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# HISTORY OF RADIO*

By S. M. KINTNER

The privilege and honor of appearing here tonight is greatly appreciated by me and yet, I cannot escape a feeling that there is a degree of fitness in it, as a result of my good fortune in having been intimately associated with some of those most instrumental in bringing about the achievements that make a record of them worthy of your consideration. These circumstances make it possible for me to know first hand several of the most important occurrences and to place them in your annals as records of outstanding achievements of this community.

The origin of radio is traced to one of those marvelous examples of abstract reasoning from a certain new theory evolved to explain something quite foreign, at least in its application, to radio. The proposer of this theory did not know how to produce radio waves and did not know how to detect them even if he had been able to make them. He did, however, reasoning from his abstract theory, quite clearly describe all of their properties and did this so well that his enunciation of their laws is used by radio engineers today. Clerk Maxwell, a celebrated English physicist, proposed his electromagnetic theory of light in 1864. His theory included waves in the ether of many lengths outside of those producing to our sense of sight, the sensation of light. Of course, the band of light waves occupies but a small part of the many possible ones.

Maxwell's theory created quite a stir among the scientists of his day but was unknown to the man on the streets. It was an attempt to explain the mechanism of light but didn't give us any new instrumentality, or indicate then, the possibility of any new results from existing ones.

The scientists' interest was aroused in trying to prove the correctness or falsity of the theory. If Maxwell was correct how could these other waves be produced? That was the task set them. To stimulate interest prizes were of-

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fered but the undertaking was so difficult that practically 25 years elapsed before such waves were produced, detected and their properties found to be as Maxwell had predicted.

Maxwell died before this confirmation of his theory was obtained and thus was deprived of the pleasure that should have been his for such an accomplishment.

Heinrich Hertz, a German, made the discovery and disclosed it to the scientific world in a set of papers that take rank with Maxwell's as classics of the radio art.

The first interest in Hertz's work was a confirmation of Maxwell's theory of light. These experiments were limited to the confines of a room and although it was known that brick walls were transparent to such waves, there was nothing to suggest distance operation and hence, no thought of communication.

The very general study of Hertz's tests by physicists all over the world soon produced improvements in his apparatus which made it possible to detect the waves at greater distances from the source and very shortly thereafter it was realized that here was a means for communication without fixed connections.

The first record of such recognition is contained in the *Fortnightly Review* of February 1892 wherein Sir William Crookes quite aptly described what we now know as radio. In this he, in effect, says, we now have the instrumentalities which, when sufficiently developed to make them more certain in their operation, will enable us to communicate without wires. He stressed the reality of such conditions by disclaiming that what he had said was simply the idle day dreams of an old scientist. He furthermore described the essentials of such a system using the Hertz waves.

A number of workers now came into this field who seriously attempted applications of Hertz waves to various practical purposes. Among them somewhat in the order of operations were: Popoff in Russia, Lodge, Jackson and Preece in England and Marconi in Italy. Popoff was interested primarly in using the waves sent from distant lightning as a means of forecasting storms. He did, however, clearly recognize communication possibilities, when, as he says, more powerful transmitters are available.

Lodge demonstrated before the Royal Society in 1895 the operation of relays at a distance and stated that his

equipment was probably capable of operation at a distance of half a mile.

Jackson's work was for the British admiralty and was for the purpose of perfecting communication means.

Preece was head of the British Post Office Service, in charge of their telephone, telegraph and some cable operations, and was solely interested in Hertz waves as a means of securing communication between places where it was impractical to maintain cables.

It was at this time that Marconi graduated from college. He was the son of well-to-do parents and did not feel the need of seeking employment which would make him self-supporting. In the latter part of his college training he had been greatly fascinated by Hertz's experiments, which he had witnessed demonstrated to his class by Prof. Righi, and decided upon graduation to devote some time to attempt at perfecting a method employing these principles for communication purposes. Marconi realized, as Crookes had previously done, that such a communication system was a possibility but unlike Crookes he had the time and money to undertake its development and did so.

The first attempts of Marconi were very close copies of what had been done by others before him. He bent his energies to improving the reliability of the various parts of his system rather than to striking out along radically new and original lines. These refinements of course brought improved results and the distance of his successful operations gradually grew until he had attained a mile. Then Marconi decided to transfer his experiments to England. He had influence and was able almost at once to effect a favorable arrangement with the British Post Office and to secure their powerful assistance.

Within a year the distance of his transmission had increased to 12 miles and within a short time thereafter, with still greater power, he succeeded in crossing the channel. This accomplishment in March 1899 was given world wide publicity and caused a number of new investigators to enter this attractive field.

The Marconi system of wireless telegraphy as it was then popularly called employed the same method Hertz had used for producing his waves, i. e., high frequency oscillations set up by an electric spark discharge and the same

methods, somewhat refined, of detecting them. The principal change Marconi had made from Hertz—aside from the size of his apparatus and the power used—was in his detecting means. While Hertz had employed a minute spark gap across which he could visually observe the passage of the tiny sparks, Marconi employed an improvement due to Branly, consisting of a number of minute spark gaps formed between minute particles of metal and which underwent a marked change in electrical resistance when the effect of the received waves was impressed upon it. This change in resistance, generally a reduction, permitted the current in a local circuit to operate some indicating mechanism, such as a telegraph sounder.

Marconi's first patent gives evidence that he thought his great advance had been made by improvement in the detecting means as it is stressed most strongly by all elements claimed.

This detector because of its tendency to have the minute particles cohere, as though fused together, was named a "coherer." The early writings about wireless are full of praises for the coherer. It was given such fanciful designations as "the electric eye" and was said to be the instrumentality that made wireless possible, the most sensitive device ever conceived by man.

Practically all investigators of that time were working along the same general lines. They accepted the coherer as the heart of the system and sought to improve it still more. There was one notable exception in R. A. Fessenden, then Professor of Electrical Engineering at the Western University of Pennsylvania.

Fessenden from results of a study of coherer principles was convinced that not only was the coherer not responsible for the success of radio but that it was an actual hindrance and was retarding its progress. It took a strong will and a firm conviction in the correctness of his position to face practically the world and tell them they were wrong and yet that is what he did and he was later found to be right. That decision, made in 1899, marked the beginning of a radical change in the methods of radio.

In the late summer of 1899 one of the New York papers offered Fessenden a thousand dollars to report the Yacht Races off New York Harbor by radio. He sought my as-

sistance and disclosed his plans. I agreed and started at once to get suitable apparatus for the work. We were unable to get our apparatus in working order in time to report the race but we had met with a sufficient degree of success to thoroughly arouse our interest in the subject and we kept right on.

We were both thoroughly convinced of the necessity of having a detector that gave an indication proportional to the strength of the received signal. The coherer was the antithesis of this as it was trigger operated and as soon as a signal strength reached the minimum tripping value no advantage by increase in signal strength would be secured by stronger signals. There was no individuality about a transmitting station and no way of judging its distance by the signal strength. Radio telephony was of course unthinkable by such means and so thoroughly was this coherer operation imbedded in the popular mind, as well as those engaged in the practice of the art, that the chief examiner in the Patent Office in charge of radio matters, has told me that he had stated positively to his friends that telephony by wireless methods was impossible.

The Fessenden idea was crystalized in a number of different forms of detectors, each giving proportional responses. With these devices it was soon observed that different transmitters had different characteristic sounds to their signals as they were observed by telephone receivers as is still practiced today. Fessenden properly ascribed this difference to differences in radiation of the individual trasmitters and conceived the idea of controlling the radiations by some form of telephone microphone and thus have radio telephony.

He tried this with crude equipment but secured a result which proved the correctness of the idea. While Fessenden did not make this test in Pittsburgh, the broad idea upon which it was based was conceived here. This was the birth of the radio telephone.

The Fessenden system for best operation required a change in the transmitter. It required more continuous radiation whereas Marconi's was best with the reverse. That is, Marconi needed a certain amplitude of impulse to trip his trigger, all that followed till the trigger was reset, was wasted.

This resulted in the concentration of as much as possible of the energy in the first impulse. A so-called "whip crack effect" was sought for best operation of the Marconi system.

On the other hand, Fessenden's system worked best with the radiation made more persistent. The principal advantage of the more persistent radiation over the less persistent, or highly damped as it is called, is the greater selectivity that can be secured by it with resonance tuning of the receiver. As resonance tuning requires the addition of many minute impulses—all exactly timed so that their effects are additive—it is apparent why the more persistent type of radiation is superior for this purpose.

Fessenden's attempt to increase persistence finally lead him to continuous radiation with no intervals of no radiation. He proposed an actual system of this kind consisting of a high frequency dynamo directly connected to an antenna and to ground. All other preceding systems secured their high frequency current from oscillations derived from discharging a condenser through a spark gap and including a certain amount of inductance.

Today, to those who have learned of radio within the broadcast period, Fessenden's continuous wave system does not sound like much of an invention, but it was a radical departure from all that had gone before. Fortunately, there is a contemporaneous writing by a radio authority which covers exactly this point.

J. A. Fleming, technical director of the Marconi Co., says in his 1906 edition of his *Electro-Magnetic Waves*, in discussing Fessenden's patents, that (1) there was no suitable high frequency alternator of the kind required by Fessenden and (2) it was very doubtful if any appreciable radiation would result if such a machine was employed as described by Fessenden. Today there is no question on that score as every trans-oceanic station employs exactly those means and every broadcasting station has equivalent means, an oscillating tube generator being substituted for the dynamo described by Fessenden.

This was the second big result following from Fessenden's conception of displacing the coherer.

His third invention of major importance followed the preceding by about seven years.

Fessenden found when he secured continuous generation that the then-existing types of receiver system didn't work very efficiently. When listening to code signals from sparks one hears each individual spark. If these are of sufficiently high frequency and regularly spaced in time, a musical note is heard. The code signal is then made up of a series of short or long musical tones to indicate dots or dashes. When continuous waves are used, there are no such impulses to produce the musical tone, but the telephone receiver simply clicks at the beginning and again at the end of the dot or dash and only the interval between clicks can be used to recognize whether a dot or dash is intended. Attempts to overcome this were made by interrupting the transmitted waves so as to break them up into groups similar to the group of waves accompanying each individual spark of that system.

Others sought to attain the same result by interrupting the receiver energy and thus make the sound heard by the listening operator, similar to that of the spark systems. Both of these methods are inferior to Fessenden's method which consists of having another source of oscillations at the receiving station which can be accurately adjusted as to frequency and intensity, and then impose the locally produced oscillations on those received from the distant station. The local oscillations are adjusted so as to be slightly different from those of the incoming signals. This results in their getting into and out of step, so to speak. When in step their effects are additive. When most out of step, they are subtracted from each other. Thus, periodic changes in signal intensity are imposed on the telephone receivers and a musical note of the frequency of that of the beats or of getting into and out of step. Generally this is made about 1000 per second as the ear is most sensitive to that frequency. This method Fessenden called the heterodyne, a coined word from the two Greek words "heteros" meaning different or several and "dyne" meaning force.

The heterodyne method is superior to all others because it is more selective; is more sensitive; and enables the operator to select a signal tone best suited to his ear. It is the universally employed method in all modern radio telegraphy. It has also found its way into the broadcasting field, where it is known as the superheterodyne because the

best frequency used there is of super audible frequency. The advantages of selectivity and sensitiveness are secured to a slightly lesser degree than is the case with the telegraph receiver when used with audible beats.

Another one of Fessenden's notable accomplishments at Brant Rock was sending a telephone message by radio from there to Jamaica, Long Island, in 1907. He also demonstrated the feasibility of using a wire line to pick up a telephone message and carry it to the radio station from which it was sent by radio and at the receiving station put back on another wire line and delivered to the listener. That is, he accomplished the transfer from wire to radio and back to wire in 1907. That of course is commonplace now but attracted considerable attention when it was repeated by the American Telephone and Telegraph Company in 1916.

While Fessenden was making the advances recorded above, others, attracted by his success, began to depart from the Marconi system and work over into or towards the Fessenden system. Even Marconi broke away from his early ideas. He first devised a magnetic detector which was midway between coherer action and that of Fessenden's detector. Fleming devised a detector known as the "Fleming valve" which was a complete change-over and Marconi used it along with his magnetic detector.

Change of detector brought a change in transmitter—just as Fessenden had previously done. However, Marconi was unwilling to give up spark transmitters even up until the close of the war. In fact, the American Marconi Company installed spark transmitters for trans-oceanic work shortly before the war and at a time when the Germans at their Sayville, L. I., station were taking out a better spark system and replacing it with a continuous wave system. Needless to add the Marconi spark system for trans-oceanic service was never commercially successful and has now been completely abandoned.

In the period of 1905 to 1910 practically all radio—or as it was then called "wireless"—was centered around ship-to-ship and ship-to-shore telegraphic communication. Only the larger vessels installed it at first, as its usefulness had not been established. However, the saving of life at sea by calling assistance to sinking ships soon made it apparent that it had a very real value. The first instance of this that

attracted very great attention was the sinking of the S. S. Republic off Nantucket. Every passenger was saved, though without the prompt assistance that was secured by radio call the loss of life would have been very great.

This resulted in a U. S. law compelling all passenger ships carrying more than 50 passengers to carry a radio set. It didn't compel them to carry but one operator and had no provision for his listening for distress calls. About a year or two later, William Jennings Bryan was on a ship. down near Jamaica, that got in a wreck and its radio operator was unable to get an answer to his calls for several hours because no one happened to be listening. He talked Congress into compelling a listening regulation to the extent one operator could be asked to work. The ship operators fought the expense of the extra operator on the score of economy—just as they fought the expense of carrying enough life boats to provide accommodations for all on the ship and succeeded in defeating both. It was not until the facts attending the sinking of the Titanic came to light that the ship operators were compelled to give in on both of these regulations.

At the time of that awful disaster there were two other ships within 20 or 30 miles of the Titanic, each provided with radio sets but their operators had gone to bed. It was in fact only by the best of luck that the Carpathia's lone operator heard the call and answered from her position, 70 miles away, that they would arrive on the scene in four hours.

Operator Cotton, of the Carpathia, told me within a week of the rescue, that he had sent all his messages save one, and had received all from all ships and shore stations that had offered him, and was undressing to retire. He decided to make one more try to raise the ship for the one message he still had undelivered and it was while listening for a reply to his call that he heard the Titanic's distress signals. He was only half dressed and 30 seconds more would have found him in bed.

The safety of the 1000 or more saved was determined by that bit of fate.

All ships carrying passengers have a continuous radio watch now and a condition like that described will not happen again.

In 1910 the U. S. Navy Department decided to erect a powerful radio station with which to reach the North Atlantic Fleet. This station was not completed although the equipment was finished and tested in 1910, until early in 1913. This was the first large transmitting station in the United States—the Arlington Station at Arlington, Va. Fessenden's company, the National Electric Signalling Company, owned principally by Pittsburgh men, built and installed the Arlington Station equipment.

Prior to Arlington, the Brant Rock, Mass. station of the National Electric Signalling Company had been the largest and was one of a pair of stations that effected the first successful interchange of messages between England and the United States. These stations were for experimental work only and should go down in radio history as monuments to the courage and faith in the future of radio that T. H. Given and Hay Walker, Jr., both of Pittsburgh, had, as these two paid the total cost of installing and operating these stations for several years.

The first interchange in messages between Brant Rock, Mass. and Machrihanisch, Scotland was January 1, 1906.

Shortly after Arlington's site was selected by the Government, the Germans started the erection of a big station at Sayville, L. I. Ostensibly this was for ship-to-shore communications but immediately upon the outbreak of war in 1914, it was put into use in communication directly with Germany. The original equipment was not large enough and was replaced with one of larger power and of a different type, within a year after the outbreak of war.

Another German station was started at Turkerton, N. J. about a year prior to the war and was practically completed at the time of its opening and was immediately opened up and operated for its owners by the United States Navy Department.

The Marconi Company were also working on several large trans-Atlantic and trans-Pacific stations about this same time. These stations did not do very much sending as they were obsolete at the time they were installed.

The Navy Department, as a result of their experience at Arlington, decided to erect several other large radio stations and started very soon after the completion of Arlington first at Darien, Panama Canal Zone and then short-

ly after at San Diego, Cal., Pearly Harbor, Honolulu and Cavite, Philippines. Each of these later stations was of the continuous wave type and employed heterodyne reception.

The generators of the high frequency oscillations were arcs of a type developed by Poulsen but in the radio operations served an equivalent function to the high frequency dynamos proposed in Fessenden's continuous wave transmitter.

The Federal Telegraph Company of California owned the United States rights to the Poulsen arc and first called it to the attention of the Navy Department during the acceptance tests of the Arlington Station in 1913. They installed an arc at Arlington which when received on the Cruiser Salem by the heterodyne receivers supplied as part of the Navy contract for the Arlington equipment, gave results so strikingly superior to the spark signals, that the Navy was convinced at once of the superiority of the continuous wave system. The Navy immediately adopted it as standard and placed contracts with two firms for the equipment; one firm built the transmitters and the other the receivers. Neither had rights under the Fessenden patents which were later adjudicated and shown to be valid. The Federal Company operated over 2000 miles between Honolulu and San Francisco quite successfully during this time and up until the war.

## TUBES

An important line of development had taken place and an important part had been done just prior to the war. This was the development of the vacuum tube, known first as the Fleming valve, later when improved by DeForest as the Audion and made really useful by a circuit arrangement invented by Armstrong that made these vacuum devices take on a new order of importance.

Fleming had discovered that a device, like an incandescent lamp but having a sheet metal plate surrounding but insulated electrically from the filament, would allow current to pass across the vacuous enclosure from the cold plate to the hot filament but not the other direction. It thus acted like a check valve in a pipe and was called a valve.

DeForest made an improvement in the Fleming valve when he introduced an additional element, in the form of

a metal screen, between the filament and plate. With his arrangement amplification was possible, as the feeble energy impressed on the screen, or grid as he called it, made it possible to control a much larger current in the other circuit including a connection to filament and plate.

Strangely enough this improved form of tube did not meet with much favor probably because the tubes were so poorly made and were so erratic in their behavior that operators preferred the more reliable even though less sensitive forms of detectors.

Armstrong's invention of the feedback circuit changed this condition very much, as it gave such marked amplification and such great improvement in range that tubes rapidly displaced all other forms of detectors.

Armstrong's invention also disclosed a method of making an oscillating current generator from a tube. This was of the greatest importance as it supplied the missing link in the Fessenden continuous wave system to make it possible for short waves such as are now used for broadcasting, as well as for the long waves obtainable direct from dynamos.

This was the state of the art in 1914 when war broke out.

The preceding period of about 7 or 8 years is best characterized as one of fraudulent stock selling and general patent infringment. Millions of dollars of stock was sold; the most of this money went to other uses than those for which it was contributed.

This condition of infringement greatly hampered developments as those having valuable rights were compelled to spend much time in defending them and this slowed up the progress that would otherwise have been made along scientific and technical lines. Among the most flagrant offenders in this respect were the Army and Navy Departments, particularly the latter.

The outbreak of war in 1914 resulted in placing of restrictions on radio operations with the intention of trying to maintain neutrality. It has always been difficult to understand how radio required such close supervision, while cables and telegraphs across the borders didn't.

The marine operations continued for a time about as they had been but when the submarine warfare started,

practically all marine operations ceased as a ship gave her position away and greatly increased the risk of a submarine attack if her radio transmitter was used.

The trans-oceanic operations by radio to Germany were greatly stimulated as the cables were cut, as that afforded the only means of direct communication.

Later when we got into the war, it was expected that the Germans would cut the cables to England and France and the fact that they did not do so was probably due to their getting more benefit than suffering harm from their continuance. Provision was made, however, or rather started, for caring for such an emergency by the erection of a very powerful radio station in France—known as the Lafayette Station. This was not completed until the close of the war and was then sold to France.

The Sayville, L. I. station was run almost continuously, with all messages passing through resident Navy censors and all messages were supposed to be in plain English as no code messages were passed. There were many messages that had all the appearance of plain messages but were in reality coded, that were passed and sent to Germany. This method of operation continued until we entered the war when the station was taken over by the Government.

The Tuckerton station had just been completed and tests were in progress when war broke out. It was not granted a license to operate, as the radio treaty regulations prohibited the granting by a neutral country of a license to operate a radio station erected on their soil by one of the belligerent countries, during war times. The Navy Department came to the rescue of the German operators and took the station over and operated it for them, and held the profits, some $400,000, for them.

When in April 1917, this country entered the war, all radio stations were taken over by the Government and either shut down or operated in the Government service.

The opening of war found our Navy Department quite well equipped with radio apparatus and with a trained personnel ready to operate it. Quite the reverse was true of the Army. The Army's equipment was very poor both in quality and quantity. They didn't seem to know what they wanted and so were unable to place any orders for about six months following the declaration of war. The greater

part of the Army's new radio equipment either never was used or was used only for training purposes. About the only exception to this was a few airplane spark sets used for shell control work, some of which saw actual service.

The United States' part in radio during the war consisted largely in developing sets that the French or British were using and had found most serviceable and in contracting for and building them in considerable quantities. The part for the Navy was used: that for the Army was not. It is all obsolete now.

Direction finding systems were found to be very useful during the war and these were built in considerable quantities. These were used by ships to locate the direction from which a message was coming; by airplanes to find their way home at night after bombing expeditions.

Large numbers of radio tubes were used in receiving sets and many stages of amplification were employed, so as to make possible the listening to enemy communications. The overhearing of such a message passing between vessels of the German fleet lying in the Kiel Canal, by a listening station in England, gave the English the first information that the fleet was coming out. The battle of Jutland resulted and might have been disastrous for the English but for that information.

The close of the war found all radio stations in the Government's hands and the Departments were very loath to relinquish them. The Secretary of the Navy went before Congress urging that radio be made a Government monopoly and placed in the Navy's hands. Congress refused to do this. The Navy then purchased all the marine stations of the Marconi Company, together with their agreement not to re-build, and all stations of the Federal Company. They had, in fact, all stations excepting three or four belonging to International Radio Telegraph Company and located along the New England coast. This company declined to sell and blocked the carrying out of the Navy's plan of operating all marine stations.

The war brought the big electric companies into contact with radio matters as they built much of such material for the Government. In doing this they developed an organization that was anxious to continue in this line. The engineers of these companies saw advantages to be gained

from such work and urged it more because of the possible improvements in their standard lines that would likely result from such work than with the intention of carrying on radio operations proper.

While these companies, under war conditions, were able to proceed regardless of patent rights, under peace conditions they could not without incurring serious risk of infringement and resulting suits.

Each of the large companies started acquiring patent rights or licenses under them. Within a short time all of the more important patents were under the control of one of three large companies: the General Electric Company and the American Telephone & Telegraph Company, and the Westinghouse Company.

It soon became apparent that none of these companies had complete rights and in fact no one was well enough off in this respect to make it possible to supply a non-infringing equipment with any reasonable degree of efficiency. This situation will be better appreciated when it is known that the General Electric Company owned the basic tube patents as well as many details of construction, while the American Telephone & Telegraph Company owned the DeForest improvement on the tube that was essential to get the real value from the tubes. The Westinghouse Company owned the circuit patents that were required for effectively using the tubes.

Thus the General Electric and American Telephone & Telegraph Companies had tubes but no way to use them while Westinghouse had the way but no tubes to use. A complete deadlock that had but one solution—cross licensing. This followed and the Radio Corporation of America resulted.

The creation of the Radio Corporation of America took each of the three old companies just mentioned out of radio operation and placed the radio communication business in its hands. The older companies, i. e., General Electric and Westinghouse undertook the development of apparatus for the Radio Corporation's requirements. The American Telephone & Telegraph Company undertook radio developments for its own uses in telephone communication.

The R. C. A. immediately rebuilt its stations and prepared itself to conduct the radio communication business of

America. It provided facilities for communication direct with most of the countries of Europe and South America and with Japan. Its equipment and service are so far superior to that of any other country as to insure it the great bulk of the business. Approximately 30% of all messages crossing the Atlantic by cable or radio are transmitted by the Radio Corporation.

## BROADCASTING

At the close of the war the Government removed their ban on amateur operations and immediately this activity was renewed with the vigor that one would expect after several years of radio prohibition. The first operations were by code, the number of operators having been greatly increased as a result of the war training of service operators. The result was a number of stations transmitting code messages to anyone they could pick up as a correspondent. Messages that were of no importance to either sender or receiver, but served their purpose in supplying each a tie for the time that enabled them to practice on each other.

The interest in this kind of service was very slight to the listener who understood code and absolutely nil to the one who didn't.

In the latter part of 1919 Mr. Frank Conrad, Asst. Chief Engineer of Westinghouse Electric Co., at his residence in Wilkinsburg, installed a transmitting set which could be used either for code signals or for radio telephone. He experimented with a great many circuits and modifications of parts. In making these tests he soon formed many acquaintances by people writing or wiring in comment on his performances. This interest soon became so great that it proved quite a burden to comply with the great number of requests by 'phone or wire for "just one number" so that the enthusiastic radio listener could demonstrate to some friend the marvels of radio. To relieve this condition Mr. Conrad announced he would give radio concerts each Wednesday and Saturday nights. This continued throughout the winter and following spring, summer and fall, and established quite an audience of regular listeners.

This interest became so general by early fall that the department stores offered radio receiving sets suitable for

listening to Mr. Conrad's concerts. It was one of these advertisements in one of the Pittsburgh daily papers by the Joseph Horne Company that caught the eye of Mr. H. P. Davis, Vice President of the Westinghouse Company and started him to thinking about the possibilities of radio broadcasting. His analysis of this lead to the conception of a radio broadcasting service at regular advertised hours, every day. Arrangements were made for a broadcasting station at East Pittsburgh, in the face of much misgivings on the part of the rest of the Westinghouse Management as to the outcome of the venture. Application was made for a broadcasting station license and in the fall of 1920, in time to broadcast the results of the Presidential Election, the Department of Commerce issued the first radio broadcasting station license and assigned the station call K D K A

KDKA started with a very small group of listeners measured by today's standards, but there was sufficient response in the form of letters to assure Mr. Davis that his judgment of broadcasting possibilities was well on the way towards complete vindication.

KDKA has continued now for five years to send its messages each night and has not ceased to live up to its original high ideals of regularity, high quality of modulation, a diversified program, a freedom from anything that would offend and something of interest for each member of the family.

The beginning of broadcasting found the listeners unprepared with suitable equipment and what was worse, no manufacturers of radio sets had any thing to offer in relief of this situation. This condition did not continue long, but the rush to supply something quickly resulted in much very inferior apparatus reaching the Pittsburgh public. Manufacturers of telephone head sets, dry batteries and other parts found the major part of their product Pittsburgh bound and they were at a loss at first to account for the sudden increase in their business.

Within a few months after KDKA's opening, a second station was started at Newark, N. J. where it could broadcast to the New York audience. There was considerable speculation at first as to whether New York would take to broadcasting as Pittsburgh had. A short experience there soon proved conclusively that not only did they take to it as

well but that they were fairly taken by storm by this new form of entertainment, for that is all it would be termed at that time.

These first two stations of the Westinghouse Company pioneered broadcasting as a public utility. It was known prior to that time that such a service could be rendered but no one appreciated that it would arouse such general interest or that there would be so much good will value as to warrant the continuing of such an expensive operation.

Even today, after five years of broadcasting, it is difficult to see how such a condition of service can continue indefinitely. Of course there never was such a good advertising means as broadcasting, and were it not for that fact it could not have continued and become the institution that it has. There never was an advertising means employed however that required more skillful manipulation to make it effective. Direct advertising by radio is futile because the "audience will walk out." The advertising matter must be fed over in such small doses or must be so thoroughly disguised as to make it unobjectionable to the listener. Through some strange strain of human nature we are always most critical of those things we get for nothing, and so we find radio broadcast listeners always ready to complain about what is offered them "in the air." Under such conditions it is apparent that direct advertising would kill a broadcasting station quicker than anything else.

KDKA's opening, in Pittsburgh in the Fall of 1920, marked the beginning of a new public utility. Within a comparatively short time every populous community in this country had followed the lead of this Pittsburgh innovation and had put into operation one or more broadcasting stations.

At this writing there are approximately 550 broadcasting stations in operation in the United States, and the only thing that prevents there being several times that number is the physical limitation in the lack of a sufficient number of available wave channels. There has not been much change in the total number of stations for the past two years, for as fast as one discontinues, a new one steps in to take its place.

All radio is regulated by the Federal Government under an act of Congress, passed in 1913. This act put into ef-

fect an international treaty which, among other things, provided for the reservation of certain wave lengths for marine and government uses. This reservation is of waves from 600 to 1600 meters length and was, at the time of passage of the act, the choice bands for the then existing means of radio communication.

When, therefore, KDKA requested a license for broadcasting a wave length of 360 meters was assigned as one least apt to cause interference with marine service or to be interfered with by the amateurs.

As additional broadcasting station licenses were requested, the Department of Commerce, charged with the duty of regulating radio, were at a loss as to how to proceed and so assigned the same wave length to each of the several first stations.

With the growth in number of stations, all on the same assigned wave lengths, interference of the severest kind resulted. This soon caused some of the stations to slip away from their assignment in an effort to find a channel free from such interference and it was not long until one could find stations at most any place over the entire range from 200 to 600 meters, although officially they were all supposed to be on one and the same wave length.

An attempt was then made to improve conditions by creating a special class of stations, each of which was required to maintain a certain standard of excellence to qualify for such special privileges as were given those stations. It was expected that the expense incurred to meet the requirements would deter many from seeking admission to this grade. This proved not to be the case and the Department at Washington soon found itself embarrassed to just about the same extent as before. Since then conferences have been held in Washington at which all those interested are given an opportunity to be heard for purposes of criticism and suggestions of improvements. A great amount of good has come from these conferences, one of which is generally held each year. These conferences deal with ways of making voluntary regulations, or perhaps more properly termed—agreements, more effective in improving broadcasting conditions. How much good can come from voluntary regulations is quite well illustrated by the freedom from amateur interference that we enjoy today compared

to the very general and frequent troubles experienced in the early days of broadcasting from the amateurs' transmitting code signals. The credit for this change in things is due to the amateurs themselves as their organizations undertook educational campaigns directed towards improvements in the amateurs' equipment and towards their more considerate use of it during broadcasting hours.

While your chief interest in broadcasting developments lies in American accomplishments and centers perhaps in the important part played in Pittsburgh where it originated, sight should not be lost of the things that have taken place abroad. In Holland some of the earliest broadcasting outside of the United States was done.

This was greatly restricted by government regulations and was confined almost exclusively to musical numbers. It was sufficient, however, when coupled with the stories of the wonderful things being done in America, to create a popular demand of sufficient strength to gradually break down the barriers and give to each of these several European countries its broadcasting service. To us here in America who get what we want, it is difficult to appreciate conditions as they are in other countries where all the communication systems, aside from direct conversation between individuals, are government monopolies. No provision had been made in the government organizations for a broadcasting service and no other agency under then existing regulations was permitted to do so. There it required more than simply a desire and willingness to build a suitable station and begin operations, as was the case here.

Some change in law, or at least in regulations, was required and this took time before such a service could be started. These changes have been made in the regulations or laws of practically all countries and now we have broadcasting stations in practically every civilized nation on earth. Even Soviet Russia is erecting a high powered station from which we will no doubt soon hear some of their propaganda. Their orators, who cannot come to our shores, will cross, in voice, our frontiers unchallenged. We can no longer be sheltered from hearing things said that are believed against our interest. All such fallacious teachings will have to be combatted by open radio forum discussions and in this way the truth should be sifted out.

The success of efforts in America to enlighten those in other lands will depend largely upon how generally radio sets are owned by foreign individual users and thus an opportunity is afforded to each to select what they personally prefer. We do not appreciate how rich we are here in America where everyone owns an automobile—and nearly every home has a piano, a victrola or a radio and many of them have all three.

While to you it may seem unnecessary to recite the general nature of radio broadcasting programs, still if this is to be a history, then some record should be made of the general and most characteristic types of broadcasting performances.

When KDKA started there was no standard to follow, and so the first programs were made up largely of phonograph records as these were most readily obtained. It was, however, recognized that these would be permissible only during the novelty period and attempts were early made to add original productions to the programs. Speeches and music at banquets found great favor. Late news items, reports of sporting events, such as baseball and football scores and the reports from the ring-side of prize fights, met favor from the first. Church services have been favorably received from the beginning. The conception that was held of a broadcasting program was that it was similar to a great newspaper and the conduct of the service was patterned after that in the thoughts of trying to supply a service for every member of the family and a service fit for each to hear. With very few exceptions, there have been no departures from that early ideal.

Today our programs have grown and in the directions indicated by the listening public. No longer do we listen to phonograph records and there are few times when some really worth while program is not available to us. Now a number of first class stations maintain an orchestra and some have gone so far as to employ a small grand opera company for broadcasting regular classical operas. A number of performers have become stars because of their successes by radio.

The past year brought the National Political Conventions into the home, and everyone learned as never before how such gatherings transact business. We all heard the

thrilling speeches, followed the maneuvers of the leaders, and learned first hand of the intricacies of such proceedings. Through days of experience in listening, we had indellibly fixed in our minds the fact that Alabama had twenty-four votes for Underwood.

Several universities are giving instruction by radio lectures. Physical Culture exponents put thousands, if not millions, through a system of "setting up" exercises just at rising time and prepare them physically for the day ahead.

Expert bridge players of national reputation play auction bridge while many interested players scattered throughout the land follow them by means of cards which have previously been arranged by them from information given by the announcer.

Housewives get instructions on every phase of their activities, in addition to the last one just named.

Father learns of important financial and political news while the young man of the family is instructed about safe automobile operation, and the real young go to bed happy in the thought that the young prince in the bed-time story managed to free the unfortunate princess from the bondage of the terrible bandit.

It is no small undertaking to provide as good program as one desires, every night in the year. The expense of operating a large broadcasting station is so great that many have hesitated to start the practice of paying performers and add at additional expense so long as suitable volunteer talent could be found. That the time will come when paid talent will be the rule instead of the exception can not be denied, but when it comes ways will be found for apportioning that added expense among those who benefit from it. This may be by the plan now in use by the American Telephone and Telegraph Co., of selling the service of their station, and a number of others connected to it by their wire lines, at so much per hour, to large corporations who make use of these facilities for advertising purposes. These large firms supply their own talent, and as the station charges are quite heavy, ranging from $600 to $2000 per hour, they can not afford to have any but the best. While the advertising they get is solely that of the announcement that the program is supplied by courtesy of such a firm, makers of etc., it is believed to be worth the cost.

In England a broadcasting company operates all broadcasting and is paid a subsidy by the Government for so doing. The Government gets its funds by collecting a tax on every listener's set. One-half of this tax is paid to the broadcasting company and they have ample funds to pay all operating expenses, including the highest priced artists.

The economies that can be effected by having the performance of any group of artists broadcasted by a number of stations each serving a different part of the country is apparent and three methods of accomplishing this are being developed. These three methods are: (1) the one now used by the telephone company in which their wires are used to connect the several stations; (2) a method being developed by the Westinghouse Company in which the connecting channels are short radio waves outside the radio broadcasting bands. These short wave channels form the same service as the wires in connecting up the several distant stations with the originating source. (3) The super-powered stations that are expected to have power enough to cover the entire country. This development is being pushed by the Radio Corporation of America. That none of these three, in their present state of development, is ideal is apparent from the fact that there are three. Each now has its serious limitations. The first is its inflexibility and the time and expense required to get and to maintain wires in sufficiently good condition to meet the exacting requirements of such service. At present only the eastern half of the country has been so connected, excepting on two or three special occasions when one or two of the Pacific Coast cities were also included.

The second method, employing short waves, has two natural enemies—static and fading. Fortunately static effects are very much less on these short waves than they are on the longer ones and during about half the year are so mild as to cause very little difficulty. The "fading" difficulties, just like those observed by all radio listeners, must be overcome to prevent the variation in intensity of the broadcasting signals as observed by the listener to one of the stations being served.

There are several methods which offer considerable promise of overcoming this trouble. This method is ideal from the standpoint of flexibility and permits of inter-

national operations as well as those confined to the territorial limits of one country.

The third method is subject to the serious "static" and "fading" troubles without the same chance of correcting that is afforded by the second method.

All radio listeners are familiar with what has been accomplished by the wire connected stations from the splendid programs sent out by the American Telephone & Telegraph Company. There is not so much known about the results obtained by the second method. While most of this has been experimental, there has been a considerable degree of success attained in its use. The Westinghouse Company have sent regular programs from East Pittsburgh to their Chicago, Springfield, Mass., and Hastings, Nebr. stations. From each of these this has been sent out on the wave length of the station being served. This has been done over periods of weeks at a time in studying the various ills that such a system is heir to and devising ways of overcoming them. The full accomplishment of this is drawing nearer and there can be no doubt of the ultimate result being a complete success.

Special replying by radio has accomplished some marvelous results. East Pittsburgh successfully sent programs to England which were picked up and re-broadcast from English stations in Manchester and in London. Later stations in South Africa picked up KDKA programs and rebroadcast them. More recently still, special programs sent from KDKA at five o'clock in the morning were picked up and re-broadcast by Australian stations at seven o'clock in the evening of the same day. Observers heard these signals at the most distant point of Australia from Pittsburgh, which is almost exactly half way round the earth. It is now possible to speak in Pittsburgh to an audience and have the voice, carried by radio, go to every place on the globe and reach the most distant radio listener sooner than those in the back of the hall where the speech is made.

From the old town crier we now have the world crier. There can be no doubt of the civilizing influence of such an instrumentality—neither can there be any question of the tremendous advantage to a particular nation of furthering such a service in a proper teaching of that nation's ideals and purposes and of preventing misunderstanding

that so frequently results from the changes in coloring of repeated stories.

We have been privileged to see radio grow up from a mere scientific novelty in 1895 to a tremendous industry thirty years later. We have seen it first prove its value to the sea in safeguarding life and property; have witnessed it reach across the ocean and insure continuous communication regardless of war and the cutting of cables; have learned of its marvelous possibilities for military uses—for airplane direction finding; and yet in general popular interest these are dwarfed by its newest applications to radio broadcasting. This latter is but five years old and yet it has grown from nothing to $400,000,000 annual expenditures for its instrumentalities and operation. This marvelous rate of growth staggers ones imagination and makes them thankful, as I am tonight, that history records only what has been done and leaves to subsequent writers the task of reporting what follows.