it could also be turned to their side. He did not threaten the rich and powerful the way Tesla had. Development of Marconi's Wireless Telegraph and Signal Company came rapidly. Communications with America were established in 1902; the station was a small shed near the beach in Babylon, Long Island (3). By 1904 Marconi could boast of stations on both sides of the English Channel, across the Atlantic, and in South America. The Pacific was opened to radio communication in 1908.

But not everybody was ready to concede that Marconi was the last word in radio. In particular, Canadian wireless pioneer Reginald Fessenden criticized the spark transmitters used by Marconi and everybody else at the time as crude and wasteful, compared to possibilities offered by continuous waves. But at the time Fessenden made his complaint, there was no such thing as a continuous-wave transmitter, nor even the means of receiving signals from one! His development of the barretter detector and heterodyne reception in 1900 took care of the second problem; he then turned his attention to the only means available at the time that seemed likely to solve the first.

Tesla had built high-frequency alternators as early as 1890 for use in some of his experiments; Fessenden believed it should possible to continue along those lines and develop large scale alternators for generating continuous radio waves. In 1900, he wrote letters to Westinghouse and General Electric asking if they were interested. A Westinghouse official replied that the company was too busy with other work, though just two years later, George Westinghouse personally requested one of his leading engineers, Benjamin Lamme, to build a 10-kHz alternator for research purposes. GE's answer came directly from Charles Steinmetz, who thought the idea had merit, but wondered why Fessenden did not use simpler methods such as induction coils. Fessenden replied that, in his experience, the associated interrupters could never be made reliable enough for commercial duty. GE's engineers had come to roughly the same conclusion, so Steinmetz ordered an experimental 10 kHz, 2-kW alternator built. It worked, but Fessenden wanted frequencies of 100 kHz or more, and much more than the 1.2 kilowatts the test unit produced. It is not known for certain how Ernst F.W. Alexanderson, hired as a draftsman by GE in 1901, got involved with the project, but he had the rare ability to combine two distinct disciplines of engineering such as radio and rotating machines, so it was perhaps inevitable that the problem would find its way to him.

For several years, Fessenden and Alexanderson went back and forth trying different designs and materials for numerous alternators and their components. After designing a double rotor machine in 1907 that functioned up to about 50 kHz—still a far cry from the 150 kHz Fessenden was by then asking for—Alexanderson lost interest because Fessenden's experimental approach to matters conflicted with his analytical nature. That might have ended the story but for a new request for high-frequency alternators, this time from AT&T, which wanted to try them in voice repeater service for wire telephony. For this application, Alexanderson conceived the single-rotor machine he would eventually become famous for. AT&T abruptly dropped the project, but by that time, Fessenden concluded, as had Marconi previously, that long wavelengths were best for long distance communication. This changed the direction of things from trying to increase the frequency of the alternators to using frequencies well within their range and increasing power levels instead. Alexanderson convinced Fessenden that his new single-rotor design had the best chances of reaching the new goal.

A developmental 35-kW single rotor machine emerged, was tested, and revised. Alexanderson opted to use a high speed for the size of the rotors (4), but by following the best steam turbine practice of the day, the design was safe and reliable. Some of the earlier prototypes suggested by Fessenden operated at speeds of 50,000 rpm or more, and had been mechanical nightmares. Sadly, Fessenden's National Electric Signaling Company (NESCO), which had spurred and paid for the original alternator development work, went into receivership in 1910 due to infighting among the owners. GE did not want to be in the communications business itself, but it became convinced that it had a valuable property on its hands when numerous promoters, including Marconi and Telefunken, expressed an interest in doing just that with the machines. GE decided to press on with the development of radio frequency alternators on its own, so Alexanderson completed a 50-kW demonstration machine and then went to work on the auxiliaries needed to make it into a practical radio system. These included the first precision electronic speed control to keep the machine on its assigned frequency, a magnetic modulator so it could be keyed (he later connected this to a bank of vacuum tubes, enabling the machine to transmit his voice), and the multiple-tuned antenna, which got the output of the alternator into the air with an unusually high degree of efficiency. To complete the system, Alexanderson developed a receiver circuit that most antique radio collectors today would recognize as a close cousin of the TRF.

Of all the parties interested in the system, Guglielmo Marconi personally brought the biggest order to fill, so GE signed an exclusive contract that replaced NESCO with Marconi. Fessenden, who had provided so much of the early impetus, money, and practical test results, was out of the loop. The first installation under the new agreement was the 50-kW demonstration unit at the American Marconi station in New Brunswick, New Jersey, in 1915. It proved so superior to the spark stations then operating that GE put Alexanderson to work on a 200-kW version of the machine.

With the U.S. entry into World War I in 1917, the government seized and shut down all radio stations on American soil. Many were stripped of equipment that could be used by the armed forces, except for a few high power stations that were assigned to the navy. Since American Marconi no longer had control of its facilities, it told General Electric to mothball an almost-complete 200-kW Alexanderson alternator that had been ordered for New Brunswick. The navy felt the machine could be of great value in service and asked GE to finish it instead. American Marconi balked at paying for something it was not allowed to use, so as a patriotic gesture, GE installed the alternator at its own expense and rebuilt other parts of the station to handle its full capacity. Starting in June, 1918 it was America's most reliable means of transatlantic communications, and it carried President Wilson's terms for armistice to the German people.

Following the war, the government was required to return all radio stations that belonged to Americans or friendly foreign nationals, or pay for them. But even before the hostilities ended, some factions tried to make the government monopoly on all aspects of radio permanent. Secretary of the Navy Josephus Daniels appeared before Congress in support of a bill that would have given the navy complete control of radio in the United States. David Sarnoff, then a manager at American Marconi, and others presented the argument to anyone who would listen that private enterprise—not the navy—had made all the important discoveries in radio, and navy control would end any further development of the science in America. This was more emotion than fact, but it was poignant because the deadliest and most destructive war up to that time had just been concluded, and there was a general revulsion towards anything military. The bill was killed in committee, and the New Brunswick station was returned to private hands in March, 1920. But the importance of radio during the war, and the potential danger of having such facilities under foreign control, was not forgotten.

Although England was our ally, the navy feared that if Marconi acquired full control of Alexanderson's inventions, they might not be available to America in the event of another military emergency. There were also some doubts about the wisdom of allowing England to gain a stranglehold on wireless as strong as the one she held on the undersea telegraph cable system. Edgar Rice, General Electric's president, was very patriotic, and after some discussion with navy representatives, backed out of the deal that had been made with Marconi before the war. Barred from controlling radio itself, the navy wanted to ensure that the Alexanderson alternator stayed in American hands. To do this, a way had to found to make Americans use it themselves.

RCA IS FORMED

Rear Admiral William Bullard developed a plan calling for American investors to purchase American Marconi, which would be reestablished as an American corporation. British Marconi could then buy the Alexanderson alternators it previously wanted, but it had to share its exclusivity with the U.S. government and the new corporation that would be established. He urged General Electric to organize the new corporation, which it did after three months of strenuous negotiations with Marconi's home office. It was named the Radio Corporation of America, and with David Sarnoff as general manager, it opened for business on December 1, 1919. General Electric was the majority shareholder. A cross-licensing agreement for its radio-related patents was made with RCA (which acquired the patents held by American Marconi), but GE reserved for itself the right to do all manufacturing of apparatus sold by RCA. RCA was to be a sales organization, and to operate the communications services of the former American Marconi Company. In June, 1920 a cross-licensing agreement was reached with AT&T, which gave RCA and GE access to the telephone company's all-important vacuum tube patents. Westinghouse joined the group in 1921 by trading its radio-related patents, which included Edwin Howard Armstrong's regenerative circuit, for a large block of RCA stock and 40% of the tube and equipment manufacturing business.

RCA's first priority was the development of its own international wireless business. It installed 200-kW Alexanderson alternators at Marion, Massachusetts, and Bolinas, California, to supplement stations acquired from American Marconi. The former Telefunken station at Tuckerton, New Jersey, acquired from the navy after the war, received new Alexandersons as well when its Goldschmidt alternator proved to be too temperamental to put up with. Transoceanic radio telegraph service was inaugurated between New York and Great Britain, San Francisco and Hawaii, San Francisco and Japan, and Hawaii and Japan on March 1, 1920. In the spring and summer of 1920, service was extended between New York and Norway, and New York and Germany. A link between New York and France was opened in December, 1920. RCA was by this time handling more than a million words a month at 18 cents a word.

The words carried by RCA could only increase in number because the war had left Europe in shambles and the United States relatively unscathed. Afterwards, America emerged with the strongest economy in the world. New York City was the business capital of America, and the greatest demand for communications services was there. On the east coast RCA had inherited an odd collection of stations and equipment from Marconi and some of its competitors, making operations inefficient and difficult to manage. Some smaller stations were closed, and the rest were reorganized. British Marconi used England's many colonies for relay stations, as did the French and German wireless networks in their respective colonial territories. But with no American colonial possessions to use, and its ties to Marconi severed, RCA's designers initially planned for a future with a minimum of relay stations. To handle large volumes of traffic economically, multiple channels that could operate simultaneously were essential. Many powerful transmitters and large antennas had to be installed. For various reasons, none of the existing sites around New York City were considered suitable for the amount of expansion necessary, so RCA went looking for new ones.

Long-wave radio was the only means considered practical for long-range work in 1920. Long waves are most effective over bodies of water, so coastal sites were essential. To minimize the effects of man-made interference, the antennas had to be located away from urban areas. The sites had to be properly oriented for the circuits they were to handle, have suitable soil characteristics, and be reasonably accessible. Power, telephone, and telegraph connections had to be economical. Throughout the world, RCA did extensive tests to find suitable locations for transmitting and receiving stations, and then built or leased telegraph and telephone lines to connect the stations to offices in cities where it was convenient to handle the messages and collect the tolls.

Figure 1. *The main transmitter building at Radio Central as it appeared in 1925.*

RADIO CENTRAL

For New York City, the eastern end of Long Island proved to be a superb choice for a long wave receiving site. The sandy soil was more resistive than desirable for transmitting, but it was felt that other considerations made the installation of an extensive ground system worthwhile. Its roads, ferries, and the Long Island Rail Road (5) offered ready transport, and its proximity to Manhattan made land-line connections to the city a simple matter. In 1920, 6,400 acres of farmland (6) was purchased at Rocky Point, about 65 miles from Manhattan on Long Island's North Shore, and the construction of Radio Central was begun.

The original designs called for ten 200-kW Alexanderson alternators feeding twelve antennas arranged like the face of a clock, with 12 due north. Arrangements were contemplated that would have made it possible to parallel as many as all ten of the alternators together for a total output of two megawatts. Had these plans been realized, Radio Central would have been the world's leading superpower station for many years. By the autumn of 1921, the first part of the transmitter building was completed. Two alternators (7) and two 6,250-foot antennas suspended from 150-foot cross arms on towers 410 feet high had been installed. Some 170,000 feet of copper wire was buried beneath the antennas by specially constructed plows hauled by steam tractors. Radio Central became a sensation in the radio fraternity. The technical feats it represented and the scale of the

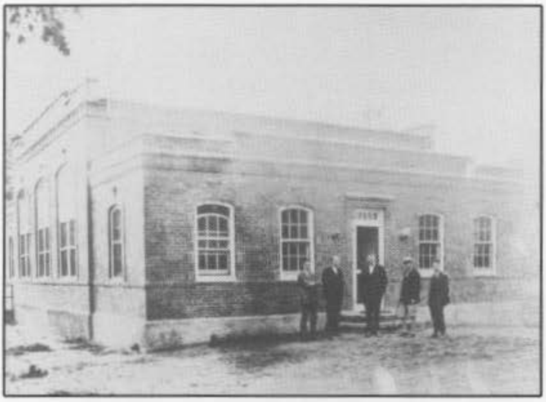


Figure 2. *Building #2 at Riverhead, constructed in 1923 for long-wave receivers. Harold H. Beverage, center.*

project were just as impressive, in their day, as those of the space program have been to later generations. Virtually every magazine and book on radio published in the early 1920s mentioned Radio Central, and a few textbooks, such as *Radio Theory And Operating* by Mary Texanna Loomis, hoped to avoid early obsolescence by describing the station as it appeared in slick artwork from RCA's publicity department, with all ten alternators and twelve antennas almost ready for action!

The station ultimately became a small town in its own right, including transmitter and administrative buildings, a separate building for the Program Department (which handled facsimiles and program relays), laboratory buildings, maintenance shops, and a diesel power plant for use during outages. Cottages were built for the temporary housing of married engineers and their families, along with a stately community house that provided sleeping, eating, and recreation facilities for single engineers and guests. In front of the transmitter building was an in-ground oval pool with fountains. Not only did the fountains add a decorative touch, they were also the radiator for the station's water-cooled transmitters!

Receiving was not planned for Radio Central because the large transmitters operating continuously would make interference very hard to control. Instead, a 2,000-acre parcel of land at Riverhead, New York, some 16 miles southeast of Rocky Point, became the "Ears of the East" following successful experiments by Harold H. Beverage to determine the suitability of the site. The Riverhead Receiving Station, as it was officially known, also became quite extensive. At the peak of activity, it included a virtual forest of antennas, buildings for both long-wave and short-wave receivers, laboratories, workshops, and a barn. For many years no gasoline-powered vehicles or machines were permitted within a mile of the antennas due to interference considerations, so the antenna riggers and maintenance staff went about their duties on horseback.

Beverage had worked for Alexanderson at GE on receiving equipment, including Alexanderson's famous barrage receiver, which had allowed the

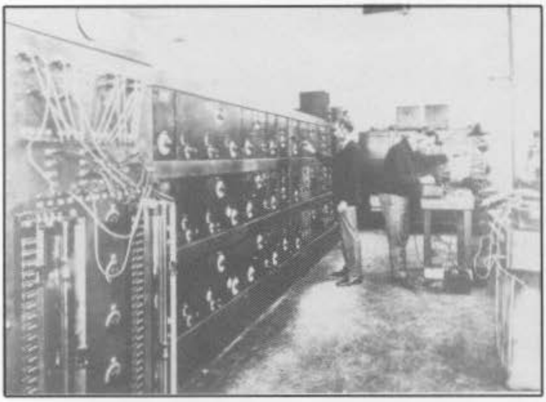


Figure 3. *Inside Building #2. Each of the three horizontal rows in the picture is one complete long-wave receiver. The apparatus with the sliding adjustments at left was used to minimize static on the balanced antennas.*

Allies to maintain communications during the war in spite of German jamming. When RCA was organized, Alexanderson was made chief engineer. One of his first actions was to have Beverage transferred to RCA to take charge of receiving systems, and in the winter of 1919-1920 Beverage found himself in a tent near Wildwood Lake, Riverhead testing antennas. During those early experiments, he perfected an antenna he had been developing for some time previously. It was known that vertical polarization gives the best results for long-wave radio communication over great distances. However, vertical receiving antennas are not desirable for fixed-station reception because they tend to pick up signals from all directions, making it difficult to separate desired signal from everything else. Beverage realized that when vertically polarized long waves encounter the sandy, loose soil of a coast, the higher ground resistance causes them to tilt and become more horizontal. Earlier experiments he had performed at Otter Cliffs, Maine proved that long horizontal wire antennas could be used for long-wave reception. While they were more directional than vertical antennas, they were less than ideal because signals coming either way along the length of the wire would be picked up.

Using a theoretical analysis by General Electric researchers Chester Rice and Edward Kellogg, Beverage and Rice discovered that when the far end of a long-wire antenna is terminated in its surge impedance, a great improvement in directivity is obtained. Signals from the opposite direction are largely absorbed by the terminating resistance and do not cause so much trouble at the receiver. The Wave Antenna, or Beverage Wire, as it later became known, gave far better results than any other type of long-wave receiving antenna available in 1920, and was RCA's first technological breakthrough in communications.

A headquarters for the entire system was built at 66 Broad Street in New York, near the Financial District in lower Manhattan. Telephone lines tied the operations center, which was known as the Central Radio Office, or CRO, to Rocky Point and Riverhead, and also to stations at

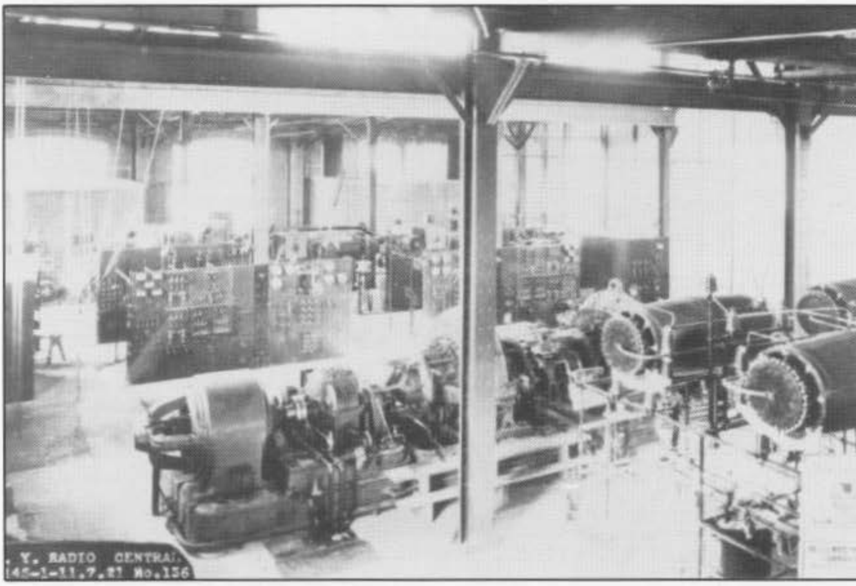


Figure 4. *The two Alexanderson alternators in the transmitter building were installed end-to-end to conserve space. The glass wall at right was removed when left and right wings were added to the building in 1925. Note the heavy rails for a gantry crane. The crane was needed to disassemble the alternators for repairs and maintenance. This picture was taken on November 7, 1921, just two days after the station opened.*

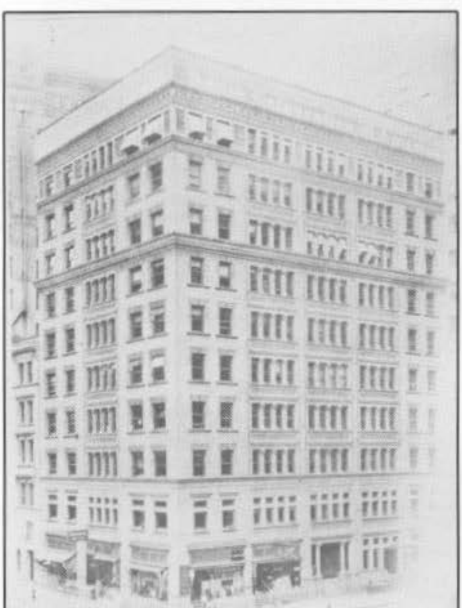


Figure 5. *66 Broad Street, New York City, in 1929. This building housed the Central Radio Office, a laboratory, and the general offices of RCA Communications for many years.*

Figure 6. *The Community House at Radio Central, which provided eating and sleeping accommodations for single engineers and company guests.*

Marion, Massachusetts, and Tuckerton and New Brunswick, New Jersey. Aside from operations, other floors of the building were used for the general offices of the system and for RMCA. Rocky Point and Riverhead handled the bulk of the communications with Europe, South America, and later with San Francisco. Marion, New Brunswick, and Tuckerton were used for east coast maritime communications, for alternate service paths that were used when magnetic storms disrupted signals to and from the other stations, and for the overflow when all circuits on Long Island were busy. During the 1920s, an additional long-wave receiving station was operated at Belfast, Maine, primarily for service when summer thunderstorms made receiving at Riverhead impossible.

Initially, all of the circuits carried Morse code. Manual keys and headphones quickly gave way to machines that punched the code onto paper tapes which were then fed through high-speed (100 word-per-minute) readers. These readers keyed mechanical tone-wheel oscillators for the land line hop to the transmitting stations. The frequencies of the tone wheels were carefully selected so that ten different messages could be placed on an ordinary telephone line without interference. At the receiving stations, the reverse procedure was used; the receivers keyed tone-wheel oscillators for land line feeds back to the city offices. There, ink recorders copied the high speed Morse code. Operators translated these tapes back onto message blanks. The city offices had uniformed foot and bicycle messengers who made the final deliveries; if a message had go farther than the messengers could carry it, it was sent on a local telegraph circuit to the nearest RCA branch office.

To expand the branch office concept to a national scale, domestic radio circuits were established to New York, Boston, Baltimore, Camden, Chicago, Detroit, Los Angeles, New Orleans, Philadelphia, San Francisco, Seattle, and Washington, DC. These circuits carried traffic between the cities and the international stations, and also handled telegrams in competition with the wire-based services. They were ordered off the air by the Board of War Communications in June, 1942, and except for the one between New York and San Francisco, they never reopened. Although it was an emotional loss for those who heard familiar circuits go dead and saw fellow employees drafted into the armed services or put out of work, the effect on operations was nullified by the merger of the Postal Telegraph Company, which had handled much of RCAC's land line traffic, with Western Union. This effectively made every telegraph office in the country a RCAC "branch office." Similar arrangements were made with the telegraph systems of most countries in the world.

TECHNOLOGICAL DEVELOPMENTS OF THE 1920S

Within two years of its opening, the alternator network had already started becoming obsolete. The first experimental high-power vacuum tube transmitters from General Electric arrived at Radio Central in 1923. One of the Alexanderson alternators was used at low power as an exciter for the tests; vacuum-tube exciters did not exist yet. The tubes were so successful that RCA decided on the spot that it would not be needing any more alternators! Also in 1923, frequency-shift-keying (FSK) was attempted for the first time on radio. One alternator at Radio Central was used to send the "mark" signals, while another alternator at Tuckerton, New Jersey was used to send the "spaces." This experiment was too unwieldy for regular operation, but it proved the merits of FSK, which became important some years later.

In December, 1921 a revolution in radio communication began. Amateur radio operators discovered that night transatlantic radio communications were possible on what had been considered the "commercially useless" wavelength of 230 meters (1.3 MHz). By 1923, General Electric and Westinghouse had built experimental short-wave transmitters, which were tested in service on some RCA circuits. As so often happens in a technical business, the "tests" never really ended; the traffic department simply kept using the equipment after the engineers stopped taking measurements. RCA officially inaugurated its short-wave service in 1924. It was noted that magnetic storms over the North Pole frequently disrupted east-west short wave communications, particularly with stations in the higher latitudes, but the storms did not have as much effect on north-south communications, so in 1925-26, additional short wave equipment was installed, mainly for South American circuits.

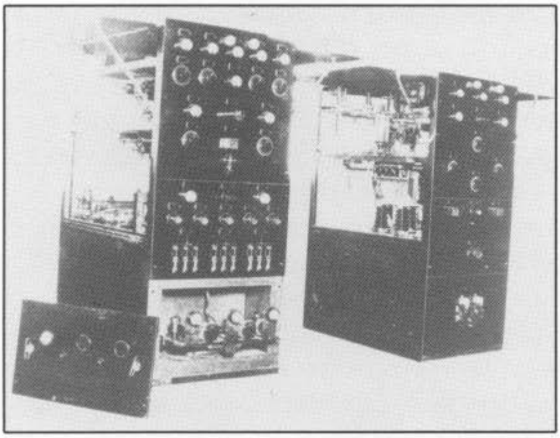
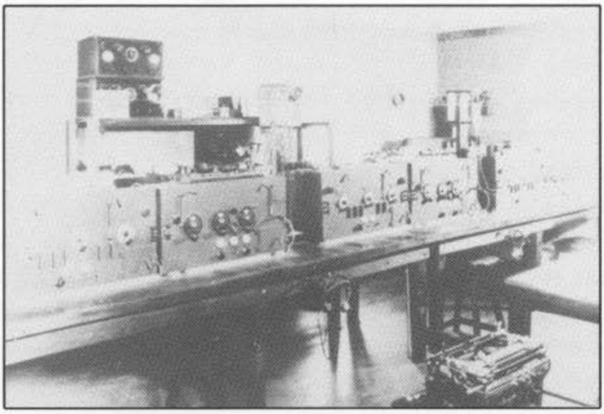


Figure 7. *Two early short-wave transmitters installed at Radio Central, ca. 1925. They operated on a wavelength of 16.5 meters.*

Figure 8. *Prototype diversity short-wave receiver on laboratory workbenches at Riverhead. Most of the equipment in the picture was built in the Riverhead shops.*



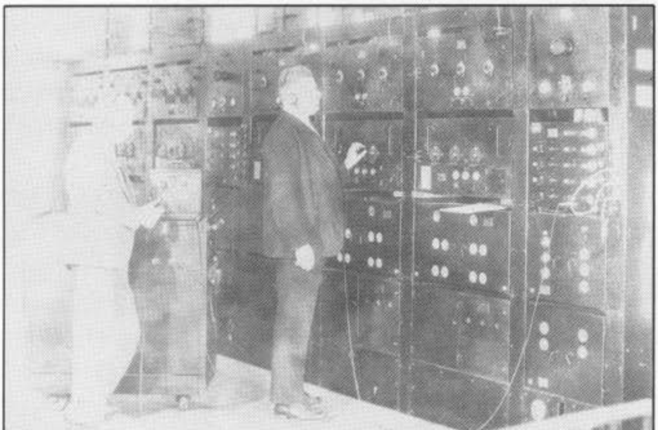


Figure 9. *Production-model diversity receivers were manufactured by RCA from the laboratory prototypes. Harold Beverage (center), and Harold Peterson (left) are testing a group of new diversity receivers in Building #10, which was built for short-wave service at Riverhead in 1928.*

Not long afterwards, Marconi announced the discovery of long-range communications day and night on 30 meters (10 mHz). Now everybody was interested in the possibilities of short-wave radio: freedom from crowding, less man-made and natural interference, and far more capacity with less costly equipment. But there was a problem with it that did not exist on the longer wavelengths, and many experts thought that while the short waves might be acceptable for amateurs and for some commercial circuits where only moderate traffic had to be handled, they would never replace long-wave radio for high volume circuits such as the ones to Europe.

Unlike long waves, which propagate between the earth's surface and the lower levels of the ionosphere, short waves travel up at an angle to the higher layers of the ionosphere where they are reflected back to earth hundreds or thousands of miles away. The problem is, they often take more than one path from transmitter to receiver, and these paths constantly change as the reflecting layers move. Signals from different paths can arrive at an antenna out of phase, in which case cancellation occurs. The degree of this cancellation depends upon the relative strengths of the signals and the extent to which they are out of phase, and it ranges from almost unnoticeable to a total loss of reception. This effect, known as short-term fading, is usually not objectionable with manual Morse code because the human ear can recognize the "dits" and "dahs" through the cancellations. But it renders level-sensitive electromechanical or electronic systems, such as automatic Morse, teleprinter, or facsimile unreliable. Marconi developed a system to get around the problem using powerful transmitters and beam antennas on one end, and very high gain receivers with sufficient AGC to hold the output level constant at the other. The receiving end of one of these systems was installed at Riverhead in 1927 (a Marconi short-wave beam transmitting antenna was also installed at Radio Central at the same time) but it was not a success because a complete cancellation of the waves still resulted in a loss of output.

While Marconi struggled with higher power levels and phased-antenna arrays in an attempt to overcome short-term fading by brute force, professional curiosity brought the answer to RCA's doorstep. Harold Beverage and his associate Harold O. Peterson decided to try an experiment, using short-wave receivers in their homes, to see if short-term fading was localized, or if it was the same over a wide area. By tuning the same station in simultaneously and comparing the reception by telephone, they promptly discovered that there was very little correlation in the fading between the two locations. With this insight, Beverage and Peterson began experimenting with multiple antennas and receivers at Riverhead. They found that two antennas, separated by a few wavelengths, and two receivers would out-perform any single antenna and receiver. Three antennas, arranged roughly in a triangular pattern, and three receivers allowed them to vanquish fading.

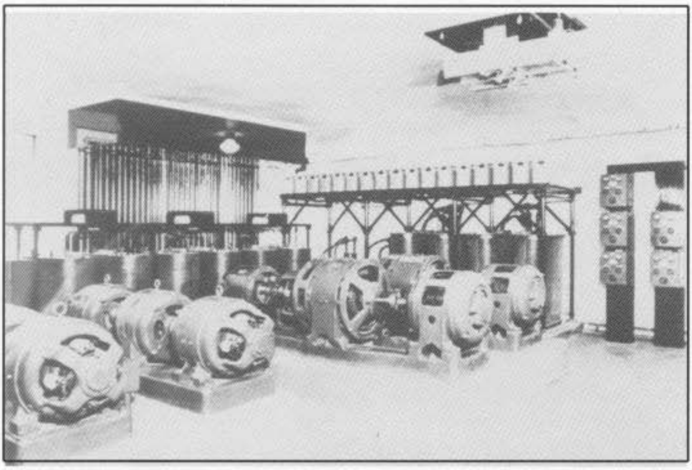


Figure 10. *Everything in Building #10 ran on battery power to minimize power line interference and to avoid service interruptions due to power outages. The motor-generator sets kept the batteries charged. This system was used until the Riverhead facility closed in 1975.*

The beauty of the diversity system, as Beverage put it, was that it was simple, it worked, and it was a lot cheaper than anything else!

The company's directors then had to take a big gamble. Rebuilding the network with short-wave equipment would be expensive—not only were new transmitters, receivers, and antennas needed for each station, but millions of dollars' worth of almost-new long-wave equipment would become redundant. If short-wave radio did not work as planned, a great deal of money would be wasted and RCA would be the laughingstock of the industry. On the other hand, if somebody else got there first, it could imperil RCA's future because the far greater efficiencies possible with short-wave radio could be used to beat RCA at its own game, and the corporation would not be able to argue for its own short-wave frequency allocations from the high ground of prior use. Largely on the basis of work done by Beverage and his colleagues, the decision was made to go short wave, and by 1930, most of the network was converted. After a few years, it became apparent that the gamble had paid off, and at a few stations dismantling of some long-wave antennas began. The company heartily congratulated itself for not buying the additional eight alternators and ten long-wave antennas that had been planned for Radio Central, as the loss on the investment would have been disastrous. But most of the existing long-wave equipment was retained. It was used on occasions when the short-wave circuits became temporarily unworkable due to magnetic storms, and also when the short-wave circuits were full and additional traffic had to be handled. An advertisement in the January 3, 1938 edition of *Life* Magazine shows one of the Radio Central alternators above a then-new

Figure 11. *Another view of Radio Central in the mid-1930s. Note the poles for short-wave antennas alongside a long-wave antenna tower. The economy of short-wave antennas was one of the reasons RCA and its competitors eventually abandoned long-wave radio.*

short-wave transmitter. The caption reads, "This particular alternator is now retired from ordinary duty, except when occasional magnetic storms hamper short-wave message transmission...This equipment is always ready, although needed a very small part of the time."

TECHNICAL HIGHLIGHTS OF THE '30S AND '40S

To go along with the diversity short-wave receivers, Beverage developed the "fishbone" short-wave receiving antenna at Riverhead. Similar in principle to the Wave Antenna, the fishbone got its name from its appearance: a long horizontal wire with 39 perpendicular elements on insulators projecting from either side. Used in conjunction with the four-wire transmission line that was developed for them, fishbone antennas gave excellent directivity and sensitivity over their frequency ranges, and better noise characteristics than rhombics. Given their higher cost of construction, however, fishbones were only used where necessary, and large numbers of rhombic antennas were built as well. After a great deal of experimentation, the rhombic also became the standard for short-wave transmitting at Radio Central, and 137 of them were eventually installed there.

Teletype machines were first tried on some radio circuits in the early '30s, but they only ran at 60 words per minute, slower than the Morse code senders and readers already in use. However, multiplexed teleprinters were already well established in wire telegraphy, so Charlie Shoreys at the New York Central Radio Office developed multiplexing for radio channels in

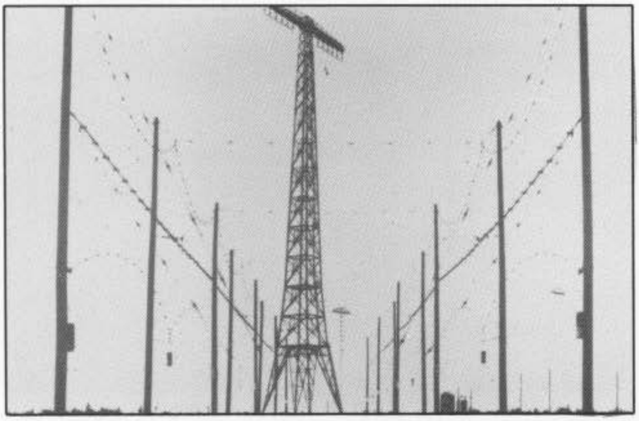


Figure 12. *An unusual photograph of three generations of antennas at Radio Central, ca. 1930. In the center is an Alexanderson long-wave tower, and the tower behind it is part of a Marconi short-wave beam antenna. The structure on either side of the towers is a RCA "Type A" short-wave transmitting antenna.*

1934. At first, two, then three, and finally four channels were combined onto one carrier by a commutator. At the receiving end another commutator, kept in sync by special timing signals, demultiplexed the carrier. The multiplexers worked just as well with automatic Morse code senders as with teleprinters, so they were installed to increase the capacity of some of the channels in the system to as much as 650 words per minute even before teleprinters came into general use.

Ordinary make-break keying proved to be unreliable for teleprinters because the machines could not distinguish between a series of space signals and a complete loss of signal, so frequency shift keying (FSK) was introduced in the late 1930s. Special FSK converters were designed for the diversity receivers. Three receiver channels could not be handled simultaneously due to phasing problems, so each FSK unit compared the outputs from two receivers and a gate circuit picked the best signal from either. The FSK converters had limiters, which largely made up for the loss of performance caused by using only two receivers, and as a side benefit, each pair of three-set diversity receivers could be reassembled into three dual-set units, obtaining more capacity from existing equipment.

The reliability of radioteleprinter communications was further enhanced by the introduction of Seven Level, or Self Correcting Code, conceived by John B. Moore at Riverhead in 1940. While not automatically self-correcting in the same sense modern digital systems are, it did detect when an erroneous character had been received in a message, which solved a rather peculiar problem. On very rare occasions interference could "fool" a FSK converter into changing a mark to a space or vice-versa. The result, called

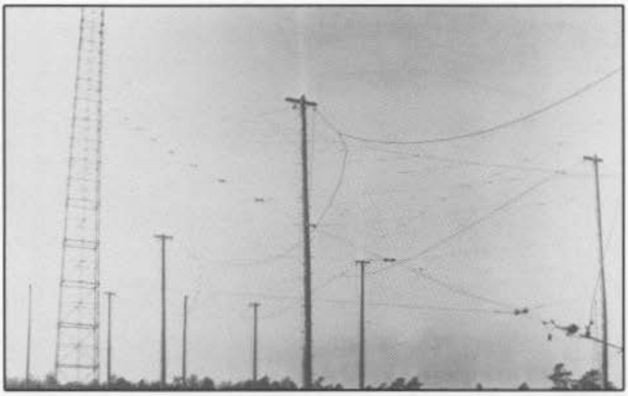


Figure 13. *Developmental fishbone antenna at Riverhead. The steel tower being used to suspend part of the fishbone was for the 1927 Marconi shortwave system. It was blown down by a hurricane in 1938.*

a transposition, was usually still a valid character that would be printed, but not the same one that was originally sent. This was inconsequential in most plain-text messages because a single erroneous character was usually obvious. But in messages that contained numbers or encryption, transpositions could radically change the meaning of the message, and they would not necessarily be apparent. In Seven Level Code, two more levels were added to the standard five-level Baudot teleprinter code so that all characters had three marks and four spaces. A special counter mechanism developed by the engineers at the New York office compared the ratio of marks to spaces for each character, and if it was not 3:4, the teleprinter rang a bell and made a special mark at that point in the text. This warned the operator that a transposition had occurred, and he or she would request a retransmission of the message. Moore accomplished perhaps the first practical application of the principle of parity, which has been a part of digital communications ever since.

FREQUENCY MODULATION

In the early 1940s FM was put through its paces by the Riverhead laboratories. Measurements of FM signals encouraged Beverage to dash off an upbeat memo to Sarnoff that said, watt for watt, FM had three times the effective coverage of AM. As part of the project, Murray Crosby, a research engineer at Riverhead, developed the ratio detector and reactance tube modulator circuits. It is interesting to note that while Armstrong got into a bitter fight with Sarnoff after World War II over FM, and he had nothing favorable to say about ratio detectors after RCA's patent department publicized the circuit as a wondrous new invention that did not require an

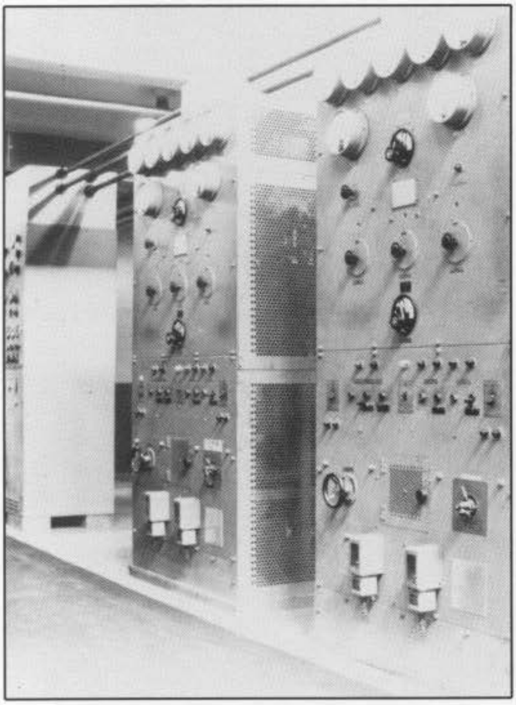


Figure 14. *Two 40-kW short-wave amplifiers at Rocky Point. Units of this type, installed in the late 1920s, were still in service nearly 50 years later.*

Armstrong license, Armstrong and his wife Marion remained on friendly terms with Beverage and others at RCAC. It might be remarked that the ratio detector, as it usually appeared in consumer radios and TVs, did not offer the same degrees of noise immunity or fidelity as Armstrong's classic limiter-discriminator arrangement. On the other hand, it required fewer parts and produced a higher output, making FM radios and tuners more affordable. It was therefore a significant contribution to the growth of FM's popularity in the 1950s and '60s.

TELEVISION

Alongside the FM work, RCA Communications did research on television signal propagation at Riverhead during the late 1930s and early 1940s, which helped with the development of present-day broadcast TV. One project involved attempting the reception of video signals across the Atlantic Ocean. Special arrangements were made with the BBC's television broadcasting facility at Alexandra Palace, near London, to reverse the pattern of their antenna and beam signals towards America after the end of their regular broadcasts every day. In December, 1938, images were received and recorded on film at Riverhead, on a frequency near 45 MHz. The film was shown at a Washington convention of the Institute of

Figure 15. *This elegant branch office was opened in 1944 at 24 State Street, New York City.*

Radio Engineers, where it created quite a sensation even though all that is on the film is a minute or so of badly broken-up images that appear and disappear. The experiment was repeated in 1946 and 1952, but no additional images were obtained and the project was discontinued.

RCA COMMUNICATIONS DURING THE WAR YEARS

World War II brought about the last revival of the Alexanderson alternators. Short waves are practically undetectable just a few feet under water. Long waves, on the other hand, can be heard by submarines at depths sometimes as great as 150 feet below the surface. When war was declared, the navy needed powerful long-wave transmitters and antennas immediately, and it knew where to find them. Both alternators at Rocky Point ran around the clock, and a special land line was installed so they could be keyed directly from navy headquarters in Washington.

The navy also desperately needed long-wave facilities in the Pacific. RCA responded with a two-pronged approach. To meet the immediate need, the old Marconi tubular steel long-wave antenna at Bolinas, California was refurbished, and the station's long-idle alternators were overhauled. The antenna had been partially dismantled before the war, so Marshall Etter, the Junior Plant Design Engineer in the New York Office, who years later would be the last Engineer-In-Charge of Radio Central, prepared designs

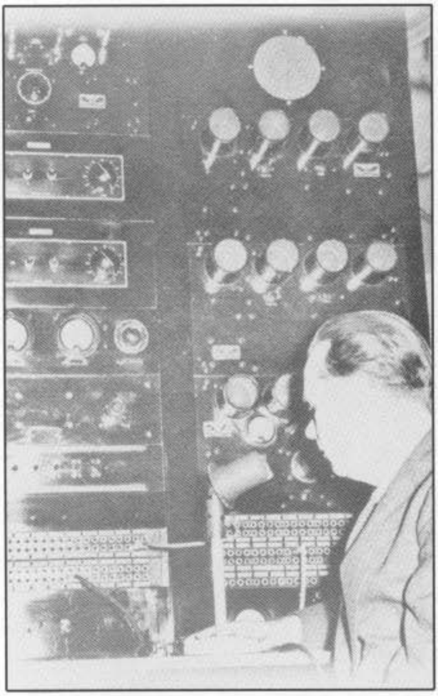


Figure 16. *Control equipment of "Station X" being tested in New York prior to shipment to Italy in 1943.*

for replacing the missing sections. The chief rigger at Radio Central, Bill Dunn, was rushed out to Bolinas to complete the repairs. The second part of the job was to build a station that was better situated for long-wave coverage in the Pacific. Naval Commander Hedley Morris, a former RCA engineer who was extremely familiar with Alexanderson alternators and long-wave radio, found an extinct volcano in the Haiku Valley of Hawaii that was an ideal site for a station. With 7,200-foot cables stretched across the rim, there was a 1,500-foot vertical drop to the station building on the volcano floor, making a superb vertical radiator. The station, which was top secret until after the war, was designed and its construction supervised for the navy by James L. Finch, Chief Plant Design Engineer at RCAC's New York Central Office. RCA sent two Alexanderson alternators, one from Bolinas and one from Marion, Massachusetts, to give the new station its backbone (8).

With all the military and government messages flowing through the telephone lines between New York, Rocky Point, and Riverhead, it was felt that the telephone system was a weak link that could be exploited by saboteurs. To keep the system secure, a VHF (145 MHz) relay system was set up between the stations and the central office. This relay operated until after the war, when it was replaced by a UHF (438 MHz) relay system.

After the Mediterranean Campaign got into full swing in 1943, the War Department wanted a complete commercial communications

Figure 17. *Radio Central's control room in 1960. Notice the absence of cords on the patch bays. RCA's technicians prided themselves on keeping their control rooms neat, so they kept the wiring up to date. Consequently, patching was only necessary for special purposes.*

facility as close to the war zone as possible. RCAC engineers in the New York Central Office were put to work on the highly secret project, which was dubbed "Station X." Much of it was assembled from spare parts Marshall Etter appropriated from various RCAC storerooms, along with some modified RCA Victor broadcast apparatus, including the transmitters. In November, 1943, a team of RCAC engineers, technicians, operators, and station managers departed for Naples, Italy (which was identified only as "Somewhere in South Italy" in news releases of the day) with their equipment, which they got into operation while under fire. The station sent teleprinter, facsimile, and voice to Riverhead. It was the first fully American owned and operated commercial station on the European continent, and though it was intended exclusively for military communications, the public was treated to a show called "The Army Hour" that was done there weekly, relayed to Riverhead, and rebroadcast by the NBC network. Station X was highly successful and others soon followed. Station Y was opened in Rome, allowing Station X to be closed and moved closer to the front. As circumstances permitted, Station A was opened in Austria, Station C in Berlin, and Station Z in the Philippines (9).

With the approach of D-Day, the armed forces knew there would be a communications bottleneck between England and the United States as military and news media demands stressed every available circuit to the limit. David Sarnoff was personally called out of his Rockefeller Center office to England by General Eisenhower to take charge of D-Day public relations. At the same time, Harold Beverage and other specialists from RCA Communications were brought in to help put together a plan for D-Day communications. Using practically every piece of equipment at RCA Communications that could pressed into service, not only were all military requirements met, but the American public was given more timely news coverage of the invasion than ever before at any previous event.

As the war in Europe wound down, the last bits and pieces of Station X, which had moved several more times to keep up with the front, finally

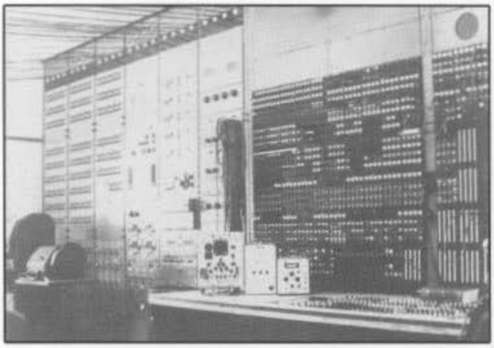


Figure 18. *The control room at Riverhead, ca. 1960. The wires at the top are from the antenna terminal panels to the receivers. As at Radio central, the patch bays were maintained so that no patch cords were needed for regular operations.*

arrived in Nuremberg. There they were set up one last time and used to transmit news of the war crimes trials back to America.

THE POSTWAR YEARS

Following the war, it was realized that a superior means of handling traffic between America and Europe would be to build a relay station in the Tangiers zone of Northern Africa. A team was sent out to find a suitable site, and the station was built. By avoiding the auroral zones of the northern latitudes, far more reliable communications were secured between Long Island and Scandinavia, Russia, and Germany. As the east-west route to Europe and the Tangiers route were not affected by magnetic storms to the same degree at the same time, there was no longer any need for the old long-wave equipment to remain on standby. The Alexandersons at Radio Central met the scrapper's torch in 1954, and the long-wave receiver building at Riverhead was emptied and turned over to RCA Laboratories and the Frequency Measuring Department.

Predictions were that recovery in Europe would mean new demands on RCAC's capacity. No more space was available in the short-wave bands, however, and there was no "new frontier" in the spectrum that could do what short waves did for the business in the 1920s. But through improved technology, better use could be made of the frequencies that were available. Once again the laboratories at Riverhead and Rocky Point went to work. The old commutator-type multiplexers gave way to more advanced devices. When multipath difficulties appeared to limit the number of circuits that could be multiplexed, single-sideband modulation was introduced. With 15 diplexed, time-division multiplexed channels on each sideband, up to 60 teleprinter channels could be handled by each voice-grade carrier. Far more stable receivers were needed for SSB, so DeWitt Goddard,

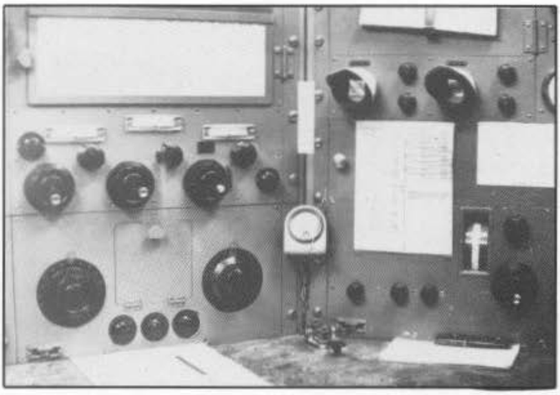


Figure 19. *Riverhead frequency measurement station. The telegraph key just to the right of center on the console was for a direct line to Rocky Point. When the operator didn't have any commercial work to do, he was expected to perform frequency checks on Radio Central. Morse code was a job requirement for operators. In addition to land line telegraphy between Radio Central, Riverhead, and the CRO, Morse was used over the air for communications between all other stations in the network.*

working at Riverhead, developed the captive oscillator to meet the requirement. It was found that the most stable oscillator circuits seldom have the best output wave forms for use in receiver mixer stages. Goddard got around this problem by using a Collins PTO as a captive-mixer signal source, with the then-novel concept of phase lock to a precision oscillator providing the desired stability.

The resurgence of the economies of Europe and Japan in the early 1960s came about as predicted, and RCA Communications enjoyed its busiest traffic years ever. Unfortunately, the demands of technologies that were maturing in the 1960s made the glory days of the short-wave network remarkably short. A single broadcast-quality baseband color video signal without sound requires about 4 MHz of bandwidth, and it would have been difficult to accommodate even a single television program relay in the spectrum space allocated to RCAC. High-speed computer data was almost as demanding. It could be sent over multiple channels, but the phase relationship of the channels must be consistent. The multiplexed sideband teleprinter system gave RCAC a great deal of capacity, but it was in the form of narrow-bandwidth channels that had an arbitrary phase relationship to each other. It was the opposite of what was needed to meet future challenges.

But along with the new problems came new solutions. Satellites and coaxial cable not only offered far more bandwidth, but bandwidth that was more predictable in nature, making far greater automation possible. The grandeur of big antennas and immensely powerful transmitters, with men at the controls making contact with other men in far away places was coming to an end; the future was in earth orbit, on telephone poles, buried in the ground, and ironically, back under the oceans. As Bob McGraw, a technician who worked at Radio Central in the 1960s and '70s said, they felt like blacksmiths watching the first automobiles coming down the road.

Figure 20. *These three-set diversity receivers were built in 1936 to replace the original models. This picture, taken about 20 years later, shows them modernized with captive oscillators and FSK converters. Many of the receivers were still in service when the Riverhead station closed in 1975.*

EPILOGUE

The 75th anniversary of the inauguration of Radio Central is a time to commemorate the multitudes of worthwhile and historic things that were done there. Sadly, the fate of Radio Central's physical facilities proved to be no different than that of the millions of radiograms that passed through its circuits: timely and important for a while, then obsolete, discarded and nearly forgotten. Towards the end of December, 1978, the last message was sent. Only a few people in the New York Central Office, and the operators on watch at Radio Central, knew there would never be another. The Riverhead Receiving Station had been shut down three years earlier and a few of its receivers had been set up in the control room at Rocky Point for the little terrestrial radio service that remained. The last of these international radio circuits was now abandoned. It was the end of an era that began with Marconi's first transatlantic experiment in 1901.

Then the final chapter began. Under Radio Central and the Riverhead Receiving Station were the largest parcels of undeveloped private land remaining on Long Island. RCA decided to donate the land, then valued at $22 million, to New York State rather than deal with the long and costly process of developing it. Some employees had spent their entire working lives at Radio Central and Riverhead. Now their last assignment was to make the properties ready for the new owners. New York State had no use for a commercial short-wave station.

A few of the newer sideband transmitters were slated to go to WCC, the Radiomarine station in Chatham, Massachusetts. Several RCAC technicians kept themselves busy adapting the transmitters for that service. The last long-wave tower, which had been stripped of its cross arm and used to suspend UHF relay antennas and an aircraft beacon, met the same doom Tesla's tower had 61 years earlier when a blaster's plunger crumpled it to the ground. Inside hundreds of pieces of old electronic equipment

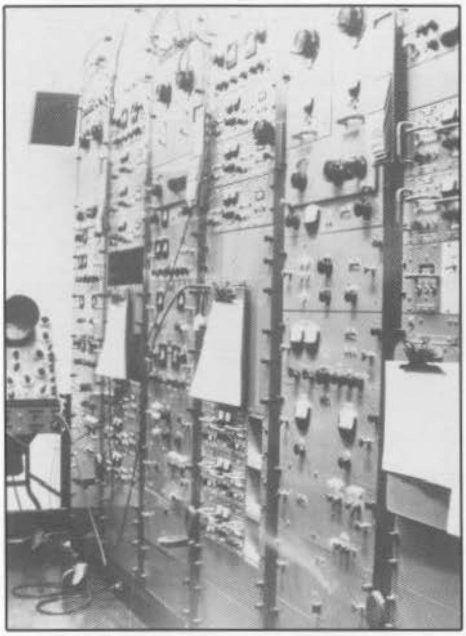


Figure 21. *Three SSB-R3 sideband receivers at Riverhead in 1960. Each of the large knobs tunes a dual-channel, single-band RF and mixer system. The captive oscillators are below the tuning units. In the racks to the right of each receiver are the demultiplexers. A few of these sets were move to Radio Central after the Riverhead station was closed, where they saw RCA to the end of its shortwave days.*

headed for the landfills were thousands of small PCB-filled capacitors. They had operated safely and efficiently for decades but they were now deemed a toxic waste hazard. Technicians removed them from the equipment, sealed them in drums, and shipped them off to a special disposal site. Official paperwork had to be filled out to accompany them to the grave. Old asbestos insulation that had never caused a sick day in anybody's recollection was removed by men in space suits. Huge dumpsters were piled high with tons of old equipment, paper, and office furniture. Employees took bits and pieces home with them for sentimental reasons or for projects they hoped to do in retirement. Of the employees who were too young to retire, some were offered transfers to other positions in the company, and the rest were given their severance pay.

After the State took formal possession, the properties were guarded day and night. Without official permission, nobody was allowed in, including former employees and hunters and hikers who had enjoyed free access for years. The land was turned over to the New York State Department of Environmental Conservation (DEC), which declared it a watershed area. But others, including former RCA employees, a few local people, and some public officials thought that at least the administration building at Radio Central should be preserved. A museum would have been a fitting afterlife for the two-story Mission-style stucco structure, which had been added as an annex to the main transmitter building in 1923. Its massive oak doors opened into an atrium with offices on both sides of the first floor, and iron stairs led to a second floor balcony. On one wall was a mural map of the world centered on Rocky Point. The intricate bas-relief

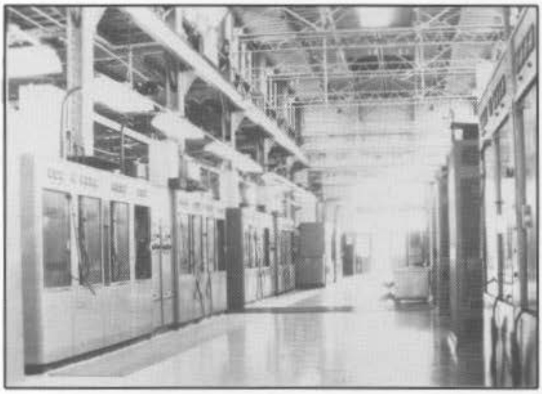


Figure 22. *10-kW short wave transmitters at Radio Central in the late 1950s. Note the gantry crane rails. The right bank of transmitters is standing where the Alexanderson alternators were in Figure 4.*

ceiling was a spectacular, awe-inspiring tribute to radio, only in its adolescence when the sculpture was done.

DEC officials were initially receptive to allowing a private group to establish a communications museum at Radio Central. The main transmitter building with its annex, and what was known as Building 9, which had been built in 1930 for the facsimile and program-relay services, were placed on the National Register of Historic Places. Several quasi-public and private groups were contacted, including the State University at Stony Brook, the Society for the Preservation of Long Island Antiquities, and the Armstrong Foundation, but nobody could reach a consensus with the DEC on what should be done with the buildings, who was going to do it, or most importantly, who was going to pay for it.

The constant surveillance ended when Governor Cuomo decided that services he considered nonessential would be deeply cut in response to a New York State budget crisis that began in 1981. There was no longer any money to guard empty buildings at Radio Central, let alone find new uses for them. Vandals who had been causing damage even before the station closed were now unimpeded in their efforts to get past the gates and a chain link fence that had been installed around the transmitter building. The gates could only keep vehicles out and the fence did not last long against those who took it as a challenge to break in and destroy everything they could. Almost completely lost was a collection of artifacts left locked in a storeroom in the annex by former employees for the museum they hoped somebody would establish. Included were samples of transmitting tubes, some of which were still valuable. But instead of being taken and sold, they were simply thrown off the second-floor balcony and smashed on the tile floor below. Historic equipment was bludgeoned to bits, not for sale as scrap metal, but merely for the sake of destruction. Filing cabinets full of documentation, some of it going back to the American Marconi days, were dumped on the floor, and the only reason subsequent attempts to burn it were not completely successful was due to some hunters. They

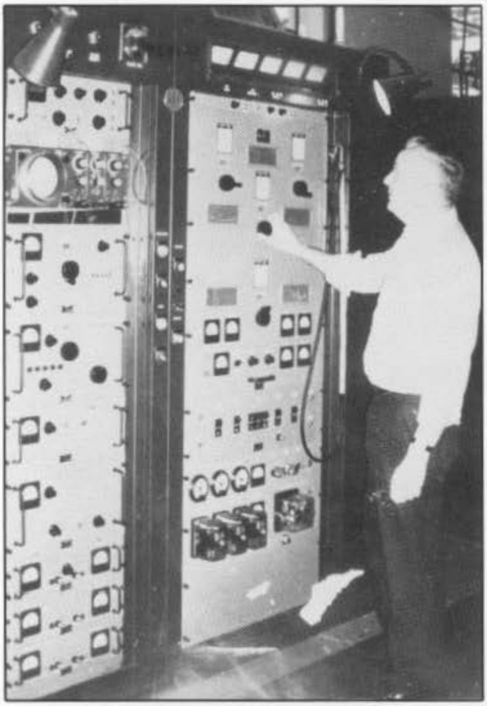


Figure 23. *Bob McGraw tuning one of the SSB-T3 sideband transmitters at Radio Central in the 1960s.*

had shot the red roof tiles off the annex for target practice and rain leaked in, making the paper too wet to catch fire.

In the late 1980s the DEC asked for an informal study among its various departments as to the best course of action regarding Radio Central. Given their weather-beaten, unsafe condition, open to anybody who wandered in, the legal opinion was that the buildings were a liability hazard that could not be eliminated soon enough. As if to prove the point, vandals smashed the porcelain insulators of two large power transformers on the lower level of Building #9, and PCB-laden oil leaked out. General Electric, which had assumed RCA's liabilities as part of the merger, hired a contractor to do a clean-up for the DEC. The contaminated portions of the concrete foundation were hastily chopped out and removed, leaving the building on the verge of collapse. A DEC petition to withdraw it from the National Register consequently met with no opposition. The transmitter building was next to be delisted. The DEC declared it a ruin, an empty shell from which everything of historical or cultural value had been stripped. With nothing historic left, the justification for keeping it on the National Register of Historic Places was gone. No such arguments were needed to condemn the buildings at Riverhead. Having never been on the National Register, there was no need to label them ruins first—though they certainly fit the description by then. The administration annex at Radio Central was the only building left that had a chance of serving as a reminder of RCA's presence on Long Island.

A landmark review declared that there was nothing architecturally significant about the exteriors of any of the RCA buildings. The mural map of the world in the annex would have been worthy of preservation as a work of art, the review continued, but it was now so deteriorated that none of the original material could be saved. When vandals set a fire that caused heavy damage to the annex, it too became a ruin.

In June, 1992, the bulldozers arrived.

FOOTNOTES

1. In some references, the name "Radio Central" is applied to both the transmission and receiving stations. Internally, however, "Radio Central" always meant Rocky Point, separate from Riverhead.

2. The U.S. Navy recently started experimenting with a similar system as a possible replacement for the ELF radio systems that are currently used for communications with submarines cruising at great depths. See "Scope System Also Offers a Tool For Submarines and Soldiers," *New York Times*, November 21, 1995, page C10.

3. Marconi's 1902 Babylon shed has had a rather long and interesting history. Marconi soon moved his operations to larger facilities, keeping the Babylon station as an operator school. In 1912 the property was sold for farmland, and the shed became either a workshop or a chicken coop, depending on whose account one goes by. In 1929, Major Edwin Armstrong and Captain Harry Round "rediscovered" it. Armstrong bought it from the startled farmer and presented it to David Sarnoff, who had it cleaned up and displayed in front of the main transmitter building at Radio Central. Years later, the shed was given to the Sons of Italy, who placed it in front of their lodge on Route 25A in Rocky Point. The lodge was sold in 1994, and the shed, suffering from neglect and vandalism, was moved to the Rocky Point High School, where it has once again been restored and placed on display.

4. On the 200-kW Alexanderson alternators, the rotors were 64 inches in diameter and ran at approximately 3,000 rpm.

5 The Riverhead LIRR station is approximately 1½ miles from the site of the Riverhead Receiving Station. The Rocky Point LIRR station was about two miles from Radio Central on the old Wading River Branch. This line was torn up in 1938, leaving the nearest stations at Port Jefferson and Yaphank, both about 10 miles away.

6. Approximately 1,300 acres of Radio Central land were sold in the early 1930s. The proceeds of the sale contributed to RCAC's "solidly profitable performance" which helped keep RCA afloat during the depression!

7. There were actually four Alexanderson alternators at Radio Central, though only two of them ever operated. A pair of the machines had been dispatched for a South American circuit. A suitable location on the Argentinean coast could not be found, however, so the machines found their way to Rocky Point, where they were stored for many years.

8. The Haiku station was built for two alternators, but one of the machines did not get installed until after the war. It had been misrouted to Guam, where it sat until somebody finally figured out what it was. Even on one alternator, submarines were able to copy the station all the way into Tokyo Bay.

9. Plans were made for Station B as well, but the need for it did not arise and it was never built. During the Korean conflict, Station K was built and tested at Radio Central. It was shipped to Korea but never activated, and its equipment was ultimately sold off.

ACKNOWLEDGMENTS

All photographs courtesy of Marshall Etter except figures 5, 15, and 16. Figures 5, 15, and 16 originally appeared in *RCA Relay*, April, March, and February (respectively), 1944.

This article could not have been created without the assistance of:

Marshall Etter, for sharing history, remembrances, and artifacts of Radio Central, and for taking the time to keeping me on the "straight and narrow" while reviewing the article.

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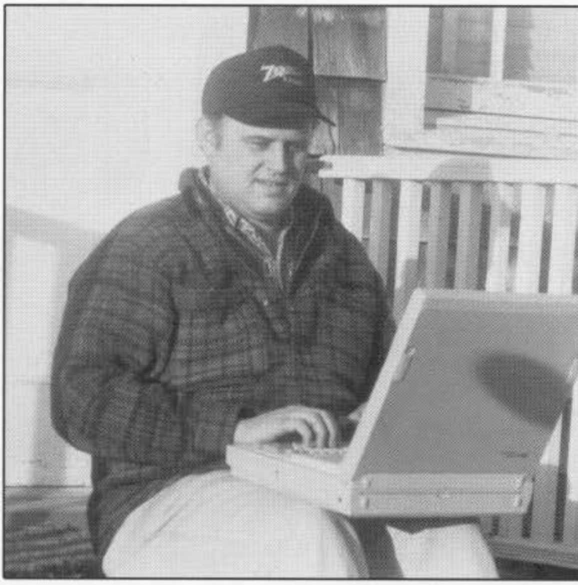
Jeff Lawrence, who came to the rescue just in the nick of time with additional research information.



CHRISTOPHER BACON

Some years ago, popular singer Paul Simon had a hit song called "Late In The Evening," in which he credits a radio left playing near his crib by his mother for his lifelong career in music. Christopher Bacon might have done likewise, except he took the radio apart to see how it worked and wound up in electronics instead!

Bacon's interest in RCA Communications was sparked in 1971, when he was tutored by William Kimmich, a retired mechanical engineer who developed teleprinter apparatus in the organization's New York Central Radio Office.

Chief Engineer of DuArt Video, a film and television postproduction facility in New York City, Bacon is also Executive Vice President of the Friends of Wireless History on Long Island, a member of the Society of Motion Picture and Television Engineers, and a member of the Radio Club of America. He lives in Rocky Point and holds amateur radio call KA2IQB.

DEFIANCE IN THE WEST
THE HEINTZ AND KAUFMAN STORY

Hank Olson,
Menlo Park, CA,
and
Al Jones,
Crescent City, CA

INTRODUCTION

Sarnoff: "When are you and your tin-horn group of amateurs going to stop infringing our patents, out there in the back-waters of San Francisco Bay?"
Heintz: "When are you and your corporate thugs who think that every time you blow your fetid breath on young radio inovators, expecting us to keel over; going to give up? We'll defend our patent position in court, against R.C.A. and your incompetent blowhards, any time."

This acrimonious exchange was something like the only conversation that ever actually took place between David Sarnoff and Ralph Heintz, at a chance meeting in a hallway in Washington, D.C. This exchange and a number of letters between the lawyers of R.C.A. and Heintz and Kaufmen, set in motion a pivitol patent infringment trial of the 1930s.

THE RADIO TRUST

R.C.A. and its allied corporate friends, called the "Radio Trust" by many outsiders in the radio field, was a power to be reckoned with from just after WW1 until the middle of the 1930s. Originally, R.C.A. was set up, principally at the urging of the U.S. Navy, as a government sponsored radio monopoly to push Marconi and other foreign-controlled radio companies, like Telefunken and Homag, *out* of the U.S. This was deemed necessary as the U.S. was being drawn into WW1 to assure that our Navy and other U.S. departments did not have to rely upon foreign-controlled companies for communications, which might not have the most pro-U.S. interests.

On April, 7, 1917, the U.S. Navy either closed or took over control of all Marconi stations in the U.S. At the same time, the German-controlled Telefunken and Homag stations were expropriated, that is, seized as spoils of war. The desired aim was achieved for the duration of WW1. Later, in 1920, Marconi America was taken over by R.C.A., becoming a U.S. radio company and a near monopoly. However, after the takeover, bickering over patents among various U.S. companies in the radio field commenced. To solve these inter-company disputes, the "Radio Trust" was formed wherein

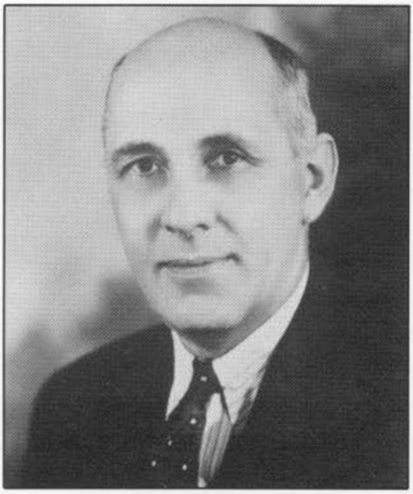


Figure 1. *Ralph M. Heintz*

G.E., R.C.A., Westinghouse, Western Electric, and the United Fruit Co. (Tropical Radio) agreed to share their patents, and to buy into each others stock, to cement a monolithic organization of mutual cooperation for the betterment of the radio art in the U.S.

The Radio Trust agreement worked better than the original U.S. Government's wildest dreams, the Radio Trust becoming so monopolistic as to almost freeze out any new competitors like Heintz and Kaufman or Collins Radio. This was the situation facing H&K and Dollar Radio in 1928.

RALPH M. HEINTZ

The Heintz and Kaufman Company revolutionized the vacuum tube industry in the formative days of high-frequency radio communication when their company introduced their Gammatron family of transmitting tubes. This is the story of one man, Ralph M. Heintz (Figure 1), and his company that successfully challenged the large, monoloplistic, power-hungry East coast corporations for his right to participate in the growth of the fledging radio industry of the 1920s and 1930s.

Ralph Heintz was born April 20, 1892 in St Louis, Missouri. He began his radio career as a young radio amateur (6GK, later W6RH) in his early teens building his own receivers and transmitters. Typical of many young amateurs of the period, who later in life made great contributions to the electronic field, he was continually experimenting to improve his equipment and find new applications for his hobby. As an example, while attending High School in San Francisco, California young Ralph Heintz played hooky one morning in July, 1910. With his home-made receiver he participated in one of the very first aircraft to ground radio communications experiments at Tanforan Race Track.

After serving in England in the U.S. Army Air Corps during WW I, he finished his chemistry degree at Stanford University, then formed his own consulting company in 1921, called Ralph Heintz Scientific Instruments, located in San Francisco, CA. At the small office on Mission Street he conducted experiments, designing and building receivers and transmitters for the high frequency (HF) bands (200 meters and down) which recently had been assigned to radio amateurs by the Commerce Department of the U. S. Government. These high frequencies, or short wavelengths, 200 to 30 meters, were just starting to be explored by the amateurs, and were proving to be far superior for long distance communications than the long wavelengths. The high frequencies also provided other significant advantages, such as better day-night (24-hour) communications, smaller, lighter weight equipment and antennas, reduced power requirements, and lower operating costs. These features were very appealing to the communications industry and amateurs of the 1920s.

Heintz began his career by building HF radio equipment for wealthy amateurs and other customers looking for custom-made equipment for use in new applications, such as on board ships and aircraft. Heintz soon became recognized on the West Coast as an expert who could provide well-designed, high-performance, reliable radio components or complete radio stations for use on the new high frequency bands.

In 1924 Heintz, with his brother-in-law Herman Kohlmoos, formed a new company called Heintz and Kohlmoos, located at 219-22 Natoma Street, San Francisco, CA. This new company continued the design and manufacturing of transmitters and receivers of high quality, in single and small quantities for experimental use. Eventually, the company acquired larger contracts providing equipment to U.S. Government agencies and geographical expeditions, such as Commander Byrd's expeditions to the North Pole, and later Antarctica.

Heintz & Kohlmoos provided custom-made HF radio equipment for several history-making pilots of the 1920s and their aircraft participating in early cross-country and ocean-hopping contest flights of that era. Two notable flights were The *The Pabco Flyer,* the first plane to fly the Pacific from Oakland, Ca. to Honolulu successfully and winning the Dole prize, and later, on June 9, 1928, Charles Kingsford-Smith completing the first flight from Oakland, CA to Sydney, Australia with stops at Honolulu and the Fiji Islands. Both of these flights used Heintz & Kohlmoos HF radio equipment. Another first for Heintz & Kohlmoos was the design, construction and installation of a two-way voice communication system for use between aircraft and ground stations for Boeing Airlines. This system successfully demonstrated the use of airborne HF voice radio systems for future airlines and military applications.

In 1925 Heintz & Kohlmoos participated in a demonstration to prove the reliability of high frequencies for long range marine communications over the Pacific Ocean during a cruise of the yacht *Kaimiloa.* Heintz & Kohlmoos was contracted by the *Kaimiloa* owner, Medford Kellum, to install an HF station aboard his yacht. A 500-watt transmitter using a pair of 204s was constructed. After the ships equipment installation and checkout

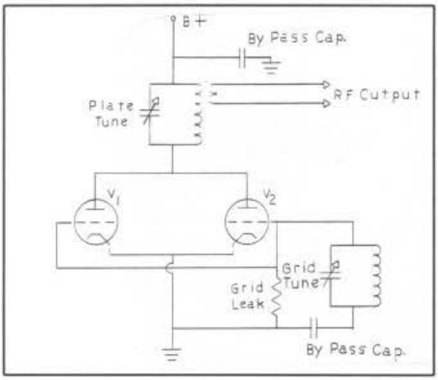


Figure 2. *Simplified T.P.T.G. oscillator.*

was completed in Hawaii, the *Kaimiloa* put to sea with Fred Roebuck (FD) as its HF operator. The radio world followed with keen interest as the *Kaimiloa* maintained successful scheduled contacts with U.S. shore stations and amateurs from the far reaches of the Pacific (1, 2).

By 1927, differences in their temperaments led to the dissolution of the Heintz and Kohlmoos partnership. In the settlement, Heintz kept the business and Kohlmoos retained the building on Natoma Street.

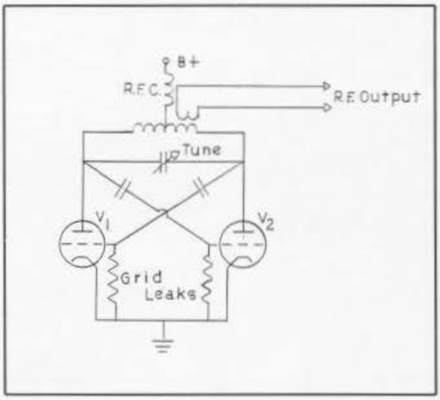
Heintz then sought out a former University of California classmate, Jack Kaufman, to be his partner in a new firm "Heintz and Kaufman" (H&K). Jack Kaufman was to be the business-managing partner and Ralph Heintz the technical expert. The new H&K company was incorporated in the State of California and remained at 219-22 Natoma Street, San Francisco, Calif. The business goals remained the same as those previously in effect at Heintz and Kohlmoos.

Heintz's reputation as a manufacturer of reliable HF transmitters and receivers continued to grow. Most pieces of radio equipment built by H&K for the expanding new HF bands used conventional circuits (such as the tuned-plate, tuned-grid oscillator, TPTG), and employed standard grid-type transmitting tubes such as the 203, 204, and 211 triodes. As a small supplier of experimental radio equipment, H&K was not a threat to R.C.A. and the other East coast companies making up the Radio Trust.

ENTER, THE DOLLAR STEAMSHIP COMPANY

The first use of high frequencies by the Dollar Steamship Company occured in July, 1924. Then Company Superintendent, Charlie King, an amateur, asked one of the Dollar Line's radio operators, W. H. Philips, also an amateur, to install amateur HF amateur equipment on the ship on which he served . Successful communications were held between King and Philips on several voyages to China, at many times when communication was not possible using low-frequency spark equipment. This experience with HF convinced King of its usefulness for long-range communications, and he contacted Heintz and asked him for a bid on HF equipment for 30 ships and ten land-based HF stations. The Dollar Board of Directors rejected the bid (3).

Figure 3. *Simplified Simpson oscillator, as used by H&K.*



In 1926, as the result of the successful experience of the *Kaimiloa* and tests in the Pacific by the U.S. Navy on board *U.S.S. Seattle* (NRRL), the use of HF began to be more seriously considered by the Dollar Board of Directors as a mode of communication for their line.In an effort to take advantage of the impending change-over from spark low frequency equipment to tube-type HF equipment, Dollar promptly applied for and was granted 17 HF frequencies from the U.S. Department of Commerce (now the FCC). Dollar next contacted the Simpson Radio Company in Seattle, WA to explore the possibility of their supplying HF station equipment. Fredrick Simpson held several radio patents, most important among which was patent #1,775,327 for a push-pull triode power oscillator.

Negotiations with Simpson were slow due to his poor health at that time. In 1928, Heintz, as a Dollar representative, visited Simpson Radio in Seattle to study the Simpson power oscillator to determine if it would work with H&K's new gridless Gammatron tube. Once convinced that the low-Mu Gammatron would function in the Simpson oscillator, he requested Dollar to negotiate the purchase of the Simpson Radio Company and its patents. Simpson agreed to sell the company and its radio patents to Dollar.

The Simpson oscillator was intended to give H&K and Dollar a way of getting around the de Forest 1924 triode oscillator patents #1,507,016 and #1.507,017 which were controlled by R.C.A. and the Radio Trust. Since H&K had been building two-tube, tuned-plate, tuned-grid (TPTG) transmitters anyway, the change to the Simpson Oscillator circuit was not a major shift. The two circuits are shown for comparison in Figures 2 and 3. The original Simpson Oscillator circuits are shown in Figures 4 and 5, as depicted in patent #1,775,327.

In 1928, Dollar asked H&K to outfit one of its freighters, the *President Taft* (KDRW), with HF equipment to further test the efficiency of shortwave communications with a shore station near San Francisco, CA.

HF receiving tests done there by Fred Roebuck and Ron Martin (W6ZF) of Hearst Radio, (6ARD, later KUP), the Mobile Press station for the *San Francisco Examiner* newspaper. Dollar purchased land at Salada Beach just south of Mussel Rock, constructed a small wooden shack and outfitted it with H&K HF equipment. The call sign was 6XBB. The original transmitter

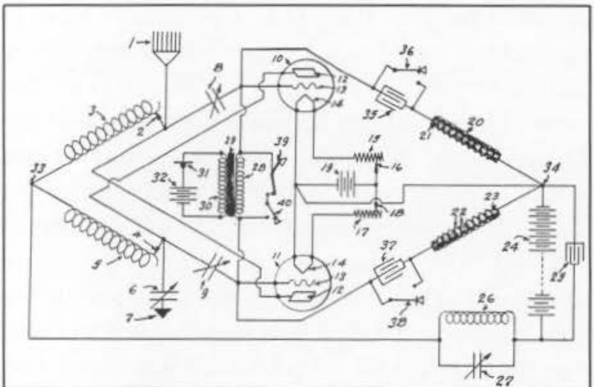


Figure 4. *Simpson Oscillator circuit, Patent #1,775,327; Version One.*

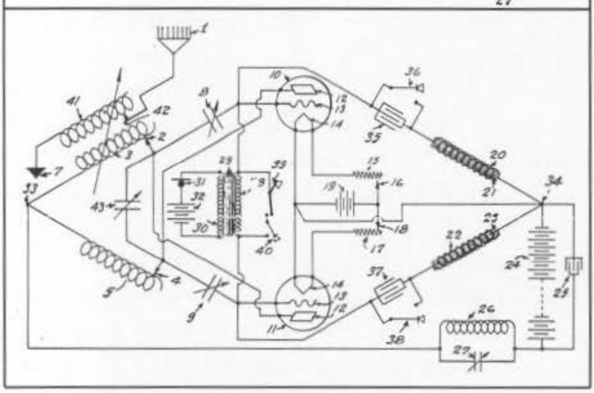


Figure 5. *Simpson Oscillator circuit, Patent #1,775,327; Version Two.*

at 6XBB consisted of a single English Mullard NT54 silica transmitting triode tube operating in a self-rectifying power-oscillator circuit. The transmitter was fabricated in typical breadboard fashion, as was normal for prototype equipment of that era, and was powered by a 500-Hz motor generator set. The self-rectifying circuit produced a 500-Hz modulated, continuous wave (MCW) note. This MCW note greatly improved the readability of the signal in atmospheric noise or QRN.

The first voyage of the *President Taft*, with Charles Cross as radio operator, departed in November, 1928. HF tests conducted between the President Taft and Mussel Rock (KDRW & 6XBB) gave mixed results. The standard Dollar "Horse Shoe Run" across the Pacific, starting in San Francisco and returning to Seattle, was the test itinerary. The lack of consistent communications with the Mussel Rock station was traced to a poor understanding by the radio operator of how to resonate the existing MF (500 kHz) ship's antenna at the high frequencies.

The *President Taft* ended the first transpacific tests at Seattle on February 29, 1929, and Mussel Rock operator Roger Bunce joined engineer Niel Brown in Seattle to find an answer to the problem. By the time the *President Taft* was ready to sail again, on the reverse "Horse Shoe Run," adjustable loading taps for each of the operating H.F. frequencies were in place on the ship's MF antenna, thus transferring more transmitter power into the antenna. The *President Taft* sailed in March, 1929 with three radio operators aboard for a second HF test. These operators were Bob (Pop) West, Harold Van Wegan and Roger Bunce. Scheduled contacts were maintained with Mussel Rock every hour all the way to Shanghai. Although a few hourly contacts were not successful between Shanghai and Manila, the overall test was considered a success by Dollar management.

As H&K began to commit itself to the creation of a Dollar Steamship Company HF communications system in 1929, it was reincorporated in the State of Nevada for an improved tax position as Heintz and Kaufman, Ltd. Then, with the success of the Pacific tests aboard the President Taft, Dollar bought into H&K as the majority stock holder (66%). The new exclusive mission of H&K, under Dollar control, was to outfit the Dollar ships and shore stations with HF equipment. (Meaning: To provide no services or equipment to anyone outside the Dollar organization.) The shore complex took the name "Dollaradio" although it was not a separate corporation from the Dollar Steamship Company.

Before the second HF test voyage was completed aboard the *President Taft*, another Dollar ship was loaded with H&K high-frequency radio equipment and sent en-route to Manila to establish an Orient-end shore station for Dollaradio. The next Dollar ship to be equipped with H&K HF equipment was the *President Polk* (KDOZ), and it sailed in July, 1929 with Fred Roebuck (FD) aboard as radio operator on a round-the-world cruise. These were the initial steps taken by Dollaradio to establish its HF communications network.

In early 1929 H&K began equipping five shore stations for Dollaradio on the U.S. West coast and one each in New York, Hawaii, Manila, Guam, and Shangahi, plus the entire fleet of Dollar ships. During this period the Dollar Steamship company and its supporting communications companies (H&K and Dollaradio) were expanding rapidly. To improve management and cost control, Robert Stanley Dollar decided to split out the communications business from his steamship operations. The U.S. Government also had concerns of a monopoly developing under Dollar's control. In January, 1930 Dollar formed Globe Wireless Ltd., incorporated in the State of Nevada, and installed Jack Kaufman as Vice President and General Manager. The mission of this new company was to provide operational communications equipment and services for all the Dollar Steamship Company shore stations and its fleet of ships. H&K was to continue supplying equipment solely to this new Dollar company, Globe Wireless, Ltd. The 17 HF frequency assignments originally granted to the Dollar Steamship Co. were transferred to Globe Wireless, Ltd.

Globe Wireless, Ltd.was now handling almost all of the Dollar Steamship Company operational communications traffic. This had a negative impact upon the revenues of the various Cable and Radiogram companies in the Pacific that Dollar had previously used, and caused an immediate reaction from R.C.A. and the "Radio Trust. Their response was to refuse to sell transmitting tubes to H&K for use in equipment that H&K was supplying to Globe Wireless. After all, it was printed right on their tubes and cartons that the tubes were sold "for experimental purposes only."

HEINTZ STUDIES PATENT PROBLEMS AND SOLUTIONS

Earlier, in 1928, Heintz and Dollar had anticipated some sort of serious legal action from RCA and members of the Radio Trust, as Heintz had been threatened with a patent infringement suit. He personally had done a study of all the patents controlled by R.C.A. and the Radio Trust to identify those on which H&K might be subject to patent infringement litigation. The study identified four problem areas. These were:

Problem 1. de Forest patents for the Audion, three-element, grid-type triode tube. Actually the grid-type Audion patent had expired in 1925, but the-term "Grid" carried over into later, still-valid, patents.
Problem 2. Patents covering the use of thoriated tungsten filaments in tubes.
Problem 3. Patents covering the use of flashed getter materials, like magnesium and phosphorus, in tubes to maintain a hard vacuum.
Problem 4. Patents covering oscillators using triodes.

How Ralph Heintz and his H&K team avoided the potentially devastating effect on Globe Wireless, Dollar, and H&K, should they lose a patent infringement suit involving any one of the above four problem areas, follows.

Problem 1 Solution. R.C.A. controlled the deForest patent #879,532 for the grid-type Audion triode tube. R.C.A. and members of the "Radio Trust" were manufacturing and marketing grid-type transmitter tubes, such as the 203, 204 & 211. Heintz, anticipating the potential loss of these tubes from these suppliers, began developing his own tube design and manufacturing capabilities at H&K. In addition, Heintz explored the purchase of foreign tubes for his needs. However, foreign tubes were very expensive and had the same patent problems as tubes made in the U.S. Mullard, Marconi Osram of England, and S.I.F. of France were the foreign tube suppliers considered.

Heintz researched existing tube patents for ways to circumvent the R.C.A. held tube patents. This effort was considered by Heintz to be the most critical of the four problem areas, as the other three problems were dependent upon the solution to the tube problem. After extensive study, Heintz

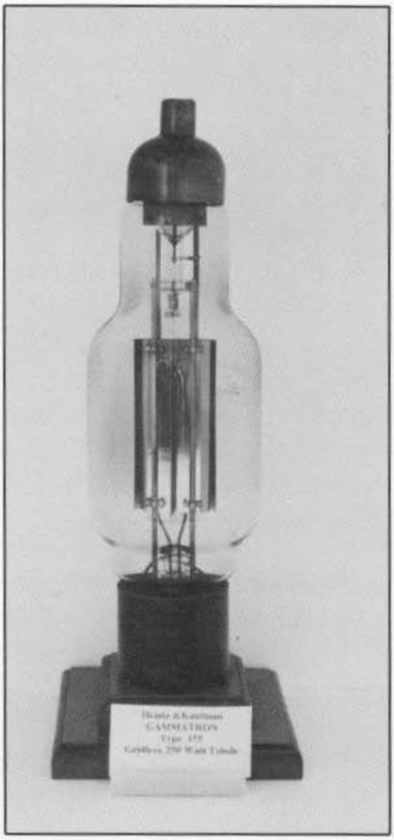


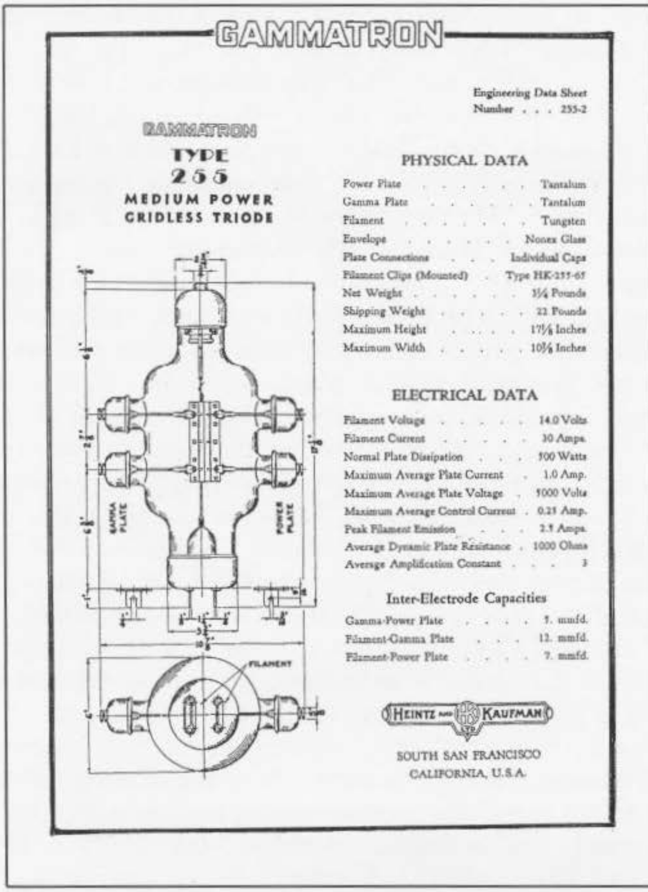
Figure 6a. *HK155 tube.*

concentrated his effort on several gridless types of three-element tubes. One of these three-element tubes was invented and patented by Herbert Metcalf of the S.F. Bay Area firm, Magnavox. The patent (# 1,626,858) had been applied for on Feb.28, 1924 and granted on May 3, 1927. In this patent by Metcalf, the concept of a control electrode (which Metcalf called a "grid") on the opposite side of the filament, and closer to it than the anode, is clearly put forth. Reference 4 mentions Ralph Heintz' close relation to Metcalf and Magnavox, and his contributions to their tube development program in the 1925 period, so undoubtedly he was familiar with this patent.

An earlier triode tube was one invented by Robert Goddard, the famous rocket scientist, while a physics professor at Clark University. Goddard's oscillator tube patent #1,159,209, was dated November 2, 1915. The tube in Goddard's oscillator had two plates and a filament, rather than a plate, grid and filament. Heintz' interpretation of the Goddard tube patent and accompanying file wrapper indicated, to him, that this tube was not similar or covered in the deForest patent, #879,532. Analytical studies were made of various tube-element configurations of the Metcalf and Goddard tubes to establish a design that produced optimum performance for H&K's needs. It was found that this dual plate-configured tube would have a very low amplification factor (Mu), but Heintz felt it would serve their needs.

In 1928, Heintz started design and fabrication of prototype gridless tubes for testing and evaluation, in transmitter power-oscillator and amplifier circuits. One of the first gridless transmitter tube designed was to be a replacement for the popular 250-watt type 204A, a grid-type triode transmitter tube, and was given the designation type HK155. It was designed with a glass envelope and base configuration the same as the type 204A. In fact, some of the early HK155 prototypes used 204 envelopes and bases with their original manufacturer's markings still on them.

The first HK155 (Figure 6a) was evacuated in 1929 and subjected to bench testing in both power-oscillator and power-amplifier circuits. Later



GAMMATRON

Engineering Data Sheet
Number . . . 255-2

GAMMATRON
TYPE
255
MEDIUM POWER
GRIDLESS TRIODE

PHYSICAL DATA

Power Plate	Tantalum
Gamma Plate	Tantalum
Filament	Tungsten
Envelope	Nonex Glass
Plate Connections	Individual Caps
Filament Clips (Mounted)	Type HK-255-65
Net Weight	3¼ Pounds
Shipping Weight	22 Pounds
Maximum Height	17⅞ Inches
Maximum Width	10⅜ Inches

ELECTRICAL DATA

Filament Voltage	14.0 Volts
Filament Current	30 Amps.
Normal Plate Dissipation	500 Watts
Maximum Average Plate Current	1.0 Amp.
Maximum Average Plate Voltage	5000 Volts
Maximum Average Control Current	0.25 Amp.
Peak Filament Emission	2.5 Amps.
Average Dynamic Plate Resistance	1000 Ohms
Average Amplification Constant	3
Inter-Electrode Capacities	
Gamma-Power Plate	5. mmfd.
Filament-Gamma Plate	12. mmfd.
Filament-Power Plate	7. mmfd.

HEINTZ AND KAUFMAN LTD
SOUTH SAN FRANCISCO
CALIFORNIA, U.S.A.

Figure 6b. *Heintz & Kaufman, H&K 255, Engineering Data Sheet, #255-2.*

it was tested in operating HF stations. Performance of the HK155 was as predicted, but it was not up to the power output level requirements desired by H&K. Their goal was to develop a tube, that working as a pair in the Simpson oscillator circuit, would provide 1-kW of input power. Hence development on the HK155 was suspended in favor of a higher-power version. Limited numbers of prototypes of the HK155 were fabricated, and only three are now known to be in existence.

During this period of gridless tube development at H&K, a new employee, Bill Eitel (W6UF), came to work to assist Heintz in the tube department. Together they started work to develop a larger, 500-watt plate dissipation gridless tube, the HK255. In June, 1930 another new employee joined the tube department, Jack McCullough (W6CHE). Both of these amateurs soon became transmitting tube experts and Bill Eitel became the head of the H&K Tube Department. They brought new vigor and enthusiam to their work and soon had prototypes of the HK255, (500-watt plate dissipation) completed and under test. The results proved this tube to have great potential. A pair, operating in a Simpson oscillator circuit, easily provided the required 1-kW input power. (Heintz' goal was 1-kW input power for ship transmitters and some shore stations, and 10-kW input power for key shore stations). A higher-power version of the HK255 was built later with a 750-watt plate dissipation, and designated the HK255H. Production of both versions of the HK255 went ahead, and as these tubes came off the production line they were installed in the MC-201 and other transmitters used in ships and Globe Wireless shore stations.

The design of the HK255 gridless tube was unique for its time, utilizing new tube fabrication techniques and materials which would revolutionize the transmitting tube industry for years to come. The tube elements consisted of two separated vertical plates approximately 4" long and 3" wide with a spacing of 5/8" between them. The two side edges of the plates were angled to minimize electron bombardment of the glass envelope of the tube. The filament was located approximately 1/8" from one plate called the Gamma Plate (control element). The opposite plate, the anode, was spaced ½" from the other side of the filament. The filament was of a double-V shape made of pure tungsten. Figure 6b, H&K Data Sheet #255-2, presents a sketch of this tube and its specifications. The glass envelope of the HK255 was made of Corning Nonex glass with a diameter of 6" drawn down to 2 3/8" at the top and 4" at the base. Overall length of the tube was 18" including it's base. All support for the internal elements were to the glass envelope and lead stem press, no internal support or spacer insulators were used. Two terminal caps on each side of the envelope were used for connections to the anode and gamma plates, respectively. The tube base was approximately 4 ¼" in diameter with two blade terminals for filament connections and tube support. A dummy plate cap was installed on top of the tube, for mounting support only, as shown in Figure 6b. Note that the pure Tungsten filament required a large amount of power (compared to the equivalent thoriated tungsten types): 14 V @ 30A = 420 watts!

The HK255 gridless tube soon became known as the "Gammatron," a name coined by Jim Brown (W6AY), an H&K employee. The name was apparently derived from the name of one of the three tube elements which were called Alpha, Beta and Gamma. Later, the name Gammatron was used as a trade mark name for all H&K tubes.

In talks with tube historians, collectors and former H&K employees, it is has been established that there were eight different versions of H&K gridless triodes built. These were the HK5, HK55, HK155 (2 versions), HK255, HK255H, HK255X, and a large water-cooled gridless tube with no type number on it. (However, it has been designated by Al Jones, of the Ye Olde Transmitting Tube Museum, as the HK355 for purposes of this discussion.) A brief description of the above tubes follows:

HK5. This is a small gridless receiving tube with an "S" envelope and a 4-pin UX base. No data nor anyone with detailed knowledge of these tubes has ever been found (Figure 6c).

Figure 6c. *H&K 5 tube.*

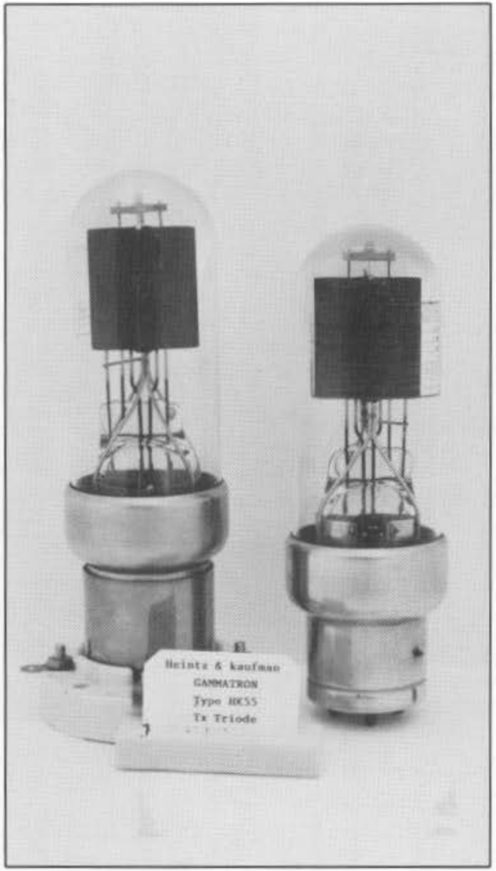


Figure 6d. *H&K 55 tubes.*

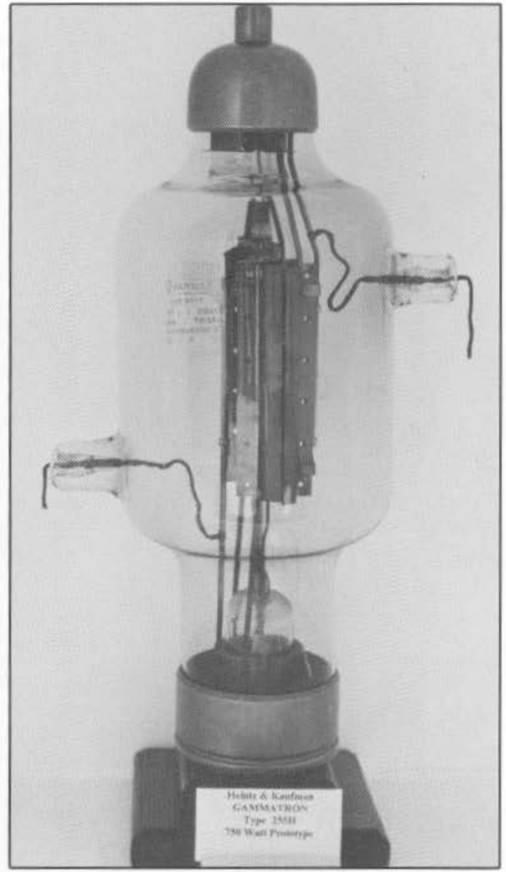


Figure 6e. *H&K 255H tube.*

HK55. This was the smallest of the gridless transmitter tubes built by H&K with a plate dissipation of 75 watts. Its configuration differs from other gridless Gammatrons in many significant ways. It has a conventional oval enclosed carbon anode, 1.75" long. The gamma plate (control element) is a flat tatalum plate approximately 1.25" square, positioned in the center of the carbon anode. The gamma plate has a cutout in the shape of an inverted V in its center. The filament (also an inverted V) is positioned in the center of the gamma plate V cutout and in the same plane. The tube has a tubular glass envelope 3" in diameter and overall length of 8.5" with a 50-watt base (6d).

This design configuration of the HK55 tube was most likely the result of Heintz's engineering support that he freely gave to Magnavox engineers earlier, also designing tubes to get around the RCA held deForest patents. The Magnavox Type A receiving tube has a similar element configuration.

HK155. There are two different configurations of the Type HK155 gridless Gammatron. The initial HK155, (Figure 6a) was the replacement for the 250-watt dissipation 204A previously discussed. Later, a smaller gridless transmitting tube with a plate dissipation of 150 watts was built for the amateur market and also given the designation HK155. A sketch of this tube is depicted in an ad on the back cover of the 1936 *Radio Handbook* and described in Reference 12. It is not known if this tube was ever built as no former H&K employees nor any collectors we have talked with had any recollections or have seen one .

HK255. This gridless Gammatron was described earlier. The HK255 and HK255H described below were the only gridless Gammatron tubes to see production (produced by the hundreds) and used exclusively in operational service by Globe Wireless for a period of four years. A few were provided to other commercial stations (like KUP) for test and evaluation. The HK255 was advertised by H&K, but none were ever sold on the open market (Figure 6b).

HK255H. This tube is similar to the HK255; however, it is rated at 750 watts plate dissipation. To achieve this higher rating, the anode and gamma plates were each extended one inch longer to 5", and the filament current increased from 30 ampso 40 amps. Very few of these tubes were produced and were used mostly in Globe Wireless shore stations (Figure 6e). Note: Some of the HK255H tubes seen are labled HK255 only, no "H."

HK255X. This is a prototype tetrode version of the HK255 tube configuration with a screen grid. Only one of these tubes is known to exist, and the printed data on the glass envelope is the same as that printed on the HK255H (Figure 6f).

HK355. This type number was assigned by K6DIA as there was no type number printed on the tube, just "Heintz & Kaufman" and "Gammatron." The HK355 (Figure 6g) is a water-cooled, gridless tube, and very similar

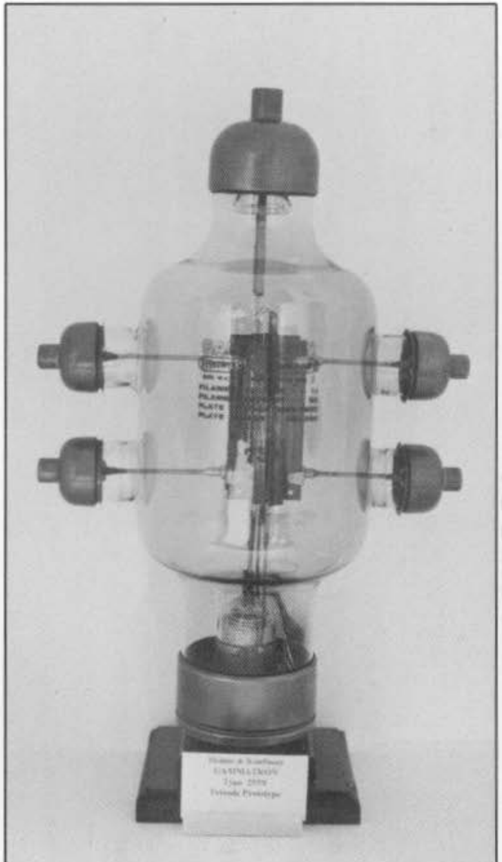


Figure 6f. *H&K 255X tube.*

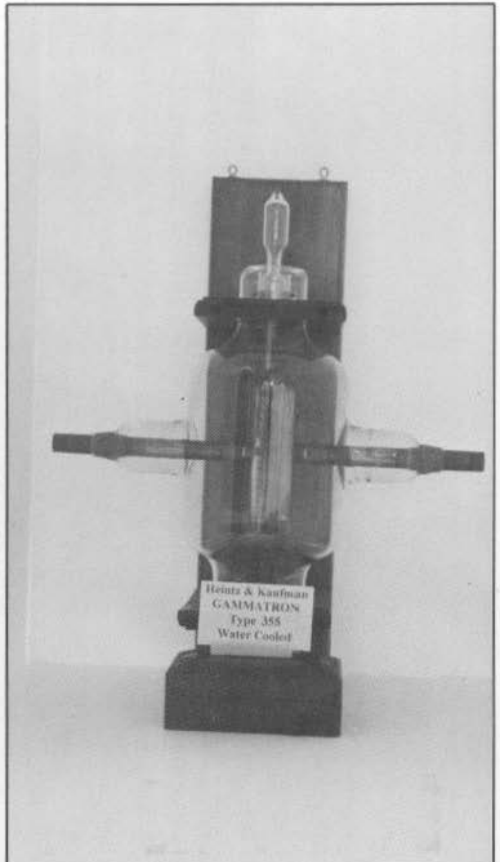


Figure 6g. *H&K 355 water-cooled tube.*

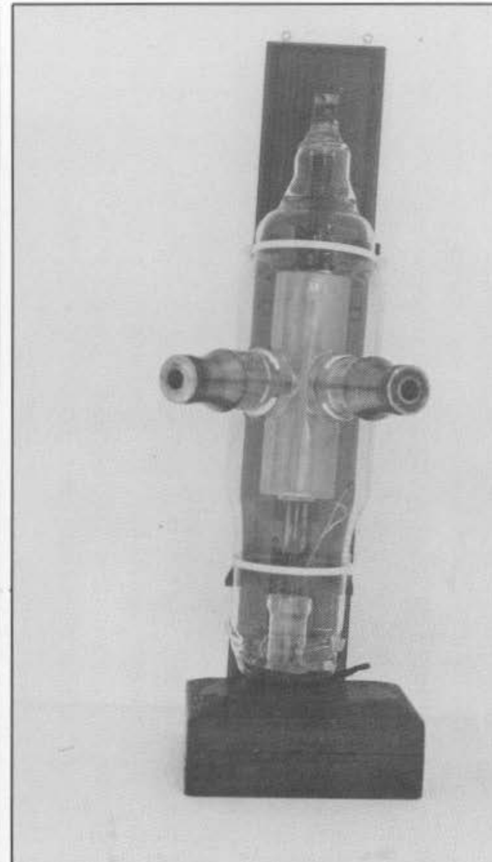


Figure 6H. *H&K undesignated water-cooled tube, with grid.*

to the HK255, but is about 20% larger in all dimensions. Both the anode and gamma plates are constructed as water jackets of T.I.G.-welded stainless steel. Kovar pipe, ¾", with copper (Cu) seals are used for water circulation into the plate jackets, one brought out each side of the glass envelope. Each Kovar pipe also supports its water jacketed plate within the tube. There are no data on this tube, but it is believed to be in the range of 5- to 10-kW plate dissipation.

There was also another prototype H&K water-cooled transmitting tube made with a different configuration. This tube is similar in size to the HK355 water cooled tube, however, it is a grid-type tube. The anode is a 8" long by 2" wide with a water jacket shaped in the form of a crescent (half circle). The grid consists of vertical wire rods between the plate and filament. which is located in the center of the crescent. No data has been found on this tube either (Figure 6h).

All of the above H&K Gammatron tubes in Figures 6a thru 6h are on display at the Ye Olde Transmitting Tube Museum, Crescent City, CA with the exceptions of the HK155 and HK255.

The question arises as to why, in 1928, Ralph Heintz should be worried about the deForest patent #879,532 on the grid type triode, and not about the dual-plate triode, patent # 841,357. Both patents would have expired after 17 years, respectively, in 1925 and 1924. The answer seems to be the "grid-leak" patent. The grid-leak in an oscillator circuit keeps the bias from straying too far from its operating point on the tubes's characteristic curve (ie: plate current as a function of the grid voltage). It is obvious that the gridless tube has no need of a grid-leak and so does not infringe on the grid-leak stabilization method which is inherent in the de Forest's patent #1, #507,016 of 1924. Patent #841,357 describes a dual-plate triode, using plates equally spaced on opposite sides of the plane of the filament. This two-plate design has the disadvantage of having no voltage gain (ie: Mu = 1). Heintz designed his Gammatron tube with its gamma plate closer to the filament than the anode; this configuration produced a voltage gain of 2 to 3. In de Forest patent #841,357, the filament was centered between the plates and provided no voltage gain; Mu = 1 because he did not envision the tube as anything but a detector.

Heintz not only believed that the gridless Gammatrons with their low gain would perform in power oscillators, but he demonstrated their use in operational service on ships and at shore stations for over four years in the Globe Wireless system. He now had a means of getting around the R.C.A-held de Forest patents. With this solution to Problem 1 in hand, Heintz proceeded to move forward.

Problem 2 Solution. Heintz was unable to find a method of getting around the R.C.A-held G.E. patent for the use of thoriated tungsten filaments of Langmuir. His temporary solution was to use the less efficient electron emitter, pure tungsten.

Problem 3 Solution. Patents for the use of getter materials flashed on the tube envelope, like phosphorus or magnesium, to produce and maintain high vacuum in tubes, were easy for Heintz to circumvent. From his college chemistry classes, at University of California, Berkeley and at Stanford University, he recalled the property of tantalum to adsorb large quantities of gas when heated. This material was used in his Gammatrons for the gamma and anode plates, and supporting rods. While vacuum pumping his tubes, he brought the plates to a white hot temperature to drive out any remaining gas within the tube elements. Normal operation of the tubes, then near their design loads, also would continue to remove unwanted gas. The use of tantalum in transmitting tubes for this purpose was first used in the Heintz gridless Gammatron, and subsequently became the choice of materials for transmitter tube plates and grids by tube manufacturers for years to come.

Problem 4 Solution. As previously discussed, in the year 1928, Dollar had purchased the Simpson Radio Company and its oscillator and regenerative detector patents. The Simpson oscillator was intended to give H&K and Dollar a way of getting around the deForest 1924 triode oscillator patents #1,507,016 and #1,507,107 which were controlled by R.C.A. and the Radio Trust. Since H&K had been building two-tube, tuned-plate, tuned-grid (TPTG) transmitters anyway, the change to the Simpson oscillator was not a major problem. The two circuits are shown for comparison in Figures 2 and 3. The original Simpson Oscillator circuit are shown in Figures 4 and 5 as depicted in patent #1,775,327.

The patents that H&K wanted to avoid infringing were the pair of de Forest patents on vacuum tube oscillators #1,507,016 and #1,507,017. These two patents were granted on September 2, 1924 and were still in force, even though they had been applied for much earlier, in 1914 and 1915. The reason for the long delay between application and granting of these patents was apparently due to all the litigation that was associated with them. At least three other inventors besides de Forest vied for the patent on the triode vacuum tube oscillator: Edwin Armstrong, Irving Langmuir, and Alexander Meissner. The controlling date on the de Forest patents, granted by the patent court, was Aug. 6, 1912, the date that de Forest's technician Van Etten entered the experimental data in his lab notebook at the Federal Telephone and Telegraph Co. in Palo Alto, CA. As it turned out, a vacuum-tube oscillator patent was applied for by Robert H. Goddard only five days before Van Etten's logbook entry, but Goddard's patent was never a consideration in the litigations that occurred between 1914 and 1924.

There were also two other vacuum-tube oscillators which were granted patents well before the controlling date of de Forest. The Veeland oscillator was patented in 1906, and the (Norwegian) Sindling-Larson oscillator was patented in 1908. None of these three earlier oscillators were directly involved in the de Forest litigation prior to the granting of patents #1,507,016 and #1,507,017 in 1924. Apparently, Veeland and Goddard oscillators were considered to be so different from the deForest audion oscillator that they were not considered (both were forms of the magnetron). The Sindling-Larson oscillator was probably not even known in the U.S. at the time of the oscillator patent litigation. But, it too, was a very different sort of vacuum-tube oscillator (to the casual observer), using a cold cathode and very high voltages. So, although there are clear records (patents) to show that Vreeland, Sindling-Larson, and Goddard had vacuum-tube oscillators prior to de Forest, the court awarded the triode oscillator patent to de Forest, and it ended up in the patent portfolio of the Radio Trust.

Meanwhile, back at the Heintz and Kaufman plant, Ralph Heintz realized that perhaps the Simpson oscillator patent, which was now Dollar property, might not have had the uniqueness that could stand the test of a patent infringement trial. In fact, in an interview he made with Arthur L. Norberg, much later in life, Ralph Heintz said, candidly, of the Simpson Oscillator: "The trouble is, it is based on a fallacy." The full quote from Reference 4 is shown below:

Norberg: "What exactly was the Simpson circuit like ?"

Heintz: "Well, it was just like a conventional Hartley circuit, except it was double. There were two sets of inductances, two separate tuning condensers, two tubes. Then instead of taking the excitations for this tube from its coil, we took the excitations for this tube from this coil, we took the excitations from the other coil. That's all there was to the Simpson patent. This tube excites that tube. Therefore it isn't a single tube; therefore it doesn't infringe deForest. That's all. The trouble is , it is based on a fallacy."

Norberg: "Which is?"

Heintz: "And that is the internal capacity of the tubes is enough to affect excitation. If you take the plate lead off of the one tube over here, it'll go blithely along half-power, running on one side alone. But they don't do that. They pull the tube out and, of course, that cuts the filament off, too. Then, of course, nothing is going to work. That's all it was. The plate energy of this tube excites the grid of this tube and vice versa. Of course the other parts of the circuit were conventional."

Norberg:. "Did you ever use that circuit?"

Heintz: "Yes and no. We had to make the thing at least look like the Simpson. But the proportions were changed, vastly changed. We had to keep within the confines of the claims of the Simpson patent, at least attempt to. If that had ever gotten into patent court and we had to demonstrate that it was indeed a cross-excited system, probably the patent would have been declared invalid. That's being frank, but reason would tell you that that's so."

Because of Ralph Heintz' uncertainty about the strength of the Simpson oscillator patent, he began tests of another type of high-frequency oscillator that was clearly non-infringing upon the de Forest vacuum-tube oscillator patent. This oscillator was invented by Philo T. Farnsworth, a local San Francisco Bay area friend of Heintz, and who is best-remembered for his invention of the first all-electronic T.V. system. The Farnsworth oscillator depended on the transit-time of electrons, and for this reason is included in the early literature on klystrons (5).

A test of the Farnsworth tube was performed at a local I.R.E. chapter meeting at the H&K plant in South San Francisco (S.S.F.), on Sept. 13, 1934. This meeting was well publicized and was done in conjunction with the Globe Wireless station at Mussel Rock, with F.C.C. permission for a temporary test on the 35-meter commercial C.W. band. Mussel Rock functioned in its normal receiving mode, but the Farnsworth oscillator was used at the H&K plant in S.S.F. to drive a pair of 150-watt tubes in a final amplifier into a 35-meter antenna at the S.S.F plant. Phone lines brought the received signals from Mussel Rock to S.S.F., where the actual keying was done by licensed operator Mort Brewer. To be strictly legal, Bernard H. Linden of the F.C.C. office was present at the meeting and Mort Brewer (now W6JU) was the operator (both an I.R.E. member and a licensed first-class Radiotelegraph Operator). During this I.R.E. meeting, signals from the Farnsworth oscillator-driven S.S.F. transmitter were received at the New York and Honolulu stations of Globe Wireless, and also reported R9 by a ship 500 miles west of Honolulu and also by Sir Hubert Wilkins in New Zealand (6). The object of the test was to show representatives of R.C.A., G.E., and Western Electric (Radio Trust members) in the meeting audience, that H&K had a new oscillator for their transmitters that did not infringe any de Forest patents. In a magazine article in *Radio*, Oct., 1934 Arthur H. Halloran described the test of the new Farnsworth oscillator tube at the I.R.E. meeting (7). This article reports that the Farnsworth tube drove a pair of 150-watt tubes as a final amplifier in this test. This final amplifier was likely a pair of HK354Ds (high Mu version) that became the buffer-amplifier of the H&K type 920 transmitter. Mort Brewer recalls that the Farnsworth oscillator was intended to be the master-oscillator for the new 10-kW type 920 transmitter, as originally conceived.

The Farnsworth tube was truly different (although it still could be called a triode), and is shown in Figures 7a & 7b. It had two cold cathodes, each with a coating of cesium oxide on its emitting surface, one at each end of the tube. The anode was an annular ring in the center, midway between the cathodes, with electrons confined by a DC axial magnetic field. Since cessium oxide was not only a good photo cathode, but also a good emitter of secondary electrons, an electron emitted from one cathode (jolted by a flash of light) was accelerated toward the anode, and passed through the annular anode due to its own inertia and the confining axial magnetic field. This electron then struck the other cathode, releasing several more secondary electrons, and so on.

The facts that Farnsworth used a solenoidal magnetic field for focusing, cesium oxide cathodes for secondary emission, with photo-initiation of electrons and an annular anode, are all reminiscent of his work on the "image-dissector" camera tube that he used in his T.V. system. The involvement in H&K's efforts to get around the Radio Trust oscillator patents is yet another example of how the San Francisco Bay electronic innovators pulled together to "beat the big boys in the East." They had all, at one time or another, been the victims of R.C.A. and its friends trying to jump their patents or squeeze them out of the radio market.

As it turned out, Farnsworth had some quality-control problems with the oscillator tubes built for H&K. Subsequent tubes delivered to H&K were unreliable, so ultimately the H&K 920 transmitter was re-designed to use the old reliable Simpson oscillator that had served Dollaradio, Globe Wireless, and Dollar steamships for years (8). The fact that the Farnsworth oscillator had to be "shock excited" into oscillation, with a flash of light on either of its photo emissive cathodes, seems to have left a lasting impression on the audience of the I.R.E. meeting where the oscillator was demonstrated. This fact was to surface again in the future litigation in the H&K *vs* R.C.A., A.T.&T., and Vreeland patent infringement suit, which finally came to trial in late 1936 (9).

THE R.C.A. *vs* H&K LITIGATION ARRIVES

R.C.A. had been threatening to sue H&K for patent infringement for some years over a number of patents. The 1932 Consent Decree had defused many of these claims by the Radio Trust, but over the years David

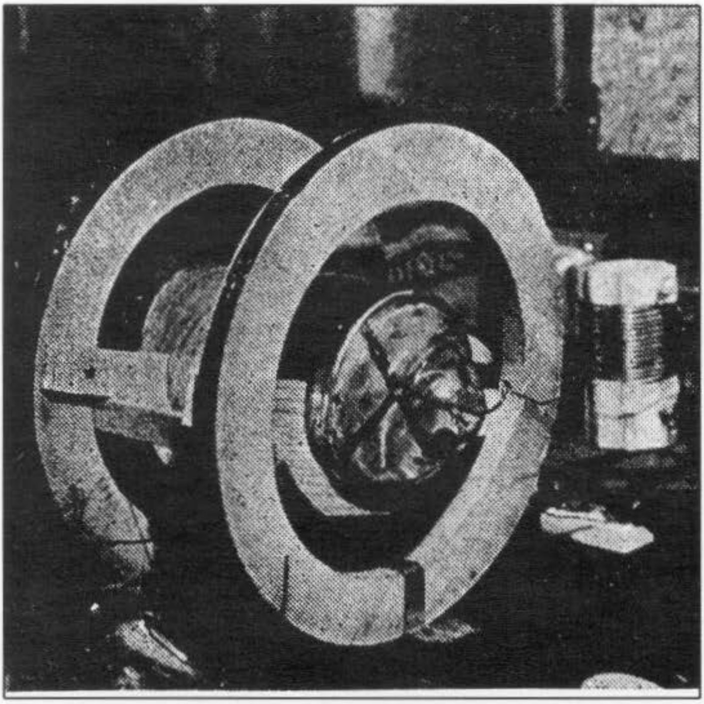


Figure 7a. *Picture, Farnsworth oscillator tube assembly.*

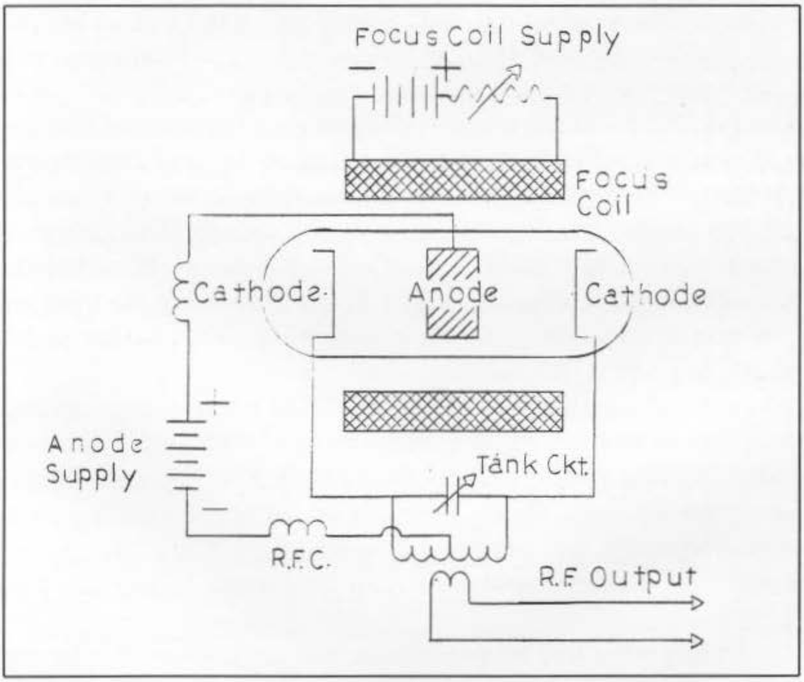


Figure 7b. *Farnsworth oscillator, circuit diagram.*

Sarnoff and Ralph Heintz had apparently developed an intense dislike of each other, probably because the latter had been consistently defiant of any legal threats from R.C.A., *et al.*

Finally, in 1935, R.C.A., A.T.&T. and Vreeland Apparatus Co. (a variation on the Radio Trust theme) filed suit against H&K in Federal Court for infringement of the deForest triode oscillator patents #1,507,016 and #1,507,017. The Suit did not come to trial until late 1936 in San Francisco Federal Court. In the interim, H&K assembled its technical defense. The bright young Stanford University professor Frederick E. Terman was hired as H&K's technical consultant, and a number of depositions were made by Terman, Heintz, and Globe Wireless employees for the defense. From the outset, the aim was <u>not</u> to try to defend the validity of the Dollar-owned Simpson patent, but to try to show that the deForest oscillator patents were invalid by reason of prior-art. Since it was a matter of historical fact that three triode oscillators (Goddard, Sindling-Larson, and Vreeland) had preceded deForest's patents, the trial strategy was to attack the deForest patent's validity.

A translation of the Norwegian patent by Sindling - Larson (#18,491, Feb.8, 1908) was made, and Heintz accompanied it with a deposition to show that the Sindling - Larson oscillator was equivalent to a triode-tickler feedback oscillator, in every way, even if the particular form of the tube used a cold cathode. The Vreeland patents (#829,934 and #829,447 of Aug. 28, 1906) were <u>not</u> <u>sited</u> by H&K in the patent infringement case, presumably because Vreeland was already signed up on the side of the prosecution. The Goddard patent (#1,159,209 of Nov. 2, 1915) was, however, used extensively in the H&K defense.

The H&K Tube Department embarked on a tube re-creation program to build nearly exact replicas of the oscillator tubes and circuits from figures of the Goddard patent and from drawings in the file wrapper of patent #1,159,209. Also, <u>variations</u> of the tubes and circuits in Goddard's patent file wrapper were constructed. These Goddard-derived "breadboard exhibits" were presented in depositions, by Ralph Heintz, for the trial, and also at a pre-trial demonstration for the prosecution, in the Dollar Building at 311 California Street in San Francisco.

When the trial finally came to court in San Francisco in late 1936, the key to a locked wooden chest containing the "breadboard exhibits" was presented to Judge Louderback by Ralph Heintz at the outset. Almost immediately the attorneys for the prosecution asked for a recess. At the end of a very short recess, they announced that R.C.A., A.T.&T., and the Vreeland Apparatus Co. wished to withdraw their complaint. Heintz and Kaufman <u>had</u> <u>won!</u>

Apparently what had happened was that the lawyers for the prosecution had realized that if H&K with its massive technical defense should prevail, then R.C.A, *et al* would lose a valuable patent position that had been held for over a decade, and had another six years to run. This was not an attractive prospect when weighed against the damages to be collected by the relatively small company, H&K, if R.C.A. *et al* should lose. Cooler heads, however, did prevail, and Sarnoff would have to calm his personal vindictiveness for the greater good of the Radio Trust.

Shortly after the court trial and decision, Ralph Beal, Vice President, R.C.A. and members of the R.C.A. legal staff flew to San Francisco for a formal settlement with H&K. After short discussions with Heintz, R.C.A. offered H&K the same terms and conditions they had in place with members of the Radio Trust — General Electric, Westinghouse, etc., granting use of R.C.A. held patents for a small royalty fee. Heintz and Kaufman agreed to these terms, thus bringing down the curtain on this historic litigation between the powerful Radio Trust on the East coast and the small, highly skilled West coast company and its founder, Ralph Heintz.

POST TRIAL POSTULATION

Looking at pictures of the breadboard exhibit (Figures 8 & 9) from Case 3945 L (8), and the careful notes taken on these tubes and oscillator circuits by Thorn Mayes when these were located at the Foothill Electronics Museum (now the Perham Foundation), an interesting progression seems to emerge (10). A sequence of exhibits, A through J, were fabricated and measured by H&K for the trial. They start with the bulbous glass double-anode, magnetically-deflected Goddard tube depicted in patent #1,159,209, (Fig. 11) and worked their way through simpler tubular magnetically deflected forms of Goddard's tube (as depicted on the file wrapper of patent #1,159,209), but not on the final patent (Figure 12), to electrostatically deflected versions of the tube as covered in the text of Goddard's patent. The electrostatically deflected versions of the Goddard tube in the "Breadboard Exhibits" use a single control electrode external to the tube in exhibits G through I, and then in the last exhibit, J, the electrostatic control electrode is put inside the tube. It would appear that Ralph Heintz intended to show that his Gammatron was a descendent of the Goddard tube, and that therefore the Gammatron oscillator as well as the Goddard tube oscillator represented prior-art to the deForest triode oscillator patents.

It seems a rather large stretch of the imagination to accept the fact that the Gammatron idea was derived from the Goddard patent, but nevertheless it is an interesting defense strategy. The first Gammatrons were built in 1928 and 1929, and none of the exhibits for the trial were built until 1935 and 1936. Perhaps it was better for H&K that such a defense was never used in open trial, if indeed that defense was the one intended.

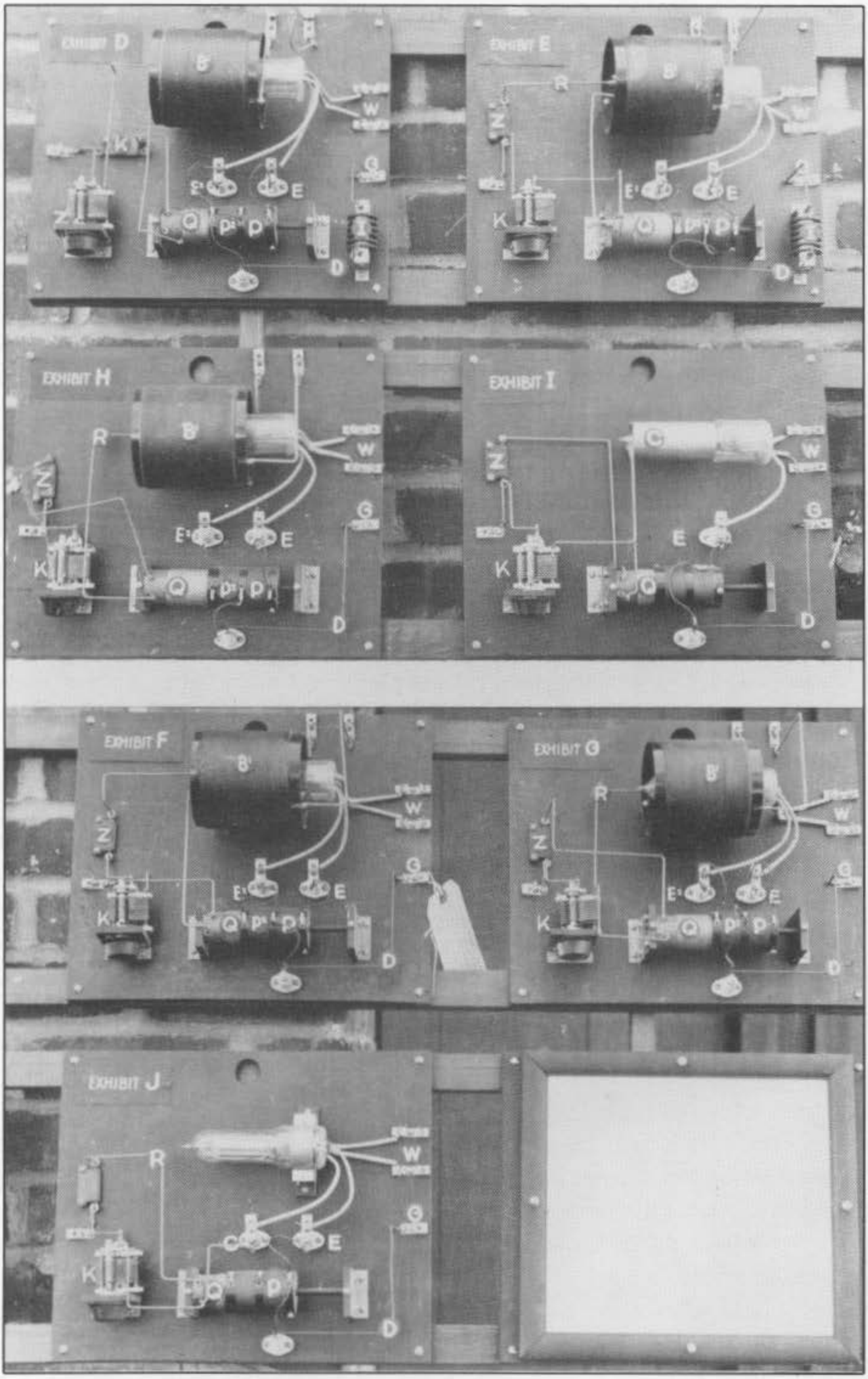


Figure 8. *Picture, H&K breadboards (Exhibits D thru J).*

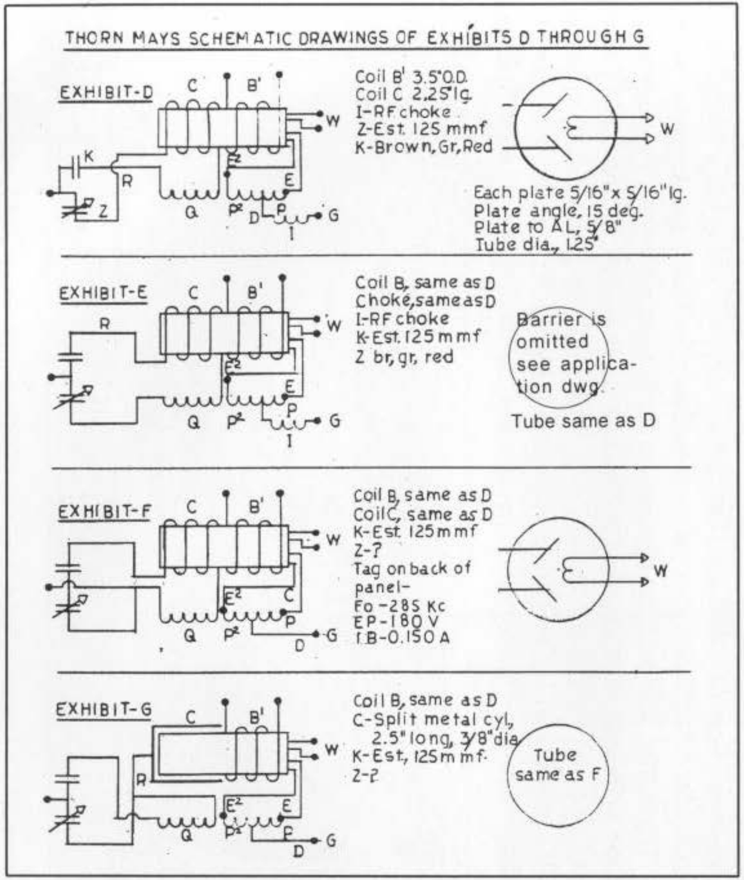


Figure 9a. *Thorn Mayes schematics of Exhibit D thru G.*

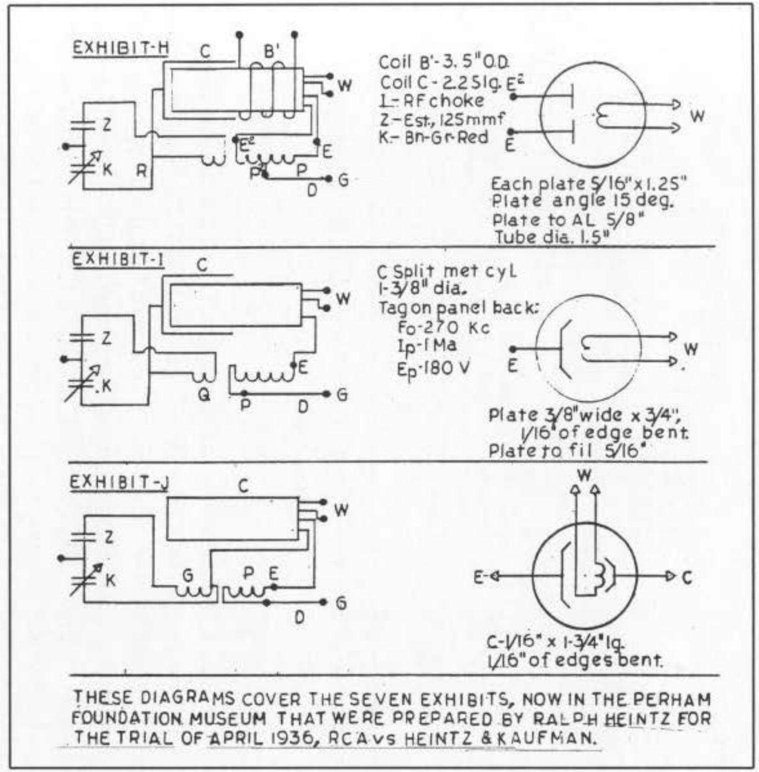


Figure 9b. *Thorn Mayes schematics of Exhibit H thru J. These diagrams were prepared from copies made by Thorn Mayes, June, 1936.*

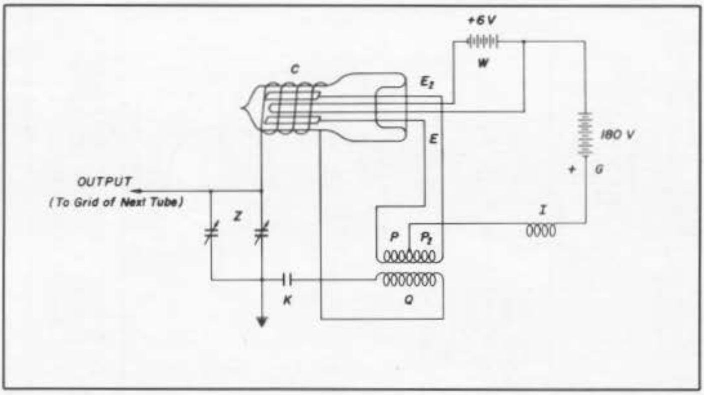


Figure 10. *Circuit of Exhibit D (without coil B) as used for the Mussel Rock tests, KGL.*

On the other hand, the depositions made by R.C.A., *et al* for the prosecution, by their own experts, seem even weaker. R.C.A.'s depositions declare that their vacuum tube experts had fabricated Goddard type oscillator tubes, but could not get them to produce sustained oscillations. They state that such tubes, if they oscillated at all, would have to be shock excited (memories of the H&K Farnsworth tube demonstration ?). The fact that the R.C.A. technical experts could not make the Goddard oscillator function pales in the face of a defense that had a chest full of working variations of the Goddard oscillator in court and available for real-time demonstrations.

H&K also had another deposition on file from Chester Pelmunder (of Globe Wireless) that attested to the fact that on July 21 and 22, 1936 the point-to-point station at Mussel Rock, KGL, had sent, with F.C.C. approval, paid commercial HF traffic to Manila and Honolulu with the Goddard oscillator equipped with Gammatron tubes, replacing the normal Simpson

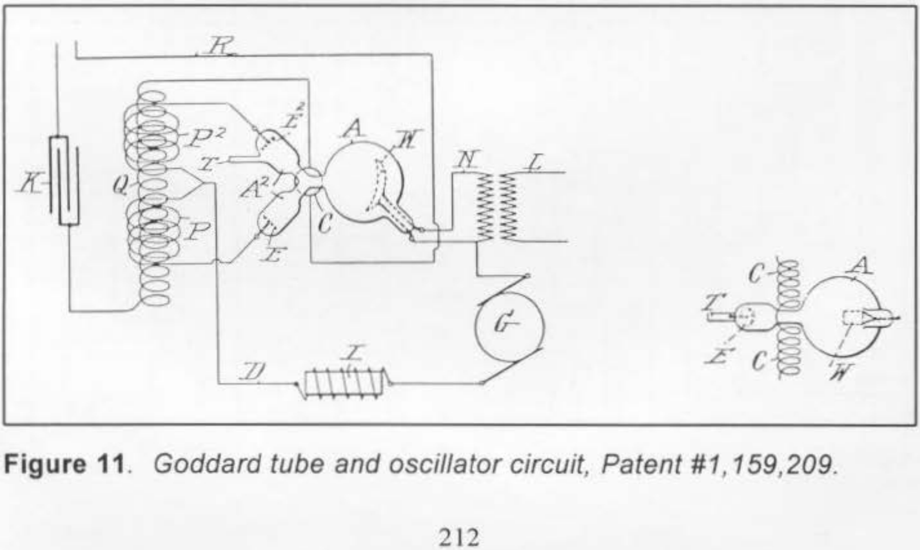


Figure 11. *Goddard tube and oscillator circuit, Patent #1,159,209.*

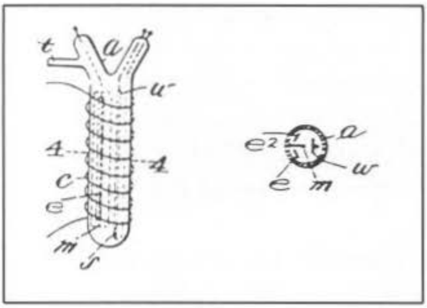


Figure 12. *Tubular form of Goddard oscillator or tube, Patent #1,159,209, file wrapper.*

oscillator. The transmitter that had its Simpson oscillator substituted for by the experimental Goddard oscillator was, no doubt, the new HK920 10-kW unit, which had such oscillator switching capability. The Goddard oscillator which was used for this test was exhibit "D" but without the DC magnetic field, coil "B." It is shown in Figure 10. This unit was blueprinted at the H&K plant on July 6, 1936 and has the print number 875-1 (3).

H&K developed a 10-kW transmitter for Globe Wireless key shore stations, designated the HK920. From a surviving Operations Manual its blue-line prints indicate that six were built (serial numbers 101 to 106) in 1935. The original block diagram of the H&K 920 transmitter is shown in Figure 13. As can be seen, it was a balanced design using push-pull and push-push pairs of H&K tubes from oscillator through final amplifier. The oscillators, of which there were two, selectable from the a front panel switch; were of the self-excited, push-pull Simpson type, normally using a pair of gridless Gammatrons. As to just which gridless Gammatrons were used in the 920 transmitter oscillator, the record is not entirely clear. The 920 manual does not have a tube specification sheet bound into it for the oscillator section tubes as it does for all the other stages. It would appear that the 920 manual goes out of its way to show that the oscillator section uses a Simpson oscillator and gridless Gammatrons, so as to be sure that the Radio Trust patents on the triode oscillator were not infringed. The reality may have

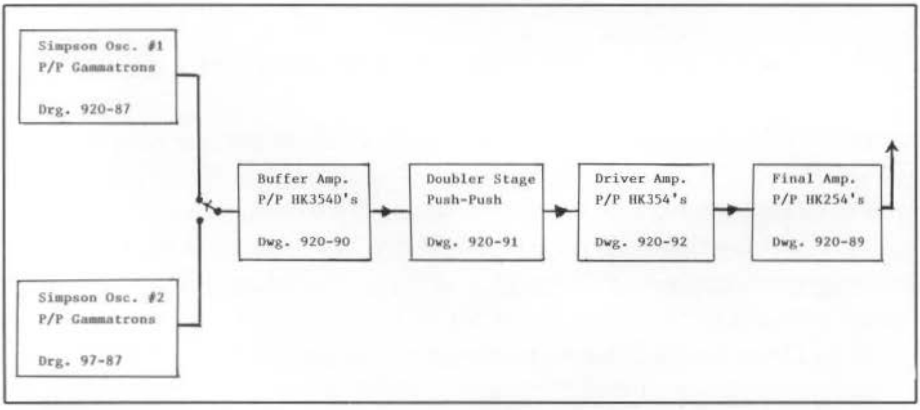


Figure 13. *H&K 920 transmitter block diagram.*

been, however, that HK354s were actually used in these Simpson oscillators, as they have been red pencilled in on the oscillator section print (920-87) by some operator. It is to be noted that the year 1935 was the year that R.C.A., A.T.&T., and Vreeland Apparatus Co. brought suit against H&K for patent infringement of patent #1,507,016 and #1,507,017, and that everyone at H&K and Globe Wireless was acutely aware of the impending trial.

Another puzzling question: What was the type of tube used in the final output stage of the HK920 transmitter? The HK920 Operators Manual specifies HK254 tubes for the final amplifier, complete with a bound-in copy of an HK254 tube spec-sheet, when everyone who ever had anything to do with the HK920 transmitter recalls the final amplifier tubes to be HK3054s. The problem with accepting the HK254 as the high power amplifier tube is three-fold.

Specification sheets were produced by H&K and advertisements published for both a large transmitting triode designated HK254 and for one designated HK3054, each having a plate dissipation of 1500 watts. All the other specifications are the same also, except for two items. The HK254 had a diameter of 7" and a weight of 10¾ pounds, and the HK3054 a diameter of 9" and a weight of 12½ pounds.

Heintz and Kaufman also made and marketed a much smaller tube, also designated HK254, a 100-watt plate dissipation tube. This smaller 100-watt tube was very popular, well documented and widely found by tube collectors.

No former H&K personnel nor tube collector/historians we have talked with have ever seen the larger type HK254, 1500-watt plate dissipation tube. We are inclined to believe that the high power HK254 tube never existed and that the tube used in the HK920 transmitter was indeed the HK3054. In any case, the HK3054 tubes were made solely for use in the HK920 transmitters and not sold on the open market.

H&K ENTRY INTO THE TUBE MARKETPLACE

During the depression years of the early 1930s many companies, large and small, were suffering from reduced revenues. Globe Wireless seemed to be holding its own, but the Dollar Steamship Company was experiencing very serious financial problems. Many Dollar ships were tied up at docks throughout the Pacific for lack of cargo and others were bing repossessed by the U.S. Shipping Board for lack of payment.

In 1932 the Radio Trust was ordered by the United Stated Government to stop its "restraint of trade" practices which were inhibiting other U.S. tube manufacturers. A "consent-decree" spelled out the cessation of exclusive cross-patent licensing, and detailed a plan whereby the Radio Trust companies would divest their holdings of each others stock. After the consent-decree H&K and other tube manufacturers, like Amperex and Taylor, began to make transmitting tubes with conventional grid structures and thoriated-tungsten filaments.

Taking advantage of the 1932 consent, H&K began producing and marketing grid-type transmitting tubes. The first H&K tube produced was the Gammatron HK354. H&K was now using the name Gammatron as a trade mark name for all its tubes. The HK354 was a low Mu triode with a rating of 150-watts plate dissipation, utilizing tantalum for its plate and grid, and using a thoriated-tungsten filament. The Mu of the HK354 was only 13.5, which was usable in power-oscillator service, and also suitable for amplifier applications. Heintz and Kaufman had decided to push its new HK354 in the amateur radio market, with a full-page ad in the January, 1934 issue of *Radio* magazine. The cover article introduced the new tube with its tantalum plate. Also, there was a feature article on the HK354 itself, and a construction article by Clayton F. (Bud) Bane (W6WB) on a 20- & 40-meter final amplifier. The tube campaign was started. A parallel effort by Frank Jones (W6AJF), in the *Radio Handbook* of Editors and Engineers, sought to expose hams to the new and old tubes made by H&K. Unfortunately the *Radio Handbook* took longer to go to press and thence to the ham market, so the 1936 Edition of the *Radio Handbook* was not seen by hams for over a year after the initial HK354 announcement in *Radio* magazine. Both *Radio* magazine and the *Radio Handbook* had West coast staff who were enthusiastic supporters of the tubes and people at Heintz and Kaufman.

The H&K marketing staff during this period realized the need for additional transmitting tubes in power ranges from 50- to 500-watts plate dissipation for the growing amateur and commercial market. To satisfy this need, the tube department developed both conventional and gridless transmitting tubes. Resulting from these efforts came the HK54 series of grid types and HK55 gridless transmitting tubes. Some of these tubes were advertised in 1936 (12). However, soon thereafter the gridless tubes were pulled from their product line. A month or so after H&K entered the ham transmitting tube market it was all over. Robert Stanley Dollar, still the majority stock holder of H&K, decided that the ham business would divert the labors of H&K staff from its main business, seeing to the needs of the Dollar steamship line. He therefore stopped the fledgling ham tube development and sales in its early stages. This came as an severe blow to the H&K staff, many of whom were amateur radio operators. Two noteworthy hams from H&K who could not accept this unwanted setback were Bill Eitel (W6UF) and Jack McCullough (W6CHE). In September, 1934 both Eitel and McCullough quit H&K and started their own business in a old store at 508 San Mateo Avenue in San Bruno, CA. The first tube produced by this new company, "Eimac," was the 150T, introduced to the ham radio market in November in *QST*, an amateur radio magazine.

The Eimac 150T used all the same materials, design and manufacturing techniques Eitel and McCullough had learned while at H&K, the only significant difference being the shape of the glass envelope. The HK354 used a tubular envelope and the Eimac 150T a globular envelope. Even this difference in the envelope was prompted by experience gained at H&K. The HK354 had the occasional problem of its tubular glass envelope collapsing when operated at excessively high temperatures.

Less than a year after Robert Dollar's decision caused H&K to cease its amateur radio tube efforts, he began having trouble meeting his company payroll, including that of H&K. In a meeting with Dollar, Heintz finally convinced him that H&K should be permitted to produce and market its products and services to outside customers to reduce the cash shortage problem. Dollar agreed, and H&K was back in the tube business on the open market. But the tube department's morale had been badly damaged by the loss of Eitel and McCullough, who's new company was now a strong competitor.

In late 1937, a year after the H&K victory over R.C.A and the Radio Trust, Heintz left the Dollar controlled firm to go to work for Eclipse-Pioneer, a division of Bendix in the East. The trial and constrained management imposed on Heintz and the H&K staff was taking its toll. He returned to the San Francisco Bay area after a two-year stint at Eclipse Pioneer designing 400-cycle, three-phase power systems for aircraft. He founded his own company in Palo Alto, with Bill Jack, an ex-president of Pump Engineering Services Co. (PESCO), a division of Brog-Warner. The new company, Jack and Heintz, was formed to make a new simplified aircraft starter that Heintz hoped to bring to market. The aircraft starter was a success, but in expanding their plant they ran afoul of local union practices and one night, with the aid of loyal employees, loaded all their factory equipment onto a railroad car and moved to Cleveland, Ohio. Cleveland was Bill Jack's home town, and he felt that the firm could better deal with the local unions there than in the San Francisco Bay area. Jack and Heintz went on to become a firm with thousands of employees, making aircraft starters, generators, bombsights, autopilots, and other sophisticated electromechanical devices throughout WWII.

After Heintz's departure from H&K, tube manufacturing and sales continued under the direction of other engineers at the plant. H&K Gammatron tube sales to amateurs and commercial markets grew steadily as new types were introduced. One significant new tube development in 1939 by H&K was the first transmitting power pentode, developed by Winfield G. Wagener of the tube department (11). The HK257 was the first of a generation of low grid-to-plate capacitance (Cgp) transmitting tubes, requiring minimal neutralization and having low drive requirements. The HK257 was used as a driver in the Globe Wireless updated MC-201 transmitters (A-4001) when these were converted to crystal-controlled M.O.P.A. transmitters from the original free-running high-power Simpson oscillators. The HK257 later became the 4E27 in its military version, and was used extensively in various WWII equipments.

As WWII approached, both H&K and Eimac found to their surprise that their West Coast style HF triodes were being designed into prototypes of military equipments for a new secret electronic apparatus called RADAR. It seemed that the simple, strong construction of these triodes provided the low inductance and low parasitic capacitance that was required for VHF radar ring-oscillators. During WWII, H&K expanded its production facilities to produce types 24G/3C24, 304TL, 304TH, HK257/4E27 and some of the VT- series radar tubes for the war effort. Eimac also tooled up to make these tubes, plus a whole line of other special radar tubes, such as the 15E, VT127, VT227, VT327, and VT527, in addition to vacuum capacitors, for the war effort.

In the late months of WWII there was further disagreement between H&K employees and Robert Dollar, resulting in the departure of Jack Kaufman and several others. In 1946 Kaufman teamed up with Garret Lewis (a tube manufacturer and rebuilder) to form the Lewis and Kaufman Company, a division of International Glass Corp. There they manufactured transmitting tubes under the trade name "Los Gatos," located in Los Gatos, California.

By the time WWII ended, H&K and Eimac had produced thousands each of over 75 different types of transmitting tubes and four types of ionization gauges. The world seemed to be awash in surplus transmitting tubes and sales prospects for new tubes did not seem promising. The trick to surviving in this era of plentiful surplus would be to offer new tubes that could outperform the existing cheap surplus types. To create this new demand, H&K had the design basics in their HK257/4E27, (and related pentode prototypes HK57 and HK357) and decided to reduce its R&D of new products. H&K had moved to newer, smaller and more efficient production facilities at 947 Broadway, Redwood City, CA in 1947. In order to solve a cash flow problem, the company decided to take advantage of a large U.S. Army contract to produce 40,000 more 3C24 triodes (for Army Radars that had been obsolete before WWII had ended). This conservative decision actually hastened the demise of H&K, and the remaining plant and its equipment were sold at auction on July 14, 1953. The building is now a welders' supply house near the corner of Broadway and Woodside Road (Highway 84) in Redwood City, CA. Many of the H&K tube personnel who wanted to push the pentode R&D at H&K joined Eimac. Years later, some of these Eimac employees, who were "Pentode Believers," formed a new transmitting tube company in Santa Barbara, CA called Penta Labs. They were successful on a relatively small scale at making transmitting pentodes, and the company was later absorbed by Raytheon.

Eimac, on the other hand, put its research efforts into creating their own version of the low-drive, low-Cgp transmitter tube, the tetrode. These were the Eimac 4-65, 4-125, 4-250, 4-400, 4-1000, etc. These tubes become widely used and the most imitated transmitter tubes in the world. Eimac, of course, prospered, and after merging with Varian Associates (which got its start with another type of tube important to radar, the klystron), became one of the largest transmitting tube manufacturers in the world.

If H&K had been free to seek its own market, which it was not permitted to do under the control of Robert Dollar, who knows what H&K and Ralph Heintz may have become in our information age of today. This is but one story of men, their inventiveness, foresight and leadership and most of all their human quirks that cause them to create and/or destroy giant industrial corporations.

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Jane Morgan,	Electronics In The West, National Press Books
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(SK: "Silent Key"...deceased.)

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Hank Olson, born 1931, San Mateo, Calif. has resided in Menlo Park, Calif. from 1936 to the present. At Stanford University he was fortunate to have Dr. F. E. Terman as instructor in radio engineering. As a student, Hank worked as a research assistant for the Radio Propagation Laboratory under Dr. "Mike" Villard, W6QYT, and Dr. Allan Peterson, ex W6POH, and with Dr. Lenord Fuller as a laboratory administrator. Returning to Stanford in 1956 following a two-year stint with the U.S. Army Electronics Proving Ground, Ft. Huachuca, Arizona, Hank worked on HF backscatter radar for two years during the International Geophysical Year (IGY), traveling to foreign sites about 40% of the time. He then transferred to Stanford Research Institute in 1958 for continuing work with the Radio Physics Laboratory for the next 28 years. Licensed W6GXN, Hank wrote articles for amateur and other technical publications (he stopped counting at 150). He taught night classes in electronics at Foothill College and is now consulting in electronic circuitry and researching radio history. His hobby is tinkering with a '56 Austin-Healy and a '73 Lotis. Hank lives in Menlo Park with his spouse of 33 years, Jane McKenzie Olson.

(EDITOR'S NOTE: It is with deep sadness that we record here the sudden and unexpected passing of Hank Olsen on March 9, 1996. The amateur fraternity and AWA have lost a valued friend and eminent historian. He will be missed.)

AL JONES, W1ITX/K6DIA

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Al was introduced to radio in his early youth by his father, W4OSN, and other local Connecticut amateurs. He was licensed in 1934 and acquired a BSEE Degree in 1939. His work career began as an Instrumentation Engineer in Experimental Flight Test with Pratt & Whitney Aircraft (P&W). During WW11, Al joined the U.S. Army, Signal Corps as a Radio Fixed Station Engineering Officer and assigned to the Pacific Theater, General McAurther's Headquarters, GHQ. There he was responsible for installing high-power transmitting stations, 2.5- to 50-kW, for GHQ throughout the Pacific. Following WW11 he returned to his former work at P&W and in 1951 joined North American Aviation, (NAA) in California as a Instrumentation Engineer on the Navaho Missile Program. Al held various engineering management assignments directing design, development, and fabrication of airborne and ground instrumentation and flight control systems. He followed these systems through successful flight test operations at Patrick Air Force Base, Atlantic Missile Test Range, now the Kennedy Space Center.

In the formative days of the U.S. Space Programs Al participated in many studies and proposals to provide instrumentation and communications systems for various future satallite and spacecraft programs including the Apollo. Following the Apollo contract award award to NAA, Al became Chief of Apollo Spacecraft and Ground Instrumentation Systems. After the successfull Apollo landing on the Moon, Al transferred to the NAA, Science Center where he managed several research projects developing new instrumentation systems for future planetary and earth resources programs. He holds several patents for multispectral and passive microwave radiometry instrumentation systems for earth atmosphere and surface monitoring observations.

Al retired in 1984 and remains active with his many interests and hobbies, principally, tube collecting and amateur radio. He is the owner and curator of the Ye Olde Transmitter Museum, Crescent City, California and has received the AWA Houck and Tyne awards for his contributions to documentation and preservation of vacuum tubes. His tube museum currently contains over 10,000 tubes from countries around the world, of which 4000 different tube types are displayed.

THE COLLINS RADIO COMPANY INGREDIENTS OF SUCCESS

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INTRODUCTION

My compelling reason for reason for researching and writing this paper was that I was curious as to why, of all the communication equipment designers and manufacturers, Collins rose to a level of success and eminence far exceeding any of the others. In my opinion, this success was assured as early as 1925 by the circumstances and events leading up to Collins', at the age of 15, handling the traffic for the MacMillan expedition. The paper had to go beyond that time, however, to show how the catalyst of the depression, followed by Byrd's success, pushed Collins into business and rocketed him to fame and fortune far exceeding anyone's expectations. As such, the paper is essentially limited to the period of 1920 through 1933, from Collins' boyhood days through Byrd's radio transmissions from the South Pole using Collins equipment.

PROLOGUE

Arthur Andrews Collins was born on September 9th, 1909 in Kingfisher, Oklahoma, the only child of Merle Hunter Collins and Faith Andrews Collins.

His father, M.H. Collins, was interested in improving farming techniques through specialization, combining smaller tracts into large, single crop farms and utilizing modern, high production farm equipment. Basically, his idea was to establish farm co-ops as we know them today. This idea did not sell well in Oklahoma, so the family decided to move to a more fertile and crop conscious area of the country. M.H. selected Iowa, and when Arthur was only a youngster of three the family moved to a modest two-story frame house (Figure 1) at 1725 Grande Avenue in Cedar Rapids, Iowa, only several blocks away from 1720 6th Avenue, the home of Arthur's paternal grandparents. In Iowa M.H. Collins convinced land owners that his ideas would improve profitability of their tenant farms, and the Collins Farms Company was formed. The company prospered over the years and ultimately moved the Collins family from the "modest" to the "wealthy"

Figure 1. *Arthur Collins first boyhood home at 1725 Grande Ave. SE in Cedar Rapids, IA. The family moved here from Oklahoma when Arthur was three years old. (Photo by author in 1992.)*

category. At its peak, the company managed over 60,000 acres of farmland in Iowa.

As with many young boys of that time, the radio bug bit Arthur early, at the age of eight. He and his friend, Merrill Lund, built crystal receivers at Merrill's house. Merrill's father worked for the Quaker Oats company (still located in Cedar Rapids today) and supplied the boys with cardboard tubes for coil forms. Next, the two pals got into spark transmitters using Model-T Ford ignition coils, but Mr. Lund drew the line when lightening hit their aerial and caused a small fire in the basement. M.H. was not exactly convinced that the boys should move their experiments to the Collins home, but while he was at work one day two wagon loads of radio "junque" were smuggled into Art's bedroom at 1725 Grande Avenue. At this time, young Collins was ten years old, World War I had just ended, and radio was poised for an explosive expansion.

THE INFLUENCE OF AMATEUR RADIO

To fully appreciate the Collins Radio Company success story, it is necessary at this point to divert somewhat and look at some general amateur radio history.

Marconi was successful in transmitting the first wireless signal across the Atlantic ocean from Poldhu, England to St. John's, Newfoundland in December, 1901. Suddenly, wireless became a household word, and thousands turned to more than a casual interest in radio experimentation. From this group emerged a contingent of experimenters who were referred to as "amateurs." They became proficient in Morse code, built modest stations and began to communicate with each other, albeit on a limited basis. Their primary interest was in experimentation, and it has been said that every major development in radio can be traced in one way or another to "amateur radio." Even Marconi considered himself an amateur.

The first piece of legislation governing radio stations was signed into law by President Taft in August, 1912. To the amateur it basically meant: he was restricted to wavelengths of 200 meters and less; he could not exceed one kilowatt of transformer input; and he was required to obtain a license from the Department of Commerce. At this time radio waves were considered by experts to be effective in proportion to their length, and the general belief was that waves shorter than 250 meters were worthless, except for very limited use. In other words, this was the lawmakers' way of legislating the Radio Amateur out of existence. With only minor modifications, this law was to regulate the amateur for the next 12 years.

World War I halted all private radio communication in 1917, but the wartime need for radio engineers, instructors and operators was largely filled from the ranks of the amateur radio community.

The year 1920 was the dawning of a new age for amateur radio. Advances in vacuum-tube technology brought about during the war years were being perfected, but the price and lack of availability of suitable tubes held back wide spread interest. "King Spark" was still the predominant amateur transmitter, and 200 meters, plus or minus, the wavelength of choice. Amateurs as a group became more oriented towards operating than experimenting and a great deal of emphasis was placed on handling and relaying messages, with new transcontinental relay records being set regularly.

In February 1921, RCA announced the availability of the UV-202 and UV-203, 5-watt and 50-watt transmitting tubes. This cleared the way for full scale amateur building of low and medium-power CW transmitters. Also, in February of the same year, the first series of one-way transatlantic amateur tests were conducted. U.S. hams transmitted pre-arranged signals which were listened for by British amateurs. Although commercial high-power stations were regularly communicating across the Atlantic at this time, no amateur signal had ever been heard from across the "pond." Unfortunately, the February tests were a failure, due in part to the number of British stations with oscillating regenerative receivers interfering with each another, as well as harmonic interference from high-power commercial stations.

The tests were repeated in December, 1921, this time with great success. Paul F. Godley, 2XE, the foremost receiving expert in America, was sent over to supplement the efforts of the British listeners so that "every chance of success might be provided." The first station heard was 1AAW on 270 meters, using a 60-cycle synchronous spark. Unfortunately, on subsequent verification this station turned out to be a bootlegger and to this day the operator has elected to keep his historical triumph to himself rather than admit his mischief. The next heard, and most consistent throughout the remainder of tests, was the now famous 1BCG of Greenwich, Connecticut. This was a station assembled especially for the transatlantic tests by a group of six prominent amateurs, notably including Edwin H. Armstrong. The transmitter consisted of a MOPA using a pair of 204s as the final amplifier and operated on a wavelength of 230 meters. The plate supply was a 2000-volt dc motor generator.

All in all, over 30 U.S. amateur stations were heard in Europe, but the most significant fact was that two thirds of them were using vacuum-tube oscillators which were running, on average, substantially less power than were the spark transmitters which got across. The superiority of continuous-wave RF energy over that produced by the damped wave of the spark set was clearly demonstrated once and for all. Another interesting point concerning these tests (which lasted for ten days) was that all listening was done in the vicinity of 200 meters. In fact, Godley's receiver was only capable of tuning down to 160 meters. The term "short wave" was still synonymous with 200 meters!

Also, in 1921 an amateur radio operator important to the Collins story began to attract considerable attention for his technical contributions. John Reinartz, 1QP-1XAM, of Manchester, CT was first recognized for his invention of an extremely simple and very effective regenerative receiver for CW . He did not stop there, however, and was ultimately credited with: first successful work below 150 meters; application of antenna theory to practical amateur antennas; first east coast station to work west coast (6TS) on 20 meters; first to recognize the involvement of the sun and ionosphere in long-haul, short-wave radio communication; first to experiment with crystal controlled oscillators, and the list goes on. One could not read many 1920s radio technical journals without stumbling over the works of John L. Reinartz over and over again.

During 1922 amateurs began building low-power CW tube transmitters, but were hampered by the high cost of transmitting tubes and the lagging technology for rectifier tubes suitable for supplying adequate DC plate current. Indeed, many CW transmitters were of the "self-rectifying" type with raw AC applied to the plates.

Many construction articles still promoted spark transmitters as the way to go, and all amateur transmissions were still taking place on "short waves" – 200 meters plus or minus 50 meters. It's no wonder that the transcontinental daylight tests continued to be dismal failures! The year 1922 did see some improvements in receiver design, including Armstrong's superregeneration concept and Reinartz's tuner and superheterodyne refinements, and it ended with some very successful one-way transatlantic tests (in both directions), but all in all, 1922 was a rather lackluster time for amateur radio.

Following this, 1923 started off at the same sluggish pace as 1922, but was destined not to end that way. Indications began to appear that, at last, the move to shorter wavelengths was about to begin. In the March issue of *QST*, Robert S. Kruse, technical editor, wrote an article entitled "Exploring 100 Meters" telling about a few innovative souls (led by John Reinartz) who had been experimenting with wavelengths around 100 meters with excellent results. He went on to give some ideas on how to tune down to 100 meters, and ended with an announcement of a 100-meter QSO party. Mr. Kruse followed up this article with another in the September, 1923 *QST* entitled "Getting Away from 200 Meters," which was more or less a scolding to all amateurs for dragging their feet in building new equipment and using the shorter wavelengths. In the best Amateur tradition, though, the article was quite helpful in that it summarized much of the technical information which had been written to aid hams in building equipment for the shorter wavelengths. For the first time, 200-meter operation was referred negatively to as "this long wave business." Also, very successful 105-meter tests, conducted by the National Bureau of Standards, were reported in the July, 1923 *QST*.

On November 27, 1923, at a time pre-arranged by cable agreement, both John Reinartz,1XAM and K.B. Warner, 1MO called French amateur Leon Deloy, (f)8AB on 100 meters. Deloy promptly answered both! Asking 1XAM to QRX, (f)8AB gave the honor of the first transatlantic amateur QSO to K.B. Warner,1MO, Secretary and Director of the ARRL. That all three stations were using transmitting circuits designed by Reinartz was certainly a tribute to his technical contribution to this great achievement. The age of amateur transcontinental communication had finally arrived! Going from sublime to ridiculous, the November *QST* reported on the negative results of the daylight transcontinental tests which had been held in September on – you guessed it – 200 meters!

As 1923 came to a close, the light was finally dawning for thousands of amateurs who had doggedly stuck on 200 meters trying to punch their high-power signals through daylight paths of atmospheric static and absorption, only to sit by and watch as a few of their more progressive fraternity received the accolades and recognition for many new international communication firsts using the "real" short waves.

Before we return to our Collins story, there is one more preface of history to relate: that of the expeditions of this era.

ARCTIC EXPLORATION

In the late 1800s and early 1900s there was a great deal of interest in global exploration. Many parties had casualties, perished, or were lost and never heard from again. The use of two-way radio communication would obviously have been of tremendous help, but was not a viable option for most expeditions until the 1920s.

One well known explorer significantly affected the destiny of the Collins Radio Company. Donald B. MacMillan was no novice; he had made eight trips above the Arctic Circle before 1923, and maintained that isolation from the rest of the world was his greatest fear. On one trip he had carried a receiver and listened to broadcast stations, amateurs, ships and government traffic, but on his next journey, he was determined to have two-way radio communication. MacMillan consulted with Hiram Percy Maxim, 1AW, the President of the ARRL, in early 1923, and by June, when his schooner *Bowdoin* sailed for a 15-month expedition to Greenland, a 200-meter amateur station was aboard along with a very capable operator, Don Mix, 1TS. Although communication during the summer months of long daylight periods was spotty, the autumn, winter and spring months allowed for reliable communication with WNP and proved to be a great comfort for the seven-man crew, who spent the winter frozen in the harbor at Etah, Greenland.

By the time *Bowdoin* returned to its home port in Wiscasset Maine, in September, 1924, plans were underway for her next trip back to Greenland in the spring of 1925. This next expedition was co-sponsored by the U.S. Navy and the National Geographic Society. Its primary purpose was to explore an unknown area of approximately one million square miles near the north pole to determine whether or not land existed there. To execute this formidable task, the Navy sent along with the USS *Peary* three Loening amphibious airplanes and a contingent of pilots and mechanics led by a young, yet-to-be famous, naval officer. The planes were to perform the exploration work from an advanced inland base while *Bowdoin* and *Peary* remained at Etah harbor in Greenland.

The Zenith company of Chicago, Ill. provided the special radio equipment for both the *Bowdoin* and the airplanes, and John Reinartz was employed by them to design and oversee the construction and testing. The expedition left Wiscasset, Maine on June 20, 1925 and was scheduled to return in about four months. Because of the time of year, the ships would be in continuous daylight once above 66 degrees North latitude.

ARTHUR COLLINS

Now, having brushed upon the historical facts most significant to our story, we may return more directly to it.

Art Collins was a studious child and devoured all the radio information he could find. He was different from the other kids, opting to experiment indoors with his radio equipment rather than play outside with the other children. It was providential that neither Art or his father was a licensed amateur prior to 1920 because as such, there was no commitment to pre-WWI equipment and practices, thus leaving the studious young experimenter with the time and inclination to research, evaluate and experiment with the exciting new developments which were just around the corner.

Art attended the Cedar Rapids public school system for his junior and senior high school years, and is remembered to be a tall, rather quiet lad to whom school work came easily. This was fortunate in that it gave him time to pursue his interest in radio. Having digested as much basic magnetic, electric, and radio theory as he could find in the library textbooks, Art stayed current with new developments by reading such periodicals as: *QST*, *Popular Radio, Radio Age, Wireless Age,* and *Radio Mechanics*.

He was always urged by the need for improvement and could see from the literature of the time that the unexplored region of the "real" short waves would provide the most fertile territory for discovery and development. He was also, no doubt, greatly impressed by the works of John Reinartz. Pushed by the desire to expand his experimental horizons and to discuss new ideas with contemporaries, Art obtained his amateur license from the Bureau of Navigation, Department of Commerce, in early 1923, at age 13.

In the same year, when most amateurs were still on 200 meters (many using spark), he was experimenting with a short-wave CW transmitter with an electrolytic rectifier power supply! This fact is evidenced by a letter he wrote to the editor of *Popular Radio*, published in the February, 1924 edition concerning questions about a coupling method between grid and plate coils and his desire for a "pure DC note." Such notes were a rarity amongst amateur stations in 1924, and it wasn't until 1929 that any serious emphasis was placed on achieving such purity. By June of 1924, 9CXX was a well known amateur station and was regularly seen in the "Calls Heard" columns of *QST*; by early 1925, his station was being heard all over the world.

Art Collins possessed what can only be described as an exceptional knowledge and divine-given insight regarding the behavior of RF energy. Even at the age of 14, his transmitter designs and construction techniques revealed these extraordinary gifts. Within the following several years, this young genius was to set the pace for solutions to some of the most vexing problems which plagued short-wave transmitter design at the time, including:

- control of parasitic oscillations,
- control of frequency instability,
- neutralization of RF amplifiers,
- efficient coupling of antenna to transmitter,
- single antennas for multi-frequency use, and
- efficiency and quality of class B modulators.

The first ingredient in the Collins success formula, then, was this young genius' own innate knowledge and skill.

By this time, M.H.'s business, The Collins Farms Company, was doing quite well and he decided to build Faith Collins' dream house which was to be a rather large, quarried stone federal colonial (Figure 2). A pleasant knoll, rare in the flat Cedar Rapids area, was selected as the site, and by 1924 Arthur had moved his ham station into a 12' by 9' third-story attic room which had sloping ceilings and a small window facing east overlooking the back yard. Arthur's father frowned on antenna masts which he felt would distract from the beauty of the splendid new house so, for now, Art would have to be satisfied with his 50-foot aerial and 48-foot counterpoise supported by the maple trees which were growing in the back yard. M.H did support his son's interest in radio, however, by agreeing to purchase transmitting tubes, high voltage transformers, and other parts.

Tubes such as 204As, which Arthur wanted, were not exactly cheap in those days and commanded a price between $150 and $200. In 1924, this was equal to 10 to 12 weeks' salary for an average working man! Serendipitous as it was, M.H. provided the second important ingredient in the success recipe for the future Collins Radio Company. So, young Collins had his components to build some effective transmitters, and he certainly did.

THE MACMILLAN EXPEDITION

In 1924, Art Collins, via ham radio, became friendly with John Reinartz who was 16 years his senior. In spite of the age difference, Reinartz had a great deal of respect for Collins and the two contacted each other often on various short-wave frequencies and exchanged ideas on transmitter, receiver and antenna design and construction. By early 1925 they were maintaining regular schedules on 20 and 40 meters. As such, the two became very familiar with each other's operating habits and other subtleties by which one Morse operator knows another. Art Collins spent the month of June, 1925 in New England visiting Reinartz and attending the sailing ceremonies of the MacMillan - Navy expedition. Certainly neither of these two fellow amateurs could know of the birth of the Collins Radio Company, still eight years in the future, yet this fellowship, spawned by nothing more than mutual respect and a common interest in radio, was to provide the third ingredient to this incredible recipe for success.

As the MacMillan expedition pushed its way towards Greenland in late June and early July, east coast amateurs and shore naval stations easily maintained radio contact with the expedition. The *Bowdoin* (WNP) primarily communicated with amateurs whereas the *Peary* (WAP) worked naval stations. Once the expedition was above 66 degrees north latitude, however, communications became spotty, and by late July there was 24-hour daylight and no radio communication.

The ships arrived at Etah harbor on August 2nd and the task of off-loading the planes began, along with the numerous other chores involving the plans and logistics attendant to the mission of setting up inland bases and providing for the ships' stay in the harbor. As expected, a great deal of traffic for both naval authorities as well as the National Geographic Society began to accumulate for the radio operators at WNP and WAP. The latter ship station was equipped with two transmitters: a standard Navy 2-kW, 500-kc spark set and a Zenith 2-kW vacuum tube set to be used to operate only on 500 meters. These were not the best choices considering the continuous daylight conditions, and WAP was unable to make any contact whatsoever. All traffic, therefore, would all have to be handled by WNP where the transmitter was a different story. John Reinartz had designed what he knew would be needed to maintain communication; a simple, 250-watt single 204A CW short-wave transmitter capable of operating on 20, 40, 80, and 150 meters.

On August 4th, WNP fired up to unload the many messages which had accumulated, but was unable to make any contacts on 40 meters, leaving 20 meters as his next resort. While the operator changed the coils to tune up on 20, he was thinking: "Hopefully, the band will be open, but will there be anyone on to hear me?" After all, 20 meters was still sparsely populated and knowing one's own exact wavelength was an art few had mastered. He sent out a general call, signed and listened for an answer. Tuning near his own frequency, he heard a strong, steady signal with a very familiar fist pounding through and he breathed a sigh of relief. Not only was John Reinartz the designer of the *Bowdoin*'s transmitter, but he was also its operator, and the answering signal was signing: "WNP WNP DE 9CXX 9CXX QRK? QTC? K."

For the next three weeks Art Collins was the only link between the Macmillan expedition and the rest of the world. He worked many hours each day copying thousands of words sent out in Morse code, letter by letter, in the form of messages to the U.S. Navy, National Geographic Society, and friends and relatives of expedition personnel. Each day he would deliver the messages to the Cedar Rapids Telegraph office for forwarding over the wire-lines as instructed. Soon news of this marvelous achievement spread throughout the country and many wondered how a 15-year old boy could accomplish a task which the Navy could not. Certainly not the least impressed by this incident was the young naval officer in charge on the *Peary*, Lieutenant Commander Richard Evelyn Byrd.

Fate arranged that Reinartz was to be the radio operator on this expedition and that Byrd (with his fame and exploits still ahead) was exposed

Figure 2. *Arthur Collins' second boyhood home at 514 Fairview Avenue in Cedar Rapids. From his attic radio room, radio amateur Arthur Collins astounded the public by contacting the 1925 MacMillan Greenland expedition (Photo by author in 1993.)*

first hand to young Collins's wireless skills. This was a decisive circumstance which would prove invaluable to Collins in the years ahead. In addition to the publicity focused on the young radio expert by many newspaper reports, there were also articles in the October, 1925 *QST* and November, 1925 *Radio Age* Magazine featuring pictures of the station at 9CXX. Arthur's mother and father were duly impressed by their son's notoriety, as evidenced by the appearance of two 30-foot antenna masts on top of the Collins residence.

So, the fourth and final ingredient of success for the Collins Radio Company had been folded into the pot and now the recipe could simmer to its full potential while the young Arthur Collins matured into manhood during the next five years.

AUTHORSHIP AND PROGRESS OF THE RADIO ART

As the year 1925 came to a close, the state of the art found wireless communication still using spark or self-excited CW oscillators with raw AC on the plates. Some more affluent amateurs were using battery packs or motor generator sets for their DC plate supply and some less fortunate but progressive souls were experimenting with electrolytic (slop jar) rectifiers and rotary synchronous rectifiers. Most realized the importance of cleaning up their signals as regards tone, stability and wavelength, but were hampered by lack of reasonably priced components.

In 1926 Arthur Collins wrote two articles for the *Radio Age* Magazine. In the April, 1926 issue, his article was titled "Getting Acquainted with the

Short Waves." Featured in the magazine's "Blueprint" section, it described the design and construction details of his receiver and included a picture and schematic. The May, 1926 article, also in the "Blueprint" section, discussed design considerations for short-wave transmitters with some pictures and schematics of the two transmitters at 9CXX. From these two articles one can easily grasp Collins' superior understanding of the behavior of RF energy, his penchant for circuit simplicity, rugged construction practices, and pleasing design appearance. His ability to express his technical ideas in clear, concise written words belied a youth of his age.

During the first part of 1926, 9CXX was quite active on 37½ meters, working New Zealand and Australia and handling traffic. The rig in use at that time was a pair of 204-A's in parallel and most probably used a mercury arc rectified DC plate supply. A brief encounter with an electrolytic plate supply had ended in frustration and the dumping of the jars out the window. Faith Collins, Arthur's mother, complained to friends years later that she was unable to grow any flowers in that area. Later, in 1926, for what reason is uncertain, 9CXX became inactive and the station address changed to 2619 Bever Avenue. This address is within a mile or so of both the Collins homes and probably was the result of understanding parents giving in to the wishes of an adolescent only child craving a degree of independence. Whatever the reason, 9CXX was officially moved back to 514 Fairview Drive by the end of 1927.

Art Collins was to have graduated from high school in June of 1927. Although he had completed the necessary prerequisites for graduation, he became bored with school and left sometime that spring and never bothered to return or graduate. No doubt the school saw fit to award a diploma at some later date.

THE 1927 INTERNATIONAL RADIOTELEGRAPH CONFERENCE

With world-wide pressure for more of the radio spectrum, an International Radiotelegraph conference was convened in Washington, DC in September, 1927 and by the end of November an international agreement among 55 countries and 23 dominions was signed. Most delegates, including those from Canada and Great Britain, were against the interests of the Amateur; however, through the efforts of K.B. Warner of the ARRL and the U.S. Military representatives to the conference, the amateur came out fairly well.

The main impact of this conference was agreement on the following points:

1. The amateur must be licensed by an agency of his government and the agency must assure themselves of the proficiency of the operator.

2. The amateur bands were now clearly defined and must be strictly adhered to.

3. The amateur must comply with all the general requirements particularly with regard to wavelength, stability and freedom from harmonics.

4. Call signs will be issued using prefixes from those assigned to each country.

5. The new law would go into effect on January 1st, 1929.

In early 1928, the ARRL initiated a technical development program funded by a cash surplus which the league had. This program investigated receivers, transmitters, and wave measuring techniques to enable all amateurs to better meet the 1929 standards. Under this program, Ross A. Hull wrote some very important articles. The two on transmitters dealt primarily with proper tuning of self-excited circuits to achieve a good note. Unfortunately, no coverage was given to DC plate supplies or crystal-controlled transmitters which were already beginning to show up quite frequently and held, of course, the immediate answer to frequency stability and clean clear notes.

The following quote is taken from the January, 1929 *QST* editorial: "It is the duty of every Amateur to prepare himself for the new life which exists on the other side of January, 1929."

THE BIRTH OF THE COLLINS RADIO COMPANY

Arthur Collins enrolled in Amherst College but it was not a rewarding experience. He was having a lot of trouble with his eyes (a familial problem) and corresponded with his father a great deal during this period. Probably due to a combination of eye trouble, boredom and homesickness, he left Amherst and returned to Cedar Rapids before his freshman year was over. As an only child Art was extremely close to his parents and called his mother from wherever he was every day of his adult life. He also observed a tradition of sending her roses on his (yes, *his*) birthday every year. After dropping out of Amherst, Collins took courses that interested him at Coe College in Cedar Rapids and also at the University of Iowa at Iowa City, but this radio wizard was never to graduate from college. Later, it was not uncommon for Arthur to have his secretary phone his high school math teacher and request an audience so Art could get help in solving a geometry or algebra problem associated with his design work.

Subsequent to becoming a nationally known teenage radio expert as a result of his accomplishment in contacting the MacMillan expedition, Arthur Collins' advice regarding high-frequency transmitter design was constantly sought by fellow hams as well as commercial and military interests. As he approached adulthood, (and with marriage in mind) it occurred to him that there must be a way in which he could make a living using his expertise.

Figure 3. *Arthur Collins' paternal grandparents home at 1720 6th Avenue SE in Cedar Rapids. In the basement, the Collins Radio Company was born in 1931 and operated there until the end of 1932. (Photo by author in 1992.)*

In 1930, Collins married his high school girlfriend, Margaret (Peggy) Van Dyke. The couple moved into Arthur's grandparent's house at 1720 6th Avenue (Figure 3) which was vacant due to the recent death of his grandmother. In the basement of this modest house, the Collins Radio Company was born. At first, small revenues were received for consulting and design services, and a few kits and transmitters made to order for some affluent hams sustained the fledgling "one man company." By 1931, the depression which was spawned by the stock market crash of 1929 was having a disastrous effect on the economy and the Collins Farms Company. When farmers were unable to meet financial obligations, it was customary for the Farm Company to extend credit in the form of loans backed by mortgages on the farm property. In turn, when the Farm Company was pressed for payment by its creditors, it had no alternative but to begin foreclosure on some of these mortgages. This situation was extremely distasteful to M.H. Collins and he sold his business to an insurance company in 1931. At this point, Arthur Collins, no doubt, realized that without the cushion of a profitable family business, his future depended on the success of his radio company. It was then that he began to design and construct what he knew the ultimate "1929" amateur transmitter should be: crystal controlled; pure filtered DC plate supply; separate oscillator plate source; parasitic suppression; proper neutralization; rugged construction and pleasing appearance, and most of all - HIGH QUALITY!

EARLY COLLINS TRANSMITTERS

By the end of 1931 the prototype of the first "production" RF exciter unit - the 10A - had been built and tested (Figure 4). The unit was constructed on a polished aluminum chassis with a bakelite front panel and used a 247 crystal oscillator, 247 buffer-doubler and a 210 output. This unit performed so well that it was used in six of the eight different transmitters produced by Collins during the next two years.

In early 1932 Collins began producing and selling complete transmitters in earnest. First came the 30W (Figure 5). This was a 30-watt CW-only rig which utilized the 10A RF unit with a power supply mounted below.

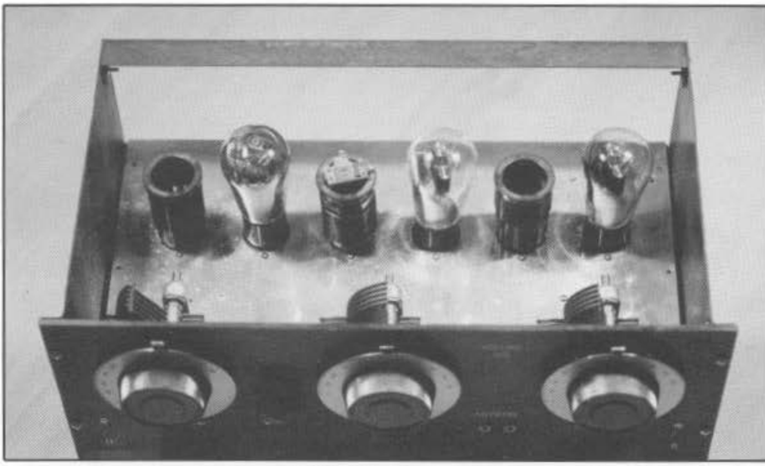

Figure 4. *The Collins 10A RF deck. This was the first Collins production unit. Using a 247 crystal oscillator, a 247 buffer-doubler, and a 210 final, the design was incorporated in six of the first eight transmitter models manufactured by Collins. (From the author's collection...photo by author.)*

Figure 5. *The Collins 30W transmitter. A 30-watt, CW-only unit, this was the first complete transmitter marketed by Collins. It used the 10A RF deck above with a 500 AX power supply below. (From the author's collection...photo by author.)*

Next was the 40B (Figure 6), a phone and CW version of the 30W using 46s as modulators.

The Collins 150B (Figure 7) was a 150-watt phone and CW transmitter which used the basic 10A exciter and a single 203A power amplifier modulated by a pair of 203As.

Toward the end of 1932, Collins designed and constructed his first "high"-power transmitter, the 20B (Figure 8). Although the creation of this transmitter was prompted by an affluent Illinois amateur who wanted a money-no-object ultimate ham transmitter, it resulted in Collins' debut into the commercial broadcast transmitter business. High-level class B modulation for low- to medium-power amateur transmitters had been pioneered by Collins. For this new transmitter extensive tests were conducted which proved that 204As and 849s were well suited to Class B higher-power circuits. The 20B utilized push-pull 204As modulated by 849s and proved to be a highly effective, low-distortion phone transmitter capable of a fully modulated carrier output of more than 750 watts. Although most transmitters could be delivered from stock, customers were advised that "20Bs are made to order and will require 30 days for delivery."

By the end of 1932, the company was rapidly outgrowing its quarters in the basement of Arthur's house and arrangements were made to lease the ground floor (actually three feet below ground) of a 1600 square-foot brick building at 2920 First Avenue (Figure 9). By January, 1933, the move was completed and operations resumed. Although there were only a few employees at that time, a newsletter was introduced to keep past and prospective new customers abreast of company progress. The first issue of the *Collins Signal* was published in February, 1933 and showed the first company trademark logo, a globe showing the western hemisphere with lines

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Opposite page:

Figure 6. *The Collins 40B transmitter. Introduced in mid-1932, this was an AM and CW version of the 30W, using PP46 modulators driven by PP 245s. (From Collins Bulletin 200.)*

Figure 7. *The Collins 150B transmitter. The first group of these 100/150-watt output AM/CW transmitters was actually made in the Collins cellar "Factory." Two 150Bs were carried on Byrd's 1933 South Pole expedition. (From the author's collection...photo by author.)*

Figure 8. *The Collins 20B transmitter. The first of these 750-watt output AM/CW transmitters was built in the Collins cellar "factory" for W9BHT. A 20B was carried by Byrd to the South Pole in 1933 and used for "broadcasts" via CBS to the USA radio listening audience in 1934. (From* The First 50 Years *by Rockwell International.)*

Figure 6. *The Collins 40B transmitter.*

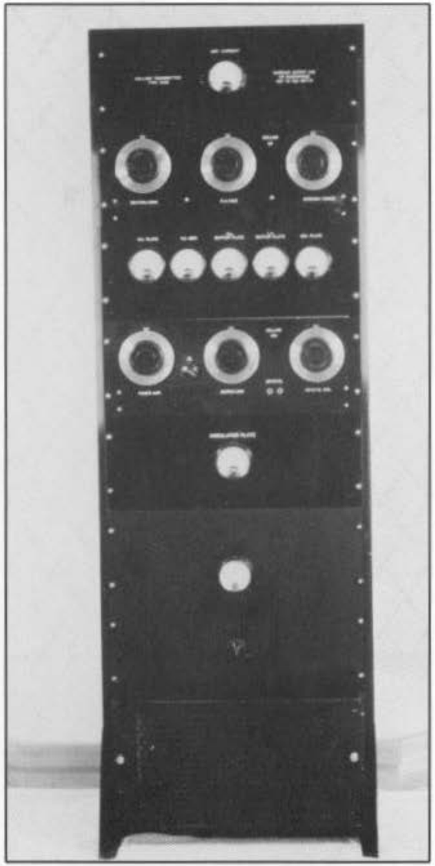


Figure 7. *The Collins 150B transmitter.*

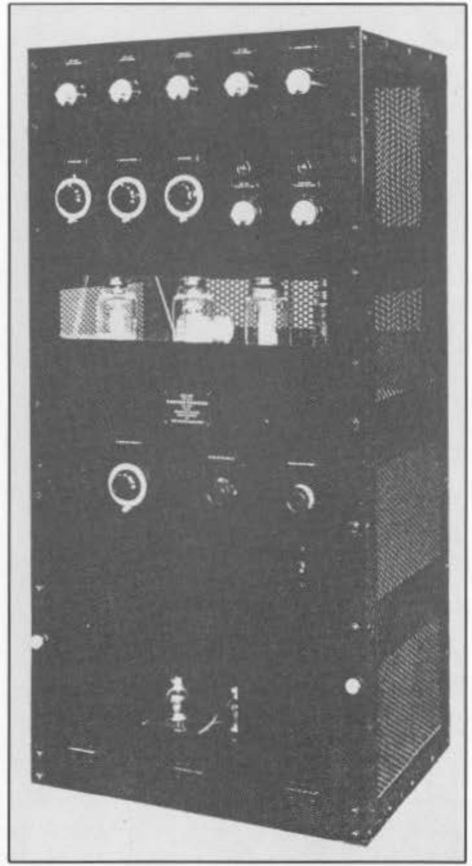


Figure 8. *The Collins 20B transmitter.*

Figure 9. *Site of the first "real" Collins Radio Company factory, 2920 First Ave. NE, Cedar Rapids. The company had outgrown its cellar location by the end of 1932 and moved into the ground floor of this building in January, 1933. (Photo by author in 1993.)*

of latitude and longitude and with long wings extending from each side (Figure 10). By mid-1933 the trademark had been modified by enlarging the globe, attempting to depict the entire world, and removing the latitude and longitude lines. The February, 1933 *Signal* was a four-page issue consisting of a detailed description of the new 20B kilowatt transmitter and showed a picture of a 150B and 20B installation at amateur radio station W9BHT. This provides important historical evidence that these relatively large transmitters were actually produced in the basement of Arthur Collins' house at 1720 Sixth Avenue.

In March of 1933 the 32A (Figure 11) and 32B transmitters were introduced. These units incorporated the 10B RF unit which utilized a pair of parallel 46s in lieu of the single 210 used in the 10A. The 32A was a CW-only unit while the 32B incorporated push-pull 46 modulators operating class B. Separate power supplies for the oscillator and final RF stages were incorporated in the lower section of each transmitter. Although these transmitters ran slightly less power (20 to 25 watts output), they were essentially lower-priced substitutes for the 30W and 40B units previously described.

In April of 1933 three new units were announced: The 300B, the 42A and 42B, and the 4A. The 300B was as higher-power (300 watts output) version of the 150B incorporating the 33A (push-pull 203As vs. single 203A) power-amplifier deck. Due to the greater size of the transformers involved, a second rack unit was utilized to house the modulator and modulator power supply decks.

The 42A and 42B units were not very well advertised and probably very few were actually manufactured. They did, however, herald a new look in RF-exciter deck design which became the Collins mainstay for the next two years. Using the same size chassis and front panel as the 10A and 10B units, the new design used a 47 crystal oscillator, parallel 46 buffer/doubler and a single 203A output tube. With 750 VDC on the 203A plate, outputs as high as 80 watts were achieved. It is not certain how many versions of this exciter deck were actually built but they were used in many of the 1934, 1935 and 1936 transmitters with known designations of 10J (Figure 12), 10K and 10M.

COLLINS SIGNAL

Published By COLLINS RADIO COMPANY Cedar Rapids, Iowa

FEBRUARY 1933

THIS is the first issue of a little bulletin which the Collins Radio Company will publish periodically and mail to all of its friends who have requested the Collins general catalogue. The COLLINS SIGNAL will serve principally as a supplement to the general catalogue and will keep it up to date. The format is such that it can be inserted in the binder furnished with the catalogue. In this way it will be possible to describe the equipment a little more fully and discuss in detail certain subjects which prove to be of general interest. However, we also propose to include newsy bits which will acquaint you with the radio activities of many of your friends and our friends. May we suggest that you write to us whenever something unusual or interesting occurs within the sphere of your activity. We will welcome suggestions as to what additional material should be included.

A Recent Collins Installation . . . .

The first installation of the 20B was made at W9BHT, the station of Mr. W. P. Ingersoll at Canton, Illinois. Mr. Ingersoll is an old-time amateur. Before installing the 20B, he had built several record making transmitters which had won him a WAC certificate and a host of friends throughout the country. Mr. Ingersoll's desire to have a station which would be the "last word" in appearance and performance led to the creation of the 20B. W9BHT now operates on [illegible] kc and [illegible] kc and "Bill's" voice has become familiar to amateurs and short wave listeners all over the globe.

Figure 10. *Page 1 (of 4) of the first issue of the* Collins Signal, *February, 1933. Only a month out of its cellar "factory," Collins published its first of many* Collins Signals. *This page shows the first version of the company logo and provides evidence that the relatively large transmitters pictured, the 150B and the 20B, must have been manufactured in the cellar location. (Author's collection...photo by author.)*

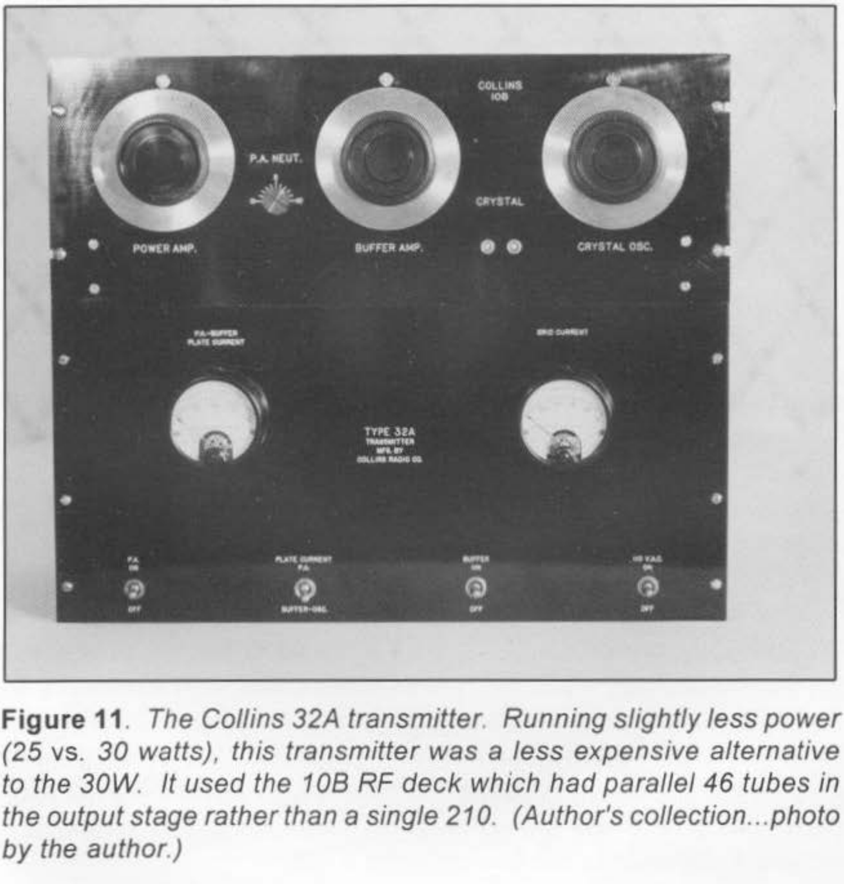


Figure 11. *The Collins 32A transmitter. Running slightly less power (25 vs. 30 watts), this transmitter was a less expensive alternative to the 30W. It used the 10B RF deck which had parallel 46 tubes in the output stage rather than a single 210. (Author's collection...photo by the author.)*

The 4A transmitter (Figures 13 and 14) was Collins' first and last stab at the "extremely low priced" amateur transmitter field. This classy little table top rig used a 47 crystal oscillator and parallel 46s as the output stage and was capable of putting out a clean 20-watt CW signal on 160, 80 and 40 meters. Separate oscillator and final power supplies were self- contained and typical Collins quality is evident throughout. The selling price was about $60, less plug in coils and tubes.

Only top quality parts were used in Collins transmitters. General radio knobs and dials, Weston and Westinghouse meters, and Hammarlund and Cardwell variable condensers were all standard.

Transformers and filter chokes were made to Collins' specifications by The Chicago Transformer Corporation, a high-quality parts manufacturer who put only the OEM part number on the unit. In its sales literature, Collins freely provided specifications, diagrams and parts and price lists for all components of each transmitter. If one was so inclined he could build a copy of any unit by purchasing only those items which he was unable to obtain elsewhere.

All transmitters introduced before 1934 left the sticky problem of effectively coupling the output stage to the antenna pretty much up to the user. In a classic paper written by Arthur Collins and published in the February, 1934 *QST*, this situation was put to bed once and for all, and subsequently all Collins transmitters were equipped with adequate antenna impedance matching networks.

ADMIRAL RICHARD BYRD AND THE SECOND ANTARCTIC EXPEDITION

Sometime in mid-1933 a remarkable and fortuitous series of events began to unfold. Rear Admiral Richard Byrd was planning to depart in late 1933 on his second expedition to the Antarctic and contacted Arthur Collins about the possibility of supplying the necessary radio transmitters. To fully appreciate this, we must take a moment to glance back in time.

In September, 1928 Commander Richard E. Byrd had departed from New York on his first expedition to Antarctica. The two main ships were the SS *Eleanor Boling,* (WFAT) and the SS *City of New York,* (WFBT). Both ships carried 2kW self-excited transmitters capable of operation on intermediate and high (up to 22 mc) frequencies. The ships arrived at Dunedin, New Zealand in late November, 1928 and by January, 1929 a base station on the polar ice barrier at the Bay of Whales had been established. Amateur as well as commercial and naval radio communication, primarily CW, was readily maintained throughout Byrd's first Antarctic expedition which returned to the U.S. in the late spring of 1930.

Figure 12. *The Collins 10J RF deck. Announced in mid-1933, this RF deck was first used in the 42A and 42B lineup. (Author's collection...photo by author.)*

Figure 13. *The Collins 4A transmitter. This was Collins' first and last try at the "low price" amateur transmitter market. Introduced in mid-1933 with a selling price around $60, less coils and tubes, it had 20 watts of CW output on 160/80/40 meter bands. (Author's collection...photo by author.)*

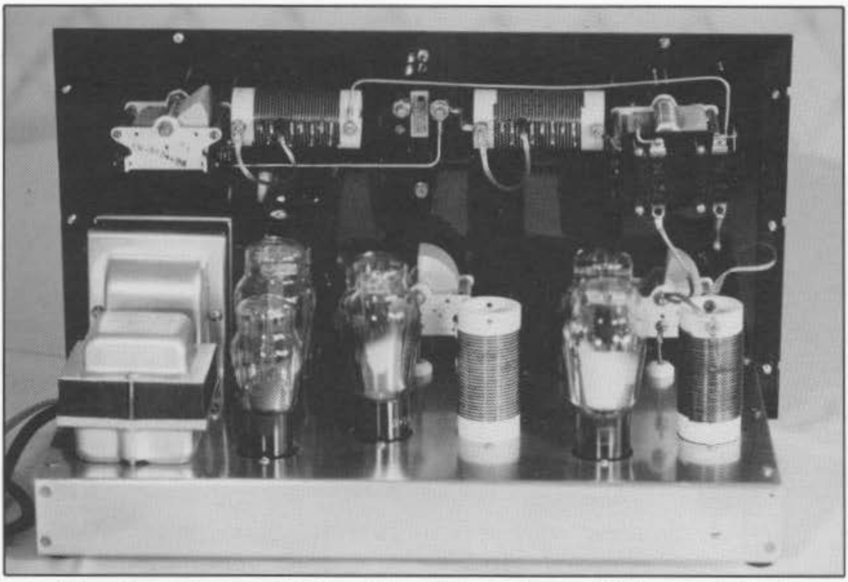


Figure 14. *A rear view of the 4A. Separate oscillator and final power supplies are on the left, the crystal oscillator is in the middle, and the final pair of 46s is on the right. The 2C antenna matching network is on the top. Collins quality throughout! (Author's collection...photo by author.)*

The use of short waves for long distance work together with advances in receiver and transmitter design had certainly provided the desired safety and effectiveness for the exploration work of Richard Byrd. Ironically, though, they probably allowed for a certain lack of fanfare and public acclaim for the explorer and his achievements. What Admiral Byrd wanted for his second expedition was not only dependable short-wave transmitters, but ones that would provide for reliable telephony communication between the Antarctic and major cities in the U.S.!!! Quite naturally, he turned first to the one person he knew, who as a boy of 15 had accomplished a communication feat which all others found impossible.

Commercial, trans-continental radio telephone transmitters were, of course, in use at this time but were found only with output powers in the vicinity of 50 kilowatts. Because of weight and power limitations of the polar expedition, Admiral Byrd needed reliable equipment which would be in the one kilowatt-size category, and Collins had just what he needed - the 20B, which had recently been designed and was successfully in operation at W9BHT.

Admiral Byrd fully realized that dependable CW equipment would provide adequate communication to insure the safety and success of the expedition, but he wanted more - to create public awareness and support for future polar exploration by transmitting directly to the homes of the broadcast audience from the South Pole.

After several rounds of consultations and negotiations, CBS not only agreed to underwrite the project, but was able to sell the proposed broadcasts to a prominent advertiser, General Foods Corporation. Hindsight shows that this bold proposition was an incredible gamble for all involved. Failure undoubtedly would have damaged the reputations of Byrd, Collins and CBS to say nothing of the financial repercussions. With more of this thought in mind than would probably would have been admitted to, the Collins Radio Company, with eight employees and a capital of $29,000 was incorporated on September 22, 1933. Originally, 250 shares were authorized and issued as follows: one each to Arthur A. and M.H. Collins and 124 each to Margaret and Faith Collins.

Byrd's flagship, the *Jacob Ruppert*, departed Boston harbor on October 11, 1933 bound for the South Pole. Aboard were a Collins 20B and two 150B transmitters together with countless spare tubes, parts and accessories to maintain these units for a period of two years.

The first broadcast was made from a position approximately 1600 miles south of the equator and several hundred miles west of Chile. Propagation was not the greatest and the *Jacob Ruppert* was pitching and rolling in heavy seas. Nevertheless, their transmission was received in New York and placed on the network at the announced time. Broadcast listeners all over the country were amazed and entertained with sounds of the ship's whistle and the barking of over 100 huskies as well as narratives by various crew members throughout the ship, including some words by Admiral Byrd himself. Other broadcasts were successfully made from different locations as the expedition continued on to its destination. The first radio "broadcast" from the Antarctic continent was made on February 3, 1934 from the expedition's mess hall some 15 feet below the surface. Subsequently, regularly scheduled broadcasts became routine and the Collins transmitters continued to perform with "little to be desired".

The gamble had paid off for all involved. Word of the performance of Collins equipment spread rapidly and soon orders and requests were coming in from all over the world. More importantly, the interest was coming from governments, civil agencies, companies, rulers, and affluent persons, all of whom had special or unusual requirements and could afford to pay for what they wanted.

From there the Collins Radio Company went on to become a virtual giant in the electronic communication, avionics and telecommunication fields. It ultimately rose to a peak employment of over twelve thousand people, successfully defended itself against an unfriendly takeover by a small data processing firm owned by H. Ross Perot, and negotiated an amicable merger with the North American Rockwell Corporation.

All of that, however, including the many other Collins breakthroughs such as permeability tuned oscillators, autotune transmitters, aircraft radio navigation, and others, is another story for another time.

F. PARKER HEINEMANN

Parker Heinemann became interested in amateur radio through Boy Scouting and received his FCC license at the age of 15. He graduated from King's Point in 1953 and served on active duty in the United States Navy until 1956. After 10 years of employment as a nuclear submarine design engineer with General Dynamics, he founded Custom Marine, Inc. a marine and aerospace manufacturer. He is a licensed professional engineer in the states of Florida and Connecticut, and for the past 15 years has spent most of his amateur radio time researching and collecting pre WW II amateur equipment.

GILFILLAN BROS. INC., EARLY RECORDS

Floyd A. Paul
1545 Raymond Avenue
Glendale, CA 91201

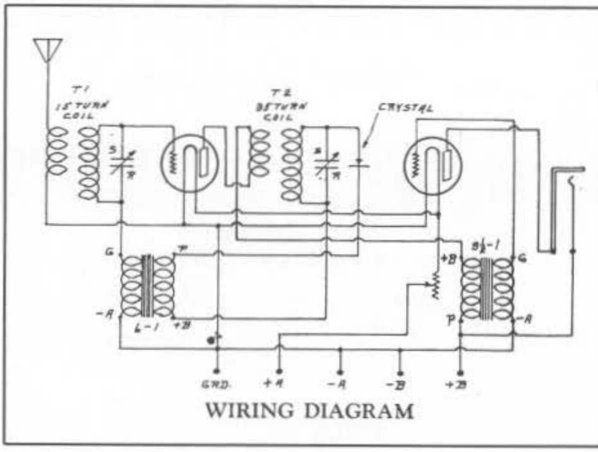
PROLOGUE

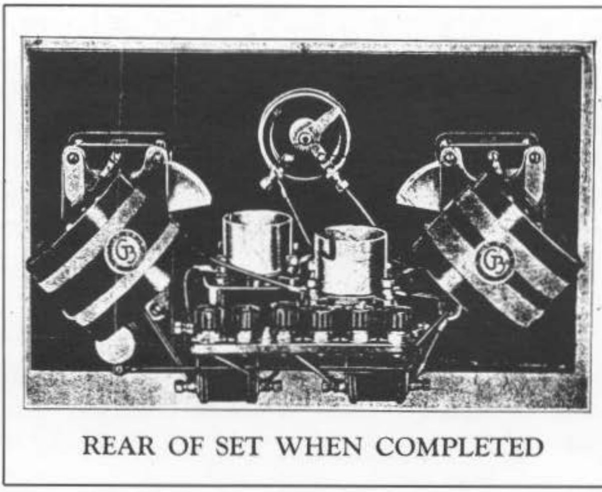
The author had an opportunity in May of 1993 to review early records of Gilfillan Bros. Inc. between 1917 and 1940, located in the ITT-Gilfillan archives. Ed Reitan, a member of the Southern California Antique Radio Society (SCARS), who is the ITT-Gilfillan historian, arranged for the author to meet Brian Eden, Director of Public Relations, who allowed Ed and the writer into vault files. Records included sets of minutes from annual stockholder meetings, a Radio Corporation of America 1927 licensing agreement, a 26-page 1940 RCA Commercial Radio and Miscellaneous Apparatus license-agreement form, correspondence between RCA and Gilfillan on licensing issues, and old Gilfillan stock certificates. Since these records shed light on early conditions in the radio industry, including the licensing arrangement that RCA used in 1927-28, the author felt it important to publish some additional history related to Gilfillan, RCA and the rest of the industry.

This article keeps its material in chronological order within the subject matter. For it to be most meaningful, the reader should see the article on Gilfillan Bros. in Paul [1], since that information is not repeated here.

1815 VENICE BLVD.

The Gilfillan Bros. Smelting and Refining Company changed its name to Gilfillan Bros. Inc. in 1921. S. W. (Sennet William) Gilfillan was president of the company and his brother Jay was vice president. It was located at 217 W. Sixth St. in Los Angeles. Minutes of the company show that on October 9, 1922, the company purchased a site at 1815-1825 W. 16th St. (later renamed Venice Blvd.) to erect a factory and office building. On February 21, 1923, the last corporate minutes were recorded at the Sixth St. address. The March 21, 1923, minutes list the new site. Directors S. W. Gilfillan, G. L. Alspach, and A. W. Klusmann (secretary) were present.





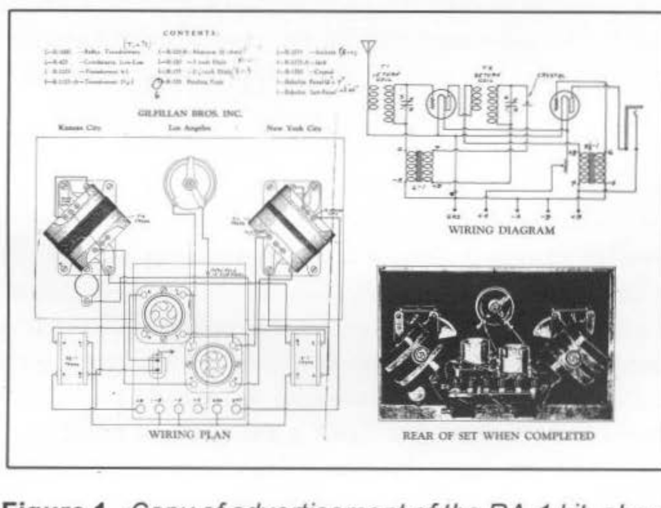


Figure 1. *Copy of advertisement of the RA-1 kit, about 1923. (Courtesy of John Stokes, New Zealand.)*

OUT-OF-STATE BRANCHES/FACTORIES

The Kansas City branch was opened about 1922. The author talked to Mrs. Jay Gilfillan about company history in 1984 and again in 1993. She vividly recalled Gilfillan employee Paul Breting being assigned to go east in the early 1920s to manage the Kansas City facility. Records show that the company had a location at 1925 McGee in 1923 and 2525 W. Penn Way in 1924-25. No address was found for later years [2]. The 1925 McGee address was likely a rental facility; the February 20, 1924, meeting minutes showed a 15-year lease was made on W. Penn Way for a one-story business building.

A New York City branch was opened about 1922. Advertisements in *Radio News* in 1923-25 had "Gilfillan Neutrodyne sets manufactured in our three factories, Kansas City, 2525 W. Penn Way; New York City, 225 W. 57th St.; and Los Angeles, 1815 W. 16th St." However, an instruction booklet for the Gilfillan GN-5 neutrodyne, a set marketed by the Fall of 1925, had an address of 25 Wilbur Ave., Long Island City, New York. Minutes of a directors' meeting of November 17, 1926, stated "it would be for the best interest of Gilfillan Bros. Inc. to close the Long Island Branch and carry on the middle west and eastern business from the Kansas City Branch."

The third branch, in Waukegan, Illinois was opened in 1928. The Kansas City plant was closed and its functions were transferred to Waukegan about the time Gilfillan signed a contract (1928) with Fansteel Products Co. to make radio sets for the latter in the Chicago area. The Waukegan branch closed about 1931 (see section below on Fansteel and Balkeit).

1927, A LICENSING YEAR FOR RCA

By the mid-1920s RCA held many key radio patents and had been considering ways to capitalize on them by licensing radio manufacturers to make tuned-radio-frequency (TRF) sets. Industry too, was clamoring to use RCA patents and the company was being forced to move on the issue. To establish a precedent and a controlling position in the industry, RCA brought a lawsuit against Splitdorf in 1926 (see Douglas [3]). The lawsuit, which was settled out of court in March of 1927, was RCA's key case. It brought other makers into line to sign agreements and pay royalties to RCA. (The Splitdorf case should be read because there was a scenario which suggested Splitdorf did well for itself, but RCA did better, by settling out of court.) *Radio Retailing* magazine of April 1927 reported Zenith was the first of the independents to be licensed by RCA.

On the West Coast, Gilfillan Bros. was the first company to be licensed. The date was July 1, 1927. The ITT-Gilfillan files contain a copy of a

Gilfillan Bros., Inc.

Figure 2. *Personal stock certificate of S.W. Gilfillan, Number A1, dated May 12, 1924.*

10-page form-contract, "License Agreement between Radio Corporation of America, General Electric Company and Westinghouse Electric & Manufacturing Company, and Gilfillan Bros., Inc." The agreement's minimum annual royalty assessment of $100,000 per customer would presumably weed out small manufacturers and limit the issuance of licenses to larger, better organized, and more financially responsible customers.

BACK ROYALTIES

When RCA signed agreements with radio makers, it expected to collect back royalties for sales each company had previously made from the manufacture, use, and sale of TRF receivers. RCA termed such royalties "liquidation damages." The license provisions on liquidation damages were very specific and stated an assessment amount, but RCA allowed for partial payment of liquidation damages up-front. Credit toward the balance owed would be allowed from future royalties collected from the licensee (and hence most likely never collected). Gilfillan was assessed, up front, 20% of the $109,865.94 that RCA decided was due for back royalties.

Splitdorf and Atwater Kent may have avoided back royalty payments altogether (not public information in 1927; see Douglas [4]), and other companies may have made only partial payment. Zenith was allegedly assessed over $500,000 in back royalties. Licensees did not have knowledge of what RCA charged others for back royalties, and thus RCA kept every company in the dark about others' payments.

1927-28 ROYALTY PAYMENTS

Douglas [5] has some figures indicating that RCA received less than half of the potential royalty payments in 1928 from the companies which it had just licensed. Obviously, RCA must have made concessions. One such concession showed up in the Gilfillan files. A letter of March 9, 1928 from RCA, signed by David Sarnoff, made the case for Gilfillan owing royalties of $50,000 for the year 1927 (prorated from July 1 to Dec. 31 at $100,000 for the year). The letter stated the royalty payment for sales in 1927 amounted to less than the prorated amount of $50,000, namely, $41,094.25. It stated that the deficit amount was forgiven (waiving the enforcement fees) and that all others who had not met the agreed assessment fees for that year were also forgiven. In the Spring of 1929 Gilfillan received a similar letter for the 1928 yearly royalties of $100,000. It also forgave a $20,000 deficit due RCA.

From July 1927 through 1928, Gilfillan, operating under RCA license, made only its own sets at the Venice Blvd. plant. Concern for future RCA deficits may have been a cause for S. W. Gilfillan's decision to bring unlicensed Los Angeles manufacturers into his plant. He could make up the potential royalty deficit for 1929 and earn additional income from the use of Gilfillan plant space.

Background on RCA licensing and royalty payment will be found in MacLaurin [6]. He reports that the 7½% royalty was reduced to 5% in 1932 and then to 2½% in 1939, and that the minimum annual royalty was reduced to $10,000 in 1932 and removed altogether in 1946. Licensees, according to MacLaurin, went from 25 in 1928, to 55 in 1941, and 186 in 1947.

FANSTEEL, BALKEIT, AND GILFILLAN

This author envisions the following conditions existed and events took place in 1928. Fansteel Products Co. of Chicago was a metallurgical company making battery chargers and battery eliminators in the mid-1920s. It decided to add a line of radio sets. With no history of receiver-manufacturing capability, and with RCA issuing licenses only to companies which were established and able to pay $100,000 yearly royalties, Fansteel looked around for a nearby RCA licensee which could make radio chassis for them.

Gilfillan Bros. had undoubtedly been purchasing tungsten and tantalum products from Fansteel in the 1920s for the production of automotive ignition parts, and the two companies knew each other. Fansteel presumably knew of Gilfillan's RCA-licensed radio plant in Kansas City. Perhaps the plant could be moved closer to Chicago under a beneficial financial arrangement to assemble sets for Fansteel.

S. W. Gilfillan, on the other hand, was looking for a quantity set producer to increase his RCA royalty payments and thus make up the royalty deficit being experienced in 1928. Gilfillan Bros. most assuredly put feelers out to RCA about the possibility of moving the Kansas City plant to the Chicago area and, as history shows, got positive vibrations from RCA. So fate brought Fansteel and Gilfillan together.

The following information comes from the historical files. In February, 1928 Gilfillan contracted with Fansteel to make a line of radios under the name Balkite. In April, RCA granted Gilfillan authority to transfer its Kansas City branch (factory) to Waukegan (suburb of Chicago) for set production. In May, Fansteel was showing its first sets at an annual Balkite sales meeting in Chicago. By June, it was running full-page ads in *The Talking Machine World* showing three models. Management was quoted as saying "The Balkite line has never been the lowest priced," and "The product does not attempt to enter the low price field." To prove it, the A-7 highboy model was priced at $487.50.

In February of 1929 Fansteel and Gilfillan amended their contract to have the latter make at least 48,000 radios per year at Waukegan. About the same time Fansteel formed a subsidiary, Balk*eit* Radio Co., and renamed the product line accordingly. Fansteel put all radio-production responsibility into the subsidiary, including Fansteel "Balkite" battery chargers and eliminators.

Glenn Alspach, treasurer of Gilfillan Bros., had been the coordinator of the Fansteel negotiations, and knew Fansteel management. He became affiliated with Balkeit Radio Co. in February of 1929, according to Gilfillan records. Alspach saw an opportunity to go with the newly created firm, and on June 5 tendered his written resignation from Gilfillan to become president of Balkeit.

Balkeit made sets for itself under the Balkeit label and produced radios for a wholesale distributor, First National Radio Corp. of New York City. First National resold the sets by the thousands to volume dealers who wanted their private labels on the sets.

Balkeit put sales emphasis into large expensive consoles which were not selling well, and the company was soon struggling. A letter of July 28, 1929 from Paul Breting, Gilfillan's branch manager at Waukegan, to Gilfillan in Los Angeles showed some of the complexity of the Gilfillan-Balkeit operation:

> "Balkeit Radio Company first of all issue a purchase order to us [Gilfillan] covering a given number of sets, we in turn issue an order to the Balkeit Radio Company covering a like amount of materials. Our parts order to them is in detail and shows the price of each item. On completion of our orders, the Balkeit Company bill us for all parts delivered – their

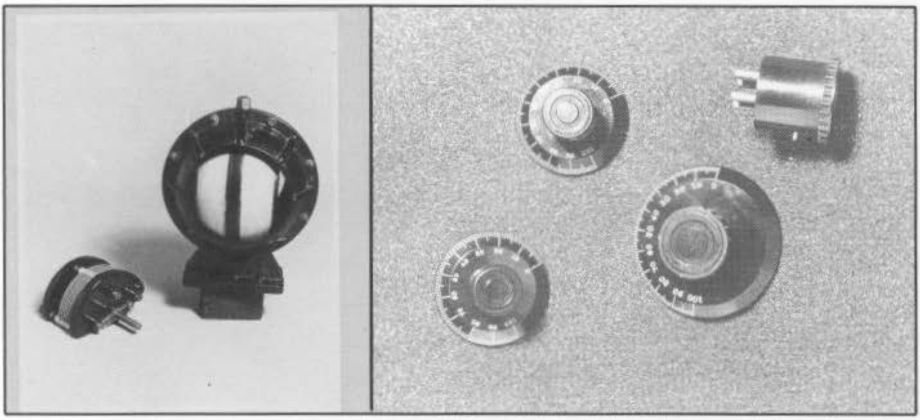


Figure 3. *Gilfillan Bros. Molded bakelite components, 1923. (F.A. Paul collection.)*

invoice also showing each item properly priced and extended. After the sets are completed by us, we of course, bill the Balkeit Co. in the usual manner – you no doubt being acquainted with the details of our invoices."

Concern by E. C. Anderson (license coordinator of RCA) was expressed in Breting's letter:

" Mr. Anderson did say that it was not exactly 'according to Hoyle' for us to buy all of our material from the Balkeit Company . . . As far as the model 'F' or stencil* set is concerned, it is not necessary for us to pay royalty on the speaker, as the chassis only is sold by the Balkeit Company to the First National Radio Company."

Early manufacturing problems at Waukegan plagued Fansteel. A wire to Gilfillan from Fansteel on October 3, 1929 said, "As you know the first twenty five hundred Balkite sets were erratic. Jobbers very skeptical on all serial numbers below twenty five hundred - stop - can you suggest any method where we can renumber the sets and install new name plates bearing a higher serial number . . ."

The stock-market crash of late 1929 cut radio sales further. Fansteel found itself in difficult times, with an unprofitable subsidiary and its own assets being reduced to near-fatal levels. By 1930 Fansteel ceased support to Balkeit Radio Co. [7]. According to a *Radio Broadcast* news item of April 1930, "The plant, good will, and assets of the Balkeit Radio Co., No. Chicago, has been purchased." The new firm was named Balkeit Sales Company. Glenn Alspach stayed with the spun-off company for about a year.

*A "stencil" set was one made by Gilfillan for another company.

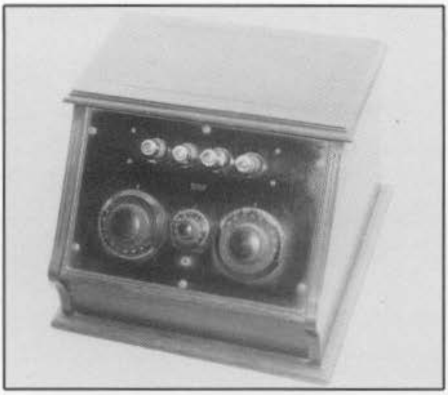


Figure 4. *The Gilfillan GN-3, 1925. Four tubes - $65. (ITT Gilfillan Collection.)*

A Postal Telegraph Co. telegram from RCA to Gilfillan on October 27, 1930, read "The Balkeit Radio Company has signed license agreement." Thus, Balkeit became independent from Gilfiflan Bros. By the end of the year Balkeit had dropped the high-end price policy for its sets. A December 1930 item in *Radio Retailing* stated that two new models were available: a mantel set at $54.50 and a consolette at $64.50, and gave an address of 205 W. Wacker Dr., Chicago, for the firm.

A January 24, 1931, letter from Alspach of Balkeit Radio to S. W. Gilfillan described a visit by Anderson of RCA to the Waukegan plant in July of 1929. Alspach said RCA reviewed details of the entire setup between Balkeit and Gilfillan. The letter concluded with a royalty being paid on the following: cost of material, cost of labor, cost of overhead, cost of commission, and 7½% on a $2.00 cabinet.

A letter dated June 7, 1932 in the ITT-Gilfillan files contains a poignant resignation from Alspach to S. W. Gilfillan as a director of Gilfillan Bros. After all, Alspach had been at the helm of Balkeit when the company had broken away from Gilfillan and obtained its own RCA licensing agreement. The letter stated "I am no longer a stockholder in the Gilfillan Bros. Inc. ...circumstances have forced me to sever years of contact with you."

As for the years after 1932, the author found Balkeit Radio Co. in a set-specifications listing in *Radio Retailing* for September 1934. Alan Douglas located a brochure from Balkeit dated 1935. The brochure had Balkeit introducing a new sales plan, "Buy Direct from Balkeit." The company had apparently gone to direct-mail sales. The 14-page brochure showed radios (mostly table models but with a few consoles), a wind charger, a battery charger, doublet antennas, storage batteries, and an auto radio. It listed prices from $11.95 to $36.50. The author has found no other Balkeit advertising or reference to the company in later years.

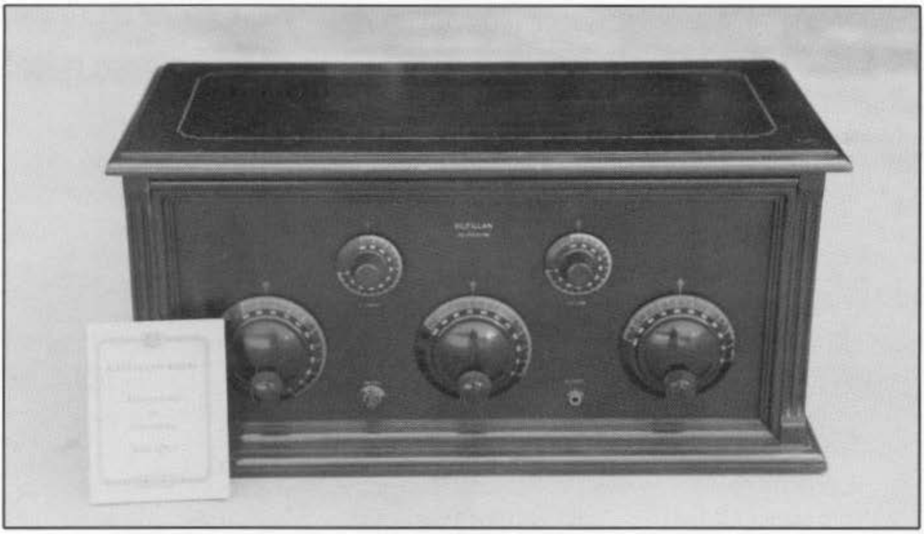


Figure 5. *The Gilfillan.GN-5, 1925. (F.A. Paul collection.)*

1929, A BIG YEAR

By late 1928 S. W. Gilfillan certainly was thinking about bringing local radio makers, small as they might be, into his plant. The company's income would increase, easing the $100,000 annual royalty to RCA. RCA and Gilfillan worked together. To start, Gilfillan helped select a company for RCA to use as an example. Advance Electric and its owner Fritz Falck were picked, and in January 1929 RCA filed suit for patent infringement.

By May of 1929 the Advance Electric case was settled out of court. The company allegedly paid RCA $500 in back royalties and in addition brought its production assembly work to Gilfillan Bros. In the ITT-Gilfillan files, a letter dated February 21 from Gilfillan to RCA said, "When the Radio Corporation of America filed suit against Advance Electric Co. of Los Angeles, Kemper asked me if we would manufacture their receivers and [we] have been doing so since January 1st." A letter of June 12 to RCA noted Jackson-Bell, Kemper, and Master Radio were the first three companies to come to Gilfillan voluntarily to have their sets manufactured. (It is obvious that RCA's suit against one company was intimidating and was instrumental in getting other local manufacturers to sign agreements and bring their parts and chassis to Gilfillan for assembly.)

The June 12 letter to RCA identified infringing radio makers in Los Angeles: Beverly, Echophone, Flint, Long's, Los Angeles, Magic, Patterson, Powell, Standard (Radio Apparatus), Standard (Radio Co.), and Trojan. Of these, Beverly, Magic, and the Standard companies did not appear in any advertisement; it is likely they were small, garage-shop operators, deciding against licensing formalities and then dropping out of business by the end of 1929. The letter went on, "Patterson of Patterson Radio Supply Co. informed me [S. W. Gilfillan] that he had contributed to the defense of Falck in recent litigation between RCA and Advance Electric Co. I believe that Echophone Radio also contributed to the defense."

In these formative months of 1929 RCA and Gilfillan both wanted to bring the local unlicensed manufacturers into camp. After all, 7½% royalty on a maker's net selling price of approximately $30 per set would be over $2. Since unlicensed makers may have produced upwards of 40,000 receivers in Los Angeles in 1929, the royalty payments would amount to $80,000. S.W. Gilfillan notified RCA of the "infringers" periodically in 1929. Gilfillan correspondence to RCA in December noted that Flint, Los Angeles Radio and Ufonic (Echophone) were now licensed. A letter to Anderson of RCA stated:

> "We have more or less been in the dark as to the exact status of Patterson Radio Co. of Los Angeles, who claim they are working under a Radio Corporation of America license through some kind of a combination deal with Continental Radio Co. We would like to know from you if the Patterson Radio Co. have the right to put RCA license plates on their radio receivers under the wing of the Continental Radio Co. I believe the Continental Radio Co. is located somewhere in Indiana."

1930 EVENTS

A letter of May 29 to Anderson thanked RCA for writing to Powell Co. and Zaney-Gill Corp. in an attempt to bring two more unlicensed operators into the fold. The letter noted both parties had already contacted Gilfillan to discuss an "arrangement." Further, the letter inquired if Gilfillan shouldn't be licensed by RCA to manufacture chasses in the San Francisco area.

A June 16 wire from Anderson to Gilfillan Bros. stated "We are forwarding you by Air Mail today permission for you to manufacture at your plant in San Francisco." A June 18 directors' meeting showed a need to approve an agreement between Powell Manufacturing and Gilfillan Bros. A July 3 Postal telegram addressed to Gilfillan stated "Radio Corporation is about to offer to its present broadcast receiver licensees supplemental licenses to include hetrodyne [sic] receivers ...Send engineer to two day technical meeting...under the direction of Mr. A. Van Dyck."

In an August 1930 issue of *Radio Retail & Jobber*, published in Albany, New York (sometimes identified as a tabloid and gossip-column sheet), a "news" item appeared, "Gilfillan Farms Out... The Gilfillan Bros. 'farm out' their radio set production to independent, but unlicensed radio receiver manufacturers, then those sets, as made on order by others, are delivered

Figure 6. *A New Zealand advertisement for the 1931 "Lyratone." (Courtesy of John Stokes.)*

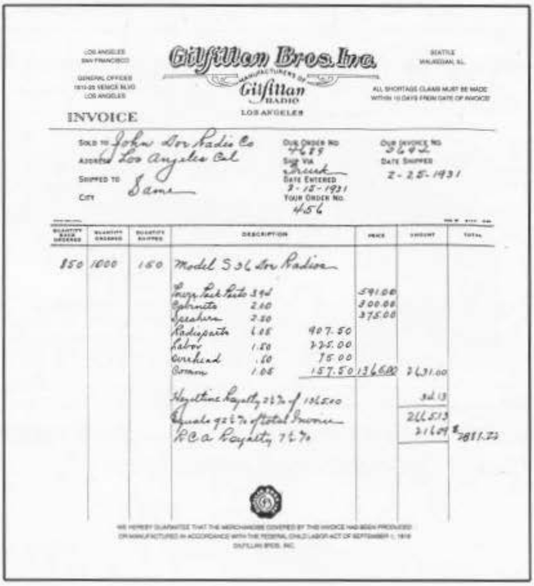
to the factory of Gilfillans ... The Gilfillan [sic] really do pay regular royalty rate on such sets." The author has never confirmed this.

A September 25 letter to RCA noted that Remler and Rola were having their chassis made at the Gilfillan plant in San Francisco and that Echophone and Baldwin were having their chassis made at the Gilfillan site in Waukegan. Baldwin (of Salt Lake City) had assembled chassis at the Gilfillan location in Los Angeles in June 1930 but moved production to Waukegan about September. The same letter noted:

> "I am enclosing copy of a letter sent out by Zaney-Gill Corporation in which they claim they are fully licensed under RCA and associate patents. I presume this company has made some connection in the East, as their manufacturing operations here in California have fallen off considerably, however they are still manufacturing at their plant in Los Angeles. So I will be posted, will you give me information as to under whose license these people operate? I am glad to state that with these people out of the way, the coast territory has practically 100% licensed production of the radio sets."

The September 25 letter identified the following companies as having their chassis manufactured at Gilfillan's Los Angeles plant: Advance Electric, Davison-Haynes, Echophone, Flint, Horn, Jackson-Bell, Keller-Fuller, Kemper, Long, Master Radio, Patterson, Powell, and Griffin-Smith.

By the end of 1930 Gilfillan was becoming a significant contributor to RCA's royalty kitty. Although not a Philco or Atwater Kent in size, Gilfillan's collective assembly work at Los Angeles, San Francisco and Waukegan may have exceeded 200,000 sets in 1930. Those sets would have produced royalties of about $400,000.



Gilfillan Bros. Inc.
MANUFACTURERS OF Gilfillan RADIO
LOS ANGELES
INVOICE
ALL SHORTAGE CLAIMS MUST BE MADE WITHIN 10 DAYS FROM DATE OF INVOICE

Sold to John Don Radio Co
Address Los Angeles Cal
Shipped to Same
City
Our Order No 7689
Ship Via Truck
Date Entered 2-15-1931
Your Order No. 456
Our Invoice No. 3642
Date Shipped 2-25-1931

Quantity Back Ordered	Quantity Ordered	Quantity Shipped	Description	Price	Amount	Total
850	1000	150	Model 536 Don Radios			
			Cabinets 2.00		300.00	
			Speakers 2.50		375.00	
			Radio parts 6.05	907.50		
			Labor 1.50	225.00		
			Overhead .50	75.00		
			1.05	157.50	1365.00	2631.00

Figure 7. *A Gilfillan Bros. Invoice, dated February 25, 1931. Note the 7½% RCA royalty entry.*

A February 25, 1931 Gilfillan invoice showed how royalty was calculated. (See Figure 7.)

No date was found in historical files or literature as to when Gilfillan closed the Waukegan plant, but as soon as Baldwin, Balkeit and Echophone got their own RCA licenses, Gilfillan would have left Waukegan. That was most likely in 1931.

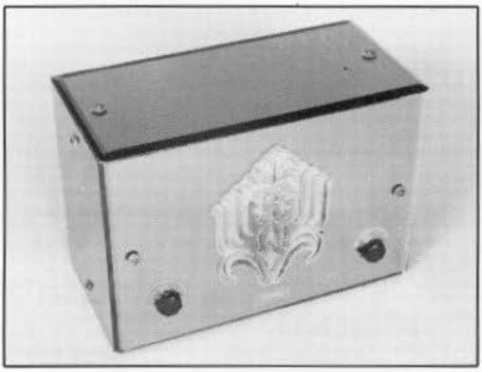


Figure 8. *A rare Gilfillan personalized mirror radio made specifically for a few family members. About 1934.*

1933 ROYALTY PAYMENTS

RCA asked for routine audits of licensees' records to assure itself of getting proper royalty payments. A February 27, 1935, Gilfillan letter to license coordinator Anderson addressed that issue. It referenced an attached copy of Arthur Young & Company's audit report for 1933 showing a total unrecorded royalty due RCA of $657.99. The report listed the following companies with unrecorded royalty payments.

Chanticleer Radio	$3.32
El Rey Radio Mfg.	81.91
Golden Bear Radio	1.42
Horn Radio Mfg.	7.01
Melburn Radio	4.99
Mission Bell Radio	155.36
E. R. Patterson	383.60
Royale Radio Mfg.	5.05
Troy Radio	15.33
	$657.99

Arthur Young's report said, "Our procedure was, as far as possible, to build up the various contents of the different models according to blue prints or diagrams, where available, or where not available, by inquiry from the engineers of the respective contractors... With the exception of E. R. Patterson, the costs claimed by the various contractors were substantially supported by vouchers and found to be substantially correct." An individual recap sheet (example, Troy) is shown:

Troy Radio Mfg. Co.
Recapitulation of Shortage

Model No.	Assembled Sets	Shortage Per Set	Total Shortage	Unrecorded Royalty 5%
Hi-Way	87	1.765	153.55	
4U	2134	.015	32.01	
Chief & J4	3045	.015	45.67	
Dwarf	1027	.09	92.43	
487	175	.015	2.63	
Special 4	100	.13	13.00	
5-JB	50	.10	5.00	
5S	285	.05	14.25	
7 tube super	48	.05	2.40	
Leader	61	.015	3.05	
5 battery	4	.04	.16	
			364.15	$18.21

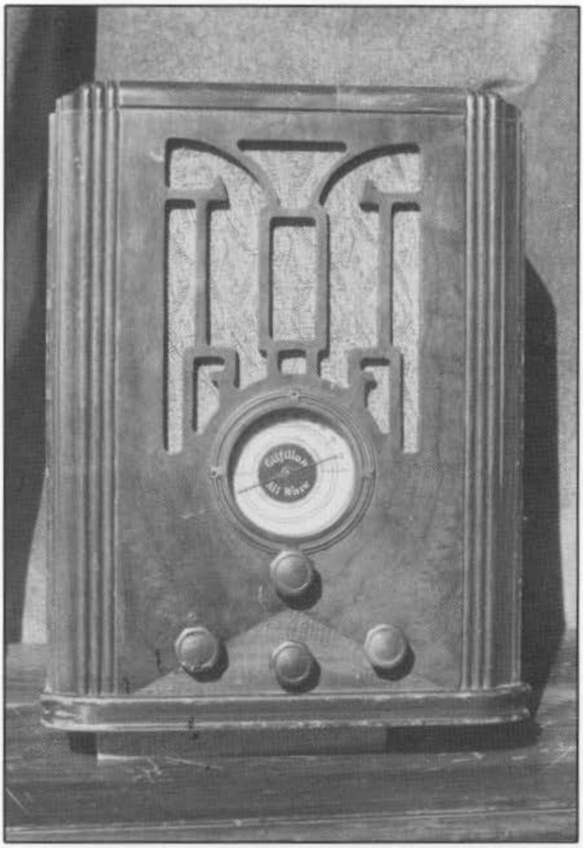


Figure 9. *The Gilfillan all-wave Model 63B, about 1936. (Courtesy of John Stokes.)*

Gilfillan's letter summarized that it owed RCA $657.99 and that a bill for the audit was $380. The letter asked "Shall we send you a check for the difference?"

MISCELLANEOUS INFORMATION

A meeting of the stockholders was held on January 28, 1936. The following were listed as owners: S. W. Gilfillan, 151,006 shares of common; Jay Gilfillan, 1400 shares of preferred; Harvey and Seeley Mudd, 1250 common shares and 1250 preferred; Paul Breting, 100 shares of preferred; and others.

The fire of November 30, 1940 at 5:30 AM burned the entire Gilfillan plant. A temporary office was set up at 1609 S. Western Ave. A directors' meeting called on December 10 had S. W. Gilfillan, Edna Gilfillan (his wife, a major common stockholder), Jay Gilfillan, Harvey Mudd and I.

Kemp present. At that meeting S. W. Gilfillan was appointed lawful agent for Gilfillan Bros., with power to act on all matters regarding insurance claims and losses from the fire. S. W. and Edna Gilfillan owned 82% of the common stock at the time.

CONCLUSION

From 1927 to 1937, Southern California radio manufacturing progressed from a follower to a producer competitive with the rest of the nation in quality and styling of radio sets. Much of the Los Angeles area's growth involved Gilfillan Bros. Inc. This article has revealed many operational practices of a remarkable and uniquely positioned company and in addition has exposed RCA's handling of its licensees.

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Floyd A. Paul, W6THU

The author has specialized in the history of radio horn speakers for twenty years. He has published over 65 articles in CQ, SCARS Gazette, AWA Old Timer's Bulletin, CHRS Journal, ARCA Gazette, *and* The Antique Radio Trader. *He wrote a booklet in the early 1980s entitled* The Horn Speaker Notebook, *and in 1984 he received the AWA Houck Award for historic documentation. In 1986 Floyd published his book, Radio Horn Speaker Encyclopedia. He has since published* Los Angeles Radio Manufacturing - The First Twenty Years, *with a follow-up supplement. He has edited the loudspeaker column for the* Old Timer's Bulletin *since 1980 and was the editor of the* Southern California Antique Radio Society's Gazette *for eight years.*

He obtained his amateur license, W6THU, in 1940 and after WW II Army service, received an electrical engineering degree from USC in 1951. Floyd spent 27 years in the aerospace industry, retiring from the Cal Tech Jet Propulsion Lab (JPL) where he worked twice in his career. He received the Presidential Award for Management Improvement from chief executive Gerald Ford in the mariner Venus-Mercury 1973 deep-space program while at JPL.

AN APPRECIATION

This documentation of the myriad of details of historical events long past is a tedious and painstaking task, requiring a substantial investment in time, effort, and often personal expense on the part of the writer. Volume 10 of the *REVIEW* reflects this fact just as emphatically as did all the previous editions. To each of the authors we extend our thanks for their devoted efforts and continual work in first writing and then correcting and modifying their respective papers to arrive at a presentation that is as complete and historically accurate as possible.

Of course, once the papers are in the hands of the editor, the editing and production, the process of converting the numerous presentations into the finished book format, begins. To the production staff at Sun Litho-Print of East Stroudsburg, Pa. we extend our thanks for another job well done. Special recognition is given to Barbara Beyer who spent many hours at the computer translating the editor's layout and instructions into the finished form for printing, and to Kathy Werkheiser who demonstrated again her skill in reproducing the some 190 illustrations into the final layout. Thanks are due also to AWA member John W. Haught of Aliquippa, Pa., who converted many of the original crude drawings in the Heintz and Kauffman paper into a finished form.

William B. Fizette
Henryville, Pa., August, 1996

Appendix 3: Supplement to the *AWA Review*, Volume 12, 1999

THE ATWATER KENT RADIOS

By Ralph O. Williams

TUNED RADIO FREQUENCY RECEIVERS BATTERY AND HOUSE POWERED — MASTERLIST 1

SET NO.	YR	TUBES NO	FIL	PWR	CH TYPE	CH NO.	CAB	STYLE	CTRLS KB	DIAL	SPKR	RF	DET	AF	OUT	AK DATA	RDRS DATA	SET NO.
1	22+	2	5	BATT	BOARD GRN	3925	OPEN	TAB	1	1	M		200		201			1
2	22+	3	5	BATT	BOARD GRN	3945	OPEN	TAB	1	1	M		200	201	201			2
3	22+	3	5	BATT	BOARD GRN	3955	OPEN	TAB	2	1	M		200	201	201			3
4	22+	3	5	BATT	BOARD GRN	3975	OPEN	TAB	5		M		200	201	201			4
5	23	5	5	BATT	BOARD GRN	4333	OPEN	TAB	3	1	H	201A(2)	200A	201A	201A			5
6	23	4	5	BATT	BOARD GRN	4052	OPEN	TAB	3	1	M	201	200	201	201			6
6	23	2	5	BATT	BOARD GRN	4120	OPEN	TAB	3	1	M	201	200					6
7	23	5	5	BATT	BOARD GRN	4066	OPEN	TAB	4	1	M	201(2)	200	201	201			7
7	23	3	5	BATT	BOARD GRN	4275	OPEN	TAB	4	1	M	201(2)	200					7
7	23	5	5	BATT	BOARD BLK	4205	OPEN	TAB	4	1	M	201A(2)	200A	201A	201A			7
8	23	5	5	BATT	BOARD GRN	4325	OPEN	TAB	3	2	M	201A(2)	200A	201A	201A			8
9	23	4	5	BATT	BOARD SMA	4445	OPEN	TAB	3	2	M	201	200	201	201			9
9	23	4	5	BATT	BOARD LGE	4445	OPEN	TAB	3	2	M	201A	200A	201A	201A			9
9C	24	4	5	BATT	BOARD BLK	4660	OPEN	TAB	1	2	H	201A	200A	201A	201A			9C
10	23	5	5	BATT	BOARD GRN	4340	OPEN	TAB	4	3	H	201(2)	200	201	201			10
10A	24	5	5	BATT	BOARD BRN	4550	OPEN	TAB	4	3	H	201A(2)	200A	201A	201A		1-1	10A
10A	24	5	5	BATT	BOARD BLK	4560	OPEN	TAB	4	3	H	201A(2)	200A	201A	201A		1-1	10A
10B	24	5	5	BATT	BOARD BRN	4550	OPEN	TAB	5	3	H	201A(2)	200A	201A	201A	28P26	1-1	10B
10B	24	5	5	BATT	BOARD BLK	4560	OPEN	TAB	5	3	H	201A(2)	200A	201A	201A	28P26	1-1	10B
10C	24	5	5	BATT	BOARD BRN	4700	OPEN	TAB	3	3	E	201A(2)	200A	201A	201A	28P27	1-1	10C
12	23+	6	5	BATT	BOARD GRN	4375	OPEN	TAB	5	3	H	201(2)	200	201	201(2)			12
12B	24	6	5	BATT	BOARD BRN	4620	OPEN	TAB	6	3	H	201A(2)	200A	201A	201A(2)		1-2	12B
12C	24	6	5	BATT	BOARD BRN	4910	OPEN	TAB	4	3	E	201A(2)	200A	201A	201A(2)	28P28	1-2	12C
19	24	4	5	BATT	PANEL	4880	WOOD	TAB	2	2	E	201A	200A	201A	201A	2	1-2	19
20	24	5	5	BATT	PANEL	4640	WOOD	TAB	2	3	E	201A(2)	200A	201A	201A	28P29	1-2	20
20C	25	5	5	BATT	PANEL	7570	WOOD	TAB	2	3	E	201A(2)	200A	201A	201A	28P31	1-2	20C
20CL	25	5	5	BATT	PANEL	7960	WOOD	TAB	2	3	E	201A(2)	200A	201A	201A		1-3	20CL

SET NO.	YR	TUBES NO	FIL	PWR	CH TYPE	CH NO.	CAB	STYLE	CTRLS KB	DIAL	SPKR	RF	DET	AF	OUT	AK DATA	RDRS DATA	SET NO.
21	25	5	5	BATT	PANEL	7780	WOOD	TAB	2	3	E	199(2)	199	199	199		1-3	21
22	24	6	5	BATT	PANEL	4930	WOOD	TAB	2	3	E	201A(2)	200A	201A	201A(2)			22
24	25	5	5	BATT	PANEL	4920	WOOD	TAB	2	3	E	201A(2)	200A	201A	201A	28P27	1-2	24
30	25	6	5	BATT	PANEL	7950	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A	28P34	1-4	30
30	25	6	5	BATT	PANEL	8000	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A		1-4	30
30A	26	6	5	BATT	SHELF	8000	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A		1-4	30A
32	26	7	5	BATT	PANEL	8270	WOOD	TAB	2	1	E	201A(4)	200A	201A	201A	28P36	1-4	32
33	27	6	5	BATT	SHELF	8930	WOOD	TAB	3	1	E	201A(3)	200A	201A	201A	28P38	1-5	33
33Pa	27	6	5	BATT	SHELF	8970	CNSL		3	1	E	201A(3)	200A	201A	201A		1-5	33Pa
35	26	6	5	BATT	SHELF	8100	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A	28P34	1-4	35
35A	27	6	5	BATT	SHELF	8100	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A		1-5	35A
36	27	7	1.5	110 60	SHELF	9390	WOOD	TAB	2	1	E	226(3)	227	226	171A	28P46	1-6	36
37	27	7	1.5	110 60	SHELF	9500	MET	TAB	1	1	E	226(3)	227	226	171A	28P52	1-7	37
37C	27+	7	1.5	110 60	SHELF	9700	CNSL		1	1	E	226(3)	227	226	171A		1-7	37C
37F	27	7	1.5	110 60	SHELF	9740	MET	TAB	1	1	E	226(3)	227	226	171A		1-7	37F
37FC	27+	7	1.5	110 60	SHELF	9830	CNSL		1	1	E	226(3)	227	226	171A		1-7	37FC
38	27	8	1.5	110 60	SHELF	9400	MET	TAB	1	1	E	226(4)	227	226	171A	28P56	1-7	38
40	27	7	1.5	110 60	SHELF	9800	MET	TAB	1	1	E	226(3)	227	226	171A	28P64	1-9	40
40F	27	7	1.5	110 25	SHELF	9960	MET	TAB	1	1	E	226(3)	227	226	171A		1-9	40F
41	27	8	5	110 60	SHELF	9910	MET	TAB	1	1	E	112A(4)	112A	171A	171A(2)	28P93	3-11	41
42	27	7	1.5	110 60	SHELF	9850	MET	TAB	1	1	E	226(3)	227	226	171A	28P64	1-9	42
42F	27	7	1.5	110 25	SHELF	9970	MET	TAB	1	1	E	226(3)	227	226	171A		1-9	42F
43	29	8	1.5	110 60	SHELF	9870	MET	TAB	1	1	F 2	226(3)	227	226	171A(2)	28P101	3-15	43
44	28	8	1.5	110 60	SHELF	9900	MET	TAB	1	1	E	226(4)	227	226	171A	28P66	1-19	44
44F	28	8	1.5	110 25	SHELF	9980	MET	TAB	1	1	E	226(4)	227	226	171A		1-19	44F
45	29	8	1.5	110 60	SHELF	9880	MET	TAB	1	1	E	226(4)	227	226	171A	28P66	1-19	45
46	29	6	1.5	110 60	SHELF	14100	MET	TAB	1	1	F 2	226(3)	227	226	171A(2)	28P101	1-15	46
47	29	9	1.5	110 60	SHELF	14500	MET	TAB	1	1	F 2	226(4)	227	226	171A(2)	28P66	1-15	47

SET NO.	YR	TUBES NO	FIL	PWR	CH TYPE	CH NO.	CAB	STYLE	CTRLS KB	DIAL	SPKR	RF	DET	AF	OUT	AK DATA	RDRS DATA	SET NO.
48	29	6	5	BATT	SHELF	9640	WOOD	TAB	2	1	E	201A(3)	200A	201A	201A	28P34	1-5	48
49	29	6	5	BATT	SHELF	9860	WOOD	TAB	3	1	E	201A(3)	200A	201A	201A	28P38	1-5	49
50	27	7	5	BATT	SHIELD	8500	WOOD	TAB	2	3	E	201A(4)	200A	201A	201A	28P42	3-20	50
51	27	7	5	110 DC	SHELF	9890	MET FL		1	1	13600	112A(4)	112A	171A	171A(2)	28P93	1-11	51
52	28	7	5	110 60	SHELF	9930	MET FL		1	1	13600	226(3)	227	226	171A	28P64	1-9	52
53	29	8	5	110 60	SHELF	13100	MET FL		1	1	14500	226(3)	227	226	171A(2)	28P64	3-15	53
55	29	7	2.5	110 60	BIG	14900	MET	TAB	2	WIN	14380	24A(2)	227	227	245(2)	29P4	3-21	55
55C	29	7	2.5	110 60	BIG	14800	CNSL		2	WIN	14100	24A(2)	227	227	245(2)		3-23	55C
55F	29+	7	2.5	110 60	BIG	15600	MET	TAB	2	WIN	14760	24A(2)	227	227	245(2)		3-24	55F
55FC	29+	7	2.5	110 60	BIG	15700	CNSL		2	WIN	14300	24A(2)	227	227	245(2)		3-24	55FC
56	29	7	1.5	110 60	SHELF	13900	MET FL		1	1	13600	226(3)	227	226	171A	28P64	1-9	56
57	29	7	1.5	110 60	SHELF	14000	MET FL		1	1	13600	226(3)	227	226	171A	28P65	1-9	57
60	29+	8	2.5	110 60	BIG	15000	MET	TAB	3	WIN	14770	24A(3)	227	227	245(2)		3-39	60
60C	29+	8	2.5	110 60	BIG	15100	CNSL		3	WIN	14410	24A(3)	227	227	245(2)	28P203	3-31	60C
60CL	29+	8	2.5	110 60	BIG	15100	CNSL		3	WIN	14380	24A(3)	227	227	245(2)		3-32	60CL
61	30	7	5	110 DC	BIG	15300	MET	TAB	3	WIN	14480	22(3)	112A	112A	171A(2)	30P141	3-36	61
61C	30	7	5	110 DC	BIG	15400	CNSL		3	WIN	14490	22(3)	112A	112A	171A(2)		3-40	61
66	30	9	2.5	110 60	BIG	15800	CNSL		3	WIN	14490	24A(3)	227	227	250(2)	30P143	3-40	66
67	30	7		BATT	BIG	15500	MET	TAB	3	WIN	14510	22(3)	112A	112A	171A(2)	30P145	3-43	67
67C	30	7		BATT	BIG	15200	CNSL		3	WIN	14520	22(3)	112A	112A	171A(2)		3-43	67C
70	31	8	2.5	110 60	BIG	16000	LO BOY		3	FAN	16400	24A(3)	27	27	45(2)	30P221	3-47	70
70F	31	8	2.5	110 25	BIG	16100	LO BOY		3	WIN	16400	24A(3)	27	27	45(2)	30P230	3-46	70F
70Q	31	7		BATT	BIG	16800	LO BOY		3	WIN	16920	22(3)	112A	112A	171A(2)	30P243	3-55	70Q
70D	31	7	2.5	110 DC	BIG	16700	LO BOY		3	WIN	16900	22(3)	12	12	71A(2)	30P246	3-52	70D
74	31	8	2.5	110 60	BIG	16000	TABLE		3	WIN	16400	24A(3)	27	27	45(2)	30P221	3-47	74
74F	31	8	2.5	110 25	BIG	16100	TABLE		3	WIN	16400	24A(3)	27	27	45(2)	30P230	3-46	74F
75	31	8	2.5	110 60	BIG	16600	PHONO		3	WIN	16600	24A(3)	27	27	45(2)	30P231	3-60	75
76	31	8	2.5	110 60	BIG	16000	HI BOY		3	WIN	16400	24A(3)	27	27	45(2)	30P221	3-47	76
76F	31	8	2.5	110 25	BIG	16100	HI BOY		3	WIN	16400	24A(3)	27	27	45(2)	30P230	3-46	76F

EARLY BIG CHASSIS SUPERHETERODYNE CONSOLES — MASTERLIST 2A

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
72	31	9	2.5	110 60	BIG	16500	CNSL	LO HI	3	FAN	16400	35	35	27	36(2)	27		27	45(2)	12/31-264	3-63		130	72
83	31	6	2.5	110 60	BIG	21100	CNSL	LO-BO	3	FAN	18100		35	27	35	24			47	11/31-281	3-67	80	130	83
83L	31	6	2.5	110 60	BIG	21100	CNSL	LO-BO	3	FAN	24600		35	27	35	24			47		3-67	80	130	83L
83F	31	6	2.5	110 25	BIG	22000	CNSL	LO-BO	3	FAN	18100		35	27	35	24			47		3-67	80F	130	83F
85	31	6	2.5	110 60	BIG	17900	CNSL	LO-BO	3	FAN	18100		35	27	35	24			47	11/31-284	3-89	82	130	85
85L	31	6	2.5	110 60	BIG	17900	CNSL	LO-BO	3	FAN	24600		35	27	35	24	24		47		3-89	82	130	85L
85F	31	6	2.5	110 25	BIG	18200	CNSL	LO-BO	3	FAN	18100		35	27	35	24	24		47	11/31-284	3-89	82F	130	85F
86	31	8	2.5	110 60	BIG	23000	CNSL	LOW-HI	3	FAN	24600	35	35	27	35	24	24		47	11/31-291	3-95		130	86
86F	31	8	2.5	110 25	BIG	24700	CNSL	LOW-HI	3	FAN	24600	35	35	27	35	24	24		47	11/31-291	3-97		130	86F
87	31	8	2.5	110 60	BIG	21200	CNSL	LOW-HI	3	FAN	19800	35	35	27	35	27		27	47(2)	11/31-292	3-99		130	87
87D	31	8	5	110 DC	BIG		CNSL	LOW-HI	3	FAN	25000	36	36	37	36	36		38	33(2)	12/31-324	3-103		130	87D
89	31	#	2.5	110 60	BIG	21300	CNSL	LOW-HI	3	FAN	19800	35	35	27	35	27	24	27	47(2)	11/31-293	3-105		130	89
89F	31	#	2.5	110 25	BIG	22400	CNSL	LOW-HI	3	FAN	19800	35	35	27	35	27	24	27	47(2)	11/31-293	3-105		130	89F
89P	31	#	2.5	110 60	BIG	20000	CNSL	LOW-HI	3	FAN	19800	35	35	27	35	27	24	27	47(2)	4/32-339	3-105		130	89P
96E	32	8	2.5	110 60	BIG	26100	CNSL	LOW-HI	3	FAN	26300	35	35	27	35	24	27		47	4/32-351	3-121		130	96E
96M	32	8	2.5	110 60	BIG	26100	CNSL	LOW-HI	3	FAN	26300	35	35	27	35	24	27		47		3-123		130	96M
96L	32	8	2.5	110 60	BIG	26100	CNSL	LOW-HI	3	FAN	26300	35	35	27	35	24	27		47	4/32-353	3-125		130	96L
96F	32	8	2.5	110 60	BIG	26800	CNSL	LOW-HI	3	FAN	26300	35	35	27	35	24	27		47	4/32-355	3-127		130	96F
99E	32	#	2.5	110 60	BIG	26200	CNSL	LOW-HI	3	FAN	26400	35	35	27	35	27	24	27	47(2)	4/32-357	3-129		130	99E
99L	32	#	2.5	110 25	BIG	26200	CNSL	LOW-HI	3	FAN	26400	35	35	27	35	27	24	27	47(2)	4/32-358	3-132		130	99L
99F	32	#	2.5	110 60	BIG	26900	CNSL	LOW-HI	3	FAN	26400	35	35	27	35	27	24	27	47(2)	4/32-358	3-133		130	99F
99P	32	#	2.5	110 60	BIG	27400	CNSL	LOW-HI	3	FAN	26400	35	35	27	35	27	24	27	47(2)	4/32-358	3-133		130	99P

LATER BIG CHASSIS SUPERHETERODYNE CONSOLES — MASTERLIST 2B

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
188	32	8	2.5	110 60	BIG	28400	CNSL		4	FAN	28700	58	58	56	58	55	57		47	7/32-377	3-135		130	188
188F	32	8	2.5	110 25	BIG	29300	CNSL		4	FAN	28700	58	58	56	58	55	57		47	7/32-377	3-135		130	188F
260	32	10	2.5	110 60	BIG	28900	CNSL		4	FAN TBM	28800	58	58	56	58(2)	55	57		47(2)	7/32-381	3-149		130	260
260F	32	10	2.5	110 25	BIG	29500	CNSL		4	FAN TBM	28800	58	58	56	58(2)	55	57		47(2)	7/32-381	3-151		130	260F
469	32+	9	2.5	110 60	BIG	29000	CNSL		4	FAN TBM	28800	58	58	56	58	55	57		47(2)	7/32-379	3-155	558	130	469
469F	32+	9	2.5	110 25	BIG	29400	CNSL		4	FAN TBM	28800	58	58	56	58	55	57		47(2)	7/32-379	3-157	558F	130	469F
480	32+	10	2.5	110 60	BIG	29600	CNSL		4	FAN	28800	58	58	56	58(2)	56	56		47(2)	1/33-409	3-159		472.5	480
480F	32+	10	2.5	110 25	BIG	29900	CNSL		4	FAN	28800	58	58	56	58(2)	56	56		47(2)	1/33-409	3-159		472.5	480F
612	32+	12	2.5	110 60	BIG	30000	CNSL		4	FAN TBM	30200-	58	58	56	58(2)	55	57		46(2)	1/33-403	3-171		130	612
812	32+	12	2.5	110 60	BIG	30500	CNSL		4	FAN TBM	30400-	58	58	56	58(2)	55	57		46(2)	11/25-2	3-175		130	812
448	33	8	2.5	110 60	BIG	32400	CNSL		4	FAN	28800	58	58	56	58	55	DET		47(2)	5/33-5	4-12		130	448
448F	33	8	2.5	110 25	BIG	32500	CNSL		4	FAN	28800	58	58	56	58	55	DET		47(2)	5/33-5	4-12		130	448F
510	33	10	2.5	110 60	BIG	36000	CNSL	MOD	4	FAN SH	36500	58	58	56	58	55	56	56	2A5(2)	5/34-15	4-8	310	130	510
310	33+	10	2.5	110 60	BIG	35900	CNSL	RNDED	4	FAN SH	36500	58	58	56	58	55	56	56	2A5(2)	5/34-15	4-8	510	130	310
112	34	12	2.5	110 60	BIG		CNSL		5	FAN SH	36700	58	58	58	58(2)	2B7	DET	56(3)	2A3(2)	10/34-2	6-1		472.5	112
711J	34	11	2.5	110 60	BIG	38600	CNSL	J,T			36700	58	58	56	58(2)	55	DET	56(2)	2A3(2)	5/34-27	4-21		472.5	711J,T
711R	34	11	2.5	110 60	BIG	36800	CNSL	R			36700	58	58	56	58(2)	55	DET	56(2)	2A3(2)		4-21		472.5	711R
487	34	7	2.5	110 60	BIG		CNSL				41800	58	2A7	MIX	58(2)	2A7	DET		2A5		6-43	577	472.5	487
788J	34	8	2.5	110 60			CNSL	J,T			39400	58	58	58	58(2)	2A6	DET		2A5	5/34-29	5-37		472.5	788J,T
788R	34	8	2.5	110 60			CNSL	R			39400	58	58	58	58(2)	2A6	DET		2A5		5-37		472.5	788R
808A	34	8	2.5	110 60	BIG	34600	CNSL				34500	58	58	58	58(2)	2A6	DET		2A5	5/34-33	4-21	808	472.5	808A
509	34+	9	2.5	110 60	BIG		CNSL	W	5	CLOCK	46600	58	2A7	MIX	58(2)	56	55		2A5(2)		6-45	511	472.5	509
511	34+	11	2.5	110 60	BIG		CNSL	W	5	CLOCK	36700	58	2A7	MIX	58(2)	2B7	DET	56(3)	2A3(2)	11/34-8	6-29	509	472.5	511
559	34+	9	2.5	110 60	BIG		CNSL		5	FAN	36500	58	58	58	58(2)	55	DET		2A5(2)	9/34-7	5-25		472.5	559
328	35	8	6.3	110 60			CNSL	L	5	FAN	54100	6K7	6A8	MIX	6K7(2	6H6	DET	6F5	6F6	2/36-2	6-18	828	472.5	328
312	34											6D6	6A7	MIX	6D6(	76	DET	76(4)	2A3(2)		7-29		472.5	312
412	35	12	6.3	110 60	BIG		CNSL	G	5	FAN		6K7	6A8	MIX	6K7(2	6H6	DET	6C5(2	2A3(2)		7-35		472.5	412
412P	35	12	6.3	110 60	BIG		CNSL		5	FAN		6K7	6A8	MIX	6K7(2	6H6	DET	6C5(2	2A3(2)		7-35		472.5	412P
412X	35	12	6.3	230 60	BIG		CNSL		5	FAN		6K7	6A8	MIX	6K7(2	6H6	DET	6C5(2	2A3(2)		7-35		472.5	412X
710	36											6D6	6A7	MIX	6D6(	6B7	DET	76(2)	45(2)		7-65		472.5	710
810	35	10	6.3	110 60	BIG		CNSL	G	5	FAN	53500	6K7	6A8	MIX	6K7(2	6H6	DET	6C5	6F6(3)	11/35-2	6-44		472.5	810
649P	36	9	6.3	110 60			CNSL	RP	5	FAN	50100	6K7	6A8	MIX	6K7(2	6H6	DET	6F5	6F6(2)	7/35-4	6-37	349	472.5	649P

LATER MEDIUM CHASSIS SUPERHETERODYNE CONSOLES — MASTERLIST 2C

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
469D	32+	9	6.3	110 DC	MED	31300	CNSL		3	FAN	31600	39	39	37	39	85	36		48(2)	1/33-397	3-163	558	130	469D
266	33	6	2.5	110 60	9X14	33300	CNSL		3	WIN	33400		57	56	58	55	DET		47	5/33-4	4-6	246	262.5	266
427	33	7	2.5	110 60	MED	35600	CNSL				33400	58	58	56	58	55	DET		2A5	5/34-9	4-4	217	264	427
427D	33	7	6.3	110 DC	MED	3700	CNSL				37600	78	78	37	78	75	75		43(2)	5/34-11	4-5	264	264	427D
808	33	8	2.5	110 60	MED	34600	CNSL		4	WIN	34500	58	58	58	58(2)	2A6	DET		2A5	9/23-3	4-17	708	472.5	808
286	34	6	2.5	110 60	MED		CNSL		4	AIR	41800	58	2A7	MIX	58	2A6	DET		2A5	7/35-3	6-15	356	472.5	286
318	34	8	2.5	110 60	9X14		CNSL		5	FAN SH	41600	58	2A7			55			2A5(2)	1/35-7	7-39	577	472.5	318
325	34	5	2.5	110 60	6X12		CNSL		4	AIR 3BD	41800		2A7	MIX	58	2A6	DET		2A5	9/34-3	5-7	145	264	325
376	34	6	2.5	110 60	MED		CNSL		4	AIR	43700	58	2A7			2A6			2A5	9/34-5	5-13	206	472.5	376
425	34	5	2.5	110 60	SML	39500	CNSL				33400		57	MIX	58	2A6	DET		2A5	5/34-21	4-24	665	264	425
525	34	5	2.5	110 60	MED	38400	CNSL				38500		57	MIX	58	2A6	DET		2A5	5/34-3	5-9	185	264	525
577	34	7	2.5	110 60	MED		CNSL		5	FAN	41800	58	2A7			2A6			2A5		7-43		472.5	577
665	34	5	2.5	110 60	MED	39600	CNSL	MOD			33400		57	MIX	58	2A6	DET		2A5	5/34-21	4-24	425	264	665
667	34	7	2.5	110 60	9X14	36100	CNSL	MOD	4	WIN	33400	58	58	56	58	55	DET		2A5	5/34-9	4-4	427	264	667
667D	34	7	6.3	110 DC	MED	37100	CNSL	MOD			37600	78	78	37	78	75	DET		43(2)	5/34-11	4-5	427D	264	667D
475	34+	5	2.5	110 60	MED		CNSL		4	AIR	41800		2A7	MIX	58	2A6	DET		2A5	7/35-7	6-27	735	265	475
376D	34+	6	6.3	110 DC	MED		CNSL		4	AIR	43600	78	6A7	MIX	78	85	DET		43(2)		7-17	206D	472.5	376D
317	35	7	6.3	110 60	MED		CNSL	H	4	AIR		6K7	6A8	MIX	6K7	6H6	DET	6F5	6F6	7/35-2	6-17	337	472.5	317
435	35+	5	6.3	110 60	6X11.5		CNSL	T	3	AIR 2BD			6A8	MIX	6K7	75	DET		6F6	7/35-1	6-21	225	450	435
649	35+	9	6.3	110 60	9X14		CNSL	L	5	FAN SH	50100	6K7	6A8	MIX	6K7(2	6H6	DET	6C5	6F6(2)	7/35-4	6-37	328	472.5	649
976	35+	6	6.3	110 60	8X12		CNSL	T	4	AIR 2BD			6A8	MIX	6K7	6H6	DET	6F5	6F6	7/35-3	6-45	856	264	976
535	36	5	6.3	110 60	MED		CNSL	M		AIR	41800		6A8	MIX	6K7	75	DET		6F6		7-37	725	450	535
676	36	6	6.3	110 60	MED		CNSL	B	4	AIR	41800		6A8	MIX	6K7	6H6	DET	6F5	6F6		6-45	456	264	676
717	36	7	6.3	110 60	MED		CNSL	H	4	AIR	41800	6K7	6A8	MIX	6K7	6H6	DET	6F5	6F6		6-17	637	472.5	717
765E	36	5	6.3	110 60	MED				4	AIR			6A7	MIX	6D6	75	DET		42		7-61		472.5	765E

EARLY MEDIUM CHASSIS SUPERHETERODYNE COMPACTS — MASTERLIST 2D

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
80	30	6	2.5	110 60	MED	20820	CPCT	ROUND	3	FAN	17300		35	27	35	24			47	11/31-282	3-67	83	130	80
80F	30	6	2.5	110 25	MED	21710	CPCT	ROUND	3	FAN	17300		35	27	35	24			47	11/31-292	3-67	83F	130	80F
82	30	6	2.5	110 60	MED	21090	CPCT	CATH	3	FAN	17300		35	27	35	24	24		47	11/31-284	3-75		130	82
82F	30	6	2.5	110 25	MED	21740	CPCT	CATH	3	FAN	17300		35	27	35	24	24		47		3-75		130	82F
82D	30	6	2.5	110 DC	MED	21750	CPCT	CATH	3	FAN	18600		36	37	36	36		37	33	11/31-285	3-71		130	82D
84	30	6	2.5	110 60	MED	18930	CPCT	CATH	3	FAN	17300		24	27	24	24			47	11/31-288	3-84		130	84
84L	30+	6	2.5	110 60	MED	20060	CPCT	CATH	3	FAN	17300		35	27	35	24			47	11/31-289	3-85		130	84L
84F	30	6	2.5	110 25	MED	19270	CPCT	CATH	3	FAN	17300		24	27	24	24			47	11/31-288	3-84		130	84F
84FL	30+	6	2.5	110 25	MED	20070	CPCT	CATH	3	FAN	17300		35	27	35	24			47	11/31-289	3-85		130	84FL
84D	30	6	2.5	110 DC	MED	19680	CPCT	CATH	3	FAN	18600		36	37	36	36		37	33	11/31-285	3-81		130	84D
84DL	30+	6	2.5	110 DC	MED	20080	CPCT	CATH	3	FAN	18600		36	37	36	36		37	33		3-81		130	84DL
90	31	6	2.5	110 60	MED	25800	CPCT	ROUND	3	FAN	17300	35	35	27	35	24			47	4/32-341	3-109		130	90
90F	31	6	2.5	110 25	MED	26500	CPCT	ROUND	3	FAN	17300	35	35	27	35	24			47	4/32-341	3-109		130	90F
92	31	7	2.5	110 60	MED	25900	CPCT	CATH	3	FAN	17300	35	35	27	35	24	27		47	4/32-343	3-113		130	92
92F	31	7	2.5	110 25	MED	26600	CPCT	CATH	3	FAN	17300	35	35	27	35	24	27		47	4/32-345	3-115		130	92F
93	31	6	2.5	110 60	MED	27200	FLATTOP		3	FAN	NONE		24	27	27	NONE				4/32-347	3-117		130	93
94	31	6	2.5	110 60	MED	26000	CPCT	CATH	3	FAN	17300	35	35	27	35	24			47	4/32-349	3-119		130	94
94F	31	6	2.5	110 25	MED	26700	CPCT	CATH	3	FAN	17300	35	35	27	35	24			47	4/32-349	3-119		130	94F
228	32	8	2.5	110 60	MED	25900	CPCT	CATH	3	FAN	17300	35	35	27	35	24	27		47	4/32-343	3-139	92	130	228
228F	32	8	2.5	110 25	MED	26600	CPCT	CATH	3	FAN	17300	35	35	27	35	24	27		47	4/32-343	3-141	92F	130	228F
228D	32	6	6.3	110 DC	MED	21800	CPCT	CATH	3	FAN	18600		36	37	36	36		37	33	4/32-329	3-143	82D	130	228D
567	32	7	2.5	110 60	MED	25800	CPCT	CATH	3	FAN	17300	35	35	27	35	24			47	4/32-341	3-167	90	130	567
567F	32	7	2.5	110 25	MED	26500	CPCT	CATH	3	FAN	17300	35	35	27	35	24			47	4/32-341	3-167	90F	130	567F
558	32+	8	2.5	110 60	MED	29800	CPCT	CATH	3	FAN	17300	58	58	56	58	55	57		47	1/33-401	3-169		130	558
558F	32+	8	2.5	110 25	MED	30800	CPCT	CATH	3	FAN	17300	58	58	56	58	55	57		47	1/33-401			130	558F
558D	32+	8	6.3	110 DC	MED	31400	CPCT	CATH	3	FAN	31800	39	39	37	39	85	36		48(2)	1/33-397	3-163	469D	130	558D
627	32+	7	2.5	110 60	MED	29700	CPCT	CATH	3	FAN	17300	58	58	56	58	55	DET		47	1/33-405	3-173		130	627
627F	32+	7	2.5	110 25	MED	30700	CPCT	CATH	3	FAN	17300	58	58	56	58	55	DET		47	1/33-405	3-173		130	627F

LATER MEDIUM CHASSIS SUPERHETERODYNE COMPACTS — MASTERLIST 2E

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
155	33	5	6.3	110 ACDC	SML	32800	BOX	TREAS	2	WIN	24568		77	MIX	44	75	DET		43	3/33-2	3-179		262.5	155
165	33	5	2.5	110 60	6.5X10	34000	CPCT	ARCH	3	WIN	34100		57	MIX	58	2A6	DET		2A5	3/33-3	4-2	185	264	165
217	33	7	2.5	110 60	9X14	35500	CPCT	ARCH	4	WIN	36300	58	58	56	58	55	DET		2A5	5/34-9	4-4	427	264	217
217D	33	7	6.3	110 DC	MED	36900	CPCT	ARCH			37500	78	78	37	78	75	DET		43(2)	5/34-11	4-5	427D	264	217D
246	33	6	2.5	110 60	9X14	32000	CPCT	ARCH	4	WIN	32300		57	56	58	55	DET		47	1/33-3	3-147	266	262.5	246
555	33	5	2.5	110 60	5X10.5	32900	CPCT	CHEST	2	WIN	24408		57	MIX	58	55	DET		47	3/33-3	4-14		262.5	555
708	33	8	2.5	110 60	MED	34200	CPCT		4	WIN	34300	58	58	58	58(2)	2A6	DET		2A5	9/33-3	4-17	808	472.5	708
275	33+	5	6.3	110 ACDC	SML	36200	CPCT	FLT 8	4	WIN	26159		6A7	MIX	44	75	DET		43	5/34-13	4-7		264	275
145	34	5	2.5	110 60	6X11.5		CPCT	FLT 15	4	AIR 2BD	42100		2A7	MIX	58	2A6	DET		2A5	9/34-3	5-7	325	264	145
145E	34	5	2.5	110 60	6X11.5		CPCT	FLT 15	4	AIR 2BD			2A7	MIX	58	2A6	DET		2A5		7-11		125	145E
145X	34	5	2.5	110 60	6X11.5		CPCT	FLT 15	4	AIR 2BD			2A7	MIX	58	2A6	DET		2A5		7-11		125	145X
185	34	5	2.5	110 60	6.5X10	38300	CPCT	ARCH	3	WIN	34100		57	MIX	58	2A6	DET		2A5	5/34-3	5-9	525	264	185
206	34	6	2.5	110 60	6X11.5		CPCT	FLTARC	4	AIR 3BD	41900	58	2A7	MIX	58	2A6	DET		2A5	9/34-5	5-13	376	472.5	206
206D	34	6	5	110 DC								78	6A7	MIX	78	85	DET		43(2)		7-17	376D	472.5	206D
273D	34	3	2	110 DC	SMALL		CPCT	FLTTOP	4	WIN	NONE		1A6	MIX	34	34					7-26			273D
356	34	6	2.5	110 60	8X12		CPCT	FLT 18	4	AIR 2BD	41900	58	2A7	MIX	58	2A6	DET		2A5	7/35-3	6-15	286	472.5	356
825	34	5	6.3	110 ACDC	SML		CPCT		4	WIN	26159		6A7	MIX	44	75	DET		43	9/34-9	5-47		264	825
854	34	4	2.5	110 60	6.5X10		CPCT	FLT 15	3	WIN	34100		57			57			2A5	9/34-11	7-15		450	854
944	34	4	2.5	110 60	6.5X10		CPCT	ARCH	2	WIN	34100		57	MIX		57			2A5	9/34-11	5-49		450	944
185A	34+	5	2.5	110 60	SMALL	40000	CPCT	ARCH	2	WIN	34100		2A7	MIX	58	2A6	DET		2A5	5/34-7	5-11		264	185A
447	34+	7	2.5	110 60	9X14		CPCT		5	FAN SH	41700	58	2A7	MIX	(2)58	2A6	DET		2A5		7-39	318	472.5	447
735	34+	5	2.5	110 60	6X11.5		CPCT	FLTARC	4	AIR 3BD	41900		2A7	MIX	58	2A6	DET		2A5	7/35-7	6-27	475	264	735
735	34+	5	2.5	110 60	6X11.5		CPCT	FLTARC	4	AIR 3BD	41900		2A7	MIX	58	2A6	DET		2A5	7/35-7	6-27	735	264	475
225	35	5	6.3	110 60	6X11.5		CPCT	FLT 17	3	AIR 2BD			6A8	MIX	6K7	75	DET		6F6		6-21	435	450	225
337	35	7	6.3	110 60	8X12		CPCT	FLT 18	4	AIR 2BD		6K7	6A8	MIX	6K7	6H6	DET	6F5	6F6		6-17	317	472.5	337
545	35	5	6.3	110 60	6X11.5		CPCT	FLT 17	3	AIR 2BD			6A7	MIX	6D6	75	DET		42	6/35-3	6-35		450	545
349	35+	9	6.3	110 60	9X14				5	FAN SH		6K7	6A8	MIX	6K7(2	6H6	DET	6C5	6F6(2)		6-37	649		349
137	36	7	2.5	110 60								58	58	56	58	55	DET		47		7-7			137
168	36	8	2.5	110 60								58	58	56	58	55	DET		47(2)		7-13		125	168
184	36	4	6.3	110 60	6.5X10		CPCT	FLT 14	3	WIN	52600		6C6	MIX		6C6			42	9/34-11	7-15		450	184
184X	36	4	6.3	110 60	6.5X10		CPCT	FLT 14	3	WIN	52600		6C6	MIX		6C6			42		7-15		450	184X
200	36	7	2.5	240 60	MED							6K7	6A8	MIX	6K7	6H6	DET	6F5	6F6		6-17	317	472.5	200
255	36	5	6.3	110 60									6A8	MIX	6K7	75	DET		6F6		7-25		450	255
456	36	6	6.3	110 60	8X12		CPCT	FLT 18	4	AIR 2BD	41900		6A8	MIX	6K7	6H6	DET	6F5	6F6		6-45	676	264	456
637	36	7	6.3	110 60	8X12		CPCT	FLT 18	4	AIR 2BD	41900	6K7	6A8	MIX	6K7	6H6	DET	6F5	6F6		6-17	717	472.5	637
725	36	5	6.3	110 60	6X11.5		CPCT	FLT 17	3	AIR 2BD	41900		6A8	MIX	6K7	75	DET		6F6		7-57	535	450	725
725P	36	5	6.3	110 60	6X11.5		CPCT	FLT 17	3	AIR 2BD			6A8	MIX	6K7	75	DET		6F6		7-57		450	725P
725X	36	5	6.3	230 60	6X11.5		CPCT	FLT 17	3	AIR 2BD			6A8	MIX	6K7	75	DET		6F6		7-57		450	725X
725PX	36	5	6.3	230 60	6X11.5		CPCT	FLT 17	3	AIR 2BD			6A8	MIX	6K7	75	DET		6F6		7-57		450	725PX

AUTOMOBILE RADIOS, ALL — MASTERLIST 2F

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
81	31	7	6.3	BATT	AUTO	21048	3 UNITS			STEER'G	22600	36(3)	TRF			37	37		38(2)	11/31-383	3-69		TRF	81
81B	31	7	6.3	BATT	AUTO	21048	4UN SQ	BATT		STEER'G	22600	36(3)	TRF			37	37		38(2)	4/32-327	3-69		TRF	81B
81C	31	7	6.3	BATT	AUTO	21048	4UN FLT	BATT		STEER'G	22600	36(3)	TRF			37	37		38(2)	4/32-327	3-69		TRF	81C
91	32	9	6.3	BATT	AUTO	27700	3 UNITS			STEER'G	27900	36	37	37	36	37	37	37	38(2)	7/32-375	3-111		260	91
91B	32	9	6.3	BATT	AUTO	27700	4UN SQ	BATT		STEER'G	27900	36	37	37	36	37	37	37	38(2)	7/32-375	3-111		260	91B
91C	32	9	6.3	BATT	AUTO	27700	4UN FLT	BATT		STEER'G	27900	36	37	37	36	37	37	37	38(2)	7/32-375	3-111		260	91C
636	33	6	6.3	DYN SEP	AUTO	32100	4 UNITS		2		32600	39	36	MIX	39	85	DET		41(2)	4/33-2	3-181	756	263	636
756	33	6	6.3	CH DYN	AUTO	32200	3 UNITS				32700	39	36	MIX	39	85	DET		41(2)	4/33-4	3-183	636	263	756
756B	33	6	6.3	DYN SEP	AUTO	33600	4 UNITS				33700	39	36	MIX	39	85	DET		41(2)	4/33-4	3-183	636	263	756B
424	33	4	6.3	SYN VIB	AUTO	35000					25386		77	MIX	44	75	DET		41	7/33-4	4-11	534	264	424
534	33	4	6.3	SYN VIB	AUTO	35100		REMOTE			25534		77	MIX	44	75	DET		41	5/34-23	4-11	424	450	534
816	34	6	6.3	SYN VIB	AUTO	37400		REMOTE			26851	6D6	6A7	MIX	39	85	DET		41(2)	5/34-35	5-43	926	264	816
926	34	6	6.3	GENEMO	AUTO	39000		REMOTE			26851	6D6	6A7	MIX	39	85	DET		41(2)	5/34-35	5-43	816	264	926
936	34	6	6.3	GENEMO	AUTO	38800	3 UNITS	REMOTE			38900	6D6	6A7	MIX	39	85	DET		41(2)	5/34-35	5-43	816	264	936
666	34	6	6.3	VIBR	AUTO	39900		REMOTE			26851	6D6	6A7	MIX	6D6	85	DET		41	5/34-25	5-31		264	666
776	35	6	6.3	VIBR	AUTO	29296		CBLES ROUND			26851	6D6	6A7	MIX	6D6	85	DET		41	7/35-3	6-41		264	776
126	36	6	6.3	VIBR	AUTO	32104		REMOTE DASH			32137	6K7G	6A8	MIX	6K7G	6Q7(	DET		6F6G	5/36-13	7-3	136	264	126
136	36	6	6.3	VIBR	AUTO	32104		REMOTE DASH			32147	6K7G	6A8	MIX	6K7G	6Q7(	DET		6F6G	5/36-13	7-3	126	264	136
416	36	6	6.3	VIBR	AUTO	32104		REMOTE DASH			32137	6K7	6A8	MIX	6K7	6Q7	DET		6F6	5/36-13	7-3	126	264	416
446	36	6	6.3	VIBR	AUTO	32104		REMOTE DASH			32147	6K7	6A8	MIX	6K7	6Q7	DET		6F6	5/36-13	7-3	126	264	446
556	36	6	6.3	VIBR	AUTO	32104		REMOTE DASH			32137	6K7G	6A8	MIX	6K7G	6Q7(	DET		6F6G	5/36-12	7-49		264	556

LATER BATTERY POWERED AND 32 VOLT DISTRIBUTION RADIOS — MASTERLIST 2G

SET NO.	YR	TUBES NO	FIL	PWR	CHASSIS SIZE	CHASSIS NO.	CABINET	STYLE	CTRLS KBS	DIALS	SPKR NO.	RF TUBE	MIX	OSC	IF	DET	AVC	AF	OUTPUT	AK DATA	RIDER DATA	MATE	IF	SET NO.
70Q	30	7	6	ABC	BIG	16800	CNSL	LO-BOY	3	FAN	15920	222(3)			TRF	112A		112A	71A(2)	12/30-241	3-55		TRF	70Q
76Q	30	7	6	ABC	BIG	16800	CNSL	HI-BOY	3	FAN	15920	222(3)			TRF	112A		112A	71A(2)	12/30-241	3-55		TRF	76Q
85Q	31	7	2	ABC	MED		CNSL		3	FAN	19900	32	32		32	30		30	33	11/31-290	3-93		130	85Q
469Q	32+	9	2	ABC	MED	31100	CNSL		3	FAN	31500	34	34		34(2)	30	30	30	30(2)		3-165	558Q	130	469Q
427Q	33	7	2	ABC	MED	35800	CNSL				36400	34	1A6		34	32		30	30(2)	5/34-17	4-9	387	264	427Q
525Q	34	5	2	ABC		39100	CNSL				39200		1A6		34	32		30	19	5/34-5	4-23	165Q	264	525Q
655Q	34	5	2	ABC			CNSL				43200		1A6		34	32		30	19	3/35-3	6-23	465Q	264	655Q
978Q	34	8	2	AB			CNSL		4	AIR	43200		1C6		34(2)	30		32	30(3)		6-38	768Q	472.5	978Q
385Q	35	5	2	ABC			CNSL		4	AIR	46800		1C6		34	32		30	19	735-5	6-19	625Q	264	385Q
285Q	35	5	2	ABC	SMALL		CNSL	T	3	AIR	49900		1C6		34	30		32	33	6/35-4	6-13	415Q	450	285Q
467Q	35+	7	2	6V VIB	MED		CNSL	H	4	AIR	50800		1C6		34(2)	1B5		30	19	8/35-1	6-12	237Q	472.5	467Q
747Q	35+	7	2	AB	MED		CNSL	H	4	AIR	50800		1C6		34(2)	1B5		30	30(2)	3/36-11	7-55	657Q	472.5	747Q
485Q	36	5	2	ABC	MED		CNSL	T	3	AIR	55600		1C6		1A4(2	1B5			33	3/36-7	7-55	515Q	450	485Q
82Q	31	7	2	ABC	MED		CPCT	CATH	3	FAN	18400	32	32	30	32	30		30	33	11/31-286	3-77		130	82Q
84Q	31	7	2	ABC	MED	19550	CPCT	CATH	3	FAN	18400	32	32	30	32	30		30	33	11/31-287	3-87		130	84Q
228Q	32	7	2	ABC	MED	21900	CPCT		3	FAN	18400	32	32	30	32	32		30	33	4/32-331	3-145	82Q	130	228Q
558Q	32+	8	2	ABC	MED	31200	CPCT		3	FAN	31700	34	34		34(2)	30	30	30	30(2)	133-399	3-165	469Q	130	558Q
387	33	7	2	ABC	9X14	35200	CPCT	ARCH	3	FAN	31700	34	1A6		34	32		30	30(2)	5/34-17	4-9	427Q	264	387
165Q	34	5	2	ABC	6.5X10	38700	CPCT	ARCH	3	WIN	37170		1A6		34	32		30	19	5/34-5	4-23	525Q	264	165Q
465Q	34	5	2	ABC	6X11.5		CPCT	ARCH	4	AIR	42900		1A6		34	32		30	19	3/35-3	6-23	655Q	264	465Q
768Q	34	8	2	AB			CPCT		4		43100		1C6		34(2)	30		32	30(3)	3/35-5	6-38	978Q	472.5	768Q
625Q	35	5	2	ABC	MED		CPCT		4	AIR	46700		1C6		34	32		30	19	7/35-5	6-19	385Q	264	625Q
415Q	35	5	2	ABC	SMALL		CPCT	FLT	3	AIR	48500		1C6		34	30		32	33	6/35-4	6-13	285Q	450	415Q
237Q	35+	7	2	6V VIB	MED		CPCT		4	AIR	50700		1C6		34(2)	1B5		30	19	8/35-2	6-12	467Q	472.5	237Q
657Q	35+	7	2	AB	MED		CPCT		4	AIR	50700		1C6		34(2)	1B5		30	30(2)	3/36-11	7-55	747Q	472.5	657Q
515Q	36	5	2	ABC	MED		CPCT	FLT	3	AIR	55500		1C6		1A4(2	1B5			33	3/36-7	7-41	485Q	450	515Q
135Z	34+	5	6.3	32 VIB	SMALL		CPCT		4		42700		6A7		78	75			43	8/35-3	6-7	215Z	264	135Z
215Z	34+	5	6.3	32 VIB	SMALL		CNSL		4		42800		6A7		78	75			43	8/35-3	6-7	135Z	264	215Z
305Z	35	5	6.3	32 VIB	8X12		CPCT	ARCH	4	AIR	42700		6A7		78	75			43	8/35-5	6-9	565Z	264	305Z
565Z	35	5	6.3	32 VIB	8X12		CNSL	T	4	AIR	42800		6A7		78	75			43	8/35-5	6-9	305Z	264	565Z