THE RADIO
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To Prof A. S. Dewin[g]
from
Owen Culbertson
Dec. 1925

THE RADIO INDUSTRY

THE STORY OF ITS DEVELOPMENT

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THE RADIO INDUSTRY

THE STORY OF ITS DEVELOPMENT

AS TOLD
BY LEADERS OF THE INDUSTRY
TO THE STUDENTS OF THE
GRADUATE SCHOOL
OF BUSINESS ADMINISTRATION
GEORGE F. BAKER FOUNDATION
HARVARD UNIVERSITY

WITH AN INTRODUCTION BY
DAVID SARNOFF
AND A FOREWORD BY
DR. ANTON DE HAAS

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PREFACE

THIS series of lectures was delivered at the Harvard Graduate School of Business Administration as part of the Business Policy course during the academic year 1927-1928. We regret that several outstanding men in the radio industry were unable for one reason or another to accept our invitations to participate in this series. It is for this reason that the names of Dr. de Forest, Mr. Atwater Kent, Dr. Hazeltine, and others of prominence, do not appear among those of the speakers.

The lectures have been published as they were delivered, and the speakers assume responsibility for whatever statements were made in the lectures. I hereby express the appreciation of the School and of the class before which the lectures were delivered to all those who contributed their time and effort to making this series a success, and more especially to Mr. David Sarnoff, without whose enthusiastic support of the project we should not have dared to undertake it.

J. Anton de Haas

Boston, Massachusetts
May 8, 1928

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INTRODUCTION

DAVID SARNOFF
Vice President and General Manager,
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SINCE communication always has been the instinctive need of man, and since a new art has given illimitable range to human contact, it is natural that the rise and progress of radio should have stirred the imagination of the world. The new art has rallied to its cause the flower of scientific and engineering thought. It now calls to industry for unprecedented tasks of organization.

Perhaps the most remarkable phenomenon of radio development has been the manner in which this new art of electrical communications has swept aside the limitations which men attempted to place upon it. When wireless had first bridged the gap of a few miles, the achievement was hailed as the beginning of a new point-to-point communications system. Few minds at that time could conceive for radio an ultimate communication range of more than several hundred miles.

Then radio reached out to ships at sea and gave the world the first ship-to-shore communications system. When wireless, going further, had spanned the ocean, imagination paused. The mission of radio, it was thought, was the creation of a new system of telegraphic communications, and upon this basis marine and trans-oceanic services by radio were founded both in Europe and the United States. The destiny of radio had been set.

Then came the first faint sounds of the human voice into the home, projected from a crude wireless broadcasting set. And a new art was founded, a new service was established, and a new industry began to form upon the foundation of this service. Today, radio broadcasting is bringing music, education, and information to countless homes throughout the world.

No sooner was radio established as a great transmitting medium of sound through space than the transmission of sight began to beckon to radio scientists. We are now at the beginning of the era of television in the home, when radio will bring the panorama of life as well as the sounds of music and speech to the world's multitudes. Again inventive genius is called upon to develop a new art. Industry once more must organize to supply the mechanisms of a new service. Business again finds itself with new problems to solve.

It was, therefore, a notable task, undertaken by the Harvard Graduate School of Business Administration, to call upon authorities in the field of radio development to pause and take stock of radio progress to date in the series of lectures now presented in book form.

Radio makes a particularly effective appeal to the student of business and to the business executive. Wireless communication has added enormously to the range of business and trade activity by opening up direct communication between countries hitherto connected only through intermediate wire services. In so far as radio thus insured the independence of communications it served largely to insure the independence of world trade.

As a factor in the industrial growth of the United States the greatest significance of radio lies in its effects upon, and in the relations it has established with, other industries. The record of the industry is therefore a fitting subject for study.

The implications which may be drawn from modern radio development are not merely industrial. Radio communication presents a world problem to the statesman. For international communication requires harmonious cooperation between the transmitting and receiving ends, each under the control of a different nation. It presents many legal problems to the lawyer, because the air is still largely an undefined domain.

To the scientist and the engineer, radio still sends forth a challenge. There is yet to be defined the medium through which the electric wave is propagated from the transmitting station; there are yet to be discovered many of the laws that govern the movement of electromagnetic waves through space; there are still to be unlocked many secrets of radio transmission that will infinitely enlarge the scope of the radio art and the opportunities of the radio industry.

The Harvard School of Business Administration, through the initiative of Professor de Haas and his associates, deserves the gratitude of the American public and the radio industry in becoming the instrument for preserving the records of radio progress presented herein.

THE LECTURES

I

A RESUME OF EARLY RADIO DEVELOPMENT

E. E. BUCHER
Assistant Vice President,
Radio Corporation of America

AN ACCOUNT of the steps which led to the discovery of radio is necessarily a résumé of technical advancement; for until Marconi's great discovery of 1896, progress in the radio art was marked by isolated experiments leading to the discovery of new scientific principles, rather than by commercial application. The writer may therefore be excused if he indulges in the use of technical phraseology and launches boldly into a description of the technical processes by which intelligence is transmitted by radio. This is done with the thought that it may enable the reader to obtain quickly a broad picture of the subject. It will be followed by a recital of some of the technical stepping-stones, beginning with the sixteenth century, which led to the development of a practical system of radio communication.

Radio communication is carried on by invisible electromagnetic waves, sometimes called "electric waves," "radio waves," or "Hertzian waves"—the latter appellation resulting from the epoch-making contributions of

Heinrich Hertz. Electromagnetic waves are a combination of electric and magnetic phenomena, which are set into motion by apparatus and devices that may be broadly covered by the term "transmitter." The transmitter consists mainly of apparatus for generating what are termed "high-frequency currents." It also embodies an antenna or "aerial," which may consist of one or more elevated wires supported from a tower, pole or other structure.

When the antenna or aerial is fed with high-frequency alternating currents, electromagnetic waves are automatically radiated into space to all points of the compass. In practice, these high-frequency currents flow to and fro in the aerial system at rates from 15,000 to 20,000,000 times per second, varying with the design of the transmitter. Currents of very high frequency, say, of the order of 3,000,000 to 20,000,000 per second, radiate "short" waves; currents of frequencies from 3,000,000 down to 15,000 per second radiate what are termed "long" waves. So long as these currents flow in the aerial system, electromagnetic waves travel outward. Start and stop these currents by a telegraph key, and one can make the wave motion simulate the dots and dashes of the Morse Code. Control them by a "microphone" or a telephone transmitter, and one can transmit the acoustical undulations of speech and music.

To detect these waves, we erect another elevated wire at a distant point, that is, at a receiving station. This wire will absorb some of the energy of the passing wave in the form of feeble alternating electrical currents of the same frequency as those generated at the transmitter. Thus, if the transmitter radiates 20,000,000 waves per second, these 20,000,000 waves will induce 20,000,000 cycles of current in the receiving wire. The high-frequency currents thus induced in the receiving wire cannot be made to work directly any device that will produce an effect on the human ear. It is, therefore, necessary to "transform" these currents so that they will operate a telephone receiver or a loud speaker. The device which accomplishes this is called a "detector," of which there are various kinds.

The currents induced in the wire at the receiving station may be too weak for detection. In that event, we induce another instrumentality, known as the "amplifier." This performs the function of building up these weak currents to sufficient strength to permit the detector to function and thus operate a telephone or a loud speaker.

As the phenomena of electricity and magnetism play such an important role in the science of radio, we shall make brief note in this paper of a few of the early observations in these fields. The growing consciousness, decade by decade, particularly during the nineteenth century, that mankind might ultimately employ electromagnectic phenomena to communicate through space, constitutes one of the entrancing records of scientific history. Unfortunately, it is not possible in the space allotted here to do more than to touch upon a few of the outstanding factors in this development, or to do justice to the great labors of the leading scientific workers in the electrical field. Indeed, it will not be possible to make mention of the contributions of many of the early inventors. We shall endeavor to show, however, that successive generations gained increasing knowledge of the laws of *electricity* and *magnetism,* and that this growth of intelligence culminated in the discovery of electromagnetic waves.

It appears that mankind first observed the phenomenon of magnetism, then that of an electric force (or static electricity), and then the electric current. This was followed by the important discovery that a current of electricity always produces magnetism, and that magnetism under the proper associated circumstances produces electric currents. Lastly, there was the discovery that an elevated wire traversed by rapidly reversing currents produces electromagnetic or Hertzian waves, and that these waves could be used for the transmission of intelligence and detected at great distances. One scientific thinker predicted mathematically the laws governing the propagation of electromagnetic waves long before their existence was demonstrated practically.

STEPS THAT LED TO THE DISCOVERY OF ELECTROMAGNETIC OR HERTZIAN WAVES

Historical references record scientific phenomena which are readily recognized as stepping-stones to modern radio. The records of these early years, however, are somewhat brief, widely scattered, and often disappointing in the limited recognition accorded the work of the early savants. There are many odd touches and sidelights in the writings of the sixteenth, seventeenth, and eighteenth centuries which indicate that, although several investigators of nature's phenomena recognized the existence of the great forces that we now know as electricity and magnetism, they had practically no conception of their ultimate value to mankind. However, because they lacked the scientific instruments and the vast fund of knowledge now at the disposal of research engineers, it is not to be wondered that they understood but little of the phenomena which came under their observation. They have gone down in history as the hardy pioneers that blazed the way for the discovery of basic laws which eventually were to become the obedient servants of subsequent scientific workers.

Prior to the year 1550, it was known that a mineral, termed lodestone, would attract metallic substances, and that if floated on a cork in water, the cork would come to rest with the lodestone disposed in a northerly and southerly direction. Thus the forerunner of the magnetic compass came into existence. In that same century also it was observed that non-metallic substances, for example, amber, when rubbed with other non-metallic elements, such as silk or cloth, would attract bits of fiber, light pieces of straw, and the like. The power which enabled these elements to attract other elements was early characterized as an "electric force." Later it was termed an electro-static charge or a "static" charge, meaning electricity in a stationary state.

Many odd devices were used in the early days for generating static electricity. The principle usually employed was the creating of friction between two dissimilar elements. Thus, in 1672 Von Guericke mounted a globe of sulphur on an axle and turned it with a crank. He held the palm of his hand against the globe of sulphur and thereby created electrical charges which were retained upon the surface of the globe. The charged globe would attract many light-weight objects, such as bits of straw and pieces of cloth. Friction machines of this and similar types created a great deal of interest throughout Europe in the seventeenth and eighteenth centuries.

In 1709 another investigator substituted a circular glass plate for the globe of sulphur. He created frictional electricity by holding a cloth cushion against the glass plate. This was a forerunner of many types of so-called static or friction machines, one of which was invented by Helmholtz.

At one time in the eighteenth century, about 1780, frogs' legs were very popular as electrical indicators and were widely used by scientists of the day in various electrical experiments. It happened that the wife of Aloysius Galvani was preparing a dish of frogs' legs for the scientist's dinner at the same time that one of the scientist's assistants was working with a static machine nearby. Mme. Galvani happened to touch a sensitive nerve in one of the frogs' legs with the point of a knife, whereupon the frog's leg kicked and struggled as though alive. The experiment was repeated, the news spread throughout the scientific world, and soon there ensued a demand for frogs' legs which temporarily exceeded the supply. Householders found they could be used as storm indicators in the summer, as they would convulse upon the approach of an electrical storm, frequently when the storm was at a distance. Frogs' legs maintained a prominent place in electrical experimental work from 1780 until about 1830.

As early as the year 1600, Roger Bacon, an early English scientist, conceived the idea that a pair of magnetic compasses might be provided with a circular alphabet and in some way arranged so that one instrument could control the movements of the other, and thus be used for transmitting intelligence between two distant points. Bacon apparently did not appreciate that the position of the compass needle was fixed by the earth's magnetic currents, nor was he aware at that time of any such thing as a current of electricity. However, he was quite correct in his original assumption, for in the light of subsequent knowledge it is entirely possible to fit out compasses and control the swing of their needles by a battery and interconnecting wires. Thus, the germ of the idea that communication might ultimately be established between two distant points through some of the mystifying phenomena noted by these early experimenters was growing even in Bacon's time.

In 1719, Musschenbroek, a professor of mathematics and philosophy at Duisberg University (Germany), "bottled up," perhaps for the first time, an electrical charge delivered by a frictional machine.* He was responsible for the so-called Leyden jar, which in present-

* Other authorities attribute the discovery to Professor Cundeus of Leyden. (Ed.)

day terminology is known as a condenser. Musschenbroek's jar was a glass filled with water which was placed upon a flat metal plate. A metal rod was led to the water inside the jar, the opposite end placed near to a terminal of the static machine, and the copper plate connected to earth. Here the glass jar acted as the insulating medium between the copper plate and the water, separating the electrical charges which were impressed upon the surfaces of the glass. The observation followed that if metallic conductors were led from the water within the jar and the copper plate, and brought near one another, an electrical spark of considerable intensity would leap the gap. This clearly indicated that the electric charges produced by the static machine could be stored up and subsequently released. It was then demonstrated that several non-metallic substances, such as glass, for example, could become the medium for holding static charges of electricity. These substances were eventually termed "insulators."

Benjamin Franklin at various times during the eighteenth century conducted experiments which aroused increased interest in electric phenomena. Among other things, Franklin's early investigations led ultimately to the basic law that bodies with like electrical charges repel each other and those with unlike charges attract each other. In 1736 Franklin became convinced that lightning was simply a greater collection of the electric force than scientists were obtaining from some static machines. After a long and careful consideration of this conception, Franklin directed a letter to the Royal Society of London in 1750, in which he suggested that "electrical fire," as he termed it, "might be drawn silently out of a cloud before it came nigh enough to strike." The Royal Society, however, treated this suggestion somewhat with indifference.

Nevertheless, Franklin felt that if lightning could be conducted down a continuous pathway to ground, it would disappear without a spark and without destroying anything in the vicinity of the discharge. He proved this to be the case by an experiment in which a wire was held in space by a kite. He proved that a wire so placed would collect a certain amount of electrical charges from the earth's upper atmosphere, and that the electrical force so collected was identical to that obtained by those who were generating frictional electricity and storing it in the Leyden jar. Upon completion of this experiment, he was acclaimed by the scientific world of his day, made a Fellow of the Royal Society of London, and his name has ever since been indelibly associated with the pioneers in electrical development.

It should be noted that the static electricity stored in the Leyden jar does not manifest itself in the form of an electrical current until it is released from that medium. When a Leyden jar is discharged, that is, when its inner conducting surface is metallically connected to the outer metallic surface, it produces alternating currents—currents that flow in one direction and then in the opposite direction at exceedingly high rates per second. These high-frequency currents are a basic necessity in radio communication, for, as already pointed out, they produce the electromagnetic waves used in wireless telegraphy and telephony.

The first device for producing a continuous flow of electrical current, that is, a current which flows in one direction, was the so-called electrical battery, which was devised by Volta, an Italian scientist, in 1790. His arrangement consisted of a pile of zinc and copper discs with pieces of moistened pasteboard placed between them. Volta discerned that electrical effects could be obtained from such a combination. As was later determined, the electrical current so created was a result of the chemical action of the moisture-soaked pieces of pasteboard upon the zinc plate, which in the electrochemical process slowly disintegrated. This chemical disintegration produced a current of electricity which lasted until the zinc plates were almost completely destroyed.

In 1820 Joseph Henry of Albany, New York, discovered that the discharge of the Leyden jar or condenser through a wire produced "oscillatory" or alternating electrical currents.

In 1827 Professor Savary found that the electric discharge of a Leyden jar or condenser would induce magnetism in a steel needle placed in the vicinity of the spark discharge. This indicated clearly to him that such discharges propagated an effect through space which enabled the steel needle to take on the property of magnetism, but he made no further application of the phenomenon.

In 1831 Professor Faraday found that if a current of electricity were turned on and off in a wire, it would produce an intermittent electric current in another circuit not directly connected with it. In the language of the electrial engineer, Faraday discovered the phenomenon of electromagnetic induction—a basic principle which is employed in one form or another in most electric apparatus.

About 1850, Professor Faraday noted that if a conductor in which an electrical current was flowing was mounted on an axis and placed near a pole of a magnet, the conductor would turn, clearly indicating that the reaction of the magnetic field produced by the current in the electric conductor against the magnetic field of the pole of the magnet could be made to produce mechanical motion. This discovery later became the fundamental principle of the electric motor.

Faraday also devised the induction coil, by which a battery current of low voltage or pressure could be transformed to a current of high voltage or pressure, and thus produce electrical spark discharges of considerable length. At a later date, Faraday worked out the theory of alternating and direct currents, and also devised several machines for generating and transforming such currents. Ruhmkorff also developed an induction coil with an automatic interrupter, by which a continuous succession of high voltages could be generated, using a battery as the primary source of power.

Faraday at one time conceived the idea of utilizing the ether surrounding the earth as a conducting medium for an electromagnetic force. Here was a faint gleam of the possibility of establishing communication between two points without wires, but there is no record that any work was carried on at that time beyond this conception.

Of all the investigators and research workers of the last half of the nineteenth century, James Clerk Maxwell, a Scotch mathematician, stands out boldly in relief, primarily because of his exhaustive writings on the general subject of electricity and magnetism. He was especially fond of the study of mathematics. This undoubtedly accounts for his great mathematical treatise entitled *Electricity and Magnetism,* which is known to most students of electricity the world over.

Faraday and Maxwell were jointly responsible for bringing to light many fundamental electrical laws, but it was Maxwell who proved mathematically a theory of Faraday regarding light and electrical waves, and who wrote of the theory that "light consists in transverse undulations of the same medium which is the cause of electric and magnetic phenomena." Thus Maxwell, through mathematical analysis and computation, predicted that electrical discharges propagated effects through space in the form of electromagnetic waves. His learned treatise upon this phase of electromagnetic phenomena constitutes of itself one of the most striking disclosures in the progress of electrical science. As will be noted presently, Maxwell's publications on the subject of electric waves served as an incentive to a German experimenter, Heinrich Hertz, who proved by actual experiment the correctness of the Maxwell predictions.

Numerous experiments were made in the United States and abroad in the period of 1837 to 1882 in transmitting telegraph signals between two points without intervening wires, and with some degree of success. In all these tests, however, Faraday's principle of electromagnetic induction was utilized, not the electromagnetic waves, predicted by Maxwell, experimentally confirmed by Hertz, and now employed in radio telegraphy and telephony. It has not been found possible to transmit signals over any but very short distances by induction.

In connection with these induction experiments, Professor Morse (the inventor of the wire telegraph) in 1842 and Dr. O'Shaughnessey in 1849 succeeded in passing intelligible signals without metallic conductors across rivers. In 1872 Professor Highton made various experiments across the Thames River using the method employed by Morse in 1842. Professor Trowbridge did similar work in the year 1880. In 1882 Professor Dolbear of Harvard University was awarded a patent for communicating between two points without wires, utilizing the principle of induction.

One of the odd sidelights in the series of scientific disclosure leading to radio was that made by Professor Hughes in 1879, who determined that the discharge of a Leyden jar or condenser would cause loosely associated metal filings in the vicinity of the discharge to cling together, or "cohere." It is reported that Hughes set up equipment whereby the "cohering" phenomenon could be detected at a distance of 500 yards. In 1866 S. A. Varley made similar observations. This disclosure was of considerable importance to the success of Marconi's early experiments.

An outstanding series of experiments in connection with electromagnetic waves were conducted by Professor Heinrich Hertz of Karlsruhe and Bonn universities (Germany) in 1886, when he confirmed Maxwell's mathematical predictions concerning such waves. Hertz produced and detected electromagnetic waves; he showed that they were capable of reflection from metallic surfaces; that they were transmitted freely through insulators; that they could be refracted by prisms; and he measured their actual length. He pointed out that the shorter the electric wave, the more analogous were its properties to those of light. Sir Oliver Lodge performed somewhat similar experiments prior to the work of Hertz, but it remained for Hertz to complete the experimental proof of electromagnetic wave phenomena.

Hertz's apparatus for producing and detecting electromagnetic waves was, in the light of modern practice, rather crude and not adapted to the transmission of signals over great distances. However, he proved that the phenomena which he was able to make manifest at a distance were not those of magnetic induction, but actually an effect of electric wave propagation. Hertz took the induction coil of Faraday and Ruhmkorff and used it to charge two metallic plates which were separated by two small metallic spheres, called a spark gap. When the induction coil was energized, a discharge manifested itself at the spark gap, and the radiating system composed of the metallic plates was traversed by alternating currents of very high frequency. This caused the system to become a radiator of electromagnetic waves. Hertz then detected the existence of the waves so radiated by a circular loop of wire which contained a small spark gap and which was held at a distance. If the loop was placed in the plane of the radiated waves, a feeble spark manifested itself in the little gap in the loop of wire. If placed at right angles to the plane of the advancing wave, no spark would result. Then by the use of metallic reflectors, prisms, and the like, he verified all the electric wave phenomena recited above.

The observations of Hughes and Varley, namely, that metallic filings in loose condition would cohere when placed under the influence of an electric discharge, were rediscovered by Professor E. Branly, of the Catholic University of Paris, in 1890. He placed these metallic filings in a glass tube between two metallic plugs and then made this tube a part of an electrical circuit which contained a battery. He observed that electric discharges in the neighborhood of the tube would cause the filings to cohere, decrease their resistance, and start a flow of current from a local battery.

Thus, from 1888 to 1892, we find that scientific investigators in the laboratories of Europe and in America, stimulated by the work of Hertz and his predecessors, were conducting experiments with devices for producing and detecting electromagnetic waves. Several of these investigators had witnessed enough to enable them to predict that the dawn of a successful system for communicating through space by electric waves was just over the horizon.

One of the most remarkable predictions in that respect was made by Sir William Crookes in the London *Fortnightly Review* in 1892, from which we quote in part as follows:

> Here is unfolded to us a new and astonishing world, one which it is hard to conceive should contain no possibilities of transmitting and receiving intelligence.
>
> Rays of lights will not pierce through a wall, nor, as we know only too well, through a London fog. But the electrical vibrations of a yard or more in wave length . . . will easily pierce such mediums, which to them will be transparent. Here, then, is revealed the bewildering possibility of telegraphy without wires, posts, cables or any of our present costly appliances. Granted a few reasonable postulates, the whole thing comes well within the realms of possible fulfillment. At the present time, experimentalists are able to generate electrical waves of any desired wave length from a few feet upwards, and to keep up a succession of such waves radiating into space in all directions.
>
> This is no mere dream of a visionary philosopher. All the requisites needed to bring it within the grasp of daily life are well within the possibilities of discovery, and are so reasonable and so clearly in the path of researches which are now being actively prosecuted in every capital of Europe that we may any day expect to hear that they have emerged from the realms of speculation into those of sober fact.

Immediately following the Crookes prophecy, Sir Oliver Lodge (in 1893 and 1894) applied the Branly coherer to the study of electromagnetic waves, substituting it for the small spark gap in Hertz's loop of wire. Because of its sensitivity to feeble high frequency currents he was enabled to detect electromagnetic waves over greater distances than Hertz had been able to accomplish. In 1895 Professor Popoff, of Kronstadt, utilized the coherer, a relay, a battery, and a tapper for recording the approach of storms, one terminal of the coherer being connected to an elevated wire and the other to earth. Thus, when the filings cohered under the influence of the electrical discharges of a distant thunder storm, they were automatically disassociated (de-cohered) by the tapper and restored to sensitivity for recording another signal. Obviously, the work of both of these scientists intensified interest in electromagnetic wave phenomena.

In summary, some of the way-marks that led to Marconi's discovery in 1896 were the following:

Von Guericke, Helmholtz, Musschenbroek, Franklin, and many others proved the existence of an electric force which was later termed "static electricity." Volta had demonstrated that a steady flow of electrical current could be produced by an electro-chemical battery. Professors Henry, Savary, and others had shown that the discharge of a Leyden jar or condenser produced rapidly reversing currents. Faraday showed how the current of an electrical battery could be turned on and off in one circuit and made to generate momentary currents in another circuit. Faraday and Ruhmkorff devised the induction coil, a device for transforming low-voltage currents to currents of high voltage or pressure. Maxwell predicted the existence of electromagnetic waves by mathematical computation. Hertz proved by actual experiment that Maxwell's predictions were correct and disclosed all of the basic laws surrounding electric wave propagation. Sir William Crookes (1892) and others predicted that ere long electromagnetic waves would be used for communicating between widely separated points. Professors Hughes, Varley, Branly, Popoff, and Lodge made important observations concerning coherer phenomena and the ability of the coherer to detect electric waves at a distance.

EARLY ATTEMPTS AT WIRELESS COMMUNICATION

The discoveries of Hertz and the scientific observations made by Branly, Lodge, Popoff, and others were widely published in scientific journals throughout Europe. It appears that Guglielmo Marconi at the age of eighteen years became interested in the researches of Hertz, when he engaged in a series of experiments on his father's estate at Bologna, Italy. In a short time he had progressed to a point where he found it possible to transmit intelligible signals over a distance of 1,200 to 1,300 feet.

In these earlier experiments Marconi employed an induction coil for charging two insulated metallic spheres which were separated by small air spaces. He connected one of these spheres to the earth and the other to an elevated metallic plate. At the receiving end he employed an improved form of coherer, one terminal of which was also connected to the earth and the other to an elevated metallic plate. Marconi was thus able to transmit intelligible wireless telegraph signals over much greater distances than Hertz or previous investigators were able to accomplish. His chief contribution at this stage of development was the use of the elevated wire and the earth connection at the transmitting station, which enabled him to generate longer and more powerful electric waves than any of his predecessors, and the use of an elevated wire and the earth connection at the receiving station, which enabled him to collect more energy from the passing electromagnetic wave than that secured by his predecessors. Add to this the more "sensitive" coherer developed by Marconi, and we at once find the reason for his early success.

The improved Marconi coherer consisted of a glass tube fitted with metal plugs of silver which were slightly amalgamated with mercury and which were separated by one-thirteenth of an inch. The intervening space was partly filled with filings, of which approximately 96% was nickel and 4%, silver. The tube was then exhausted and sealed up. Marconi not only showed ingenuity in this respect, but he also made up a more practical receiving system than his predecessors, consisting of a coherer, relay, Morse ink recorder, and decoherer, which enabled wireless telegraphic signals to be recorded at speeds of 10 to 15 words per minute.

In 1896 Marconi proceeded to London and conducted further experiments at Westbourne Park. In July of that year he was introduced to Sir (then Mr.) W. H. Preece, the Chief Electrical Engineer of the Post Office, at whose request Mr. Marconi conducted experiments before the officials of the Post Office, first over a distance of about 100 yards and afterwards between the General Post Office and the Savings Bank Department in Queen Victoria Street. Shortly afterwards, Marconi conducted a series of trials before British Post Office officials and naval military officers on Salisbury Plain, when communication was established successfully over a distance of 1¾ miles. An important observation derived from these experiments was that these electrical waves penetrated buildings, intervening hills, brick walls, and other solid substances. This was merely a further confirmation of Hertz's earlier observations. In the same year, 1896, Marconi lodged his application for the first British patent for wireless telegraph circuits and apparatus.

In November, 1897, Marconi rigged up a mast at the Needles on the Isle of Wight, 120 feet high, and suspended a wire, by an insulator, from the top. Then, having connected the lower end of this wire to a transmitter of the spark discharge type, he boarded a tug boat and took with him a receiving instrument connected to a wire which was rigged up to the top of the mast on the boat. On the first trial, communication was maintained over a distance of four miles. For several months afterwards experiments were continued, the useful distance being gradually increased, until by New Year's Day, 1898, radio signals were received 18 miles away from the transmitter.

In July, 1898, the Kingstown, Ireland, yachting regatta took place. Here we find the first instance of press dispatches being transmitted to newspapers by means of radio. The *Daily Express* of Dublin, set a new fashion in newspaper methods for that time by arranging to have these races observed from a steamer, the "Flying Huntress," which was equipped by Marconi as a transmitting station and from which messages could be sent to a receiving station installed at Kingstown. From that point the information was relayed by telephone to the newspaper. Thus the *Express* was able to print full accounts of the races simultaneously with the action and while the yachts taking part were so far at sea as to be beyond the range of visibility! During the regatta more than 700 of these wireless messages were transmitted. A few days later Marconi maintained communication between the shore and the Royal Yacht with the Prince of Wales aboard. About 150 messages were transmitted in the course of a few days with entire success. Thus began the first commercial applications of radio communication aboard ship.

By means of improved apparatus and higher aerials, Marconi continually increased the range of his transmitter until in 1899 we find that he had bridged a space of 85 miles. In February, 1901, communication had been established up to 196 miles between Niton Station, Isle of Wight, and another station on the Lizard. From this point on, Marconi's work is one continual record of increasing ranges, greater reliability, and more satisfactory service in general. At last a radio signal was actually transmitted and received across the Atlantic Ocean in the form of the historic letter "S."

It had been established conclusively, prior to Marconi's first discovery, that the length of electromagnetic waves bore some relation to the dimensions of the elevated conductor at the transmitting and receiving stations, and that the "electrical dimensions" of the radiating and receiving systems must be somewhat similar to secure the maximum signalling range. Thus, if the transmitter radiated a wave of some definite length, the receiving system must be adjusted to the same wave length; otherwise, the range of communication would be limited. In the apparatus used by Marconi in his early experiments, the transmitting and receiving apparatus were not accurately adjusted to the same wave length. But apparently Marconi soon recognized the importance of the matter, for on June 1, 1898, he applied for a patent which clearly sets forth the apparatus and devices for accurate tuning of the radio transmitter and the receiver. Marconi disclosed that the physical dimensions of the transmitting and receiving aerials could be fixed, that these dimensions need not necessarily be identical, but that two such dissimilar aerials could be adjusted to the same wave length, that is, "tuned" by inserting coils of wire of variable length in the aerial system. Thus the wave length of a given aerial system could be increased by adding coils or decreased by subtracting coils. Simultaneously, Marconi contributed the "inductively coupled" system of transmission and reception. This afforded sharper tuning, that is, made it less difficult to "select" the signals of a given sending station to the exclusion of other sending stations that might be operating in a given vicinity. The patent which disclosed the two foregoing principles is popularly known as the "four circuit" tuning patent.

Sir Oliver Lodge in 1897, and Professor Ferdinand Braun, of Strassburg, Germany, in 1898, were apparently working in the same direction as Marconi, for they described inductively coupled methods and also recognized the necessity of adjusting the transmitter and receiver to the same wave length for efficient results.

The results of Marconi in his early European experiments incited the interest and the imagination of American engineers; and soon after the birth of the twentieth century experiments were conducted on a comprehensive scale in the United States—mainly between ship and shore stations. The early American radio systems embraced several of Marconi's basic principles, and also many American innovations. A large number of patents covering improved methods of radio transmission and reception were awarded in the period of 1901 to 1914 to a host of American engineers, among whom were Fessenden, DeForest, Shoemaker, Stone, Kolster, Pickard, Armstrong, Langmuir, Nichols, Logwood, and others.

Subsequent to 1901, several companies were formed in the United States for the exploitation of wireless telegraphy, among which were the Marconi Wireless and Telegraph Company of America (1901) and the DeForest Wireless Telegraph Company of America (1903). The business of the last-mentioned company was taken over in 1905 by the American DeForest Wireless Telegraph Company, which in 1907 was absorbed by the United Wireless Telegraph Company. The United Wireless Telegraph Company engaged in ship-to-shore communication under a program which had as its objective the popularizing of radio on vessels of every character and tonnage. Land stations were erected at strategic points on the Atlantic, Pacific, and Gulf Coasts. About 250 vessels of American registry were equipped with radio by the United Wireless Telegraph Company in the period 1907 to 1912.

Immediately this new science enlisted the attention of American engineers, they sought to develop a radio system which would provide more rapid reception than the Marconi "coherer-decoherer" method. Thus, instead of utilizing a coherer, a telegraph relay, and a Morse ink recorder for the reception of radio telegraphic signals, American engineers saw the possibility of utilizing the familiar telephone receiver. They foresaw that the telephonic method of ear reception would provide greater sensitivity and therefore increase the distance over which signals could be received; that it would permit much higher speeds of reception than the Marconi method; but that in order to use this device, it would be necessary to find some means of detecting electric waves which would automatically and more rapidly restore itself following the reception of each signal. Marconi evidently came to the same conclusion, for in 1902 he brought forth the magnetic detector, which also employed the telephone receiver and enabled radio telegraphic signals to be deciphered at any speed within the limits of hand manipulation of the telegraph key.

Professor Fessenden developed the electrolytic detector, a device which made use of a platinum point of exceedingly small diameter placed in light contact with an acid or alkaline solution. This constituted one element of an electrolytic cell, the other element being a small platinum plate. The cell was connected up with a local battery and head telephone. This device responded to more feeble radio telegraph signals than prior devices, but it did not afford the stability which experimenters early recognized as a prime necessity.

G. W. Pickard and General Dunwoody discovered that many minerals and compounded substances, such as carborundum, chalcopyrite, galena, silicon, zincite, and others possessed the property of "detection" and could be employed in correctly designed circuits for radio telegraphic reception over considerable distances.

American engineers, particularly Fessenden, took another step forward when they introduced the so-called high-frequency or "high-pitched" spark method of transmission. It was observed that when the telephone was employed for radio reception, the "buzzing" sounds generated therein had the tone of the spark discharge at the distant transmitter. Radio operators soon found that a spark discharge of high pitch was more easily deciphered than one of low pitch, particularly when electrical atmospheric disturbances were prevalent. American engineers introduced an improvement over Marconi's original transmitter in that respect when they used 60-cycle alternating current for energizing the transmitter, rather than the induction coil of the early Marconi system. With the view of making the spark note more musical, the frequency of the supply current was increased to 120 cycles, then to 240 cycles, and finally to 500 cycles. These systems made use of the synchronous rotary gap giving spark discharges at rates twice the frequency of the supply current. These high-frequency discharges, particularly the last-mentioned one, produced a "singing" note in the telephone which very materially reduced the liability to err in radio telegraph reception.

A further improvement in the efficiency of spark dischargers was the silent or "quenched" gap developed by German engineers. This consisted of a series of copper discs separated by insulating washers, the spark taking place between the parallel surfaces of adjacent discs. Systems employing this discharger were usually energized by 500-cycle current and therefore afforded "singing" spark notes.

In the period 1903 to 1914, American radio companies —particularly the American DeForest Wireless Telegraph Company, the United Wireless Company, and the Marconi Wireless Telegraph Company of America, all having materially improved their systems—exploited the possibilities of radio communication in the marine field on a large scale. The DeForest and United companies erected numerous land stations on the Atlantic and Pacific seaboard and in the principal cities of the United States—the latter with the view of determining by practical working whether or not radio could be employed as a competitor to land lines. The equipment used at that time for overland work was relatively inefficient and not capable of providing continuous communication except over comparatively short distances, although during the favorable months regular radio telegraphic communication was often established over a distance of several hundred miles.

The American DeForest Wireless Company engaged in very extensive research and experimentation in overland communication in the period 1903 to 1907 and thereby contributed much valuable information of a practical nature to the progress of the art. DeForest employed the tuning principle for the transmitter and receiver in his earliest installations and he was one of the first to use powerful transmitters, having 50 kilowatts or more input.

The DeForest Company erected land stations at Chicago, Cleveland, Kansas City, Buffalo, Port Huron, Michigan, in several of the leading cities of the state of Colorado, and along the Atlantic and Gulf seaports. As early as 1905 overland communication was established in daylight between Cleveland and St. Louis, a distance of approximately 550 miles. During that same year, night communication was established between stations located at Cleveland, Ohio, and New Orleans, Louisiana, and between Cleveland, Ohio, and Key West, Florida. Among the important disclosures of these overland tests as early as 1904 were the facts that during the cooler months of the year communication could be established over very great distances after darkness, that atmospheric disturbances were more prevalent in the summer than in the winter, and that transmission after darkness over considerable distances was irregular and subject to fading. Even in 1905 communication was established after nightfall between vessels on the Great Lakes equipped with radio, and vessels plying the Caribbean Sea.

Throughout the period 1903 to 1917 the efficiency of the spark type of transmitter was steadily improved; it was made more rugged and reliable; the receiving apparatus was refined and made more efficient; and the reliable distance over which communication could be established between ships and between ship and shore was increased year by year.

The principal application of radio during the first 15 years of the twentieth century was in the marine field, although many stations had been erected throughout the world for communicating over spaces where it was impractical or impossible to erect wires. By 1912 radio had received practically world-wide recognition as an indispensable aid to the merchant marine.

THE HISTORIC LETTER "S"

The increase in range which Marconi had been able to accomplish by means of improved apparatus had finally given him an idea that it might be possible, if apparatus of sufficient power and aerials of sufficient size were used, to transmit wireless signals across the Atlantic Ocean to Canada.

In working along this line, Marconi conceived that the use of a transmitter of high power required an aerial system in keeping with the amount of power used; as a result, he began using multiple-wire antennae consisting of as many as 300 or 400 vertical wires which were suspended from cables hung from towers. In December, 1901, a transmitter to be used for a transatlantic test and located at Poldhu, England, was ready. On the morning of December 14, the newspapers of the world stated that for the first time in history an intelligible radio signal had been sent across the Atlantic Ocean—from Europe to America—a distance of 2,000 miles. The letter "S" was the specific signal selected for the occasion. This letter has now gone down in history as one of the great stepping-stones in radio progress.

What made the accomplishment more striking was the fact that when Mr. Marconi came to America for the test, he had kept his own counsel and had quietly gone to the site of the receiving station, erected on a high bluff in Nova Scotia. Mr. Marconi with his two assistants, Mr. Kemp and Mr. Paget, landed at St. Johns, Newfoundland, on December 6. He set up his receiving instruments in a room of an old barrack, Signal Hill, at the harbor mouth of the city of St. Johns. On Wednesday, December 10, he made experiments with several types of balloons for the purpose of supporting a receiving wire and finally, on the 12th—a day destined to be one of the most important in the annals of radio—succeeded in maintaining a kite at an elevation of about 400 feet.

Before leaving England he had given detailed instructions to his assistants for the transmission of the Morse telegraphic "S," represented by three dots. This was to be transmitted at a fixed time each day after word had been received that the receiving station at St. Johns was ready. At noon on Thursday, December 12, 1901, Marconi sat at his instruments, waiting for the time appointed when the transmitting station in England would transmit the agreed-upon signal.

In the room where the receiving was actually done were only two persons, Mr. Marconi and his assistant, Mr. Kemp. Everything had been done that could be done. A telephone receiver (which was not then a part of the usual type of receiving equipment) had been supplied so that even the faintest indication of signals might be conveyed to the inventor's ear. For nearly half an hour after the appointed time had arrived and passed not a sound was heard. Then, suddenly, the assistant, Mr. Kemp, heard the sharp click of the tapper as it struck against the coherer. A moment later, faintly, yet distinctly and unmistakably, came the three little clicks, or dots, of the letter "S," tapped out a fraction of a second before in England. Later more signals came, and both Mr. Marconi and Mr. Kemp assured themselves again and again that there could be no mistake. Thus it was established that wireless communication over great distances was possible, and one of the greatest wonders of science had been wrought.

Even though the experiment had been successful and everything had been accomplished that had been desired, Mr. Marconi hesitated to make his achievement public lest it seem too extraordinary for belief. Finally, after withholding the great news for two days, he gave out a statement to the press, and on Sunday morning the world knew and doubted; on Monday it knew more and believed. Many scientists awaited and insisted upon a signed announcement by Marconi before they would fully credit the statements of the newspapers. This was soon forthcoming, and the actual accomplishment of this great branch of modern science became an accepted fact and from that time was so recognized and acclaimed by the civilized world.

The transmitting apparatus used at Poldhu which transmitted the historic letter "S" to Marconi's kite aerial on the bluff at St. Johns, Nova Scotia, was of the open spark type. Newspaper correspondents were unanimous in declaring that the effect was blinding if one looked at the spark with unprotected eyes. A large induction coil was used as a source of power supply for the installation, and the power input was said to be in the neighborhood of 10 to 12 kilowatts (16 to 17 horse power). The wave length used was 375 meters, or a frequency of 800,000 cycles per second. The transmitting antenna consisted of 20 masts, 210 feet high, with wires suspended from each of them.

The receiving equipment employed by Marconi in these transatlantic experiments consisted of his newly developed tuning system and an improved type of coherer which have already been described. The receiving aerial employed in these experiments consisted of a single wire which was supported at a height of approximately 400 feet by a kite.

Needless to say, the successful outcome of these experiments stimulated the interest of scientific and commercial interests throughout the world. Several projects were thereafter planned for establishing radio communication over great distances. One such project was the erection at Brant Rock, Massachusetts, of a tower more than 400 feet in height, for the purpose of establishing communication with a similar station located at Machrohenish Bay in Scotland. The transmitter at Brant Rock was a powerful one employing the newly developed high-frequency synchronous spark system of Fessenden. It was reported in 1906 that the signals of Brant Rock were recorded in Scotland. Certainly they were often deciphered in the United States at distances up to 2,000 miles from Brant Rock, but the art had not yet developed to the point where continuous and reliable communication could be obtained over such distances.

MARINE COMMUNICATION

It it hardly necessary to dwell on the fact that prior to the development of radio communication there was no means of determining the position or welfare of a vessel at sea, except when a vessel passed close enough to another to employ the visual means of communication provided for all ships, or where a vessel came close enough to shore to be reported by lookouts and observers.

The number of ships which have sailed forth and gone down to oblivion is legion. The rosters of shipping are full of such cases, and the word "missing" was all too frequently found among them. Undoubtedly, many of the vessels which have left port and met with disaster could have been given vital assistance, and perhaps an untold number of lives saved, had they been able to report their difficulties to other vessels within range. With this as a background and with the need of a means of communication so obvious and so highly desirable, it is not surprising that the early success of Marconi fired the imagination of the maritime world. This created an insistent demand for radio telegraph equipment aboard ship which was evidenced both in the United States and throughout the principal countries of Europe. Accordingly, the isolation of the oceans began to disappear, and in its place came radio stations afloat and ashore which enabled a vessel to keep in touch with land almost throughout the length of its voyage.

Impetus was given to the growth of marine communication by the very nature of the early research and experimental work of Marconi, which was conducted principally on vessels in waters adjacent to the British Isles.

In 1899 Marconi came to America and supervised the installation of a temporary radio station on the tug "Forward" of the Yankee Salvage Association, for the purpose of reporting the progress of the international yacht races which were held off Sandy Hook in September and October of that year. A corresponding land station was set up at Sea Gate at the entrance to New York Harbor. Reports of the yacht races were transmitted over distances up to 18 miles and relayed by land line to the New York *Herald,* the Associated Press, and others. Thus the status of the races was known in the heart of New York City practically as soon as it was to those on the vessels following the two racing yachts. This demonstration of the practicability of radio communication between ship and shore was a very important event in the history of American shipping and brought home clearly to marine circles that this means of keeping in touch with vessels was destined to become a necessity.

Very shortly after Marconi's first discovery, a number of transatlantic vessels were equipped by the Marconi's Wireless Telegraph Company of England. Two land stations were erected by the Pacific and Continental Wireless Telephone and Telegraph Company in 1902, one on Catalina Island, California, and one near San Pedro, California, for communication between the island and the mainland. The DeForest Wireless Telegraph Company of America in 1903 began the erection of several land stations for communicating with ships at sea. This was the first active commercial participation of American interests in marine communication. These early stations were located at Coney Island, New York; Galilee, New Jersey; Cape Hatteras, North Carolina; Key West, Florida; Galveston, Texas; and New Haven, Connecticut.

In 1903 and 1904 the DeForest Company erected marine stations at Buffalo, New York; Cleveland, Ohio; Detroit and Port Huron, Michigan, and Chicago, Illinois. Many ship installations were made by the DeForest Company on vessels of American registry up to 1907.

By 1907, land stations had been erected by the Marconi Wireless Telegraph Company of America at South Wellsfleet, Massachusetts, at Siasconset, Nantucket Island, and at Seagate and Sagaponack, Long Island.

When, in 1907, the United Wireless Telegraph Company took over the business of the American DeForest

Wireless Telegraph Company, the United Company immediately laid down a program for expanding the use of radio aboard ship on a scale larger than had been previously attempted in the United States. Additional land stations were erected on the Atlantic seaboard, at New York City, New Orleans, Mobile, Charleston, Savannah, Cape Henry, Atlantic City, Boston, Eastport, Tampa, Galveston, and Port Arthur, on the Pacific seaboard at San Francisco, Astoria, and Seattle and on the Great Lakes. By 1912, more than 250 ships of American registry had been equipped with radio communication apparatus, and the American Marconi Company soon increased this to a total of 600 vessels.

In the early days of its application, the primary purpose of the radio ship installation was the saving of life at sea. However, radio offered a very practical facility to the traveling public for maintaining communication with people ashore, for the exchange of business and personal messages. This developed a traffic in messages which grew to such proportions that a special signal had to be provided for drawing attention to a distressed vessel.

Prior to the establishment of international radio regulations, the distress signal consisted of three letters "CQD," but after the International Conference of 1912 a signal equivalent to the letters "SOS" was universally adopted. It became an international law, assented to even by those who had not signed the articles of the First International Conference, that immediately the distress signal "SOS" was dispatched by any vessel, all other vessels and shore stations within communication range would cease all radio transmission until assistance had been rendered to the distressed vessel. A few instances of the practical application of the distress signal demonstrated to ship owners that radio had become an indispensable accessory and that it might well be the means of saving many times its cost in the way of property, to say nothing of its chief value—the saving of life. Maritime interests throughout the world took cognizance. Shore stations were erected at strategic points throughout the globe. Vessels were equipped with this new means of communication as rapidly as the production facilities of the suppliers permitted.

SINKING OF THE "REPUBLIC" AS A FACTOR IN STIMULATING MARINE USE OF RADIO

Early in the present century the world was startled and saddened by the sinking of the steamship "La Bourgogne" in the North Atlantic, involving the loss of several hundred lives of passengers and crew. The steamship and a sailing vessel had collided in a thick fog during the dark hours of night; as neither vessel was equipped with radio, it was not possible to summon assistance, and the great steamship went to the bottom with all hands. It was several days before news of the disaster reached civilization, and even then the first accounts were fragmentary versions of a few exhausted survivors of the sailing vessel who were able to keep afloat until rescued by a vessel that happened to run across them.

The actual details of the catastrophe were not at once learned, and a long period of time elapsed before the news reached many sections of the civilized world. Prior to the "Bourgogne" disaster there had been one or two cases of minor marine mishaps where radio had been employed to bring relief or rescue vessels to the assistance of the ones in trouble.

Probably the first case in marine history where radio played an important part in rescue work was in the case of the East Goodwin lightship, which was severely damaged by a heavy sea in January, 1899. The mishap was reported by the lightship's wireless apparatus to a station on shore, and assistance was promptly dispatched to the damaged and disabled vessel.

Again, in January, 1901, the bark "Medora" ran aground off the entrance to the English Channel but was pulled off and towed to a safe harbor by a tug which had been summoned by means of radio on a nearby lighthouse.

In the next eight years much progress was made in equipping important ocean-going vessels with radio and in building land stations at strategic points along the coast line of maritime nations to maintain contact between the land and ships at sea. The land station of the American Marconi Company located on Nantucket Island, the sea corner turned by all craft on voyages between Europe and America, was always a busy one. It was one of the most important stations of the American Marconi Company. Operators were kept constantly on watch exchanging messages, weather data, and other information with ships at sea.

Early on the morning of January 23, 1909, there came to the ears of an operator at this station, Jack Irwin, the international call of distress of the sea in use at that time—"CQD." It was the voice of the steamship "Republic" of the White Star Line, whose operator, John Binns, informed the Siasconset station that she had been in collision with another steamship, the "Florida," a cargo ship without radio, and that the "Republic" was sinking and needed the immediate assistance of other vessels to take off her passengers and crew.

The distress call was immediately transmitted by the Siasconset station to all ships and other stations within range, with the result that within five minutes after the first call of distress had been sounded, five steamships had turned from their respective courses and were steaming at highest possible speed to the "Florida." These five steamships—the "Furnessia," "New York," "La Lorraine," "Lucania," and "Baltic"—as well as the Revenue Cutter "Seneca," were soon alongside the "Republic" and "Florida" and took off all the passengers and crew of the former vessel and such of the "Republic" passengers as had been transferred to the "Florida," the less damaged of the two ships.

Probably no event in the progress of radio caused more of a thrill and sensation throughout the civilized world. Public consciousness was aroused to the great importance of wireless telegraph apparatus as an additional safeguard to life and property at sea. This was perhaps amplified by the fact that one of the large transatlantic liners had been involved and its passengers and crew successfully rescued.

The "Titanic" disaster of April 15, 1912, was another marine tragedy that was made less disastrous by the assistance rendered by radio. Seven hundred of the two thousand passengers aboard the Titantic were saved by the distress calls which were sent out by the radio operator, Jack Phillips. All would have been rescued but for the distance separating the "Titanic" and the nearest rescue ship, the "Carpathia"; for it will be remembered that the "Titanic" struck an iceberg in mid-Atlantic and went to the bottom almost immediately.

Radio again fulfilled its destiny when it brought ten other ships to the rescue of all the passengers and crew of the steamship "Volturno," which was burned in mid-ocean on October 11, 1913. This disaster resulted in a universal demand that the use of radio on all ships should be made mandatory by law. The following year, 1910, the Congress of the United States passed a law making the use of radio compulsory on passenger-carrying vessels. Regulations for the control of radio communication at sea had been in effect in England since July 1, 1907, but the publicity given the "Republic" incident aroused all governments of the world.

WORLD RECOGNITION OF THE IMPORTANCE OF RADIO AT SEA

Early in radio history the maritime world expressed much appreciation of the value of radio as an additional safeguard to lives and shipping at sea, and of its commercial value as a means of contact between ship and shore. The intercession of governments of the various nations took place more slowly, but as the necessities of the situation became more apparent, radio became a subject of international discussion and correspondence.

In 1902, England, the greatest maritime nation in the world, was the center of radio activity. As ship and shore installations increased in number, it was believed that some degree of government regulation or control would be necessary in order that definite standards for equipment, personnel, and operation might be established and made enforceable through some government agency. In August, 1904, the Wireless Telegraph Act was passed by the Government of Great Britain—the first radio law to be enacted. This act was originally intended to govern for but two years, but it was renewed in 1906 without modification. It prohibited the installation or working of wireless telegraph apparatus in the United Kingdom, or on board British ships, without a license from the Postmaster General. Its principal object was to make wireless telegraphy "more useful for purposes of defense and general communication."

The memorandum which was laid before the House of Commons in explanation of the bill stated that the necessity of legislation depended, in the first place, on the importance from the naval point of view of giving the government control over wireless stations in time of war or emergency and, secondly, on the desirability of placing the government in the position to enter into an agreement on the subject with other countries, if it should be found expedient to do so. This law, however, affected only the radio installations afloat and ashore which came under the immediate authority or control of Great Britain, and although highly desirable and of great benefit to radio communication, it still left the main question of unified international agreement or control unsettled. The need for such international agreement was so evident and so obviously necessary, however, that it was certain the question could not be allowed to remain an open one for any length of time.

The German Government finally took the initiative, and as a result of its suggestions and recommendations, the First International Radiotelegraphic Conference was held in Berlin beginning on August 4, 1903. The outcome of the conference was that substantially all the important powers agreed to certain proposals, to be considered at a suggested subsequent conference, for the international regulation of radiotelegraphy. Great Britain and Italy did not fully agree with the proposals and recommendations of the First Conference, for the reason that they both had radio regulations in effect which were partly in conflict with the proposed international regulations and which could not be amended or abrogated conveniently.

A Second International Conference was held in Berlin in 1906 to work out the recommendations of the First Conference, with the following major objects in view:

1. To provide rules governing the acceptance and transmission of telegrams.

2. To provide means for collecting charges and settling accounts between the different countries.

3. To provide arrangements for publishing all information necessary to carry on radio communication.

4. To provide rules to prevent interference and confusion in radio transmission, with adequate provisions for enforcement.

5. To provide that (with certain exceptions) intercommunication must not be refused because of the differences in the systems of wireless telegraphy.

The documents signed at Berlin on November 3, 1906, consisted of: (*a*) the convention, (*b*) the Additional Undertaking, (*c*) the Final Protocol, (*d*) the Service Regulations. This second conference was attended by delegates from the following countries and colonies: United States of America, Great Britain, Canada, Newfoundland, Australia, New Zealand, France, Germany, Italy, Austria, Russia, Denmark, Sweden, Spain, Uruguay, Japan, China, Weiheiwei, Bahama Islands, Barbadoes, Bermuda, British Guiana, British Honduras, East Africa Protectorate, Falkland Islands, Gambia, Gold Coast Colony, Grenada, Jamaica, Mauritius, Nigeria, Norway, Saint Lucia, Saint Vincent, Sierra Leone, Somaliland Protectorate, Rhodesia, Straits Settlements, Uganda, and many other small colonies and settlements.

On June 24, 1910, the Congress of the United States of America passed an act requiring radio equipment on vessels carrying passengers and crew to the number of or exceeding 50 persons, for a distance of 200 or more miles.

On July 1, 1911, the Radio Service Section of the Department of Commerce of the United States was organized to administer the radio law of 1910 and to render an inspection service to ship and shore stations. Licenses of various grades were issued for radio stations according to the service in which they were engaged, and operators were required to pass an examination which, if successfully completed, entitled them to a license to operate stations in accordance with the grade of license issued.

On July 25, 1912, the United States Government extended the Radio Act of 1910 to cover cargo vessels. This act also required the provision of auxilliary sources of power for emergency purposes in the event that the main source of power supply of the ship should become disabled or be put out of commission by accident or by flooding of the vessel.

Although the conference at Berlin constituted a step in the direction of securing unified international radio regulations, the rules there adopted were not quite adequite in the light of subsequent developments. Another International Conference was therefore called in London, beginning July 5, 1912, at which time all the proceedings of the previous conferences at Berlin were reviewed and additional regulations were adopted. For the first time in the history of radio communication, practically every civilized country of the world had assented and agreed to abide by and enforce an international law for the regulation of radio communication, afloat and ashore. These governments undertook also to impose the observance of the provisions of the convention upon private enterprises.

The articles which formed the 1912 convention included specific regulations for the following general subjects:

1. Detailed service regulations
2. Organization and operation
3. Hours of service
4. Preparation of radiograms, numbering, and so on
5. Charges
6. Collection of charges
7. Transmission of radiograms
8. Delivery of radiograms
9. Special radiograms (reply paid, and so on)
10. Archives and records
11. Refunds and reimbursements
12. Accounting
13. International Bureau
14. Transmission of meteorological information
15. Miscellaneous provisions
16. Appendix including the standard international abbreviation

Following the adoption of the general regulations by the International Convention of 1912, practically every country signatory to these rules passed national laws and regulations which were based primarily upon the principles agreed to at the London Conference.

The central agency which has been established for the purpose of collecting and distributing information in accordance with the requirements of the radiotelegraphic conventions is commonly known as the "Berne Bureau." This is a branch of the Bureau of the International Telegraph Union, situated at Berne in Switzerland. It has no initiative or executive power, its functions being practically confined to the collection and circulation of information. The International Bureau at Berne is an organization of the highest importance, thanks to the zealous, economical, and efficient manner in which it is conducted. To this organization is entrusted the work of preparing and circulating, in accord with Article 13 of the Convention, particulars regarding each station, such as the name, nationality, geographical position, call signal, normal range, wave length, nature of service performed by the station, hours of service, and so on. The expenses of operating the Berne Bureau are apportioned among the various countries which are parties to the international convention.

On January 20, 1914, the Safety of Life at Sea Convention, drawn up by an International Conference which met on November 13, 1913, was signed at London. That section of the convention which deals with wireless telegraphy specifies the wireless telegraph equipment to be carried by vessels of different grades. The Radiotelegraph Convention of 1912 divided ship stations into three classes according to the hours for which they were open for service. The Safety of Life at Sea Convention specifies in which of the three classes vessels shall be placed.

Early in 1914 an International Wireless Conference was called at Brussels. The object of the conference was to lay down a program whereby operators in all the countries of Europe could make careful observations with a view of arriving at some practical explanation of the laws governing the variation in the strength of wireless signals.

Thus, by 1914 radio gained world-wide *government* recognition. There was hardly a civilized country at that date which had not undertaken to establish a radio communication service. If it was a maritime country, stations were established to maintain contact with ships at sea. Point-to-point overland communication was attempted in many parts of the world, but the service was not in all cases of sufficient reliability to become a competitor of existing methods, except, of course, where wire methods were impracticable or impossible or where the distances to be covered were relatively short.

ADVENT OF THE VACUUM TUBE AND ITS EFFECT ON THE COMMERCIAL PROGRESS OF THE ART

From the beginning of radio development, scientists and experimenters expended much effort in perfecting the detector. The goal sought was increased sensitivity to electrical waves and continuous reliability, but it was believed at one time that these two desirable characteristics could not go hand in hand. There were good reasons for this belief, for prior to 1906 none of the devices used for detecting radio signals at the receiving station combined stability of operation and sensitivity.

As already pointed out, the art started with the coherer —a detector which was rather insensitive to electric waves in the light of later knowledge, and sluggish and unstable in action. An improvement was effected in this respect by Marconi in 1902, when he introduced the magnectic detector—a device that was self-restoring and gave increased speed of reception. However, it was rather insensitive to any except very powerful waves. The electrolytic detector of Fessenden and the crystal-line rectifiers of Pickard and Dunwoody constituted improvements in the art of radio reception, but they lacked the necessary ruggedness and stability for commercial practice.

In 1905 Professor J. A. Fleming announced a line of research he had undertaken which led investigators to explore entirely new paths. Professor Fleming made use of certain rectifying phenomena which Thomas Edison had observed in connection with the incandescent lamp as early as 1884. Mr. Edison found that if a wire was sealed in the bulb of an incandescent lamp and the filament of the lamp was heated to incandescence, a current of electricity from an outside battery would flow from the cold wire through the vacuous space to the heated filament, but not in the opposite direction. A device of this kind obviously could be employed to convert rapidly oscillating currents into direct currents. Fleming enlarged on this idea and placed a circular plate of copper around the lamp filament, and he added a local battery and a head telephone to improve the results. He termed this vacuum tube a rectifying "valve." He placed the valve in a radio receiving circuit and thereby converted high-frequency currents into currents that would operate the head telephone.

Dr. Lee DeForest, who had been experimenting with gas mediums as detectors, made one of the most important contributions to the art of radio reception when he added to Fleming's vacuum tube a third element, called a "screen," or "grid," which he placed between the hot filament and the cold plate. DeForest made one leg of the filament and the grid or screen the terminals of his radio tuning circuits. The cold plate and one leg of the filament, together with the local battery and head telephone, constituted a local circuit; whereas Fleming had used the filament and plate of his rectifying valve as the terminals for the tuning circuit, as well as for the local battery circuit. The question may be asked—wherein did the DeForest invention constitute an improvement? By inserting the "grid" between the hot filament and the cold plate of the Fleming valve, DeForest provided a means whereby the voltage developed in the receiving system by the incoming electrical waves would set in motion a much stronger current supplied by a local battery. Thus an infinitesimal amount of energy applied to the grid circuit would release hundreds of times that amount of energy in the local or telephone circuit. Obviously, a device having that capability would increase very materially the strength of the signal produced at the receiving station. Conceive, if one can, a device whereby the pressure of a finger on a small lever would lift and lower a ton of coal, and then one can gain some recognition of the important function of the grid which DeForest inserted in the Fleming tube.

It is not deprecatory to the importance of this invention to state that the early DeForest vacuum tube (which he termed the "audion") was not the vacuum tube that we know today, although it was unquestionably the forerunner of present-day designs. The early DeForest tube was not highly exhausted of air. It therefore depended mainly for its action on "ionized" gas particles. Present-day tubes, except the so-called gas detectors, employ the pure electron discharge. Tubes that were highly exhausted were considered in the early days, say, 1907 to 1912, to be insensitive to electrical waves and practically useless. A vacuum tube manufacturer was considered to be highly skilled who could exhaust these tubes to the right degree to make them first-rate and sensitive detectors.

During the period 1907 to 1912 the vacuum tube remained largely as an experimental device with little commercial application. It was used experimentally by radio amateurs in considerable quantities during the period 1909 to 1914, and it was employed by DeForest on a small scale commercially in the various companies formed to exploit the DeForest inventions.

Subsequent to 1912, the DeForest tube was submitted to the most critical analysis and investigation by research and experimental engineers in the laboratories of the great electrical companies throughout the world, and not until this period was the underlying phenomenon of the vacuum tube thoroughly understood.

In the years following 1913 a host of experimenters made disclosures of major importance. Among these were Armstrong, Langmuir, Nichols, Arnold, Dushman, and others. Among other things, the researches of these experts disclosed the following:

1. That although a vacuum tube with the right degree of gas pressure constituted a sensitive detector of electric waves, the principle of gas ionization could not be depended upon to give reliable and uniform operation either for detection or amplification.

2. That a tube freed of all occluded gases to the point where it made use of pure electrons, rather than gas ions, would provide

a greater degree of stability and would permit many more practical applications, such as the ability to modulate and to amplify "radio" and "audio" currents.

3. The very important observation by Armstrong that the high-frequency currents impressed upon the grid circuit of the vacuum tube were reproduced as high-frequency currents in the local circuit. This led to the further discovery on the part of Armstrong that the plate and grid circuits of the vacuum tube could be electrically coupled in a way that the received radio signals would be amplified hundreds of times beyond the strength obtained from a single vacuum tube. Armstrong made the further disclosure that if the plate and grid circuits were closely coupled, the system became a self-sustained generator of high-frequency currents which could be used for radio transmission.

DeForest and others showed how the vacuum tube could be used to amplify radio signals after they had been detected and therefore give output sufficient to enable radio signals to be received on a loud speaker. Other inventors soon made the discovery that these signals could be amplified to many times their original strength prior to detection. Thus the radio-frequency and audio-frequency amplifiers came into being. This led to a multitude of discoveries of too varied a nature to be discussed here. Suffice it to say that the vacuum tube proved to be one of the most versatile devices developed in the radio art.

The discovery that the vacuum tube could be used to generate high-frequency currents made possible the present-day radio telephone broadcast transmitter. Here the tube is employed not only to generate these currents, but to modulate them in accordance with the acoustical variations of speech and music. Today, a battery of vacuum tube oscillators can be set up to generate hundreds and even thousands of kilowatts of high-frequency currents which will send a steady stream of powerful electric waves into space. Then, through the use of the amplifying and controlling properties of other vacuum tubes, the very feeble currents generated by speaking into a microphone or telephone transmitter can be made to swing the energy of the battery of oscillators, so that the strength of the wave motion follows the variations of the sound waves produced by the voice. It is only through the vacuum tube that such huge amounts of electrical energy can be so readily controlled.

The chief incentive to the adaptation of the vacuum tube to its numerous present applications in the radio art resulted from the urgent demands of the United States Government in its preparations to enter the European War. The requirements of military and naval radio communication were met by intensive research on the part of the laboratories of the great electrical companies, the contributions of which paved the way for revolutionary developments in radio telephone and telegraph practice.

FIRST TRANSOCEANIC RADIO COMMUNICATION SERVICE

In a little more than a year after the historic letter "S" had been transmitted across the Atlantic Ocean, the first complete transatlantic radio message was transmitted from the Marconi Station at Cape Breton, Nova Scotia, to Poldhu, England, the message having been directed by Signor Marconi to King Edward VII. Another message was also sent by Signor Marconi from the same station to King Victor Emanuel of Italy.

The American Marconi Company erected a high-power station at Cape Cod, Massachusetts, early in 1903, which was intended for transoceanic work, and on January 19 of that year it was put into service, the first message transmitted being one from President Theodore Roosevelt to King Edward VII. This message was dispatched direct to the station of the British Marconi Company at Poldhu, England, and relayed by wire to London. On March 29, 1903, the Cape Cod Station transmitted the first transatlantic press dispatch direct to Poldhu, and this was published in the London *Times* the following day. The Cape Cod Station, however, was not powerful enough to insure reliable transoceanic communication service and it was therefore converted for the dispatch of marine radio traffic.

Great credit is due to the British Marconi Company for taking the initiative in the development of high-power radio stations for continent-to-continent communication. One of the first of the powerful transatlantic communication circuits sponsored by the British Marconi Company and its Canadian associate was the Glace Bay–Clifden circuit, which was put into commercial service on October 17, 1907. The transmitting station for the British Company was located at Clifden on the west coast of Ireland, and the corresponding receiving station at Letterfrack, Ireland. The transmitting station erected by the Canadian Company was located at

Glace Bay, Nova Scotia, and the corresponding receiving station at Louisburg, Nova Scotia. In comparison with radio stations of high power that had been erected heretofore, the Glace Bay–Clifden installations were marked by the use of very large transmitter aerials of the horizontal or flat-top type and the use of more power at the transmitter than had theretofore been employed, thus creating more powerful waves. The Glace Bay–Clifden route also had the advantage over the Cape Cod–Poldhu route in that the distance between the stations was decreased by approximately 1,000 miles. Both stations of the Glace Bay–Clifden circuit employed the musical spark method of transmission, which was early discovered to give more reliable signals than the simple spark system. These two stations were in continuous operation until August, 1909, when the Glace Bay station was destroyed by fire. This station was rebuilt and the circuit resumed operation in 1910.

During the period 1912 to 1914 the Marconi's Wireless Telegraph Company, Ltd., of London, and the Marconi Wireless Telegraph Company of America projected a radio communication plan which involved the erection of powerful stations at strategic points throughout the globe. Engineering plans and specifications were prepared, sites were purchased, and construction begun on several of these stations early in 1913. This project included the routes listed in the table on the following page.

The first transoceanic circuit completed under the foregoing project was the New Brunswick–Carnarvon

Transoceanic Stations Projected 1912 to 1914

Transmitter:	New Brunswick, N. J	Carnarvon, Wales
Receiver:	Belmar, N. J	Towyne, Wales
Transmitter:	Marion, Mass	Stavenger, Hinna, Norway
Receiver:	Chatham, Mass	Naerboe, Norway
Transmitter:	Bolinas, Cal	Kahuku, Hawaiian Is.
Receiver:	Marshalls, Cal	Koko Head, Hawaiian Is.
Transmitter:	Kahuku	*Funabashi, Japan
Receiver:	Koko Head	*Iwaki, Japan

Stations Erected by Foreign Interests in the United States

Tuckerton, N. J	Hanover, Germany
Sayville, L. I	Nauen, Germany

route, which was ready for its experimental tests on or about the outbreak of the European War.

About the time that the Marconi Wireless Telegraph Company of America was ready to place these pairs of stations into experimental service and to determine if they were commercially practicable, the United States Government deemed it advisable, because of the strategic value of radio communication in war, to place these stations under its supervision; accordingly, all the stations erected or in process of construction by the American Marconi Company were taken over by the Navy Department and operated on a semi-commercial basis throughout the European War. Between February 21, 1919, and March 1, 1920, control of these stations reverted to the American Marconi Company.

* Erected and operated by the government of Japan.

The technical advancement which took place in the field of high-power radio communication during the European War was of notable magnitude. The early stations projected under the British and American Marconi plan of 1912 and 1913 were to employ the rotary type of spark discharger, which generated what were termed "damped" (or decaying) waves. During the period 1912 to 1917, several systems were developed for the production of undamped or continuous waves, among which was the so-called Poulsen arc system, the Marconi timed-spark discharger, and the Alexanderson high-frequency alternator. The Alexanderson alternator, which was tried out experimentally by the United States Navy at the Marconi Station at New Brunswick, New Jersey, and which was placed in active competition with all other systems, was found to be the most successful of all types of transmitters. With the experience gained in these experimental tests, the American Marconi Company made plans for the installation of the Alexanderson alternators in all of its high-power stations; and upon the formation of the Radio Corporation of America on December 1, 1919, plans were laid for equipping all of its stations with the Alexanderson continuous wave system as rapidly as circumstances permitted. This system not only provided a more reliable and stable means of producing continuous radio waves, but it also gave birth to a novel type of radiating aerial, namely, the so-called Alexanderson multiple-tuning system. This increased the efficiency of the radiating system so markedly that the reliable transmitting range for a radio station of a given power was strikingly increased.

Simultaneously with the improvements in high-power transmitters, engineers both here and abroad improved the efficiency of long-distance receiving apparatus, particularly in the type of receiver which employed the vacuum tube. With such marked advancements in transmission and reception, high-power radio was destined to become a serious competitor to the cable method of continent-to-continent communication.

We are now able to classify the various stages of development that took place in the radio art into five periods, beginning with the first records of the early experimenters and ending with the outbreak of the European War. Thus, the first period begins with the sixteenth and seventeenth centuries, ends at approximately 1864, and may be characterized as one in which basic electrical phenomena were unearthed by leading investigators who, through repeated experiments, evolved a series of scientific laws governing electrical and magnetic phenomena.

The second period, 1864 to 1896, was marked by isolated experiments with apparatus for the production and detection of electrical waves, and by the evolution of fundamental laws governing the generation, propagation, radiation, and detection of electrical waves. Notable research work in this respect was done by Professor Hughes, Maxwell, Heinrich Hertz, Professor Branly, Sir Oliver Lodge, and numerous others, culminating in Marconi's great discovery of 1896.

The third period in radio development was that of 1896 to 1903, which was attended by experimentation here and abroad with the view of determining to what extent radio could be applied practically for communication. This period began with the epoch-making discovery of Marconi, who was the first to demonstrate that electric waves could be propagated over distances beyond the reach of the human eye.

The fourth period, 1903 to 1912, was devoted mainly to the development of marine communication. During this period some progress was made in continent-to-continent communication, although the results so obtained had little commercial significance.

The fifth period, 1912 to 1917, was one in which most important and far-reaching technical contributions were made to the art in the way of improved transmitters and receivers, particularly in the field of undamped or continuous wave transmitters, and in the perfection of the vacuum tube and its numerous associated circuits. The technical developments of this period were of a revolutionary character. These years also were marked by intensive preparations for international radio communication and by the installation of several high power stations both here and abroad. The experimental attempts made in the fields of radio telegraphy and radio telephony presaged further commercial applications of the art which were pre-venued by many identified with its development.

It was the assignment of the writer to develop a historical résumé of the art, stopping with the date when the United States entered the European War. As he has already overstepped the mark, it remains for his successors to carry on the story of the development of radio from that date.

II

RADIO IN THE WORLD WAR AND THE ORGANIZATION OF AN AMERICAN-OWNED TRANSOCEANIC RADIO SERVICE

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PEOPLE today are prone to consider radio primarily as a means of entertainment. To the average person, it is a modern edition of Aladdin's lamp, whose genii, summoned by the mere twist of a dial, will instantly supply him with whatever form of diversion his mood may dictate. Sitting within the four walls of his home, he has heard the music of the world's finest composers; he has listened to the living, vibrant voices of the greatest artists of his own time; he has followed, with breathless interest, the epoch-making New York to Paris flight of the intrepid Lindbergh; in his mind's eye, he has trotted around the bases with "Babe" Ruth for a home run, twisted and turned with "Red" Grange as he sped to a touchdown, and sat on the back of Zev as he and Sande thundered through that last sixteenth.

Rarely, indeed, does he turn to his radio as a source of information. It is problematical whether he has ever considered the possibility that radio has features other than those of mere entertainment. Yet radio *is* playing, day by day, an increasingly large part in the affairs of this modern world. Commerce functions more quickly and more effectively because radio has annihilated time and distance; navigation is safer because of the radio direction finder and the radio beacon; and the increased efficiency of the Army and Navy, both in peace and war, lends eloquent testimony to the value of this new science. It is in these fields that radio has amply justified its existence and its present high place among the essential industries of this country and the world.

Trade between peoples began in the earliest days of recorded history, when adventurous pioneers fared forth, by caravan and galley, to establish contact with their unknown fellows in distant lands. War is the oldest collective form of human activity, and the spirit of conquest, rather than that of fair exchange and good will, too often dominated those early adventurers, primarily actuated as they were by a desire for plunder and slaves. But they paved the way for international contacts and subsequent trade; indeed, seven centuries before the dawn of the Christian era, the Phœnicians had already attained an enviable reputation as the foremost commercial people of the world of their time. Keeping secret their trade routes and intimate knowledge of winds and ocean currents, those intrepid traders from ancient Tyre became the first exporters and importers in history.

International trade has developed through the ages as civilization, in its forward march, has devised improved means of transportation. The Phœnician galley gave way to the sailing ship, many centuries later came the first steamer; and today, the seven seas are dotted with ocean greyhounds, freighters, and motor ships, while the airplane and airship loom up as possibilities of a distant future.

Speedy communication dates back to ancient Persia, where relays of men and horses inaugurated the first postal service. In the account of his trips to the Orient, Marco Polo tells of an elaborate system of rapid communication in China, established centuries ago by the Great Khan. A postal service, time-honored institution that it is, still remains the world's chief reliance in communication.

Speed, after reliability, is the most important factor in communication. A single day looms large in the handling of international trade. In the absence of physical contact between buyer and seller, man has long sought an instantaneous method of communication. With the growing intensity of his desire to reduce months, weeks, days, and even hours to minutes and seconds, he turned to electricity as a possible solution.

The telegraph was among the first fruits of this idea. From 1820 to 1837 many pioneers engaged in telegraphic experimentation, but it was not until the latter year that an American, Samuel F. B. Morse, evolved a really practical instrument, and thus laid the foundation for rapid communication by means of electricity.

Expanding networks of wire, binding separated cities and communities into compact national groups, marked the phenomenal growth of the telegraph. Coming to the water's edge, it encountered its first hazard. Yet the obvious necessity of laying wires beneath the surface of the water merely gave added impetus to its development, and in a short space of time, the submarine telegraph, or ocean cable, brought telegraphy into the realm of international trade.

In 1845, a cable, the progenitor of the vast British system of today, was laid under the English Channel, linking Britain and France. Six years later came a permanent Dover-Calais cable. The year 1856 witnessed the first transatlantic project, sponsored by the American, Cyrus W. Field, but involving British capital and control. The Atlantic Telegraph Company was organized with a capital of £350,000, its guiding technical genius being Lord Kelvin, who evolved, first, the reflecting galvanometer, and later, the syphon recorder, both of which bore his name.

The first transatlantic cable, attempted in 1857, broke in the course of laying. The following year, a successful attempt was made, but the cable broke after two and a half months of service, during which time 732 messages were handled over it. A third trial in 1865 was likewise unsuccessful, but in 1866 a lasting success was achieved.

Great Britain, essentially a nation depending upon international trade for its very existence, was quick to sponsor the submarine cable. A flourishing cable industry arose in England, due in large part to the fact that gutta percha, the only adequate insulator for submarine cables, was and is virtually a British monopoly. British colonies and countries throughout the world were linked with England by means of a vast and intricate network of cables having London as its nerve center. By 1907, more than 38,000 nautical miles of submarine cable had been laid, mostly of British ownership and control. With the outbreak of the world war in 1914, practically all cable lines led to London, so that the British Government found itself in a position to censor and control the interchange of intelligence between most civilized peoples. The strategic value of this was incalculable. Thus, in a trifle more than fifty years, England had acquired control of international communication.

Other nations, though forced to acknowledge British priority in the submarine cable field, were keenly interested in establishing contact with their colonies and among themselves. Radio was an inviting possibility as a substitute. At the beginning of the century, Marconi had demonstrated the feasibility of flashing signals across the Atlantic. By 1908, a transatlantic radio service between Ireland and Nova Scotia was in operation. Inspired by the success of these experiments, several nations planned world-wire communication networks of radio.

In 1913, Germany projected a pretentious network with Nauen, a suburb of Berlin, as a center. The plan featured military as well as commercial considerations, and it was obviously in keeping with the predominant Junker philosophy of the period. Spans were contemplated much beyond anything thus far attempted in long-distance radio communication.

France, too, had its world-wide radio plan, colored by colonial and military ambitions rather than truly commercial considerations. Both this and the German system paid particular attention to South America.

Great Britain, not content to rest on its laurels in the matter of submarine cable supremacy, had its own world-wide radio project in the "All-Red Chain" which was well under way in 1913, when the British Marconi Company received governmental permission to carry it through. The official style of this company is Marconi's Wireless Telegraph Company, Ltd., but the whole world knows it familiarly as "The British Marconi." Its plan provided for two routes from England to Australia and, like its French and German brothers, had a decidedly nationalistic flavor. London was the heart of this All-Red Chain, designed to supplement the British cable system and to strengthen the British grip on world communications.

A striking feature of these pre-war networks was the enormous distance between stations, quite incongruous with the development of radio up to that time. Many stations were designed to divide time among various terminal points, a condition hardly in keeping with good commercial practice. Furthermore, and most important, the projects were mainly theoretical and quite unrealizable in actual practice.

The key to reliable and economic radio communication was still missing. The spark transmitter then in use, although developing enormous energy, was unable to span vast distances with that degree of certainty needed not only for continuous service irrespective of atmospheric disturbances, but for the high-speed operation indispensable to the increasing demands of transoceanic communication. Cables remained the mainstay of overseas telegraphy.

Then came 1914. On June 28 of that year an assassin's bullet ignited the train of powder which plunged the civilized world into war. The network projects of the various nations were temporarily abandoned, but the English control of cables gave Great Britain and its allies invaluable aid in the clearing of their own communications, as well as in the censorship and control of those of other nations.

It was about this time that America took the lead in industrial research. Prior to the war, new developments in this country had been largely the result of either pure invention or chance. Systematic and purposeful research was practically unknown. But now the laboratory became one of the most important elements of our industrial life. Engineers calmly faced, studied, and solved their problems with a view to meeting the emergencies created by the war.

Radio problems, too, were included in this effort. Radio engineers had long realized the necessity of a suitable high-frequency alternator, or generator, capable of producing alternating current of the order of 50,000 to 100,000 cycles, in contrast with the 60-cycle current required for our electric light service. Constant, uniform, high-frequency energy, delivered by a reliable alternator, was needed for the ideal radio transmitter.

Dr. Ernest F. W. Alexanderson was the man destined to solve this problem. Working in the General Electric Research Laboratories, with unstinted expenditures of time, effort, and money, he finally evolved the high-frequency alternator which today bears his name. This was a noteworthy achievement for radio engineering in general, for, as stated by Dr. Alexanderson himself, the alternator is not an invention excepting as it involves some patented details.

The development of the Alexanderson alternator was hastened by the war. The great Marconi himself came to Schenectady in 1915, to witness the test of a 50-kilowatt, 50,000-cycle alternator, and shortly after the General Electric Company was in receipt of attractive offers from the British Marconi Company. In 1917, the first alternator was installed in the New Brunswick, New Jersey, station where it aided in the development of the multiple tuned antenna, the magnetic amplifier, and the receiving system known as the Beverage antenna. As a result of his prior experiments with the alternator, Dr. Alexanderson foresaw narrow, crowded wave channels. This led him to evolve the system of radio frequency tuning which now dominates broadcast reception.

In 1918, the 50-kilowatt alternator was replaced by one of 200 kilowatts. This served not only for President Wilson's peace preliminaries with Germany, which, preceded by four years of war, led to the signing of the Armistice, but also for radio telephone communication with the President's ship en route to France in the spring of 1919. The reliability of the Alexanderson alternator in the New Brunswick station attracted wide attention, particularly from the British Marconi Company, which was now preparing to resume work on the Imperial British radio network, or All-Red Chain. This company, with its American and associated branches, was then, of all radio organizations in the world, best fitted to make use of the Alexanderson alternator, which represented a vast investment on the part of the General Electric Company.

To return to the outbreak of the war, it will be recalled that the United States found itself an isolated nation. The inadequacy of our communication facilities became increasingly manifest as the war monopolized, to an ever-increasing extent, the message capacity of the British cable system.

When, however, we declared war upon Germany in 1917, the need of an all-American transatlantic communication system became acute. General Pershing stressed the need of direct radio channels, and a large station was erected by American engineers near Bordeaux. Facilities were provided for handling the enormous flow of official matter between Washington and our forces on land and sea. Few of our countrymen have any adequate conception of what radio means to our Army and Navy, and it is appropriate to consider, at this point, the important part they have played in its development.

Before the United States entered the war, the Navy's high-power transcontinental, transpacific chain was in operation. This network consisted of stations at Arlington, Virginia; San Diego, California; Darien, Canal

Zone; Pearl Harbor, Hawaii; Guam, in the Mariana Islands; and Cavite in the Philippines. In addition, it controlled numerous low-power stations at various points along our coasts and in our outlying possessions. Add to this the fact that its fighting ships were fully equipped with the very latest type of radio apparatus, and it is apparent that the Navy was well prepared for war in a radio sense. The purpose of the high-power chain was to provide communication between our Navy Department and our forces afloat, entirely independent of the foreign-owned and controlled ocean cables.

The day after war was declared, a presidential proclamation directed the Navy to take over all radio stations in the United States and its possessions with the exception of those already under control of the Army. Accordingly, four Pacific high-power stations in active operation by the American Marconi Company were added to its chain, but these proved to be of little military value and were discontinued, as the theater of war was confined to the Atlantic area.

On the eastern seaboard, however, the Navy assumed control of the same company's high-power transatlantic station at New Brunswick, which, through its communication with the German station at Nauen, played the important part during the closing months of the war, as already stated. Navy officials were so well pleased with the work of the Alexanderson 50-kilowatt alternator that they quickly instructed the General Electric Company to build one of 200 kilowatts. When this was installed, the New Brunswick station became the most effective in the world and operated almost continuously during the war. Interallied communications were effectively handled, and radio contact was established with American and Allied vessels on the high seas, throughout this period of national emergency.

The Navy also took over the German-controlled station at Sayville, Long Island, and the station at Tuckerton, New Jersey, under construction by a German firm. Both of these stations had been placed in the hands of Navy radio personnel when the United States was a neutral. The Sayville station had been, from 1914 to 1916, Germany's principal means of communication with the outside world, for the Allies had almost at once cut all cables radiating from the Central Powers.

An agreement was early reached between the Army and Navy regarding civilian engineering personnel. Radio personnel was assigned to the Navy, with the result that that branch of the service had the assistance of the best radio engineering talent available. The Navy was greatly indebted to American radio companies which furnished it with large quantities of necessary apparatus.

Thus at the outbreak of hostilities, the Navy was prepared to handle the communication requirements of its forces. It was not prepared, however, to assume a large volume of traffic between the United States and its Allies, which had previously been handled by the transatlantic cables. Invaluable aid was rendered the Navy Department in this direction by the trained personnel from the ranks of the American Marconi and the Federal Telegraph companies.

With the despatch of large numbers of our troops to France, the cables quickly became loaded to full capacity, and transatlantic radio communication presented an acute problem. If the cables were cut it was apparent that radio would be our only dependence in the matter of telegraphic communication with our Allies and our own Expeditionary Force.

Fully to appreciate the seriousness of the situation, one has only to compare the conditions existing today with those of ten years ago. Transoceanic radio was, at that time, in its infancy. Receiving equipment was totally lacking in the refinements it now possesses, static was then relatively much more of an obstacle, and short-wave radio was absolutely unknown. But even if the radio circuits of the present day, with all the improvements which the intervening years have brought, were suddenly called upon to handle the normal flow of transatlantic cable traffic due to some sudden disruption of the cable system, they would be hard pressed for the moment.

Even with the improved New Brunswick and Sayville stations available for transmitting to Europe, the Navy was still faced with the problem of the effective reception of an equal volume of return traffic. Accordingly, extensive experiments were conducted at Bar Harbor, Maine, and Belmar, New Jersey. Due to some peculiar characteristics of its location, the station at Bar Harbor proved to be the most effective transatlantic receiving station in the United States. An extensive receiving equipment was installed, together with a complement of 150 radio operators.

As a further precaution, the Navy, in conjunction with the Army and the French Government, undertook the construction of the Lafayette 1000-kilowatt arc type radio station near Bordeaux. To supplement this, it also established a 500-kilowatt arc type transmitting station at Annapolis. In addition, fourteen 2-kilowatt shore stations were established and equipped in Ireland and France for the purpose of cooperating with aircraft which were combating the submarine menace in European waters.

After the formation of the United States Shipping Board, the Navy during the course of the war supplied and maintained radio equipment on approximately 1,500 vessels, including a number of foreign ships which were seized in our ports. With the signing of the Armistice, the Navy, having assisted in the establishment of a radio administrative division, turned that branch of the work back to the Shipping Board. It still continues, however, to supply that body with such radio equipment as it needs.

The exigencies of the war gave the maritime world the first practical radio compass or direction finder. This device had been experimented with by various navies since 1912, but it remained for the desperate situation created by the submarine menace to bring about its development into a really workable instrument.

Utilizing the radio compass, the British gained foreknowledge of the fact that the German High Seas Fleet had left harbor prior to the Battle of Jutland, because the enemy persisted in an unrestricted use of radio transmitters. Later in the war, United States transports were routed from Brest in accordance with information concerning submarines obtained through the radio compass.

Upon our entrance into the war, American ships detailed to European waters were equipped with radio compasses of American design. Likewise, our Navy developed this device for aircraft, and supplied nearly all our detroyers with it.

Today the radio compass is being further developed, and personnel trained for possible future emergencies by an extensive peace-time service free to ships of all nations. The popularity of this service is attested to by the fact that it is increasing at the rate of approximately 25% annually.

Another major problem confronting the Navy during our participation in the war was the development of suitable radio apparatus for use on aircraft. Equipment of very light weight had to be produced. Engine ignition interference, which prevented the reception of all but the very loudest of signals, had to be overcome. Nevertheless, up to the signing of the Armistice, 75 planes had been fitted with spark type transmitters and vacuum tube receivers.

In concluding our discussion of naval radio we can do no less than acknowledge with appreciation the part our Navy has played in the development of an all-American radio service.

At the outbreak of the war, German-owned high-power radio stations were in operation within the United States, and there was no assurance that other nations would not follow suit. America was by no means selfsustaining in radio in 1914, and was employing considerable radio equipment imported from other countries, particularly Germany.

The American Marconi Company was merely a branch of the great parent British organization. The American Marconi entered into negotiations with the Federal Telegraph Company of California with the idea of purchasing that company's radio system, and the sole commercial rights to its patents, with the exception of those already assigned to the Pan-American Telegraph and Telephone Company, itself involved with the Marconi interests.

The Federal Telegraph apprised the Navy of this move and offered to sell to it on the same terms. The Navy immediately accepted and purchased the Federal Stations and patent rights. Subsequently, it added the American Marconi's system of marine coastal stations, with the exception of transatlantic and transpacific high-power shore chains.

Meanwhile, German stations had been seized by the Navy, while the Marconi Company had acquired control of the Tuckerton unit. Thus the United States found itself entirely free of foreign-owned and controlled radio stations and services within its borders, except for the Marconi high-power chain.

Let us now pass on to a consideration of radio's relation to the Army.

The paramount importance of communication in military operations has led to the utilization and development of all possible means by which intelligence may be promptly and accurately transmitted from one headquarters to another. The battlefield of antiquity was well within the visual scope of a commander and his aides. Today, in marked contrast, the size of the forces engaged, and the fact that several armies may be waging battles at different points, have rendered this impossible. Various means of signal communication must be employed, and although no single system is universally applicable, each has its valuable features.

Telephone communication, for instance, permits personal contact by voice and instantaneous understanding; the telegraph gives a written record of the message; the personal messenger seeks out an addressee whose location was perhaps unknown to the writer of the communication; pyrotechnic signals convey intelligence over a wide area; and the pigeon, though he does not fly at night, wings his way over impassable territory heedless of noise and shell fire.

Radio, the latest addition to this family of signalling agencies, combines many of the valuable characteristics of older methods, and has at least one further advantage which is distinctly peculiar to itself. It has furnished the only really practical means of communication between points which cannot be linked by wires.

A valuable contribution of radio to the Army has been in providing inter-aircraft communication, and contact between aircraft and ground. The airplane observer may be in touch with a vast area, but the full and complete utilization of the invaluable knowledge which may be his depends upon its instantaneous transmission to his commander. If the increased efficiency of the airplane enhances its military value, radio will play a correspondingly larger part in supplying that indispensable coordination between air and ground.

Next in importance is the service which it has rendered the cavalry. The chief value of this branch of the service lies in its mobility, and a great problem confronting signal officers has always been the maintenance of communication between the widely separated units of a cavalry command. Radio has furnished a most happy solution.

In its aerial and cavalry applications, radio is indispensable in its own right. In other cases, however, it has been found a valuable alternate or substitute for the telephone or telegraph. Communication with front-line infantry organizations is often impossible in the face of heavy shell fire. When other means fail, it is the lightweight radio set that ultimately establishes contact with the supporting artillery or superior command.

The Army has ever been alert to investigate the military value of any new invention. In his annual report for the fiscal year 1897-1898, General A. W. Greely, Chief Signal Officer of the Army, said: "Colonel James Allen has devoted much attention to the system of wireless telegraphy with a view to adopting a suitable system whenever the progress of the invention and the conditions of military service shall warrant it."

The following year, the Signal Corps established wireless communication between Fire Island and the Fire Island Lightship, and in April of 1900 a daily schedule was inaugurated between two radio stations in New York

Harbor. As part of its Alaskan telegraph system, the Signal Corps had installed a submarine cable between Nome and St. Michael. The cable, however, was annually carried away by the spring break-up of the ice, and in 1901 it was decided to substitute wireless. Two years later, the system was in successful operation, and it became one of the first long-distance radio systems regularly handling commercial telegraph business.

It was not until 1906 that the Signal Corps built its first successful portable apparatus. It was an induction coil set operated by storage batteries. About the same time, a set permanently mounted in a wagon was constructed. By 1908, both these sets had been fully tested by the Army under actual campaign conditions in Cuba and the Philippines. As a result, the induction coil was abandoned, and quenched-gap spark sets, operated by 500-cycle alternators, were adopted in 1911.

Up to the outbreak of the European War, most of the low-power fixed station sets were of the quenched-gap type. The higher-powered units were of the arc type, with a sprinkling of high-frequency alternators. Receivers were simple tuned circuits and crystal detectors, and the possibilities of the three-element vacuum tube had yet to be realized. Radio was expected to be used in work between the larger headquarters at times when the Army was moving too rapidly for the establishment of wire lines. Communication with detached bodies of troops with cavalry was also projected. But no one had yet foreseen the elaborate systems of contact, including radio, which were to be employed in the World War.

At the beginning of the War, the radio equipment of most of the combatants was much the same as our own. It soon became obvious, however, that radio had to undergo a great change if it was to adapt itself to the conditions of modern trench warfare in which short-distance service and light-weight equipment were at a premium.

War has always resulted in the intensive development of military weapons. The belligerent powers, quick to appreciate the value of radio, expended vast sums for scientific research and development. More sensitive receivers, employing vacuum tube detectors and amplifiers, were evolved, and the entire scheme of radio use was radically changed. The pre-war plan of two sets for all purposes was replaced by a new plan involving many types, each designed for a special service.

When we entered the war, we were equipped as we were in 1914, whereas our Allies had radio apparatus representing three years of intensive war-time development. Accordingly, we were forced to adopt the equipment of the French Army, but a research program was laid out with view to our future needs. A laboratory and field-test section was established by the A.E.F. in France. In this country, a research bureau was created at Camp Vail, New Jersey, and this was supplemented by work done at the Signal Corps Laboratory and the Bureau of Standards in Washington. Many improvements were made in the French sets. Indeed, the Armistice found us nearing the completion of a program for the development of radio apparatus designed to meet the special requirements of our Army.

At the close of hostilities, development work was stopped, a survey of the requirements of our Army was made, and a plan formulated for the future military employment of radio. It was decided to continue the development of portable field equipment in the Army's own laboratories.

In accordance with this policy, the Signal Corps retained the laboratory at Camp Vail and established another at Wright Field, at Dayton, Ohio, where research work, in connection with aircraft radio apparatus, is carried on. The Army, thanks to this feature, is now equipped with no less than thirteen separate and distinct types of portable field radio apparatus for use in connection with aircraft. It might seem that there is a superfluity of equipment, but such is not the case. The fact is that it is *not* sufficient, and will shortly be increased.

The yearly advance in radio art has compelled the Signal Corps to revise its program from time to time in order to keep abreast of the development and to lead the way in some of its phases. A noteworthy example of the latter angle is furnished by the Signal Corps' work with the radio beacon which was successfully employed in the recent Hawaiian flights. The last few years have witnessed an intensive development in short-wave communication. The Signal Corps is at present engaged in experimentation with a view to changing practically all portable field equipment to short-wave sets. It may be of interest to note that it was one of the pioneers in this field, and the SCR-77 loop radio set, operating on a wave-length band of 68 to 73 meters, was first developed during the World War and has been in use ever since.

Broadcast information was known during the war, although not in the form which is now so popular. Time was broadcast for the Allies from the Eiffel Tower station, and valuable meteorological data were sent out at frequent intervals by various field transmitters. An attempt at propaganda by radio broadcast was made by the Germans in the waning months of the war. Station POZ at Nauen sent out daily bulletins in German, French, and English, giving a highly colored report of Teutonic successes and minimizing their losses. This information, however, was received only by a mere handful of radio operators and was considered a matter of passing interest with little news value.

The War did much to develop a world consciousness in the American people. American business, aware of the end of our commercial isolation and eager to share in the world's markets, began to seek export trade in earnest. The United States was no longer willing to accept a "party-line," so to speak, in the scheme of world communications. The newly created nations of Europe likewise sought to establish direct contact with us in fostering good will and trade, and the way was paved for an all-American communication service.

The close of the war found the General Electric Company ready to supply anyone with the Alexanderson alternator as a means of reliable and economic transoceanic radio communication. The British Marconi Company presented the only existing market, and it was on the point of placing orders to the extent of $5,000,000 with the General Electric if granted exclusive rights to the use of such equipment.

President Wilson, in Paris at the time, sent Admiral Bullard, Director of Naval Communications, and Captain Hooper, to the General Electric with a request that it decline to sell to the British Marconi Company or issue rights to foreigners to use its inventions. The President sensed an obvious intent on the part of the British to dominate international communication and transportation. Inasmuch as they were already predominant in the cable field, the control of radio facilities, if achieved, would give them a veritable monopoly in the transmission of intelligence throughout the world.

On April 5, 1919, a small group of men, including Owen D. Young, now Chairman of the Board of the Radio Corporation of America, received Admiral Bullard in the New York offices of the General Electric. In the presence of this small gathering, this government representative disclosed the irreparable injury to American interests that would be sure to follow if the Alexanderson alternator were sold to any foreign government or private company. He pointed out that, although our citizens had never played a prominent part in cable communications, here was an opportunity to retain in American hands the complete control of radio communication, not only in the United States, but in Central and South America as well. In this connection, he outlined a policy of wireless doctrine not unlike that of our greater Monroe Doctrine.

The General Electric was, and still is, preeminently a manufacturing concern, producing electrical equipment which it sells throughout the world. The Alexanderson alternator represented to it a substantial investment. And now the opportunity had come to manufacture and sell the device to the only logical customer at a fair profit. Yet so ably did Admiral Bullard plead his case that negotiations with the British Marconi Company were canceled. This, although preventing the British from acquiring the alternator, did not provide America with a radio communicational organization, nor supply a market for the General Electric's equipment on whose development vast sums had been spent.

Accordingly, Owen D. Young, with the sympathetic cooperation of our government, took the steps which led to the organization of the Radio Corporation of America. The American Telephone and Telegraph Company, the Western Electric Company, the United Fruit Company, and later the Westinghouse Electric and Manufacturing Company joined with the General Electric Company in the work of welding together into one great central organization the principal radio inventions and radio research facilities of the American people. Financially and technically, the new company was in position to compete with any other like organization in the world. It acquired the property and rights of the American Marconi Company and made traffic contracts with its parent organization, supplementing these with agreements with German and French companies. Later it worked with all these in developing radio in South America.

It is due that I should say a few words concerning Rear Admiral W. H. G. Bullard as a man. His death in 1927 was a great loss, not only to our Navy, from which he had retired, but to the entire nation. Americans have been slow to realize the value of international communication, and our recent awakening in this respect makes his loss the more keenly felt. Admiral Bullard was one of the few men of broad vision in the United States who was familiar with the communication service. From 1912 to 1916, he was superintendent of the United States Naval Radio Service, and director of Naval Communications from 1919 to 1921. While director of Naval Communications, he played a great part in the formation of the Radio Corporation of America. In March, 1927, President Coolidge appointed Admiral Bullard to the chairmanship of the Federal Radio Commission for a six-year term. While engaged in the duties of that office, he was also taking part in the work of the International Radio Conference as a delegate.

Radio had a true friend in Admiral Bullard. Never has it had a more ardent supporter and worker. In him, the American people found a true champion of their rights in world affairs. The place he has left vacant will be a difficult one to fill.

The Radio Corporation of America came into being in response to the urgent call of an enlightened public opinion. Its mission was to secure for America that unquestioned supremacy in radio communication to which the contributions of inventive genius, industrial organization and capital justly entitled it. In the nine years the

Radio Corporation has been in existence, there has taken place a development fully comparable to that of the British cable system over a period of six decades.

Today, from New York City, the RCA world-wide wireless service offers direct communication with England, France, Germany, Italy, Holland, Belgium, Sweden, Norway, Poland, Turkey, Argentine, Brazil, Colombia, Venezuela, Porto Rico, Dutch Guiana, and Portugal. San Francisco is the center of a network which reaches out to China, Japan, the Philippines, Dutch East Indies, and French Indo-China. Additional circuits are planned in the future to countries as near as Canada and Cuba, and as distant as Spain, Czecho-Slovakia, Chile, and Liberia.

The present circuits, unlike those of pre-war days, are based primarily on commercial considerations. They are established between stations of sufficient power to span the intervening distance under all conditions. Although not in the form of physical conductors between transmitting and receiving points, they are no less firmly fixed from the standpoint of traffic flow. Operating speed has steadily increased. There was a time when 20 words a minute was considered the standard of efficiency. Today, on our latest short-wave circuits, traffic speeds of 200 words per minute and over are achieved and maintained hour after hour in clearing radiograms. Nor is accuracy sacrificed in the least, for present-day radio traffic is handled almost exclusively by automatic means. Radiograms are typed on a perforator keyboard whose tape is subsequently passed through an automatic transmitter to form perfect dots and dashes. At the receiving station, signals are reproduced on a paper tape, to be translated and typewritten directly on radiogram blanks.

The efficiency of our present circuits is reflected in lower transoceanic communication rates. Cable companies, which for years maintained high rates in the absence of competition, have been forced to lower them, and the American public has thus become the residuary legatee of cheaper and better international communication.

The past two years has witnessed the growing commercial use of photoradiograms. Radio has thus developed the added feature of the facsimile message. This service is extensively employed in flashing news, photographs, documents, fashion sketches, and signatures across ocean and continent. Checks, too, are being transmitted by radiogram, and honored when presented an hour or two later, thousands of miles away. The photoradiogram is no longer an experiment. Daily, it is handling its share of the communications of our social organization which cannot be translated into words and telegraphic code. It is even probable that the photoradiogram method may ultimately displace the time-honored code by handling messages in their original form.

The Alexanderson alternators are still at work. But American inventive and engineering genius has not been content to rest on this achievement. Within the past two years, many short-wave channels have been inaugurated, with a marked saving in original investment and operating costs and a considerable increase in traffic speed. More recently, the directive feature, as exemplified in the British beam transmitter and the RCA projector transmitter, has been added and gives promise of still greater efficiency. These developments assure the necessary radio circuits for years to come, even in the face of the threat of an overcrowded air. With both directive and selective differences, it is possible to inaugurate still more tangible radio circuits which shall maintain their individuality.

On the high seas, American marine radio has achieved a preeminent place, both in scope and efficiency. Recently, in the interests of higher efficiency, hundreds of American vessels have been refitted with the vacuum tube transmitter. This has superseded the spark or arc type, with marked gain in distance, reliability, and selectivity. The continuous-wave operation made possible by the vacuum tube transmitter permits of added channels in the limited wave bands set aside for marine radio traffic. The scattered and isolated land stations of years gone by have been replaced by a comparative handful of marine radio centrals with multiple transmitters and receivers to provide the necessary channels for taking care of the greatly increased traffic flow. More than 500 ships have already been equipped with vacuum tube transmitters and others are shortly to follow, even though the recent International Radio Telegraphy Conference at Washington has set 1940 as the date for the final conversion of all marine radio transmitters to the vacuum type.

Besides giving the modern navigator an invisible thread of communication reaching to other ships and to the shore, radio has provided him with the direction finder or radio compass as a means of determining his position. The Bureau of Lighthouses has cooperated by installing radio beacons, or automatic radio transmitters which flash identifying signals, at crucial points along our coasts. The direction finder has virtually dissolved fog and blackness, and thousands of precious hours are annually saved for American shippers and passengers.

In marine radio, as well as in the transatlantic field, America has assumed the leadership, not only for ships flying the Stars and Stripes, but also for other vessels coming to our shores and utilizing our land station facilities.

And while radio has reached out across the waves, it has also found a means of contacting the broad United States itself,and entering the homes of its citizens. Radio broadcasting had its beginnings in certain radio telephone experiments conducted by the Westinghouse organization at East Pittsburgh. The intense interest displayed by the mere handful of listeners provided with the dot-dash receivers of the time, convinced American commercial instinct that here was the seed of a new industry. Today, this infant industry supports over 320,000 workers, over 28,000 retail shops, over 1,200 factories, over 700 broadcasting stations, utilizes tens of thousands of miles of telephone and telegraph lines for network operation in reaching 35 millions of listeners, and represents an annual trade close to half a billion dollars.

America has led the way in the matter of radio broadcasting. Other nations, hitherto frowning on amateur radio activities, have been compelled to lift state-imposed bans. From the pioneer station KDKA, broadcasting has spread to many lands, until today it touches every part of the civilized world with a growing interchange of programs to make for better understanding and more lasting peace.

Returning briefly to the international aspect of radio, it was to be expected that the leadership of America in overseas radio communication could not be retained without a struggle with other nations. Thus the British Empire, so long dominant and so dependent upon communication with all parts of the world, was bound to contest with the United States the radio supremacy of the world.

With a wisdom born of the many more centuries in which the sons of Britain have gained an experience greater than that of our own statesmen in foreign policies, it is perhaps natural that they should, sooner than our government authorities, recognize the value of unification of communication in a world-wide sense.

During its 150 years of existence, the United States has never had but one consistently maintained foreign policy, namely, the Monroe Doctrine. Great Britain, on the other hand, in more than a thousand years has probably had more than a thousand such policies. The British system of government seems far better adapted to a continuity of foreign policy than our own, which is not saying that our own system is not the best in many other respects.

During the last few months, it has become apparent to the cable interests of Great Britain that the growing radio supremacy of the United States, and in particular the greater efficiency of the beam system of transmission as compared to the older cable method, has directly challenged the cable leadership of Great Britain. As a consequence of this trend, the older country has recently taken steps to meet this challenge in bringing about the unification of cable and radio interests. This will undoubtedly strengthen the position of Great Britain both in times of war and in peace, affording, as it will, communication by British circuit to practically every foreign port and principal city of the world.

The American answer to this challenge can only be made by submitting the great communication companies, both cable and radio, to proper government regulation as to rates while exempting them from the operation of the anti-trust laws and permitting unification here and thus meeting the thrust of unification from abroad.

And so the radio industry in America has played a major role, not only in the development of a national consciousness in our own people, but also in the cosmopolitan consciousness of the world at large. More than all the peace conferences of history, it has served to make the concept of "Peace on Earth, Good Will toward Men" a reality, and, taking the world by the hand, has led it one big step farther down that shadowy trail that ends in Utopia.

III

THE DEVELOPMENT OF THE RADIO ART AND RADIO INDUSTRY SINCE 1920

DAVID SARNOFF
Vice President and General Manager, Radio Corporation of America

IN AN industrial era in which discovery and science play such important parts, I need not remind you of the changing order of things in the world of business. We have gone far since the day when barter and sale were the main principles of business. Other motives than mere economic gain are beginning to influence industrial leadership. Men are contending not so directly for a share of the public dollar, as in the endeavor to develop and perfect those unlimited possibilities of achievement which science is breeding in the laboratory and executive genius exploiting in the promotion offices of modern industrial organizations. Stability must be tempered with flexibility in modern industrial development. Business no longer operates in fixed grooves and along restricted lines; it has become a highly specialized art, alive as never before to its varied possibilities and demanding nothing so insistently as room to grow and expand, opportunity for larger and deeper service to humanity.

The needs of the times will bring forth, perhaps, a new type of executive, trained in a manner not always associated with the requirements of business management. He will have to reckon with the constant changes in industry that scientific research is bringing. He will have to be able to approximate the value of technical development, to understand the significance of scientific research. He will be equipped with an even and exact knowledge of the relationship between his business and similar businesses in the same field; between his industry and other industries which it may affect or be affected by; between business and government; and even between business and politics, for no great industrial enterprise is safe from political attack. "Mind your own business" is ceasing to be an all-embracing business axiom. It may be the other fellow's business that will determine the success or failure of your own.

In all this you, who are the inheritors both of our problems and our mistakes, will find your greatest opportunities. You are free from business traditions already obsolete. You have an academic training that has given you a broad educational background. You have the advantage of varied practical study and observation denied to the man with his nose to the grindstone.

The protean part which a single art may play in modern industry has no better illustration than the position of the radio art and the radio industry, and its growth and development since 1920. For radio encompasses telegraphic communication, as exemplified in our transoceanic wireless system; sound communication as accomplished in telephony; mass communication as inherent in broadcasting; sight communication as promised by television. It is an art that embraces and goes beyond the arts of electrical, mechanical, telegraph, and telephone engineering; that touches upon the photographic and dramatic arts and is infusing new ideas into both; an art that has definite relations to chemistry, to metallurgy, to physics, to astronomy, to meteorology, to acoustics, and to dynamics.

As an industry, radio has assumed phenomenal proportions. The retail value of receiving sets, parts, and accessories in 1927 amounted approximately to $500,000,000 as compared to $2,000,000 in 1920. Receiving sets in use in the United States have reached a total of 7,500,000. From a single broadcasting station rendering an organized and regular service in the air eight years ago, 700 broadcasting stations are today transmitting, over congested wave channels, music, speech, and entertainment to 25,000,000 people in the United States.

Our wireless services supply us with invisible links of communication with the leading countries of Europe, South America, and the Orient. We are in touch with every ship that sails the sea, equipped with a radio set.

Radio has become an indispensable element of modern life. It has brought the stage, the concert hall, and the pulpit to the home. It has radically affected many industries and services. It has changed the communication map of the world. And yet it may be said that the art upon which it is based is only in its infancy.

Because of the circumstances which gave birth to our world-wide wireless communication system and to the rise of a new industry, it is impossible to dissociate the history of radio in the United States from the story of the Radio Corporation of America, which company I have the honor to represent. The Radio Corporation of America was founded to give expression to our national interests in the field of wireless communication, to develop a new art of communication to the home, and to establish a new industry. That was in 1919, immediately following the World War. The wireless communication system of the United States was largely under foreign control; the organization then existing was about to acquire new instrumentalities, the products of American inventive genius, in order to make regular transoceanic service effective by radio; a maze of patent claims and counter claims threatened the establishment of the industry in America.

Great as the need may have appeared, capital did not rush forth spontaneously to finance the project for an American owned and controlled wireless communication system. No great industrial, commercial, or other interest then sought the privilege and the risk of organizing a great system of wireless communications to compete with the long-entrenched cable interests of the world, largely controlled by Great Britain. No cry of monopoly arose before Congress to deter anyone from such a venture.

It was the urgent request of the highest officers of our government, concerned with the development of radio communication, that led Mr. Owen D. Young and his associates to undertake the formation of the Radio Corporation of America. This at a time when wireless communication was just lifting its head over the oceans, when not a single transmitting station, other than crude experimental sets, had yet begun a service of broadcasting in the United States, when a gigantic battle for patent determination threatened to remove the art from the laboratory to the courts.

UNITED STATES BECOMES CENTER OF WORLD-WIDE WIRELESS

The mobilization of patent rights and industrial resources that made it possible for the United States to take leadership in the radio art and the radio industry was Mr. Young's response to the call of national service. It was as great and courageous a pioneering effort as the first cable laid across the Atlantic under the sponsorship of Cyrus Field. But it remains for a future historian of the communication arts fully to assess what his vision, his courage, and his constancy have meant in the development of closer relationships among the peoples of the world, now connected by the invisible bonds of radio communication.

Nothing in all history has so profoundly affected social and economic development as has the phenomenal expansion of international communications. And yet nine years ago the United States occupied a wholly dependent position in world communications. We were connected with the great nations of the world by strands of wire underseas, subject to destruction at any time through the emergencies of war or the accidents of peace. The fact that a great nation could be isolated by the cutting or diversion of its undersea cables, were it not for the invisible links of communication supplied by radio, had been demonstrated in the example of Germany. The wireless transoceanic system established in the United States was fitful and uncertain. It was largely under the control of foreign interests.

It was an achievement indeed when by 1921 the Radio Corporation of America had succeeded in establishing no less than five transoceanic wireless communication circuits from the United States. We were then communicating through the air with Great Britain, with Norway, with Germany, with France, and through Hawaii, with Japan.

But let us turn to the present picture. Today the United States is the focal point of a vast system of world-wide wireless communication that reaches across the Atlantic to the East, across the Pacific to the West and over the Caribbean to Central and South America. We are in daily wireless communication, not with 5, but with 25 countries of the world. Wireless messages now radiate from New York to Great Britain, France, Germany, Italy, Norway, Sweden, Holland, Belgium, Poland, Turkey, Liberia, Porto Rico, St. Martin, Venezuela, Colombia, Dutch Guiana, Brazil, and the Argentine. From San Francisco we communicate directly by radio with Hawaii, Japan, the Philippines, Dutch East Indies, French Indo-China, and via the Philippines, with Hong-kong and Shanghai, China. And we are planning further to extend our service by including Spain, Cuba, Mexico, and several Central American countries within our communications orbit—not to mention our projected transcontinental radio service from New York to San Francisco and a service from New York to Montreal.

Perhaps the position of the United States in this field is best summarized in a leading article of recent date published by a great London journal.

> The American government, [the journal declares, referring to what it terms "a bold and magnificent policy,"] . . . have had the wisdom to realize that acting as a government, they would have no chance of acquiring any position in the communication systems of other countries; but acting through their financial and industrial organizations . . . they already have acquired a dominating position and are steadily increasing in strength. The field of international communications is one in which it is hopeless for disorganized units . . . to compete against powerful combinations under unified direction.

RADIO HAS SAVED AMERICAN PUBLIC $30,000,000 IN LOWER COMMUNICATION RATES

What have been the results, economically, of radio competition in the United States with the great cable systems of the country? First of all, a decided and substantial lowering of communication rates, by which the American public has been the beneficiary during the past eight years, to an amount conservatively estimated at $30,000,000. An equal saving has been effected abroad, so that $60,000,000 has been saved in communication rates thus far by the advent of radio. For the first three years of the development of our service, radio rates averaged 25% below existing competitive cable rates. At the end of that period the cable systems found it necessary to reduce their rates to the level of radio.

This was the first reduction in cable rates in 38 years. The following table indicates specifically the difference between former rates and present rates of international communication from the United States.

	Former Rate Per Word	Present Rate Per Word	Saving Per Word
To England	.25	.20	.05
To France	.25	.23	.02
To Germany	.35	.25	.10
To Italy	.31	.25	.06
To Norway	.35	.24	.11
To Sweden	.38	.25	.13
To Japan	1.22	.72	.50
To Hawaii	.35	.25	.10
To Brazil	.50	.42	.08
To Argentine	.50	.42	.08
To Venezuela	1.00	.60	.40
To Colombia	.65	.40	.25
To Liberia	.98	.50	.48

The extent to which radio has become a competitor of the cable systems of the country is best shown by the following table of increase in radio traffic from and to the United States for the period of 1920-1927 inclusive:

Year	Paid Words	Increase over Preceding Year *Paid Words*
1920	7,001,610	
1921	17,404,985	10,403,375
1922	22,575,861	5,170,876
1923	27,626,359	5,050,498
1924	32,043,698	4,417,339
1925	33,697,419	1,653,721
1926	36,034,566	2,337,147
1927	38,662,536	2,627,970

Our present investment in the radio stations now carrying on an international service is approximately $20,000,000. Our business in this field is of a public service character.

THE DEVELOPMENT OF THE RADIO ART

Radio has traveled far afield since its establishment in the United States as a wireless telegraphic service. It is on the ocean, aboard ship, in the home; it is about to enter the theater through talking moving picture developments based upon the latest of the electrical arts. It is equally true, however, that no industrial organization devoted to radio could have hoped to survive unless it traveled with the art. Radio had to make contact with the home, through broadcasting, before it could hope to discover many of the secrets of wireless transmission which resultant research has developed. It was the experience gained in broadcasting which helped to direct the thoughts of the radio scientists and engineers to hitherto unexplained phenomena of electric wave propagation. The present efficiency of our transoceanic radio communication system bears a direct relation to the work which the Radio Corporation and its associates have done in broadcasting. The development of receiving devices for the home has taught us much of the problems of reception in telegraphic communication. No division of the radio art can remain indifferent towards the developments that our great electrical laboratories promise for the future.

At the present time, radio holds forth the promise of an entirely new and revolutionary system of telegraphic communications. The very image of the message, and not its counterpart in code, soon will be flashed regularly across the oceans, if we are able to maintain our present progress in photoradio transmission. The abolition of the dot-and-dash system of telegraphic transmission must bring incalculable advantages. We are now engaged in the facsimile transmission of photographs, important financial documents, and similar services. But whether or not this system can be advanced to the stage where all messages, now laboriously coded at the transmitting point and decoded at the receiving end, shall be sent in facsimile form—whether or not the American public will soon receive the benefits of such a system—must depend very largely upon whether or not sufficient scope is allowed in the air for radio development.

THE GROWTH OF THE RADIO INDUSTRY

In the foregoing the effort was made to describe the position of the United States in the field of international radio communication and to indicate the progress of the radio art. Equally significant has been the growth of the radio manufacturing industry in this country. Here again I am forced to dwell upon the relationship which this bears to the Radio Corporation of America, for as the pioneer in the radio art we make a splendid target for the buccaneering elements that flock to every new industry. We have patents granted by the United States

Government for engineering and electrical developments in radio communication; we exercise the property rights inherent in these patents; we are soundly financed. These are grievances enough for those who come to reap and not to sow, who cry monopoly but who fear competition.

The extent to which the leading factors of the electrical and communication industry in the United States have advanced the radio art and the radio industry is written in the records of public service. It was, in fact, the opportunity for public service that attracted such outstanding leadership to the radio industry as is represented by General James G. Harbord, president of the Radio Corporation of America. He knew from intimate experience in the World War our national requirements for communication service. He saw a great administrative work that still remained to be done, a task for organization that required high ideals of patriotism and service, if these were to be accomplished in the national interest. Under his guidance and direction, the Radio Corporation of America has made great contributions to world communications, as well as to industrial development.

The rise of the radio industry in the United States has been the most remarkable achievement in industrial history. Starting from a single broadcasting station in 1920, —the pioneer station KDKA in Pittsburgh—erected and operated by the Westinghouse Electric and Manufacturing Company, there are today 700 broadcasting stations throughout this country. In eight years an industry that does a $500,000,000 business annually has been created, a listening public of more than 25,000,000 people has arisen in the United States and over 7,500,000 homes are equipped with radio receiving sets.

Forty-five years elapsed after Professor Alexander Graham Bell gave the world his great invention before so many homes were equipped with telephones. It was 37 years after the opening of the first Edison station that as many American homes as this were using the electric light.

In the field of radio equipment, the Radio Corporation of America today is engaged in competition with 25 licensed radio manufacturers (who are likewise in competition with each other), as well as with many others who are manufacturing and selling radio equipment regardless of patent rights. We adopted our licensing policy in an effort to stabilize the industry. For a considerable period competitors had ignored our patents or infringed upon them and were thus able to make a much higher percentage of profit. We recognized that some of these factors were awaiting patent determination in the courts.

More than 1,000 engineers engaged in radio research express the efforts of the Radio Corporation and its associates to develop this art and industry. Millions of dollars are spent annually by the Corporation and its associated interests in these efforts. We are, therefore, inevitably in possession of many valuable patent rights, the fruits of intensive, continuous, and costly research. But we doubt whether any other corporation in the industrial history of the country, possessing patented inventions, has ever licensed so many of its competitors and at so early a stage in the development of a new art.

In the manufacture and sale of radio vacuum tubes, the very heart of the modern radio receiving set, there is ample competition. Trade journals report that there are more than forty manufacturers of vacuum tubes in competition with us, and with each other, in the United States. With an excellent and expanding market at its disposal, the Radio Corporation of America, deliberately and of its own free will, has reduced the price of vacuum tubes from the original figure of $7 per tube to $6 to $5 to $4 to $3 and to half the latter price—until today we have made available to the public vacuum tubes that sell at $1.50 each. Improved methods of manufacture, quantity production, greater demand, have enabled the company to pass on these savings to the public at large. It requires a new definition of "monopoly" to condemn the Radio Corporation for reducing the price of tubes to almost one-fifth of their original cost, while adding enormously to the life of these products.

Equally baseless are the fears of a "monopoly of the air," most often expressed by those who find themselves without an audience to serve because they have no service to render. It is the audience, not the station, that determines the position of the broadcaster in the air. The interests of the Radio Corporation in the field of broadcasting are expressed through its associate, the National Broadcasting Company, organized by the Radio Corporation and its associates in the electrical industry. Its establishment came, first, at the call of national service, which required that such a system be organized so that matters of great moment to the nation, as well as outstanding educational, informational, and musical features, be made available, not to the limited audience of a single station but to the greatest possible audience in the United States; second, in the effort to find an economic solution for broadcasting so that the service upon which the industry is built might be developed upon a solid and permanent foundation; and, third, to serve the interests of good government, education, and commerce, which have found in this great method of mass communication a direct and effective channel to the home.

The National Broadcasting Company owns only one key station of the networks which it operates. It distributes a service to many other stations throughout the country, whose listening public desires or demands the kind of programs initiated by the National Broadcasting Company. The Radio Corporation of America itself owns only two of the 700 broadcasting stations of the country.

If in creating the facilities whereby the President of the United States may address, and often has addressed, an audience of between ten to twenty million people—whereby Cabinet members and government officials may discuss, and often have discussed, matters of moment to the whole nation—if in creating the facilities whereby members of Congress have sought and received the privilege of addressing a tremendous radio audience we have been guilty of efforts to "monopolize the air," it is a charge which does not lie heavily on our conscience.

If in forming a broadcasting organization that has put on the air world-renowned artists of the opera, the great stars of the concert stage, the leading symphony orchestras of the nation, we have done wrong, we have yet to hear a complaint on that score from a single radio listener in the United States. If in opening the great channels of the air to political, religious, and popular educational features, not to the audience of a single station, but of a number of stations associated in the same networks, we have failed to serve the best interest of the nation, no such indication has yet come to us from any source.

THE FUTURE OF THE RADIO ART CALLS FOR A CLEAR TRACK FOR PROGRESS

It is an interesting reflection that although more than 26 years have passed since the first wireless signal limped across the Atlantic Ocean, the very nature of radio, the medium through which it moves, and some of the fundamental laws which govern it still continue to baffle man. Only a few months ago a learned court, in the course of a patent decision, declared:

> Of course, we shall not presume to say what radio really is, for no one has told us, and so far as we can learn from an independent study of textbooks on the subject, no one knows.

That statement expresses accurately our present state of knowledge of many fundamental questions with regard to the art. Notwithstanding all that has been accomplished in the advancement of the radio art and the radio industry, an almost limitless sea of research still remains to be plumbed. The patent rights owned and controlled by the Radio Corporation of America are but a small fraction of the patent awards that await the inventor of the future.

At the present time, an entirely new era of radio communication—radio television—is opening before us. We are not now manufacturing radio television apparatus for the home because, frankly, we do not yet know how to make a simplified and low-priced television receiver practicable for home use. Nevertheless, I firmly believe that within the next few years such equipment and service will be developed and made available to the home. A virgin territory, an unlimited field, and a reward greater than present imagination can conceive, awaits those who will bring sight as well as sound to the home. What a magnificent opportunity for inventive genius and industrial enterprise to express themselves!

And yet I venture to say that when television broadcasting has become an established art, when television receiving sets are installed in thousands of homes, that the same type of industrial adventurer who seeks opportunity but avoids obligation, again will cry out demanding legislation, limitation, and even confiscation.

We are not now engaged in many other applications of radio which are hopes and aspirations today, but which challenge accomplishment tomorrow. Why? Because we have not yet been able to find satisfactory technical solutions for the problems involved. But, when solutions are found they will appear to be simple. Most great things are. More patents will be issued. Imitation will be easy. Years will pass before these patents are adjudicated. Meanwhile, those who have no regard for patents and no responsibility to the industry will again come forward with cries of "monopoly" and "restraints of trade."

Perhaps it is inevitable that a young and growing industry should pass through these experiences. Nevertheless, it may help towards a clearer view in the future if these predictions are recorded now.

Fundamentally, the problems of radio still call for study and experimentation. We do not yet know to how many uses a given radio device may be put. We know little of the laws that govern radio transmission. We have only an inkling of what the next day may bring forth from the laboratory.

No future Alexander of the business world need cry, therefore, for the lack of worlds to conquer in this new art of communication, which is still unfolding. No industry offers a greater laboratory for business and industrial effort. None has so many virgin problems to solve. None bears so intimate a relation to other established industries and none shows a greater promise of still further industrial expansion. It is upon you, the future leaders of the business world, that the greater burden and the greater glory of radio development must rest.

IV

THE DEVELOPMENT AND USE OF RADIO TELEPHONY AS A MEANS OF COMMUNICATION

INTERACTING INFLUENCES OF THE WIRE AND RADIO ARTS ON EACH OTHER AND THEIR JOINT INFLUENCE ON POSSIBLE NEW METHODS OF COMMUNICATION

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IN SPEAKING before the Graduate School of Business Administration on the development and use of radio telephony as a means of communication, I assume that what is primarily of interest to you is its development and use as a service-giving agency of communication and its economic and business aspects, rather than a survey of its more scientific and engineering features. On this assumption I propose therefore to approach the subject by giving you first some of the basic possibilities and limitations of radio as they now appear, and some of the fundamental requirements of all electrical communication. These will help to indicate the relation which exists between the radio and the wire methods of electrical communication. Then I shall take up a consideration of certain of the more promising applications of radio telephony—such as transoceanic telephony—and lastly, I shall touch briefly on one or two of the collateral forms of communication which appear to give some prospect of commercial utilization.

In approaching any matter concerned with radio transmission, whether telephone or telegraph, with a view to appraising its utility as a vehicle for distant communication, one must have continually in mind certain basic facts and a realization of what seem today to be inherent limitations imposed by Nature on all radio operation. If this is not done, one is likely to be led astray by the overenthusiastic claims which are frequently advanced concerning the possibilities of this, that, or the other development.

The whole art of radio communication is so new and so much of the truly wonderful has already been accomplished that many people are doubtless ready to believe almost anything that is claimed for it. To the quite honest misconceptions of the partially informed enthusiast have been added the overstatements of promoters who have something to sell. The interests of these people are best served by the greatest possible stimulation in the public of a desire to participate in a prospective golden harvest. As you are aware, this latter phenomenon is a common adjunct to every new invention or development which is made.

In the long run, however, inexorable economic laws sift out the wheat of substantial worth from the chaff of fantastic overstatement. Enough real information about the possibilities and limitations of radio is beginning to be available so that this weeding out process has commenced to work. Some years yet will doubtless have to elapse, however, before the whole cycle has run its course and radio communication will have settled down into its proper economic niche.

The basic facts about all radio communication are:

1. All radio is essentially a broadcast form of transmission.

2. All radio communication employs the same conducting medium, so that whatever discrimination is obtained between simultaneous services is entirely a matter of the equipment used at the sending and receiving terminals.

3. So far as we now know, all radio transmission is subject to vagaries in the conducting medium which are beyond man's power to control. Such vagaries are the well-known static phenomena, which produce in the receiving equipment electrical disturbances which at times blot out or distort the received signals, and the so-called fading phenomena, particularly evident with very short radio waves. This fading from time to time very greatly alters the amount of energy required for transmission between any two points. In many cases fading is so pronounced as practically to eliminate the possibility of *any* transmission for longer or shorter intervals of time. Possibly, though not certainly, with increased knowledge and further development work, much of our present difficulty with fading may be eliminated.

4. In the present and prospective state of the art there are relatively a very limited number of possible non-interfering channels in the whole electromagnetic wave length range available throughout the world for radio transmission.

5. Because of the single common medium involved in all radio transmission, the possibility of destructive or objectionable interference between separate radio channels is very great and very difficult to control.

6. All radio transmission is essentially non-secret. Such degree of secrecy or privacy as may be obtained is in effect one form or another of coding and can be maintained secret or private

against a malicious listener-in only so long as the integrity of the coding arrangement can be maintained.

The factors which I have just enumerated are in effect substantial obstacles in the way of developing point-to-point radio service having that degree of reliability which the world now demands of electrical communication. Offsetting these obstacles are certain inherent advantages of radio which open up interesting possibilities for development. Principal among these are:

1. The very broadcast nature of all radio transmission makes it in many respects an ideal vehicle for reaching simultaneously widely scattered places or individuals all interested in the same message. This possibility is of course clearly exemplified in the widespread interest in and use of radio for program distribution.
2. It is the only known means of communicating with mobile objects, such as ships at sea and airplanes, where the conditions are such that sight or sound cannot be used.
3. Over light traffic routes where a high degree of reliability is not a prime desideratum, or where the exigencies of traffic demand the rapid shifting of transmission from one point to a number of other points, radio frequently offers an economic advantage not possessed by any other means of communication.

In order to give a balanced picture it is necessary to stress somewhat the relations between wire and radio communication that result from the foregoing fundamental factors involved in radio. Both of these agencies of communication, wire and radio, have witnessed striking developments within the last fifteen years because of the appearance in the communication art of new devices and methods. For a better understanding I am therefore giving something of an outline of what has occurred and what the present outlook is.

In the first place, it is well to remind ourselves that the service performed by electric communication systems is essentially that of foreshortening distance and time. The intelligence to be transmitted is reproduced at a distance more or less instantaneously. The reason why electrical methods of intelligence transmission possess unique advantages is, of course, that electric waves, as distinguished from sound waves, can be made to travel enormous distances before they are so attenuated as to be indistinguishable. Further, the speed of propagation is exceedingly high.

Broadly speaking, the fundamental requirements of any electrical communication system are:

1. Accuracy of reproduction
2. Speed of transmission
3. Reliability
4. Cost

These requirements obtain quite independently of the particular type of service involved; that is, whether telephone or telegraph, whether the messages are sent as person-to-person or are broadcast, or whether the intelligence is transmitted by radio or by wire. What is required, then, in providing an electrical communication service, are reliable high-grade channels, spanning the necessary distance, into which intelligence in the form of electric currents may be poured at one end and out of which it may be taken at the other end. The public which makes use of such service does not in general care how the electrical channel is constituted. It is not interested in whether the waves are transmitted broadcast through the ether, as in radio, or are guided over their path to destination by means of wires. What the public is interested in is assurance that the service requirements are adequately fulfilled and at the lowest possible cost.

PERSON-TO-PERSON VERSUS BROADCAST SERVICE

It is well to recall also that there exist today two more or less distinct types of communication service, one that of transmitting messages between predetermined points or individuals, and the other that of broadcasting the message to a large number of widely separated receivers. I presume that by and large the public today thinks of radio, and particularly of radio telephony, as synonymous with broadcasting, because their own contact with it is in that field of service. Generally, of course, this contact with radio broadcasting is for amusement or general information reasons, and is not largely concerned with the more serious aspects of our day by day affairs.

Actually there exists behind the curtain, so far as the public is concerned, a considerable development of radio, more particularly radio telegraphy, for the sending of person-to-person messages. We all know of the use of radio in the marine field, and recent exploits in aerial navigation have called our attention to the existence of radio telegraph stations on the fringes of civilization.

Another important part of the existing picture is the considerable development which has occurred in transoceanic telegraphy, paralleling the older cable routes in many instances and establishing new lines of direct communication in others. The recently inaugurated transatlantic telephone service is in this general category.

RELATION BETWEEN TELEPHONY AND TELEGRAPHY

Irrespective of the mode of transmission employed, history has indicated certain broad relationships between the development and use of telephony and telegraphy. Because of its more personal and intimate character and the fact that it permits of instantaneous question and answer, the volume of telephone traffic measured either in messages or money paid for the service is vastly larger than that of telegraph service. So true is this that over relatively short distances, where rapid communication is desired, telegraphy has practically disappeared as a vehicle of communication. As distance increases, and particularly at very great distances, the ratio of telephone to telegraph decreases, until at the very great distances all electrical communication is at the moment essentially telegraphic. Experience has shown, however, that even at great distances the provision of a reliable and not too costly telephone service develops a surprisingly great amount of use.

RADIO IN ITS RELATION TO WIRE SYSTEMS

Broadly, we may picture the electrical communication system of the world as comprising basically a network of wires which, in the more civilized countries, is a very intensively developed network, and associated with this network a multitude of radio stations. These are of three general types:

1. Broadcasting
2. Point-to-point service stations, principally telegraph, and principally overseas
3. Services to ships and aircraft

The relation between the wire and radio systems, and the division of service between them, is determined, of course, by the physical characteristics of the two types of facilities, and in turn by relative service performance and economics. If we stop for a moment and examine briefly, but critically, the two methods of transmission, I think we shall find the key to the whole picture of how wire and radio systems are likely to intermesh in the general scheme of electrical communication. In presenting this picture I shall draw largely upon the results which we of the Bell System have obtained in the extensive study and development of the communication art, extending over more than 50 years.

Our business is that of providing to the public the best telephone and telegraph service which the art permits. I have included telegraph service advisedly, for while the Bell System is looked upon essentially as a telephone company, it does in fact a very large amount of telegraph business. While not engaged in furnishing a message telegraph service, the Bell System provides a substantial majority of all the so-called leased wire telegraph services, which the business of the country demands. As purveyors of a service rather than as protagonists for a particular method of transmission, we have been and are interested to obtain and use the best methods which science and engineering are capable of producing. We are not interested in wire or radio *per se.* For this reason, from the moment when radio appeared as a possible means of distant communication, we have continuously sought to determine its possibilities and limitations for both telephone and telegraph as compared with wire circuits.

CHARACTERISTICS OF RADIO AND WIRE SYSTEMS

As indicated a few moments ago, all radio is essentially a broadcast method of transmission, and since man has no control over the conducting medium, the technical problem is really a problem of terminal equipment. Wire transmission, on the other hand, is essentially a directed transmission in which energy generated at one point is led to a predetermined desired terminal with little or no radiation of energy in the intervening space. With wire transmission the launching of the waves at the sending end and the picking up of them at the receiving end is simple, and the power employed may be kept small by the insertion of intermediate amplifying devices. Man has to provide the guiding path in the first place, but having done so he possesses a very large measure of control over its continuous functioning.

In the matter of reliability and continuity of service, I have already indicated the inherent deficiencies of radio which result from static and fading. Against this might be set the possibility of physical damage to the wire channels, which results from storms and the like. The extent of this damage is, however, substantially within man's control, and insurance against interruption is primarily a matter of dollars and cents. To a very large extent, service interruption through failure of the wire channels has been eliminated in the more thickly settled parts of the country by placing the wires in cables of which a large part is underground. In the vast majority of cases, even where overhead wires are used, there is also almost always the possibility of overcoming wire breaks by the use of alternate routes.

In the matter of secrecy with which communications are transmitted, it is of course evident that radio suffers a distinct handicap, specially for person-to-person telephony, the messages of which are so readily understood by radio eavesdroppers. It is this very feature of non-secrecy which gives to radio its unique adaptability for general broadcasting.

Finally we come to what is probably the most important factor of all, namely, the fact that the world's communication needs require in each area and throughout the world the carrying of an enormous number of simultaneously transmitted messages. The advantage which radio enjoys for broadcasting by virtue of the fact that the transmitting medium already exists at everyone's door becomes immediately a tremendous limitation in respect to the number of simultaneous messages which can be accommodated. We are all far too familiar with this disagreeable limitation of radio. The inception of the Federal Radio Commission and the principal problems with which it has had to struggle both arose out of the inherent limitations of radio in respect of simultaneous transmitting channels. Many volumes of discussion and much acrimonious heat has been engendered in an attempt to determine who is to broadcast and how. While it is true that the broadcast waves do not travel very far before they become so attenuated as to be useless for program reproduction purposes, yet they continue out nevertheless so far in their interfering effect as greatly to limit the uses which can be made of the radio medium a thousand or more miles away.

Within the past few years a new radio territory has been opened in the form of what is known as "short waves." This has greatly multiplied the number of radio channels which it is possible to obtain for communication purposes. But when all the limitations which arise from the use of the common medium are taken into account it is found that the number of additional channels is not very large, especially when reckoned in terms of the needs of the world as a whole. In a certain section of the short-wave range, wherein the waves are more or less world-wide in their effect, it is found that there exist in the present art something of the order of 200 channels for the world as a whole. Obviously, the United States can expect to utilize only a portion of this total, but it is reported that already there are more than 200 applications for wave assignments in the United States alone. Thus at the very beginning of this new short-wave art the Federal Radio Commission is embarrassed by the limitation in the number of channels available and is faced with the necessity of discriminating between the different prospective users of these channels.

Compared with any such meagre number of simultaneous non-interfering channels as are measured by figures of 1,000 or less, we have the fact that in the United States alone there are at any given instant of the business day simultaneously in operation telephone and telegraph channels measured by the hundreds of thousands.

FIELDS OF USE FOR WIRE AND RADIO

It is interesting to observe what the picture turns out to be if we take all these considerations and draw a conclusion from them, as telephone engineers are constantly required to do in determining how best to meet the telephone needs of the country. In the first place, it turns out that there is no prospect whatever of using radio as we now know it in the giving of local or moderate distance communication service. As just stated, the number of messages which are required to be transmitted over these short and moderate distances is enormous as compared with the number of radio channels available, or in fact as compared with the amount of long distance traffic.

The cost of wires is relatively small as compared with that of the considerable terminal apparatus required in radio for converting the message waves into high-frequency form and back again, and for putting the messages into the air at the sending end and taking them out selectively at the receiving end. The ordinary telephone set is simple compared with the apparatus required for these functions. Furthermore, a very large part of the service performed in telephony is that of switching rapidly upon call as between one subscriber and another. Something like half of the total service given in telephony, as measured by cost, resides in this switching function. Radio, of course, is a mode of transmission alone and does not at all contribute to this switching service.

All that we can imagine radio doing in telephone service is the supplying of the transmission circuit and as we have already seen, the radio channels are not sufficiently numerous or sufficiently economical or reliable to justify their use in most places where wires can be installed. Actually it comes out, then, that whatever field there is for radio telephony for point-to-point service is over the longer distances, and more particularly in the bridging of natural barriers, such as oceans, or in the reaching of pioneer territory.

The broadcast type of service makes perhaps the best use of the natural physical characteristics of radio. It is upon this natural adaptation of radio that the great radio broadcast industry has been built, but even here we see the close dovetailing of radio and wires in the collection of program material and its distribution by wire to the various broadcasting stations of the country. Even for this limited service radio has already proved itself entirely inadequate, both physically and commercially.

Another type of service which avails itself of the all-pervading nature of radio waves is, of course, that of communication with ships at sea and with aircraft. While in this mobile field the volume of traffic is small, because of small population involved, nevertheless it is of supreme importance for purposes of safety of life and as an aid to navigation. It is in recognition of this that the mobile services have always been given preference in the allocation of wave lengths. As the needs for this class of service increase, the already limited store of non-interfering radio channels will be further limited so far as services between points on land are concerned. There may be some hope, through further research, of extending the wave length range and so for a time staving off the pressure to abandon already existing radio services. This hope appears not to be very great, however.

In view of the many fundamental obstacles in the path of radio, the fact that in 1928, more than 20 years after Fessenden made his Brant Rock experiments, the world has only a *single* radio telephone circuit operating as part of the regular telephone plant may not seem so surprising. Nevertheless, this end result of 20 years' intense research and development in a field for which so much has been claimed is indicative of the fallacy which lay behind many of the forecasts.

That this single commercially operating circuit is a 3,000-mile link across the Atlantic and not across an equal distance over land is proof that even it exists only because of something peculiar to the problem of telephoning over oceans and not over distance. We have many land telephone circuits more than 3,000 miles long, and more are going in with never a thought of using radio.

DEVELOPMENT OF RADIO TELEPHONY

With this background of the communication field and of the relation between the wire and the radio methods, let us now look at radio telephony more particularly. We find that radio telephony, as we know it today, had its inception really in the vacuum tube. The story of how this came about is a most interesting one in itself and an excellent example of the effect which a new tool may have upon an art and of the interacting influences which have taken place between the wire and the radio arts in the working out of the more recent developments.

The history of the vacuum tube goes back, of course, into the realm of physics, but we can take as our starting point the invention by DeForest of the three-element vacuum tube which he designated an "audion." This tube was used by DeForest as a radio detector. As manufactured originally, the tubes had in them a residuum of gas, which resulted in erratic and unstable behavior. Now it happened that investigations which had been carried on by two large companies in their individual fields, by the Bell System in its search for a telephone repeater and by the General Electric Company in its study of apparatus for power and X-ray purposes, led them into the field of electron devices, with the result that the audion was developed by these two companies more or less simultaneously into the high vacuum tube as we know it today, and adapted for use as a stable amplifier.

In 1914 the telephone company had these new tubes working on the then newly constructed transcontinental telephone line. Also, by this time the tube had been developed into an oscillator, for generating high-frequency currents, and into a modulator for enabling the high-frequency oscillations to be controlled by voice currents. The telephone engineers saw in this new situation the solution to the problem of two arts which had been worked upon for years by various pioneer investigators without having been brought to the stage of serviceability; (1) radio telephony and (2) multiplexing of wires by means of carrier currents. This latter system makes it possible for a single pair of wires to carry several telephone messages, each one of which utilizes a different wave length or frequency. In both of these arts the underlying principles were known, but ready means for applying these principles were lacking. Means for generating suitable high-frequency currents, for modulating and amplifying them in both sending and receiving apparatus, had always been lacking.

Another essential function required to make these arts successful in practice was that of filtering out undesired electrical vibrations so that communication channels could be packed close together in the frequency spectrum and yet kept free from mutual interference. The solution to this problem became available at about the same time as the vacuum tubes, through the invention of the electric wave filter by Dr. G. A. Campbell.

Recognizing the favorable opportunity for development presented by this situation, the telephone engineers applied themselves to the task of taking the vacuum tube repeater and the filter from the wire art and applying them to the solution of multiplexing the wires at high frequencies and also to the solution of the more spectacular problem of radio telephony. By the end of 1915 great progress had been made upon both of these problems. The first vacuum tube radio telephone system had been devised, had been tested in the field, and had been used in transmitting speech for the first time across the Atlantic and across the continent and out over the Pacific as far as Hawaii. You all know what a remarkable development radio telephony has had since then, especially in its application to broadcasting where, within a short space of six or seven years, a new industry has been established.

In the case of the multiplex carrier current system, of which I spoke, this has been a large and important development in the long distance telephone plant. Hundreds of thousands of miles of carrier current channels, both telegraph and telephone, are in use today in the Bell System. In the vacuum tube and the electric filter we have, then, a remarkable example of how new and powerful devices entering an art at the right time, as it were, have enabled many blades of grass to be grown where few, if any, grew before.

Let us follow the course of two-way radio telephony a little further. We find for one thing that the development work taken up anew after the war led to ship-to-shore radio telephony and the carrying on of successful experiments in linking ships at sea with the land telephone network. This was about 1920, but actually this ship-to-shore telephone development has not yet materialized in practice, primarily because it is inherently an expensive service, especially in its early stages, as compared with the simpler service of wireless telegraphy with which the ships already have been provided. Here is a good example of a development which could not be followed up immediately by service application because it was not in cost equilibrium with its environment. In time, however, as the requirements for communication with vessels increase and as the art is further developed, telephone service with ships at sea and in the air will probably come to have a place in the general extension of telephony.

The development of the transatlantic telephone service now being given between America and Europe is a particularly interesting example of the way a new service may come into being. Close upon the heels of the ship-to-shore experiments referred to above, active work was again undertaken upon the problem of telephoning across that great natural barrier, the Atlantic. Development work which had been carried on more or less continuously in the improvement of the vacuum tube itself now made it possible to build the high-power water-cooled vacuum tube, so essential in apparatus for bridging reliably the long transatlantic span. One-way transmitting tests were begun in 1923, and there ensued a long series of experimental studies of the transmission conditions obtaining over the Atlantic, of methods for improving conditions at the receiving end by special filtering circuits and the use of directive receiving antennae, and gradually it became possible to evolve an operative plant, a combined wire and radio system, capable of giving a reasonably good telephone connection between New York and London.

One thing I should like to point out is the way in which the radio and the wire links are built into an integral wire and radio circuit, extending between the two terminals; also, how this transatlantic link functions to tie together the wire network at either end over which the individual users of the service are reached. We have here another excellent example of how radio and wires can work together to great advantage, the radio being employed over the ocean link, where wires cannot be reasonably used in the present art, to tie together the normal wire networks. In the case of the extensions from England to the Continent, these wire circuits include a section of cable under the English Channel.

PRESENT VOLUME OF TRAFFIC

While the transatlantic radio connecting link has been in service less than a year and a half, and despite the fact that but a single channel, subject to the many vagaries which beset radio, is available, the amount of traffic has developed to surprisingly large proportions. There is every indication that if facilities can be provided and a satisfactory service assured, a great deal of business and social communication by telephone across the Atlantic will be had within the next few years.

While the number of calls varies a good deal from day to day, the business across the Atlantic link has at times reached an average of about 50 calls a day. On this side of the water this business originates and terminates at regular subscribers' telephones anywhere in the United States, Canada, or Cuba. In Europe it originates or terminates at any subscriber's station in Great Britain (not including South Ireland), in Paris, and in the principal cities of Germany, Holland, Belgium, and Sweden. At present more than half the calls are between points in Great Britain and America. Paris calls account for something less than half as many as go to Great Britain, Germany for half as many as France, and Holland for about half as many as Germany. The business to Belgium and Sweden is small, as might be expected.

During the early months after the opening of transatlantic telephone service, by far the largest part of the business was of a social character, presumably between American visitors in Europe and their relatives and friends at home. Gradually, however, the use of the facilities for commercial purposes increased, until now the largest employment of the circuit is for bankers, brokers, and business men.

PLANS FOR EXTENSION OF SERVICE

As the present volume of traffic is practically the capacity of the one long-wave channel available, we, in conjunction with the British Post Office, are making every effort to provide additional channels as soon as possible. At the moment, the only feasible avenue which appears open to us is in the possibility of very short wave transmission. We have already had some experience in this field, as we made use last summer of an eastbound short-wave channel occasionally when atmospheric conditions rendered transmission over the regular long-wave channel uncommercial.

Nobody has yet had sufficient experience, however, with short-wave telephone transmission to be able to predict with any degree of certainty how reliable an operation is to be expected over this type of channel, or how the costs of transmission over such channels will compare with the costs of transmission over long-wave channels. Much has been claimed for short-wave transmission both in the direction of reliability and reduced cost. However, so far as our experience has gone, at least for west to east service, the degree of reliability to be expected from short waves does not appear to be as great as that obtained from the long-wave channel now in operation. Further, the attainment of maximum reliability over short-wave channels appears likely to necessitate a degree of expense at the terminals which may very materially reduce the apparent cost advantages once thought to be inherent in short-wave transmission.

If short-wave transmission should turn out to be inadequate for the giving of a reliable telephone service across the Atlantic, and if at the same time the urgent demand for increased telephonic communication between America and Europe should arise, it is possible that the necessities of the situation may bring about the abandonment of some existing long-wave telegraph transmissions to make place for telephonic services.

With so much of present interest in radio development, and with so many able minds applied to the solution of its problems, it is dangerous, of course, to make any prediction concerning the future. At the moment, however, there is little reason to believe that long radio telephone links connecting wire networks can be established and maintained in operation with anything like the degree of reliability demanded of wire circuits in land telephony. From experience thus far it is clear, however, that a degree of reliability and at a sufficiently low level of cost can be obtained which will develop a very considerable amount of business and social traffic.

PICTURE TRANSMISSION AND TELEVISION

Two by-product communication possibilities of considerable technical and some commercial interest have grown out of the research and development work on wire and radio telephony. These are picture or facsimile transmission and television. Of the two, picture transmission has already found a limited field of application and bids fair to develop considerably farther. On the other hand, for the moment at least, television is merely in the stage of being an interesting scientific toy with limited present prospect of being made commercially available.

There are two possible utilitarian uses for picture transmission: (1) the transmission of pictures *per se*, and (2) the transmission as a picture of written or printed material as a means of transmitting intelligence which would otherwise require the use of some existing form of telegraph.

The commercial field for picture transmission *per se* is clearly the field where a substantially exact reproduction of a photograph or other document is desired at a distant point in the shortest possible time. The use to be made of the received picture may be either that of reproduction in a paper or magazine or for identification purposes, as in the case of police records, checks, and proof material or drawings.

The costs of good picture or facsimile transmission by electrical means are inherently high, not only because of the terminal charges for complicated apparatus but also because the transmission channel, whether wire or radio, must be of very high grade and essentially free from all disturbing influences during the period of transmission. For these reasons it appears that the principal field for electrical picture or facsimile transmission will be over the longer distances where cheaper means of transport, such as the ordinary mail or the airplane mail, are not sufficiently rapid. If this is so, we cannot look forward to any great development of business, because of the falling off of community of interest between widely separated points.

Considered as a means for telegraphic intelligence transmission, where facsimile in itself is not a prime consideration, electrical picture transmission is inherently difficult of operation. In part this is because the communication channels required to transmit a given amount of intelligence in facsimile fashion are inherently more expensive than those required to transmit the same kind of intelligence by ordinary Morse or typewriter printing telegraph. By far the most serious obstacle, however, is in the collection and distribution arrangements at the terminals. Ordinary telegraph messages are either telephoned to or from the telegraph office, or, if filed at any one of the branch telegraph offices as written or typewritten messages, are from there sent either by telephone or local telegraph to the main office, where they are sent over high speed printer circuits to the distant city and distributed in a manner analogous to the method of their collection.

Facsimile transmission as a substitute for existing methods would appear to involve inherent disadvantages over existing methods in that it would require physical transmission of the thing to be sent or the thing to be delivered, with corresponding increase in cost and increase in time, where now the telephone or telegraph is employed. Used merely between the main terminals in cities and as a means of transmission, facsimile in the present state of the art appears to be essentially more expensive than high speed printing telegraphy. There may, of course, be a field for facsimile transmission of intelligence where correspondents for one reason or another desire not merely to transfer intelligence but also to transfer it in a particular form.

TELEVISION

Television, as we now understand it, is essentially picture or facsimile transmission at an enormously high rate of speed. To be effective in showing at a distant point objects in movement at the sending station, each individual picture must be transmitted in its entirety within about one-twentieth of a second. Unless this is accomplished, persistence of vision will not register on the brain as uniform continuous motion.

In the present state of the art there are only two known methods available for television. One would be to provide an independent transmission channel for every segment of the received picture and to equip each transmission channel with its own sending and receiving apparatus. This scheme is entirely impractical because of the enormous number of transmission channels required; for example, if the received picture were to be shown in a 5-inch by 7-inch frame, and it were necessary for good definition to have individual units of the picture not larger than 1/50 of an inch square, 62,500 channels would be required. Even with a definition involving squares only 1/10 of an inch on a side, 3,500 channels would be required. Such a scheme would, however, transmit simultaneously all the images needed to make up a picture.

The most feasible scheme that has been proposed has been to scan the object to be reproduced with a rapidly moving pencil of light, and to use the light from this pencil reflected from different parts of the object to produce a rapidly fluctuating current in the transmission apparatus. At the distant end of the line this rapidly fluctuating current through suitably synchronized apparatus is made to produce fluctuating light effects on a plaque, each spot on the plaque corresponding in position to a similar point in the frame at the transmitting station through which the moving object is to be observed. By doing the scanning at an enormously high rate of speed, this method, through the influence of persistence of vision, produces the impression of a continuous picture.

At best, however, the image at the receiving end of the line is inferior to even a reasonably good moving picture. The apparatus is complicated and expensive, and the band of frequencies to be transmitted is wide. To produce a picture image at the receiving end which would compare favorably with good moving picture reproduction would require apparatus very much more expensive and complicated than anything hitherto produced and would necessitate the use of transmission channels which, if employed for telephony or telegraphy, would handle an enormous amount of traffic either by wire or by radio. The result of the conditions at the terminals and in the transmission system is that any scheme of satisfactory television on the basis of our present knowledge is inherently so costly as to preclude its use commercially. Purely as a novelty, television might have a vogue and possibly be made remunerative for a limited time. Until, however, we can devise a much better and cheaper scheme than any hitherto proposed, all claims of substantial commercial utilization of television would seem to be fantastic.

V

RESEARCH AND MANUFACTURE IN THE RADIO ART

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WHILE pure research is the cornerstone or foundation of the radio art, developmental and applied engineering form the indispensable bridge over which we must pass in order to reach the goal of mass production. For the sake of brevity, however, no distinction is made between the various forms of engineering entering into the solution of our problem, despite the fact that the personnel employed differs quite materially in character and in its functioning. It will be understood, therefore, that reference to research embraces other and all forms of engineering activity.

Curiosity may be termed the progenitor of research, which is defined as "A systematic investigation of some phenomena or series of phenomena by the experimental method," and is as old as the human race.

Modern industry is considered to have begun either with John Wyatt's invention of the spinning wheel in 1738 or with the advent of the steam engine and power loom, but, regardless of dates or specific inventions, the principal factor entering into present-day industrial management is the mental attitude which recognizes that science, research, development, and production must be closely coordinated.

While the radio industry that we know today started its rapid growth with the conclusion of the World War, its genesis considerably antedates this period. In the design of radio receiver and loud speaker combinations, for instance, we have been able through the medium of organized research to take advantage of the contributions of such workers as Hertz, Maxwell, Faraday, Heaviside, Helmholtz, Rayleigh, and others.

In order to better understand the character of the foundation upon which we are building, let us consider the more important, conscious enginering contributions to the radio art which have become available in this present century.

The first practical high-frequency alternator was developed by Alexanderson in 1906; it was of the induction rotary disc type, having an output of two kilowatts at 100,000 to 200,000 cycles, and marked the beginning of the end for those systems of transmission employing damped waves. This little machine with its associated equipment was the forerunner of the 200-kilowatt generator which now links this country, through radio, with Great Britain, France, Germany, Sweden, Norway, Holland, Belgium, Italy, Poland, Turkey, Venezuela, Dutch West Indies, Dutch Guiana, Colombia, Porto Rico, Argentine, Brazil, Hawaii, Japan, Dutch East Indies, French Indo-China, and the Philippines.

At the time of this development we had the Fleming valve, or two-element tube, capable of detecting radio signals. The use of this tube marked the transition from detectors of the coherer, electrolytic, and crystal types to the present three-element tube. Subsequently DeForest added a third element, the so-called "grid," which materially broadened the functions of the Fleming valve and provided not only a more sensitive detector, but also a tube capable of functioning as an amplifier and oscillator.

With the high-frequency alternator at the transmitting end and the three-element tube at the receiving end, there resulted a more dependable system of radio communication, employing Morse and similar codes, but as yet this system was not flexible enough to transmit speech effectively and practically. The coming of the power tube is an outstanding instance of the far-reaching effect of pure science on an industrial development. It has proved to be one of the most important factors in the radio art to date. Its future applications may be of even greater value to mankind.

Edison, in his early work on the incandescent lamp, observed a phenomenon which has since been known as the "Edison effect"; he noticed a blue glow in some of his lamps which rapidly disintegrated the filament near its terminals; he guessed that a current was passing through space between the terminals and proved that to be so by placing an electrode in the bulb and passing current between the filament and the electrode. He found that this current would pass in one direction only and that the tube was therefore a rectifier.

These experiments of Edison's were the basis for Fleming's inventions, which were followed by that of DeForest. The Fleming and DeForest tubes were low vacuum tubes. Only very low voltages could be used with these tubes. Prior to Langmuir's invention of the high vacuum tube, the special treatment necessary to the production of a high vacuum, hot cathode tube was not known; nor was it appreciated, apparently, that there would be any particular advantage in such a tube. Langmuir found how to produce a high vacuum, hot cathode tube and found that with such tubes very high voltages and large currents could be used. As a result of these discoveries we were able to produce power tubes of a commercial type with outputs up to 100 kilowatts.

The power tube is the heart of the broadcast transmitter. The broadcast transmitter enabled us to supplement signal transmission by voice transmission, and has become the "tail that wags the dog," in an industrial sense.

In a radio sense, there has been no more important problem than that of transmitter development. While there is little probability that transmitter design and manufacture will result in mass production, it is an outstanding fact that this development is the basic reason for mass production of receiving and reproducing equipment. Consequently, continuous scientific research and development must be employed if we are to hold the interest of the listener-in, and expand our field of endeavor.

The history of radio is like that of any other extension of knowledge, either physical or mental; it is the union of independent, partial contributions of discovery or interpretation, which are found to be interrelated parts of one harmonious, comprehensive whole.

The invention of the tungsten filament and thoriated tungsten filament are outstanding contributions of research, and constitute an important step in our endeavor to secure minimum current consumption and better overall performance. These advances are of particular interest as they indicate the economic effect of research.

The list of different-purpose tubes is large, embracing the rectifier tube used for many purposes, the various types of tubes capable of using alternating current for filament excitation, amplifier tubes, and the four-element screen grid tube, which is assuming greater and greater importance in the solution of amplification problems.

Facsimile telegraphy, television, radio beacons, carrier current communication, are all special applications centering around the transmission of radio signals. In addition, there are "other purpose" applications of radio transmission such as telemetering, remote control, and synchronization. These by-products of radio development may become important factors in our everyday life when their development is completed and their value realized.

The so-called by-products are not limited to applications involving radio transmission. Even today, devices and equipment resulting from radio research are utilized in the automatic selection and grading, by color, of cigars, pearl buttons, coffee, and breakfast foods. Many other interesting applications, such as high-frequency furnaces and automatic elevator leveling equipment, give promise of industrial expansion along lines that had not been thought of until present-day radio made its appearance.

Take one little device as an outstanding example—the magnetic pick-up—this, coupled with a method for the electrical cutting of phonograph records and electrical reproducing equipment (all products of radio development), has rejuvenated the phonograph industry, which for a time appeared to have suffered a death blow as the result of radio competition; this competition, through the good offices of research, has been converted into an ally. The far-reaching effect of this welding of the radio and phonograph industries through the medium of research was demonstrated by the operations of a giant loud speaker at Cleveland last summer. By means of this instrument it was possible for thousands of people to listen to the reproduction of a phonograph record.

Experience with a trained and highly organized research and developmental staff has demonstrated that it is extremely difficult, if not impossible, to avoid the tendency or temptation to desert a half-picked blackberry bush for the allurements and promise of one further along. These many invitations to depart from the paths leading to our main objectives, coupled with the fact that the personnel involved largely reflects the youth of the business, emphasize the necessity for careful discrimination if we are to succeed in eliminating the chaff from the wheat, and avoid the dissipation of profits from real production through engineering expenditure on interesting but relatively valueless applications. On the other hand, we cannot afford to neglect a promising lead until some definite conclusion has been reached as to its potential value.

In radio, rapid evolution results in obsolescence, marked seasonable demand, vigorous competition, patent complications, and constantly changing requirements of the public as it acquires a radio education. Such fundamental conditions obviously complicate the problems of those engaged in the development, manufacture, and sale of radio apparatus.

Today in radio we have great variety, generally resulting in expense, coupled with quantity, quality production, presumably resulting in income, both factors demanding consideration as a function of time, which is the essence of up-to-date radio industry.

As an illustration of the manufacturing problem, during the last six months of 1924 our billings were four times those of the first six months. In 1925 and 1927, the aggregate billings of the six "high" months amounted, respectively, to 82.4% and 83.5% of the whole year. In 1926, the billing ratio for the six "high" months, as compared with the six "low" months, was 68.2%. In 1927, billings for the highest week were 12.4 times that of the lowest week.

Labor turnover, resulting from seasonable demands, is an ever serious problem, both from the humanitarian viewpoint and that of production costs; the importance of this factor is emphasized because of the extraordinarily rapid development which has taken place, and which in itself has delayed standardization, preventing the stocking of parts during the valley periods of production. The personnel employed in the manufacture of radio equipment represents comprehensive diversification; specialists are required for the study of acoustics, furniture and cabinet design, photography, and other special activities not normally related or found in the pursuit of an individual industry.

Despite these handicaps, progress has been made in the reduction of engineering and manufacturing costs and of complaint expenditures, and in the prompt meeting of market demands. In 1925, for instance, at the peak of our load, we employed considerably more than twice the number of factory workers that were employed at the corresponding high peak of 1927, but the billings of the two periods were approximately equal. This improvement in operating economy is further emphasized by the fact that we produced a much larger proportion of relatively low-priced sets in 1927 than in 1925. Inventory turnover in the radio department in 1927 was substantially double that of the average turnover in other unrelated departments, and a better than average showing was made on complaint expenditures. The above figures relate to the manufacture of radio receiving and reproducing equipment, but are closely paralleled in the manufacture of vacuum tubes.

Every industry has its own particular problems which have been or will be solved by research in one form or another. In radio, possibly more than in other industries, the *sine qua non* of success is a "controlled flexibility" somewhat analogous to that exercised by the cowboy in the handling of his rope, or by the teamster in the wielding of his bull whip.

Administratively speaking, control is a primary coordinative function; it sets everything in motion; its particular task is to issue instructions in such a way that when all have been carried out the result is exactly what was intended. Lacking standardization in large degree, radio manufacturing is the antithesis of those industries engaged in highly standardized repetitive manufacture, and the degree of control required is much greater.

To obtain the degree of control necessary for the successful manufacture of radio apparatus, it has been necessary to develop the art of planning to a high state of perfection. This results in a highly functionalized engineering and factory organization.

To meet the conditions imposed, it has been found necessary to divide the work of the engineering organization into three classes: transmitting, receiving, and special. Each division is further subdivided into specialized groups handling some particular problem, apparatus, or equipment. This type of organization permits continuous research throughout the entire field; it is flexible and permits the "scheduling" of research. This means that as conditions warrant the results of any given group may be placed in production without interfering with the continuance of the work of that group.

In addition to the conventional divisions of a functionalized factory organization, there is required a planning division; this division is to the factory what the drafting room is to the engineering department. In addition, it coordinates the various factory units, tying them into one compact, controllable organization, and acts as the translating agency between the factory, engineering, and other divisions.

The problem of the planning division is to obtain economy in manufacture with due consideration to quality and delivery. The function of this division, therefore, is to determine what work is necessary, where it should be done, and when and how it should be performed.

During the past two years, considerable advance has been made in reducing the cost of factory testing. Not more than three years ago we employed 300 to 400 technical graduates to adjust and test radio apparatus, while during the past year there have been substituted fewer than 100 non-technical workers who were able to handle the entire production. This result has been brought about largely through the development and introduction of improved testing methods and equipment.

Initially, five to seven men or girls were required to check the circuits of complete cables used in certain radio equipment. This is now accomplished by an ingenious cable board which tests automatically as the cable is built up and by a system of pilot lights indicates the lay of the individual wires to the operator. By the application of other automatic and semiautomatic devices, the fidelity, selectivity, and sensitivity of receivers are visually indicated to the operator. In other instances full automatic metering methods are used to completely check performance, thus requiring no judgment or skill on the part of the test operator.

Mechanical inspection in radio manufacturing is exceedingly difficult because of the fact that decisions regarding finish and appearance involve personal judgment. This problem has been solved by the use of group checkers supervised by a relatively few highly trained inspectors instructed in detail with reference to quality requirements.

Material savings have been effected in the cost of manufacture through the introduction of the so-called group system. These groups consist of from four to twenty workers, as the nature of the assembly problem may indicate, and allows the breaking up of a job into easily understood operations. This permits each operator to become proficient in one operation. If the breakdown is sufficiently complete, each operation is usually so simple that a new operator can be trained in a very short time. The system also permits a detailed time and motion study, thus providing basic data for the engineering and planning divisions.

As production increases, new groups are formed by splitting up a working group and adding additional workers.

The group system, with its checker for each unit, is able to produce quality apparatus on a quantity basis, since the earnings of each operator depend upon the output of the group.

Our present-day activities are far removed from those of the early days, when the initial demands for radio equipment originated almost exclusively with the so-called amateur. Component part manufacture satisfied this demand so far as it is possible to satisfy the radio "bug." With the coming of broadcasting, however, the picture changed over night, and we found hundreds of thousands clamoring for receiving equipment where hundreds had been asking for parts with which to build their own. It is safe to say that the "amateur" class has not diminished in numbers, but with the tremendous growth of public interest and demand the requirements of the amateur have become vastly overshadowed, and he has lost his status as a manufacturer for himself and his friends, just as the individual cobbler has given way to the shoe manufacturing company. In other words, the normal operation of the law of supply and demand has resulted in organized mass production.

The gradual, but sure, functioning of this fundamental economic law, as it applies to this case, was aptly summed up by Charles Babbage, the British mathematician, as long ago as 1832, when he said:

> The master manufacturer, by dividing the work to be executed into different processes, each requiring different degrees of skill and force, can purchase exactly the precise quantity of both which is necessary for each process; whereas, if the whole work were executed by one workman, that person must possess sufficient skill to perform the most difficult and sufficient strength to execute the most laborious of the operations into which the article is divided.

If this law applied generally in 1832, it is obviously applicable to radio manufacture, which represents a combination of nearly every known art and science.

The gradual education of the public to a better appreciation of music and more faithful reproduction is another important factor creating a demand not only for a higher standard of broadcasting, but for greater perfection in the quality and uniformity of receiving and reproducing equipment. The listener-in now demands service and quality of performance in lieu of his previous requirement of novelty only. The manufactured set of today must offer selectivity, sensitivity, quality, volume, reliability, simplicity of operation, low cost, and the elimination of batteries where socket power is available.

The electrical manufacturer naturally assumed the role of pioneer in the development of the radio art, and early types of apparatus reflected his mechanical and engineering tastes. What many of us thought was the ultimate in artistic design quickly proved to be unacceptable to the buying public.

The first detectors were of the crystal type, quickly replaced by tube sets using the three-element tube and head phones. Several sets of these head phones were needed if more than one member of the family wished to listen in. The next step in advance came with the advent of the audio amplifier tube, which gave greater volume and led to the development of the horn type loud speaker. When the tube succeeded the crystal, the storage battery came into its own as a radio adjunct, and then, with the advent of the so-called "peanut" tube, it became possible to utilize the dry battery. The first self-contained set, tube operated, with dry battery supply and built-in loud speaker, then made its appearance.

Earlier sets usually required three critical adjustments: those for tuning, regeneration, and filament control.

Tuned radio frequency sets usually had four or five controls, three of which were critical. The superheterodyne circuit was a great step forward from the standpoint of selectivity and sensitivity. The development of power and alternating current ("A. C.") tubes gave a great impetus to the design of the higher grade sets, in that they greatly improved the quality and volume of reproducing equipment and eliminated the necessity for using batteries of any kind.

In the present art, methods of control have been greatly simplified, and development has been carried to a point where one critical adjustment plus a volume control is all that is required.

The combination of radio set and phonograph, both using a common electrical reproducer, all housed in the one cabinet, is a relatively recent and important contribution.

The ideal receiving set of the immediate future, as we see it, must be housed in an attractive cabinet harmonizing with other articles of furniture; it must receive its operating energy entirely from the electric lighting sockets we find in our homes. Selection of the desired broadcasting station must be effected by a single control, and the volume of reproduction regulated in smooth gradations from minimum to full room intensity without "blasting" or excessive volume being encountered while passing through a nearby powerful station. Sensitivity and selectivity must be such as to enable the listener to select the program desired (of course, within reasonable limitations as to distance), without interference from other broadcasting stations. Quality reproduction is, of course, paramount.

Means of remote control may be employed, enabling the listener to select at will the station desired and to reproduce the program in any one of several rooms in the house. The elimination of fading, either at the transmitter or receiver—if that can be accomplished—will contribute greatly to the enjoyment of the listener and the advancement of the art. Through relatively simple attachments, it should be possible to combine television and facsimile reception with present receiving equipment. The set must be mechanically and electrically reliable, capable of giving uninterrupted service, and so designed that repairs can be readily made when necessary.

If the purpose in mind has been accomplished, this paper demonstrates conclusively the close relationship and interdependence of research and manufacturing in the radio art; it indicates that radio, probably more than any other industry, has taken a broader and more comprehensive advantage of the many outstanding engineering achievements of the past century.

Our belief in the correctness of these conclusions, and in research as the necessary basis for successful quantity production, is tangibly indicated by our developmental expenditures, which in 1919 amounted to but slightly over $100,000, while 9 years later, or in 1927, they amounted to nearly $2,500,000—aggregating in the 9-year period approximately $10,000,000.

We are working for the ideal set as we now visualize it, and coincidentally are striving for the goal of economic, quality and quantity production, with the full realization that engineering research in its various phases is the most indispensable factor entering into the happy solution of our problems.

VI

THE LAW OF THE AIR

Judge Stephen B. Davis
New York City

IN THE field of radio communication, as in all others, the law divides itself naturally into two classes: first, those provisions which are declared legislatively and become written into our statute books under the principles and limitations laid down in state and Federal constitutions; and second, those great legal fundamentals which have come down to us through the centuries, founded upon custom, experience, and judicial decision, and which we designate as common law. In these two classes will be found all of the law applicable to the solution of radio difficulties.

Every great industrial or social or mechanical change brings with it new problems in the relationships between individuals, and between individuals and the government. New rules of conduct must be developed to meet new conditions, but they are created only as the problems arise and become understood. The law is always a matter of growth, always slow, frequently starting in the wrong direction, finally finding itself through trial and error. The student can trace that process through the development of any great industry—railroads, or automobiles, or telephones. Radio law is just entering that process. It is still largely uncertain, undetermined, and undeclared. When we realize that radio broadcasting is still less than ten years old, we should not be surprised at that condition.

A good example of the uncertainty of this law is found in the subject that has been assigned to me. I am asked to talk on "The Law of the Air," the implication being that the title includes the rules governing radio conduct. The law of the air, by which we really mean the law regulating the use of the space over and above the earth's surface, is interesting and novel and important and still in the development state, but it belongs more in the field of aviation than in that of radio communication.

I admit that as we sit at our receiving sets and twist our dials and get messages from places hundreds of miles distant, we naturally visualize them as coming to us through something, and we think of them as coming through the air. In a sense, of course, that is true, for they do pass through the atmosphere which pervades the space immediately around our world. But they do very much more than that, for if the scientists who pretend to know are correct, these waves pass far above the limits of our atmosphere, through ground and rocks, into remote underground caves, and through the walls of our houses, where no air exists. To speak of them as using the air may be all right as a popular expression, but it will not do as a legal concept.

Neither can the laws applicable to radio communication be properly designated as "the law of the ether," although that also is sometimes done. Nobody seems to know much about ether. We are told that it is a medium that pervades every substance, thus creating a path for the passage of the radio waves—about which also we really know very little.

Theories have been built up as to the character of the ether. It has been considered to be subject to legalistic concepts, such as that of ownership, and attempts have been made to base legislative authority over radio upon its ownership. Even so intelligent a body as the Senate of the United States once solemnly declared by resolution that the ether throughout the United States was the inalienable property of the people of the United States, and that no one should be allowed to use it for radio communication without the consent of the Congress of the United States—a rather novel conception of Federal jurisdiction. Even in the present radio law, there is a requirement that applicants for radio licenses must waive any claim to a prior right to use the ether as against the regulatory power of the United States, and we have recently heard on the floor of Congress a debate over whether or not there can be a vested right in the ether.

There is a vast mass of scientific opinion which holds to the view that no such thing as ether exists, and it seems to be an accepted fact that its existence cannot be actually demonstrated. Ownership of the nonexistent is impossible. Such expressions as "the use of the ether" and "vested rights in the ether" may be useful in a popular sense, but legally speaking they are wholly improper. Inexact language usually leads to loose thinking. It would be unfortunate if we were compelled to postulate radio law on a mere scientific hypothesis. We do not need to do so, for we have more secure bases.

Neither the legislatures nor the courts have ever before been called upon to deal with the fundamental problems that arise in radio communication. These are legally unique. They are inherent in the radio art itself, and before we undertake to discuss them and to consider their solution, we must have a clear understanding of what the difficulties are, of how they arise, and of the reason why they are distinct from those which have presented themselves in other forms of human communication, such as the telegraph or the telephone.

Before I begin to discuss the existing law with you, therefore, I must say something of the facts and circumstances which make the law necessary, and on the basis of which the law is to operate. I think we can start with the premise that if there were no problem, there would be no law; if there were no conflicts, there would be neither law nor regulation; and if the troubles in this field were the same as in other communication methods, we should find the same legal solutions.

Radio communication in its legal aspects is differentiated from other forms in three principal respects:

First: In every other form of communication, the individual conducting it owns his own right of way either directly or indirectly. The poles and wires are his property. There is plenty of law by which he can protect that property from physical interference and his messages from electrical disturbances. No one can use his property without his consent. Statute law does not need to forbid it. But the radio operator, in broadcasting or in any other phase, is not so fortunate. He owns nothing beyond his transmitter. He does not even know how his message travels from the sending to the receiving end. Legal precedents laid down for the protection of physical property are useless to him. He needs new rules for his protection.

Second: The telegraph or telephone company sends a message from one definite point to another. It does not try to get everywhere at once. It guides its transmission by a wire, and cares nothing about what happens except on that wire or in its immediate vicinity. It causes no interference with communication anywhere else. Its message from New York to Chicago cannot disturb another passing from Philadelphia to Atlanta. In radio communication we have precisely the opposite condition. A message, either intentionally or necessarily, goes simultaneously in every direction. Every signal is a potential destroyer of every other one. A message from New York to London travels not only between those points, but all over the world. A communication between Manila and Shanghai may upset a circuit between New York and Buenos Aires. An amateur in Phoenix, Arizona, could theoretically destroy broadcasting in New York. Some sort of order is therefore essential to make radio communication possible. The chances for conflicts and disputes are infinite.

Third: From the listeners' viewpoint, the chief essential in a receiving set is its selectivity; its ability to pick and choose between the various communications and programs that struggle to be heard. That selectivity is not absolute. But an efficient set must be able to select among broadcasting stations whose frequencies are separated by no more than 10 kilocycles. If the separation is less than that, interference is bound to occur, or at least there is an impairment of musical quality and speech intelligibility. From the viewpoint, therefore, of both the transmitting and the receiving end, there must be this separation between operating frequencies.

All of this may be summed up by saying that every transmitting station, if it is to be perfectly received, must have its own channel on which to operate. This is particularly true as to broadcasting, but the statement applies to all forms of radio communication. And perhaps this is a good time to remind you that broadcasting is only one, and by no means the most important, of radio communication activities. The stations engaged in it are only a small portion of the total. We have thousands of vessels equipped with radio apparatus and relying upon it as their only means of reaching each other and the shore; hundreds of shore stations receiving and sending messages to them. The great transoceanic stations flash their messages around the globe in competition with the cables. The telephone service reaches from our country to Europe, and from Europe to the islands in the East Indies. Thousands of amateurs use the radio nightly for their messages and experiments. By radio we send photographs over land and sea, communicate with aircraft, and we are on the threshold of many other uses. All of these services must have their channels. The technical problem is to find them and to ascertain which channels are best fitted for each.

The legal problem is to distribute these channels, to preserve order among them, to determine the rules by which the distribution is to be made, and to find a way to enforce those rules when once decided upon. Practically all the law of radio, past, present, and future, domestic and international, speaking historically and prophetically, is and always will be devoted to that single problem.

We may speak of the preserving of order in radio traffic, the clearing of the radio lanes, the preventing of interference, the creating of good order, but all of those expressions mean nothing more nor less than that somehow or other each transmitting station must have a channel for its operations and that it must be free from disturbance by others. If channels were innumerable or infinite, or if their number equaled the number of stations that desire to use them, there would be no problem. Unfortunately, that is not the case. It is as though we had too few tracks to accommodate our trains, or not enough streets for our automobiles, or too little ocean for our ships. The history of radio law is largely the story of the attempt to establish methods for the distribution of radio channels among rival stations competing for their use.

Radio problems first attracted attention internationally in Berlin in 1903, when an international convention was agreed to, but it was soon superseded and is now unimportant. By 1912, radio conditions again demanded international attention, and a conference met in London. It wrote a convention which was ratified by nearly all the nations of the world and which has constituted the international radio code since that date. Its provisions were, however, extremely limited in scope. They dealt with radio communication as it then existed. Interference problems were few. The conference was concerned only with marine communication, messages between the ships and from ship to shore, and in this respect it confined itself to the establishment of certain wave lengths for general communication and for distress signals and to the setting aside of a band for government use. This London convention has now been obsolete for a number of years, the development of international radio telegraphy, telephony, and broadcasting having brought new difficulties which are entirely beyond its purview. Even with respect to matters specifically covered by its terms, the provisions of this convention are no longer suited to modern conditions and in some instances they have been disregarded by common consent.

Contemporaneously with the London Convention of 1912 came the first attempt at the regulation of radio communication within the United States. Congress in that year passed an act which remained the statutory law for fifteen years, until it was superseded by our present Radio Act of 1927.

Here again, in order to understand this law, and what proved to be its shortcomings, we must have knowledge of the conditions existing in this country when it was passed. We must remember that broadcasting was still unknown. Transoceanic stations had not been constructed. Radio was as yet only a means for communication across the water to and from ships.

There were a few amateurs engaged in sending messages to each other, but they were relatively unimportant. The radio lanes were not congested. The interference difficulty as we know it today had not arisen. The only problem was to obviate the very slight disturbance which then existed. There were only three groups to be accommodated—the Navy Department, which was using radio very extensively in its communications, the private concerns engaged in ship communication, and the few amateurs. The difficulties were very quickly and very easily settled by assigning a few channels for commercial communication, giving the government, which of course included the Navy, a rather extensive wave band, and placing the amateurs by themselves in the shorter wave lengths or high frequencies. In general, the distribution followed the method agreed to by the nations of the world in London, although that convention had not yet been ratified. The 1912 law has now been repealed, and is of little importance except historically, and from that point of view, its principal interest lies in the fact that it was responsible for the introduction into our law, and into our national legislation, of the requirement of a Federal license for all stations engaged in radio communication.

I do not believe that this principle was written into the law as the result of any rational process. It was entirely imitative. Legislation generally is. Few of us are legally inventive, and when we have to write new laws, the tendency is to look up some old one and to follow its ideas as far as possible. That is the easiest course. It saves thought and has the advantage of allowing us to profit by experience. Since most of the radio apparatus was then on board of ships, it was natural to look in that direction for hints for the new law. The license plan there found was consequently adopted, and since the Bureau of Navigation had control of ship licenses and was a part of the Department of Commerce, it was equally natural to provide that the new radio licenses should be issued by the Secretary of Commerce.

Of course, no one at that time had any thought of the implications contained in that action or of the results that would flow from it. It must be remembered that although a vessel was compelled to have something in the nature of a Federal licence, that license was granted upon request or at least upon the fulfillment of certain very simple conditions. The power to license was never used as a means for discrimination or for selection among vessels, or to determine that of two vessels of the same class, one might receive and the other be denied a license. The requirement was nothing more than a method by which the Federal government was enabled to keep track of vessels which were entitled to be considered vessels of the United States and to fly the national flag. It was merely a registration statute. The license imposed upon radio stations by the 1912 law was of the same class and for the same purpose. There was at that time no necessity for selection among transmitting stations, for admitting some and rejecting others. There was plenty of room for all.

The 1912 law worked well and was adequate for the control of radio communication so long as conditions remained unchanged, as long as there was no congestion, there was no confusion and no difficulty. But that happy condition did not long continue to exist. The entire picture changed very rapidly after 1921, when the broadcasting stations began to be erected in the United States. There probably has never been a scientific development that was as quickly translated into popular use as was radio broadcasting. Beginning with a single station in 1921, it multiplied itself 700 times by 1927. The number of receiving sets in the United States grew from none to many millions. Stations were not systematically placed where they were needed, but grew helter skelter, controlled only by the desire of their owners to get as close as possible to the large cities.

The 1912 law, as I have said, did provide for the issuance of licenses by the Secretary of Commerce. But his duties under this provision were largely perfunctory, the law itself having practically defined the wave length which stations of a given class might use and giving the Secretary no discretion in this respect. Until the broadcasting development occurred, there was no necessity for anything more than a formal statement of the wave length authorized in the license. But when the first broadcasting station in 1921 applied to the Secretary of Commerce for a license, he found himself faced with quite a problem. Here was a new class of station, a new kind of radio service, for which the 1912 law made no provision whatever. Nevertheless, it was necessary to find a place for it, and it was essential under the terms of the law that the wave length which it was to use should be stipulated. The Secretary finally determined to license this station on a wave length of 360 meters, largely because that was far enough away from the frequencies used by ships so that interference was unlikely to result.

As other broadcasting stations were erected and applied for licenses, they were placed on the same wave length, so that by 1923 there were several hundred broadcasting stations, all attempting to use the same wave length and each, of course, finding it impossible to do so without interference from the others. The interference problem had arisen and has afflicted us ever since.

It happened that about that time, some litigation was decided in the District of Columbia by the Court of Appeals of that district. The court held that while the Secretary of Commerce had no authority to refuse a license to anybody but must grant them to all comers, irrespective of numbers, kind, or condition, he did, nevertheless, have a discretion in the assigning of wave lengths to them. Following this decision, Secretary Hoover called a general conference of all radio interests in an attempt to bring some order out of the confusion which already existed and which was threatening to continue until broadcast communication would be rendered impossible. It was as a result of that conference that a definite broadcasting band was created, with the understanding that all those stations would operate within it, and all other classes of stations be excluded from it. In fact, and to accomplish this result, the entire frequency spectrum was divided up and allocated among the different services, so that the ships, the shore stations, and transoceanic stations, the amateurs, and the broadcasters, each group had its own special zone in which it was independent and free from intrusion. In addition to this, each broadcaster was assigned a particular channel for his use.

Secretary Hoover accepted the recommendations of this conference and proceeded to assign wave lengths to broadcasting stations accordingly, with the result that each station had, so far as was possible, a wave length adequate to its needs. For a time, everyone was reasonably happy and contented. There was little congestion. There were not very many stations, and none of them was using very high power. A 500-watt station was standard size.

But the condition was too good to last. More and more people were bitten by the broadcasting bug. Applications piled in, each requiring a different wave length. Soon there were 500 stations in the field. Moreover, they began to use more and more power, which of course increased their area of interference as well as of service. There came a time when no more wave lengths could be assigned without shutting down existing stations. It did not seem just to despoil those already rendering service merely to accommodate a newcomer, and so, after the wave lengths were all gone, after all of them were in use so that there was no possible place for late applicants, the Department declined to assign any more, which meant that no new licenses were issued. This for a time established a settled condition. There were then some 500 stations, about 200 of them operating with 500 watts of power. The situation was at least tolerable.

But, in 1926, in a litigation in Chicago, the District Court of the United States held that there was no authority in the Secretary of Commerce to make these individual wave length assignments to broadcasting stations: that these stations were free to select their own channels and to operate upon them at their own will; and that there was no legal control over them.

As a result of this ruling, the entire regulatory system broke down. The doors were thrown wide open. The Department was compelled to grant licenses to everyone upon request. July 1, 1926, when departmental control ended, there were 529 broadcasting stations and there was no room for any more. By March, 1927, new stations had crowded in until the total was 734. In July, 1926, the stations were using all together 378,000 watts of power. In March, 1927, they had increased their power to nearly 647,000 watts. No wonder that the situation, none too good in July, 1926, had become intolerable eight months later. Seven hundred broadcasting stations had crowded themselves into the picture, each demanding its place in the radio sun and each struggling with its competitors for the use of a channel. Confusion reigned. The broadcasters themselves were dissatisfied because they could not get their programs out in a decent manner. The listening public, which by this time numbered 20 to 25 millions, was utterly discouraged and vociferous in its protest, for practically every program was accompanied by whistles and squeals from interfering stations.

There were two possible methods by which the situation might have been handled: first, the broadcasting industry itself, if it had been sufficiently far-sighted and sufficiently nationally minded, would have realized that it was bringing about its own destruction and would have taken steps to regulate itself, relying upon the courts to handle the situation in accordance with the fundamental rules of law which had been found applicable in other similar conditions. There were one or two sporadic movements in this direction but they never became effective, and the whole thought of self-regulation finally fell into the discard, largely, I think, because the legal bases for the determination of conflicting claims were obscure and undetermined. The only remedy that remained was the enactment of a new Federal law. If the industry could not regulate itself, it was necessary that it be regulated by the strong arm of government authority, and that is precisely what happened.

The states could not legislate upon it, for no transmitting station, whether it be in broadcasting or in another class of service, confines its emanations within the boundaries of a single state. Practically all of them endeavor to send their messages as far as possible and intentionally cross state lines. But, whether intentionally or not, it is safe to say that practically all radio transmission does cross state and frequently international boundaries. The legal result is that this form of communication becomes interstate commerce just as does a telephone message or a telegraph message from a person in one state to one in another. No one state is competent to handle the situation, for the effects are beyond its jurisdiction, and no one state is legally able to regulate it, because under the Constitution of the United States such authority is vested in the Federal Government. This authority falls under the clause which provides that the Congress of the United States may regulate commerce between the states and with foreign nations.

Here, then, we have the reason and the basis for Federal authority and Federal intervention in the radio industry. This authority is complete and ample. We do not need to seek for any other foundation for complete Federal control. This seems to be one of the few features of radio law about which there is little controversy. There have been very few attempts by any of the states to play any part in radio regulation. It has been left entirely to the Federal Government.

The Federal law which resulted from the condition just outlined was signed by the President on the 23d day of February, 1927. It was intended to remedy the chaotic conditions in broadcasting which I have already indicated. Those conditions demanded stern measures. Desperate diseases require drastic remedies, and the condition of the radio patient was certainly then most desperate. As a result, we have on the statute books today a law for the regulation of this new industry of radio communication, the most severe, the most drastic, and the most confining which was ever imposed upon any American business. I do not mean to imply that these stern provisions were unnecessary. They probably were needed. The surprising thing is that the industry has been able to grow and to prosper under such restrictions. Nevertheless, it has done so.

The first and most arbitrary feature of the 1927 law was the enactment that 60 days after the passage of the act, every radio transmitting license should automatically terminate. This did not affect broadcasting alone. It was applicable to every piece of transmitting apparatus in the United States, and there were at that time nearly 20,000 stations. It applied to the amateurs; it applied to the ships; it applied to the great trans-oceanic telegraph stations; and when we remember that the law made it illegal, under penalty of fine and imprisonment, for any person to operate a station without a license, we readily realize that this provision, on its face, amounted to the confiscation of these entire properties, with a value running into millions of dollars. I do not need to say that when you deprive a man of the use of his property, you have, to all intents and purposes, deprived him of the property itself. The only value in physical property lies in the right to use it and to obtain benefits from it.

The purpose of this provision is of course plain. These stations were then operating without any form of government supervision. They were choosing their own communication channels. They were using whatever power they chose to put into their antennae. A great number of them were operating without the slightest regard to the effect of their transmission upon their neighbor's communications. The Congress of the United States felt, and I am inclined to say rightly felt, that the only way to remedy this situation was to wipe the slate clean, put everybody upon the equal footing of no rights at all, and then let the proper governmental agency proceed, by a process of selection among applicants, to set up an adequate radio communication system in the United States in all of its phases and throughout the country.

The next innovation in the 1927 law was the provision that thereafter no person could enter the field of radio communication as a matter of right. Since then, the construction and operation of a radio station in any one of the various radio fields has been, on the face of the law, a privilege and not a right. It was an affirmative declaration by the Congress of the United States that the citizens of the United States might engage in business in interstate commerce only by Federal consent.

The express provision was that no one would be allowed to operate radio transmitting apparatus unless he first proved that his engaging in that business was in accord with public convenience and necessity. The test thenceforth was to be not whether he desired to enter the business, but whether or not the public desired that he should do so. The receiver of broadcast programs, the radio listener, the user of the public service telegraph stations, were made the dominant elements in radio, and whatever was done was to be done for their benefit. With a few very slight exceptions, the principal one being the law applicable to the construction of new interstate railroads, this is the only time that the Federal Government has announced any such principle. This idea was borrowed from the state laws regulating local public utilities. In those laws, the provision is common that the individual or the corporation who desires to build and operate a trolley line, an electric light works, or a telephone system, must demonstrate that his activities will serve the public interest and must obtain state permission before undertaking his enterprise. So here again the law of 1927 is imitative in that it adopted and wrote into Federal legislation this principle which had long been accepted in the public utility laws in the various states.

Not satisfied with these harsh measures, the law provided that the licenses which were a prerequisite to engaging in the business could be issued only for limited periods, three years in the case of broadcasting and five for the other forms of communication. This would seem to be harsh enough, but a new law passed by the present Congress in March of this year reduces the period to three months for a broadcasting license and one year for all others. A great modern broadcasting station may well cost several hundred thousand dollars, a station for transoceanic communication more than a million, yet under the terms of this law, investors are expected to furnish these large amounts of money, with the knowledge that the franchise upon which the value of their property depends expires in three months or one year, with no guaranty of extension or hope of recompense if extension is refused. Permits under the Federal Water Power Act run for 50 years; the ordinary utility franchise extends for 20 or 30 years, or for an indeterminate period. But the life of the stepchild radio is limited to twelve months.

The wonder is that anyone will hazard his money under such a permit. But they do. The trouble continues to be that there are too many applicants rather than not enough. Either there is an utter disregard of the financial security demanded in other fields—a radio recklessness—or there is a blind faith that the governing authorities will continue indefinitely to protect the foolhardy at the expense of the listening public, declining to exercise the discriminatory functions which the law clearly gives them. If this expectation fails, many station owners are due for a rude awakening.

The final result, then, is this:

First: Since the 24th day of April, 1927, no person can operate radio transmitting apparatus without Federal consent, and this is true whether he already has an investment of millions of dollars in transmitting stations or whether he is a newcomer desiring to enter the field. He can obtain a license only for an extremely limited period.

Second: Before the owner of an existing station can continue his operations, he must demonstrate to Federal authority that his operations would be to the public advantage, and before the newcomer can undertake even the construction of a station, he must demonstrate the same thing. Here, then, we have on paper the most complete and the most stringent Federal control of radio transmission which it is possible to write into law.

But, as very frequently happens, there has been a very great difference between the law as written in the statutes and the law as enforced by those entrusted with its administration.

The law provides that its provisions shall be put into effect by a board to be known as the Federal Radio Commission. This is to be composed of five members to be appointed by the President of the United States and confirmed by the Senate. It is to receive adequate funds and to be entrusted with the complete control and regulation of radio communication in the United States. Its hands are free. The slate was clean and it was given a plain standard by which to proceed.

But several difficulties immediately arose. In the first place, Congress, having created the Commission and commanded it to proceed and perform its duties, failed to give it any money with which to do so. The appropriation bill on which its fund depended failed to pass. The Commission found itself without money with which to make studies or investigations, to employ clerical or expert assistance, or, and perhaps more important to the members, even to pay their own salaries and expenses. It happened that the Department of Commerce had some funds which it was able to advance, but the Commission, nevertheless, has been compelled to operate during all of the past year without any funds of its own.

Next, the Senate of the United States refused to confirm of the Senate, the Commission consisted of three full-fledged and duly accredited members and two whose confirmation had failed and over whose heads hung the sword of Damocles in the form of the necessity for confirmation at the next session of Congress. Two of the commissioners originally appointed died, and for a long time the Radio Commission consisted of four members and one vacant chair. It was not until a few weeks ago that the Senate granted confirmation to all of its members. So I think we may say that, everything considered, the Radio Commission has not operated under happy auspices.

I think it should also be said, in answer to much of the criticism which has been directed against the Commission and in answer also to what little I may say along the same line, that the task imposed upon it is no easy one. It is a very simple thing to say to a body of men: "Here are 700 broadcasting stations in the United States. The physical conditions are such that they cannot all be allowed to exist. It is probably a fact that not more than one-half of them should be continued. You therefore will call them in before you. You will separate the sheep from the goats. You will say to a certain number of them 'Enter into the Kingdom' and to the balance 'Get thee into outer darkness,' and you will do this although you will realize that every time you exclude one you reach into the pocket of its owner and take from him anywhere from a few hundreds to several hundreds of thousands of dollars. You know in advance that he will complain, but you are not to listen to his complaints. You can explain to him that the public benefit far outweighs his individual sacrifice. And you know that he will be able to bring plenty of political pressure to his support, but of course you will pay no attention to that."

Perhaps it is too much to expect weak human nature to carry out such a task. Certainly no public officer would regard it as a pleasant one. It is inherently disagreeable. Nevertheless, the duty of the Commission to the public has been and still is clear. The trouble is plain. There are too many stations. The Commission was instructed to cut down the number and was expected to do so. The law stripped the radio patient, laid him on the operating table, diagnosed his disease, and called in the Commission as surgeons to perform the necessary operation.

When the members of the Commission first gathered to examine the patient they were about to treat, they found, speaking of broadcasting only and considering it as an entity, that it consisted of about 700 stations of all sizes, kinds, and conditions. There were a few good ones, others mediocre, and others worthless. To continue the medical simile, the patient was made up of a few hundred sound, healthy good stations, but upon them was a tumorous growth of several hundred inferior ones, which had attached themselves during the period when no one had power to prevent. It was apparent that palliatives would be useless. They might afford temporary relief, but the disease would still exist. Only one remedy was indicated —a major operation, which would cut off and throw away the excrescense. The 1927 law placed in the hands of the Commission the necessary instruments. But they have hesitated to wield them, not unnaturally, perhaps, for such an operation has never before been performed in the world of business.

To abandon metaphor and to speak again in figures, we must remember that the Commission has never had more than about 90 channels available for all broadcasting; that it found over 700 stations trying to use them; that by no stretch of the imagination could anyone conceive that it was possible with these few channels to provide efficiently for even half that number, even by resorting to time division and other uneconomic subterfuges. The task of the Commission is therefore no simple one.

Nor do I mean to intimate that the Commission has not made progress in the betterment of broadcasting conditions. It has improved them, and it deserves full credit for what it has done under its handicaps and disadvantages. But after a year of Commission control, we still have 686 stations, or did have in January of this year, and they are using over 600,000 watts of power. The major operation has not been performed. We still have confusion in broadcasting—inefficiency and interference. We shall continue to have them until the disparity in numbers of channels and stations is done away with. Progress in the art may make available more channels, and thus afford relief. But unless and until that occurs, there can be no material betterment until the stations are reduced to reasonable numbers.

To increase the manifold difficulties of the Commission under the 1927 Act, Congress last month added a further burden in the shape of some new directions as to the manner in which its duties are to be performed. The Commission must now grant its licenses in such a way that there will result "as nearly as possible" an equality among the five zones into which the United States is divided, in number of broadcasting stations, amount of power used, and time of operation, and it must make a similar allocation among the 48 states in proportion to their population.

It is easy to ridicule this new principle by saying that it is as if the law provided that hereafter the vessels sailing out of Charleston, South Carolina, shall be as many and as large as those sailing from New York, or that all cities must have the same number of subways or elevated railways. But that would not be fair. In so far as the purpose of the provision is to provide substantial equality in radio service to the people throughout the United States, it is highly commendable. Personally, I do not believe in the least that to have equality in service in different areas requires that there must be equality in number or power of transmitting stations.

I would be inclined to say, looking at the question merely from the viewpoint of service to the listener, that it would take fewer stations with less total power to serve the eight millions of people concentrated on and around Manhattan Island, than to serve half of that number scattered over the state of Texas. The service area of a station is figured in square miles, and is probably the same whether those miles include cities or desert. A station of a given power in one location may serve millions, and in another, a few hundred, which of course, explains the crowding of stations around population centers.

The Radio Commission already had so many problems that adding one more makes little difference, and if it cuts down the total number of stations, it will solve most of its difficulties. The important thing is that the public should realize that radio troubles can be solved in no other way, and that the Commission is entitled to full support when it undertakes its duties in that direction. There is every indication that it now intends to do so.

The Commission will need plenty of support, for when it starts to carry out that policy, many stations now operating will be seriously affected. Those who lose present privileges will doubtless assert that they are deprived of their property without due process of law, that it is being taken for public use without compensation, or that for some other reason their constitutional rights are violated. The questions raised will be difficult of solution. I certainly do not intend to try to give an answer to them, for it is useless to speculate about law unless we have the facts to which it is to be applied.

Much depends on just what the Commission does. Refusal to allow a station owner to operate his apparatus at all might present legal questions quite distinct from those which would arise from a mere refusal to allow him to use a certain wave length; and we do not know now which course the Commission will pursue, or whether it will adopt either.

A further uncertainty arises from the fact that all present station owners have accepted licenses of limited duration and are operating under them, so that it may doubtless be claimed that whatever rights they may once have had necessarily terminate when the license expires. The law under which they accepted licenses gives them no assurance of renewal.

The courts will be called upon to determine between, on the one hand, the undoubted right of Congress to regulate interstate and foreign commerce, even though incidental injury results to an individual, and, on the other hand, the protection afforded the individual by the Constitution against the taking of his property without compensation. No court has yet passed upon these phases of the Radio Act. The matter has not been even presented for determination. There seems to be in some quarters a feeling that legal tests must be avoided. That is a wrong attitude. Nothing can be worse for an industry than to be ignorant of its legal bases. Nothing can be more unpleasant for a public officer than to be doubtful of his own authority, and nothing can work more strongly towards inefficiency.

The Commission should proceed on the theory that the law which creates it is constitutional, and that it has the power to do what the law tells it to do. To take the opposite theory is to negative its own right to exist. Every other great regulatory Act of Congress has had to undergo the ordeal of judicial scrutiny. The Radio Act must experience the same test. The sooner constitutionality is determined and judicial construction obtained for ambiguous language, the better for all concerned, and this is true whatever the result may be. But in the meantime and until the courts speak, while we may all guess about it, and lawyers may give learned opinions based on analogies, answers remain in the realm of the legal unknown, to which belong so many other radio problems.

The principal difficulties up to date have lain in the field of broadcasting, but to those who look to the future of radio communication, there is apparent the approach of similar difficulties in the other radio activities. We used to think that the high-frequency bands, the short waves below the lower limit of the broadcasting band, were so numerous that they could never be congested. Indeed, they were once considered of little value for radio communication and were set off for amateur use; but now, largely as the result of amateur development, they are recognized for many purposes as perhaps the most useful. The time is rapidly approaching, if it is not already here, when we shall see the same congestion, the same difficulties, the same interference, in these high-frequency bands that we now find in the channels used for broadcasting. It can be obviated only by the most intelligent and far-sighted regulation on the part of the Radio Commission, with strict adherence to the provisions of the 1927 law and with the fullest exercise of the powers there granted.

Just as the growth of radio communication made our 1912 law useless by 1927, so the London International Convention of 1912 was obsolete by the same date. Radio outgrew its international clothes as rapidly as its domestic ones. New understandings among the nations became essential. Here again, the entire problem turns upon the necessity for avoiding interference by so separating the stations that their communications do not disturb one another. The only difference is that internationally the stations are separated by greater distances and that these stations are not subject to control by a single authority, while many of the stations are so powerful that their messages are heard around the globe and the station of one nation may thus interfere with those of practically every other nation.

The London Convention, in recognition of the fact that radio communication is a rapidly changing art and that international regulations must be altered accordingly, provided that further conferences should be held at five-year intervals. The coming of the war prevented the holding of a conference at the time planned, and none was held until 1927, when in October the countries of the world gathered in Washington at the invitation of the government of the United States, for the purpose of revising and modifying the London Convention and extending its terms to make it conform to present conditions.

It has been said that this conference was the largest international conference ever held. It was attended by the representatives of more countries of the world than any previous one. The final result was the adoption of an agreement which covers all international phases of radio communication, on the basis of present-day conditions and which furnishes a workable foundation for international relations on the subject. It completely supersedes the London Convention, or rather will do so if and when it is ratified. It makes no attempt to assign operating channels among the nations, an almost impossible task, but it did make a complete allocation to the various services, designating separate and distinct bands for long distance transoceanic communication, for ships and aircraft, for broadcasting, for amateurs, and for the international telephone. Frequencies are divided among them and some measure of international order is thus established.

Secretary Hoover, who was president of the conference, in his closing address expressed his gratification that eighty governments had been able to agree upon a subject of such technical complexity, with opportunity for wide divergence of view, and referred to the convention as "another milestone in the progress of international relations." It was ratified by the Senate of the United States a few weeks ago.

In what I have said so far, I have confined myself entirely to the law affecting radio communication as it is affirmatively written either on the statute books of Congress or in treaties and conventions agreed to by the nations of the world, and I think it is apparent to all of us that even in this branch of the law, there are plenty of difficulties and much uncertainty. The provisions which I have discussed are all directed to the bringing about of order in this new system of communication. They do not deal at all with the broader and even more fundamental principles which govern the rights and liabilities of individuals to one another and to the public.

In the development of every great industry, conflicts and disputes arise, and they are often settled by recourse to the courts. As litigation develops, precedents are established, and principles are determined. That process has not yet developed in the business of radio communication. The art is still too young. The conflicts and disputes that might lead to the establishing of new judicial principles have not yet arisen, so that in this branch of the law there is even less definiteness and much more uncertainty than with respect to the statutory phases which I have already discussed.

Nevertheless, it is plain that such controversies will arise, and that sooner or later they must be adjudicated. They will involve problems falling within the law of contracts, of torts, of the liability for injuries done and the right to recover for them, of defamation resulting from radio broadcasting, whether in the form of libel or slander, of the right of the individual who speaks before a microphone to control the use of his communication after it is thrown into space, and many other problems of a similar character, some of which can now be anticipated, and others which cannot even be imagined at this time.

Take, for instance, the broadcasting of copyrighted matter. Under the copyright law, no one may use copyrighted music for the purpose of a public performance for profit, without the consent of the author. Here is a fine field for controversy. What is a "public performance for profit"? An orchestra playing in a theater is certainly giving a public performance, and somebody is presumably making a profit from it, but when the owner of a radio station sets up a microphone in the theater and broadcasts the music to the public, is he also giving a performance, and is it public, and if he is not paid for it, where is the profit? There is certainly no new performance. He has merely increased the size of the audience. Problems of this sort have been presented to several courts and have received divergent and even contradictory answers, but the present state of the law seems to be that, speaking generally, broadcasting of copyrighted music is a performance for profit, and that consequently the owner of the copyright is entitled to his compensation.

Or take such a subject as defamation by radio. As an instrument for character destruction, broadcasting easily rivals the printing press in its potentialities. We know fairly well the general rules governing liability for libel and slander that have come down to us through the centuries. Now we must apply them to a new medium, and we find difficulties. If a man speaking before a microphone deliberately defames another, is he alone liable, or is there a responsibility also residing in the owner of the apparatus by means of which the defamation is disseminated? Is the liability of the broadcaster absolute, like that of a newspaper owner who must take full responsibility for what appears in his paper, whether he knew of it in advance or not, or is his responsibility to be determined on the basis of negligence only, as in the case of messages sent by telegraph? And if the person before the microphone reads from prepared written material instead of speaking extemporaneously, does the resulting defamation come under the law of libel or the law of slander? The law of these two torts differs considerably, for a man may safely say many things that he may not write without liability. About all we can say is that the courts have not yet been called upon to decide these questions, and we cannot answer them until they do, though speculation regarding them is interesting.

Again, take the situation of the artist who agrees to sing or play for the audience of a single station on some particular occasion. May any other station pick up his voice or his music and rebroadcast without his consent? May it be caught and reproduced on a phonograph record against the wishes of the originator? To what extent may the reproduction of matter broadcast be controlled? And where do we find the analogies on which to base our legal determination? Are they to be found in what we call common-law copyrights, in some new principle under which the ownership of the immaterial will be recognized, some fundamental right of the individual to control the reproduction of his own voice, or in the established rules defining and prohibiting unfair competition? Here again we are in an untrodden field, free to wander in almost any direction to our heart's content in seeking the legal answers.

The law of radio, therefore, dealing as it does with a new art and industry and with relations and conditions which have never before existed is as yet in the formative period. The development of these legal concepts will form an interesting chapter in legal history.

VII

THE EARLY HISTORY OF BROADCASTING IN THE UNITED STATES

H. P. Davis
Vice President
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IN SPEAKING upon this subject, I am embarrassed because of the necessity for occasional personal references which the chronology of events forces me to make. You will pardon me for this, I am sure.

The advances made by civilization have been very largely in proportion to the development of communications. Starting with mouth to mouth and eye to eye contacts, progressively through the ages there has been a gradual evolution of mass communication, until, in our present day, it is exemplified and developed in many ways.

MASS COMMUNICATION

It is hard even for one who has seen in his lifetime the awakening of this mighty colossus—asleep since the beginning of time—to realize the amazing achievements and developments of the twentieth century in mass communication. To you of the present generation, the perspective is less clear and therefore not so intimate, and is looked upon in a more matter-of-fact way. Yet no longer than 61 years ago a prominent Boston newspaper published the following article:

> A man about 46 years of age, giving the name of Joshua Coppersmith, has been arrested in New York for attempting to extort funds from ignorant and superstitious people by exhibiting a device which he says will convey the human voice any distance over metallic wires so that it will be heard by the listener at the other end. He calls the instrument a "telephone" which is obviously intended to imitate the word "telegraph" and win the confidence of those who know of the success of the latter instrument without understanding the principles on which it is based.
> Well-informed people know that it is impossible to transmit the human voice over wires as may be done with dots and dashes and signals of the Morse code, and that, were it possible to do so, the thing would be of no practical value. The authorities who apprehended this criminal are to be congratulated and it is hoped that his punishment will be prompt and fitting, that it may serve as an example to other conscienceless schemers who enrich themselves at the expense of their fellow creatures.

The youngest but the most promising addition to these facilities for mass communication is radio broadcasting.

EXPERIMENTS PRIOR TO THE WORLD WAR

Attempts had been made, and some successful results had been accomplished, prior to the World War, in adapting telephonic principles to radio communication. Reginald Fessenden, probably the first to attempt this, broadcast a program Christmas Eve 1906. Later, Mr. Lee DeForest did the same in the development of his apparatus. No real service, however, was attempted or introduced of a character similar to that now known as radio broadcasting. The war bringing an end to independent development work, attention was concentrated on such applications of radio as would be helpful in military operations, and the various governments engaged in the conflict enlisted the aid of all the large electrical companies that had facilities available.

The Westinghouse Electric and Manufacturing Company, having extensive research, engineering, and manufacturing facilities of a nature suitable for this branch of electric science, was requested by the British Government, shortly after the outbreak of the war, to undertake certain special work in radio. Considerable study on the part of Westinghouse engineers was devoted to this, but no special progress was made of a permanent character, as our own government began an attempt to develop such facilities, foreseeing the possibility of needing them later.

This activity took form in several fields. One, however, was the development of radio transmitting and receiving apparatus, both telegraphic and telephonic. In order to carry out this work it was necessary to have transmitting and receiving stations, and by special license from our government the Westinghouse Electric and Manufacturing Company was permitted to build and operate such facilities for experimental purposes.

Two stations were designed, equipped, and operated during the war. One was located near its plant at East Pittsburgh, Pennsylvania, and the other at the home of Dr. Frank Conrad in the Pittsburgh residential district, a distance of four or five miles separating the two stations. The calls of these stations were 2-WM and 2-WE.

Your speaker was in charge of the Westinghouse company's war activities. Dr. Conrad was then serving as one of his assistants and among other things was especially assigned to radio work. Dr. Conrad's work was very closely coordinated with that of the United States Signal Corps. Dr. Conrad became very much engrossed in this work, and in characteristic manner began to do research, developing new ideas and making important advances in the art. As a result, a considerable amount of money was invested in this equipment and a large staff of experts organized to handle the details of this complex activity.

With the end of the war, the company found itself with this investment and organization on its hands, and the reestablishment of patent restrictions, most of which were adversely held, placed it in a position of considerable difficulty in continuing this work. The progress that had been made during the war period, however, encouraged it to continue. In casting about for a way to establish itself in the industry, negotiations were undertaken, and finally successfully concluded, whereby a controlling interest was purchased in the International Radio Telegraph Company, which owned many important fundamental radio patents.

The International Radio Telegraph Company owned and operated several ship-to-shore radio stations and was a pioneer in this field. The operation and development of this service immediately became a part of the Westinghouse activities.

AN EFFORT TO DEVELOP RADIO SERVICE

A large sum of money expended for the control of the International Radio Telegraph Company emphasized in our minds the necessity for developing our new acquisition into a service which would broaden, popularize, and commercialize radio to a greater extent than existed at that time, in order to earn some return on this investment as well as to keep the radio organization together.

In seeking a revenue returning service, the thought occurred to broadcast a news service regularly from our ship-to-shore stations to the ships. This thought was followed up, but nothing was accomplished because of the negative reaction obtained from those organizations which we desired to supply with this news service. However, the thought of accomplishing something which would realize the service referred to still persisted in our minds.

During this period Dr. Conrad had continued in his experiments with the station at his home and had greatly improved his radio telephone transmitter. Following the date on which government restrictions were removed from radio stations, Dr. Conrad quite regularly had operated this radio telephone transmitter to send out interesting programs of one kind or another, and to such an extent that people with receiving sets became sufficiently interested to listen to his station.

The program material available to him was largely phonograph records, although there were some talks, baseball, and football scores. The station, whose call letters had been changed, was then designated as 8-XK and was known as one of the best amateur stations in the country.

EFFECT OF A NEWSPAPER AD

We were watching this activity very closely. In the early part of the following year the thought came which led to the initiation of a regular broadcast service. An advertisement of a local department store in a Pittsburgh newpaper, calling attention to a stock of radio receivers which could be used to receive the programs sent out by Dr. Conrad, caused the thought to come to me that the efforts that were then being made to develop radio telephony as a confidential means of communication were wrong, and that instead its field was really one of wide publicity, in fact, the only means of instantaneous collective communication ever devised. Right in our grasp, therefore, we had that service which we had been thinking about and endeavoring to formulate.

Here was an idea of limitless opportunity if it could be "put across." A little study of this thought developed great possibilities. It was felt that here was something that would make a new public service of a kind certain to create epochal changes in the then accepted everyday affairs, quite as vital as had been the introduction of the telephone and telegraph, or the application of the electricity to lighting and to power. We became convinced that we had in our hands in this idea the instrument that would prove to be the greatest and most direct means of mass communication and mass education that had ever appeared. The natural fascination of its mystery, coupled with its ability to annihilate distance, would attract, interest, and open many avenues to bring happiness into human lives. It was obviously a form of service of universal application, that could be rendered without favor and without price to millions eager for its benefits.

DECISION TO START A STATION

Resulting from this was my decision to install a broadcasting station at East Pittsburgh and to initiate this service. This decision, made early in 1920, created the present huge radio industry. Not until fall, however, was the equipment ready for operation. In the interim, I had occasion to hold many interesting and now really historical conferences to plan our undertaking in such a way that our vision of service and opportunity might be realized to its fullest extent.

Dr. Frank Conrad, Assistant Chief Engineer, Mr. J. C. McQuiston, General Advertising Manager, Mr. S. M. Kintner, manager of the Research Department, Mr. O. S. Schairer, manager of the Patent Department, Mr. L. W. Chubb, manager of the Radio Engineering Department, and Mr. M. C. Rypinski, of the Sales Department—all of the Westinghouse Electric and Manufacturing Company—participated in these conferences, and it was their experience, advice, constant faith, and loyal efforts in the undertaking and the developments that followed that carried the project to success.

COOPERATION OF THE PRESS

One of the earliest decisions was the necessity of building up and obtaining the necessary public interest in our efforts through the cooperation of the daily press. It happened that we were most fortunately situated to accomplish this. Mr. A. E. Braun, the directing head of the *Pittsburgh Post,* a morning paper, and the *Pittsburgh Sun,* an evening paper, was an officer in the International Radio Telegraph Company, and the cooperation of these papers and his hearty support were immediately forthcoming. This, with Mr. McQuiston's acquaintanceship and contacts with other press channels and his work with Mr. Braun, added much to building up the public interest which led to the final great success of the venture.

MAIN OBJECTIVES

The main objectives which we laid down as basic have guided our radio broadcasting ever since, and were:

1. To work hand in hand with the press, recognizing that only by published programs could the public fully appreciate a broadcasting service.

2. To provide a type of program that would be of interest and benefit to the greatest number, touching the lives of young and old, men and women, in various stages and conditions of life.

3. To avoid monotony by introducing variety in music, speeches, and so on.

4. To have distinctive features so timed as to assure their coming on at regular periods every evening—in other words, as a railroad does by its time-table.

5. To be continuous—that is, to operate every day of the year. KDKA has operated without a break in schedule since the opening of the station.

In our discussion, the subject of the first program was a matter of very careful deliberation. We wanted to do something unusual—we wanted to make it spectacular; we wanted it to attract attention.

FIRST PROGRAM SPECTACULAR

It happened that 1920 was the presidential election year, and the happy thought occurred to us to open our station on the night of the election returns and to broadcast this news. Through the cooperation of Mr. Braun, our plans matured with the decision to open on November 2, 1920, which we did; and the result was the historical broadcast by KDKA of the Harding election, the returns being gathered in the office of the *Pittsburgh Post,* in Pittsburgh, and from there telephoned to East Pittsburgh where they were relayed by another operator and broadcast by this new service.

A broadcasting station is a rather useless enterprise unless there is someone to listen to it. Here was an innovation, and even though advertised, few then, other than possibly some of the amateurs who had receiving sets, could listen to us. To meet this situation we had a number of simple receiving outfits manufactured. These we distributed among friends and to several of the officers of the company. Thus was the first broadcast audience drafted. This was only eight years ago when there was only station KDKA, whose audience consisted of a few head-phone listeners.

BROADCASTING BEGINS

As a matter of historical record and sequence in the origin and progress of radio broadcasting as a public service, the following chronicle of events is important:

After a period of testing and experimental operation, the Westinghouse Electric and Manufacturing Company on November 2, 1920, at East Pittsburgh, Pennsylvania, put the first broadcasting station in the world, now known as KDKA, into operation, and transmitted as its first program the returns of the Harding presidential election. Following this, a daily program from 8:30 to 9:30 p. m. was immediately instituted. The daily schedule of the station has been continued without interruption up to the present time.

After nine months of continuous operation of Station KDKA, the Westinghouse Company opened WBZ at Springfield, Massachussets, in September, 1921, followed on October 12, 1921, by WJZ at Newark, New Jersey, and on November 11, 1921, by KYW at Chicago, Illinois.

It was not until the summer of the next year that any other stations of prominence were placed into operation, and very few then, as it was a considerable time later that the great rush for wave lengths took place and the confusion introduced that now exists in the broadcasting wave bands.

Our first broadcasting was from a rough box affair on the roof of one of the taller buildings at the plant, which still stands there although no longer in use; the later development of the broadcasting studio is in itself an interesting story.

BROADCASTING THE WESTINGHOUSE BAND

In the first few months of operation of KDKA, program material was drawn largely from phonograph records. We recognized almost immediately, however, that no great interest or progress in broadcasting service would be possible if material differing from this type of entertainment were not available. The Westinghouse employees have always had a number of musical organizations, among them a very good band. We decided to broadcast this. Later, we organized the KDKA Little Symphony Orchestra.

Our phonograph was operated in the room in which the transmitter was located, and the announcer and others who had taken part in the programs up to this time also had been using this room. With larger aggregations of talent, however, it was necessary to seek bigger quarters, so one of the auditoriums of East Pittsburgh was put into use. We immediately had difficulty in obtaining fidelity in the broadcast, due, apparently, to room resonance. To correct this, we thought of placing the band in the open air and to transmitting from out-of-doors. When this was done, the result was a marked improvement. As a result of this, we saw at once that if we wished to accomplish good sound reproduction, specially designed rooms would be required to broadcast from—but how to construct them was not clearly apparent and in addition the expense incident to the construction was a serious problem.

As the warmer weather was approaching, we decided to broadcast our artists from this open-air studio, which, as before stated, was on the roof of one of the taller buildings at the plant. For protection we erected a tent. This proved good, and everything went along satisfactorily during the summer and early fall, until one night a high wind blew the tent away—and so our first studio passed out and into history.

THE STUDIO IS MOVED INDOORS

Necessity has always been the mother of invention, and having managed to keep our service going for nearly a year we could not think of discontinuing it because we had no studio—but we saw that we should have to go indoors. We therefore decided to try the tent inside. Part of the top floor of this high building was cleared and the tent was "pitched" on this floor, and we were pleased to find that it worked as effectively as it had out of doors. Thus was the first indoor broadcasting studio developed.

The subject of a specially constructed studio, however, was again revived, and designs were prepared for it. Taking the lesson of the tent to heart, we draped the whole interior of the new studio with the cheapest material we had available—burlap. We had now all the elements of the present studio.

The principles that were originated by our experience have governed the design of the present-day studios, but the lowly burlap has changed its name to the more dignified name of monk's cloth. Other materials, however, have been developed in this intervening period, and the walls, ceilings, and floors of studios are now built of materials which are non-resonant in character so that the use of monk's cloth is required less than formerly.

One cannot but be impressed with what radio has accomplished in a few short years when one compares this first tent studio with the wonderful studios and equipment of the National Broadcasting Company.

THE AMATEURS REBEL

KDKA had then a power of only 100 watts, but this, of course, was more powerful than the transmitting sets used by amateurs in those days. The amateurs, until our advent, had the field to themselves and had enjoyed the entire freedom of the air. The coming of our broadcasting transmitter into the picture was naturally not received with open arms by them, as the continuous operation of the transmitter interfered to a large extent with their work. At that time, most amateurs were using spark sets, and our broadcasting in turn was seriously marred by interference from that source. It came to a point of more or less open warfare, with the amateur operators if anything having the best of it.

It must be said, however, to the credit of the amateurs, that later, when it was evident to them that the public was seriously interested in our efforts, their organization formulated rules of ethics which, when observed, quite materially corrected this condition.

You can appreciate from this that the first year of our operations was beset with many difficulties and discouragements, and many discussions were had as to whether the game was worth the candle. But we persisted.

WESTINGHOUSE EXECUTIVES LEND SUPPORT

I am happy to pay tribute to the late General Guy E. Tripp, chairman of the Board of Directors of the Westinghouse Electric and Manufacturing Company, and to Mr. E. M. Herr, president, for their broad-minded support and patience. They had confidence in us and backed the undertaking in a personal way, as well as with contributions from the company's funds to develop this new service. Finally these efforts were rewarded by an aroused interest on the part of the public—an interest that grew almost to fever pitch in a stampede late in the the year 1921, overwhelming an industry wholly unprepared for it.

PUBLIC INTEREST AWAKENED

Radio broadcasting became a conversational topic as universal as the weather, and the spell of it became worldwide. It is probably a fact that when the response came, no facility or service ever received such a reaction from the public or grew so fast in popularity, when the public was awakened to what it really was. When this happened, almost over night a scientific novelty and a hazardous experiment was transformed into a wide-spread and popular public service.

Thus was radio telephone broadcasting born—a new public service; a service for the benefit or entertainment of anyone who might possess even the simplest receiving equipment. The secret of the success of the enterprise lay in the fact that there were then no interfering stations, and because of this only very simple receiving sets were required for "listening in." This was fortunate, as there was nothing else, and the available sets were cheap. Being telephonic, the communications could be understood by everyone. They required no translation and were substantially unlimited as to the character of the subject matter that might be transmitted and received. In addition, there was the marvel and fascination of listening to messages received out of space with very simple and inexpensive apparatus.

NEWSPAPERS ASSISTED GROWTH

We attribute much of this public response to the press work we had been doing. From the start we had sent out announcements and copies of programs to a list of representative newspapers. At first these were typewritten and went to a limited list, but later the form was improved by printing, a larger list was used, and an organized publicity program was carried out in a magazine which we started called *Radio Broadcasting News* and sent to about 2,000 newspapers. It was not long before KDKA's programs were printed in newspapers all over the United States and in every province of Canada.

In addition to this, a factor which probably contributed much to the success of broadcasting at this time was that broadcasting was done regularly, at well-advertised times of the day or night, and the programs consisted of matter that was of general interest and worth listening to.

Briefly, we endeavored to render a real public service, with regularity, presenting well-planned, high-grade, interesting, and timely advertised programs. It was our conception that it could be made a valuable service different from anything then in existence and adapted to accomplish something entirely new, which was the distinguishing characteristic of our undertaking. This, and our sense of duty to the listening public, assisted in establishing this effort as a definite and all-embracing service.

CHURCH SERVICE BEGINS

The first real pick-up service ever attempted was that of the services of the Calvary Episcopal Church, of Pittsburgh. Here, again, is an interesting story.

We had been sending out originally, as previously indicated, music and entertainment from phonograph records, and as we had determined to broadcast every day we naturally included Sunday. Our week-day form of program material did not seem quite suitable for Sunday evening purposes. Accordingly, we had a discussion about the matter and the happy suggestion was made "Why not try to broadcast a church service?" But how?

After consideration of the difficulties involved, especially in picking it up, a plan was worked out which we felt would make the technical part possible. As music was the principal make-up of our program, our thought naturally gravitated to the Episcopal service. It so happened that one of our engineers was a member of the choir of the Calvary Episcopal Church in the East Liberty section of Pittsburgh. He was called in, the matter was explained to him, and he promised to see what could be done.

We were to learn later that fortune was with us in this thought to the extent that the rector of that Church, Dr. E. J. van Etten, who is a broad-minded, far-sighted, and progressive individual, immediately was interested in our proposal, and a connection was formed then that has continued to the present day.

On January 2, 1921, the daring experiment was made of broadcasting the services of Calvary Episcopal Church. This was successful, and was so well received that it became a regular feature.

DR. VAN ETTEN, FIRST RADIO MINISTER

Dr. van Etten was the first minister whose church services were broadcast. His was the first voice to be heard in a broadcasting of divine services, and through his enthusiasm in this work he has undoubtedly done more to bring happiness and religious comfort to the masses of people than any other living man.

The broadcasting of church service alone, which was initiated by KDKA, was in itself sufficient to make radio broadcasting permanent and invaluable. The innovation was at once unique and compelling in its appeal to people of all ages, classes, and denominations, and it has proved to be one of the greatest, most popular, and beneficent features ever presented. Even today it is doing more to enlarge the church's sphere of influence than any medium heretofore employed.

It is my belief that the happy thought that led to the inclusion of a church in our broadcasting, and our success in selecting the church that we did, the idea of cooperating with the press and the public interest that we gained through it, coupled with our feeling of responsibility and with our unbounded confidence in the future of the service which we had initiated and were developing, and the soundness of the principles we had laid down for our guidance, formed the solid foundation upon which this whole broadcasting industry has been built.

Recognizing the need of expert advice in the development of programs, we sought the cooperation of Mr. Harvey Gaul, the musical director of Calvary Episcopal Church, to assist us in determining the best selection of artists and music. Mr. Gaul was thus the first radio impresario and during the period he was with us he made some valuable contributions to radio musical lore and broadcasting technique.

EARLY FORECASTING

There is a common saying that "hind sight is better than foresight," and in the light of today's accomplishments it is easy to ascribe many virtues to ourselves and to our undertaking. But what do the records show? In an article which I wrote in February, 1921, only three months after regular broadcasting had been established, the following truly prophetic statements were made:

> The adaptability of the radiophone to broadcasting reports, news, entertainments, concerts, lectures, and the like, creates a field particularly its own.
>
> It is quite possible that especially constructed transmitting rooms will be provided for such purposes, so that voices and music will be broadcast through unbounded areas and listened to by invisible and widedly distributed audiences of vast numbers. The same opportunities would thus exist for the country dweller as for the city resident, and inmates of hospitals and sanitariums, and sick people and invalids in the home, would have opportunities for pleasures and diversions now denied them.
>
> The importance of reaching such tremendous numbers of people, with practically no effort, offers great possibilities for advertising and the distribution of news and important facts, and in reality introduces a "universal speaking service." It is not unreasonable to predict that the time will come when almost every home will include in its furnishings some sort of loud-speaking radio receiving instrument, which can be put into operation at will, permitting the householder to be in more or less constant touch with the outside world through these broadcasting agencies.
>
> The field of radio application is practically unlimited in the important affairs of the world, and this development will mark one of the great steps in the progress and evolution of mankind.

Again, in another article which I prepared in January, 1922, the following appears:

And where will it end? What are the limitations? Who dares to predict? Relays will permit one station to pass its message on to another, and we may easily expect to hear in an outlying farm in Maine some great artist singing into a microphone many thousand miles away. A receiving set in every home, in every hotel room, in every school room, in every hospital room. Why not? It is not so much a question of possibility—it is rather a question of "how soon."

A dream then has become a reality now.

PIONEER RECORDS

As part of the pioneer records of KDKA we have the honor to record that Hon. Herbert Hoover's first radio broadcast address was transmitted by KDKA. The address was presented during a dinner held at the Duquesne Club, Pittsburgh, on January 15, 1921, to raise funds for European relief work. Mr. Hoover's pioneer address was followed by addresses of others of prominence. Our records reveal that on February 18, 1921, KDKA transmitted the address of Hon. Alice M. Robertson, then Congresswoman-elect from Oklahoma, the first woman elected to Congress, and Colonel Theodore Roosevelt, Jr. Their addresses were delivered before the Pittsburgh Press Club.

One month later, on March 19, 1921, three members of the President's Cabinet addressed the audience of KDKA. These were Hon. Andrew W. Mellon, Secretary of the Treasury, Hon. James J. Davis, Secretary of Labor, and Hon. John W. Weeks, then Secretary of War. At another time Hon. William Jennings Bryan made his first radio address over KDKA.

In the history of KDKA's broadcasting there have been a host of world-famous people who have addressed the station's radio audience. The pioneer speakers were of such high caliber that they surely set up a precedent for those who followed.

FAMOUS RADIO EVENTS

Then, in the following months, KDKA rapidly developed and presented a series of "firsts" in broadcasting history. Among these "firsts" were the retransmission of Arlington time signals at 10 o'clock nightly. The time signal service, introduced a few days after the start of KDKA, became at once, and has so remained, one of the most popular and appreciated of radio features.

After the time signals, KDKA introduced the first sports events by broadcast, the occasion being a boxing contest between Johnny Ray and Johnny Dundee, held in Motor Square Garden, Pittsburgh, April 11, 1921. Both boxers, I might add, have long since retired.

Next, on May 9, 1921, KDKA was the first to broadcast, from the stage of the Davis Theater, in Pittsburgh, a theatrical program. On August 4, 5, 6, 1921, KDKA first broadcast tennis matches, the occasion being the Davis Cup matches held at the Allegheny Country Club, Sewickley, Pennsylvania, about 25 miles distant from the transmitting station. On August 5, 1921, KDKA transmitted the first play-by-play account of a baseball game, held in the National League Park at Pittsburgh.

These pioneer broadcasts of athletic events were the forerunners of the tremendously interesting sports broadcasts with which the American public has been so well entertained in later years. One of the first broadcasts made from WJZ was the World Series baseball games, with one of the New York teams as a contender.

KYW's first program was an auspicious one, it being the transmission of Grand Opera direct from the stage by artists of the Chicago Civic Opera Company. This program was the pioneer of the many delightful operatic programs which are today a tremendously interesting feature of chain hook-ups.

A STORY OF FARM SERVICE

In the efforts to develop a diversified program, the agricultural population, of vast importance to any agency attempting to interest all the people of the United States, was not overlooked. To the contrary, it is another striking instance of KDKA's pioneering that the station was the first to conduct a regular farm service, which included not only livestock, hay, and grain reports, but also weather forecasts. On May 19, 1921, KDKA was authorized to broadcast government market reports and immediately began this service. Since that beginning, market reports, which from time to time have been expanded in scope, have been a nightly feature of Westinghouse broadcasting stations. Station KFKX, now located in Chicago, is one of the very few stations whose programs are almost exclusively devoted to farm subjects.

ENTIRE CITY AVAILABLE FOR PROGRAMS

To reach the wide field of program material, an extensive system of pick-ups was worked out in Pittsburgh covering some thirty points of contact with events of public interest. Included in this arrangement are schools, churches, theaters, hotels, athletic fields, and halls, with special studios at one university and two hotels. KYW, Chicago, and WBZ, Springfield, have similar but less extensive systems of pick-up. In the case of WBZ there is the striking feature of a line connection with Boston, 100 miles long, giving an additional pick-up system in that city and including also several studios.

This was all pioneering, and in the development of programs for our service the endeavor was constantly made to develop new and unusual features, as it is these that attract special attention, maintain public interest, and win the greatest applause. It can be stated as a fact that there is hardly an element in program service today that was not covered in these early undertakings. In other words, the Westinghouse Electric and Manufacturing Company not only created broadcasting but has been one of the most active forces in developing it.

ANNOUNCERS' SCHOOL

We soon found that training announcers in diction and pronunciation was necessary, since for every mispronounced word we were certain to receive many letters of criticism. This condition prompted us to start an announcers' school, under the capable direction of Mr. T. H. Bailey Whipple, our literary critic, who held daily rehearsals of the various announcements to be made.

Most opportunely for us, we were also able to secure the services of Miss Marjorie Stewart who, although blind, wrote daily constructive criticisms of all programs, pointing out where improvements might be effected. She thus became the first radio critic, necessarily a most important activity for the perfection of broadcasting. Through her exceptionally keen perception, false notes in our broadcasting, exceedingly difficult for the program manager to detect before delivery of the actual program, were eradicated.

FEEL PUBLIC PULSE BY LETTERS

We continually felt the pulse of the public through the thousands of letters sent to us, to determine their wishes in program arrangement. Some of these early letters were very interesting and instructive, and because of them we were from the very first led to maintain a high standard, not only in musical offerings but also in the lectures, addresses, and other forms of program. It is believed that because the most important broadcasting stations have maintained their quality of program, the radio listeners in the mass appreciate the quality offering more than one of ordinary grade. Broadcasting, without question, has had an uplifting effect upon the taste of the public in music, a fact well appreciated by the musical fraternity.

DEVELOP MODULATION METER

It was very soon discovered that the characteristics of the microphone were quite different from those of the human ear. The microphone responds to certain frequencies more readily than to others. Consequently, a grouping in a studio that would be satisfactory to the ear direct might not be at all pleasing when heard over the radio.

A little experience showed that it was necessary to determine accurate standards that can be applied in advance to assure that music as reproduced in the receiver is properly balanced—that is, has proper blending of high and low tones and also proper relation of volume of accompaniment and leading melodies.

Musical tones vary in pitch from the lowest tone on the piano, which produces 27 vibrations per second, to the highest tone of more than 4,000 vibrations per second. These fundamental tones are superimposed by higher harmonies which determine the nature of the tone produced. These "overtones" make it possible to distinguish between the sounds of the violin, flute, clarinet, trumpet, and other instruments, or the most complicated sound, which is that of the human voice.

To provide a means of control, a modulation meter calibrated from 1 to 100 was devised. This instrument is now standard equipment in every transmitter. It is used to study the effect of different kinds of music or frequencies upon the current in the modulating tubes—an important factor that determines the quality of broadcasting. Overmodulation causes distortion, and undermodulation gives too weak a signal, difficult to reproduce clearly in the receiving sets.

For a given volume of sound a high-pitched tone produces a higher reading on the modulation meter than a lower tone—that is, the higher tones more easily produce distortion of music. This fact makes it evident that the arrangement of instruments in an orchestra, for example, when broadcasting, must be different from that of the usual set-up in an auditorium. It was found that the lower-pitched instruments must be placed nearer the microphone than those of higher pitch. On the basis of data compiled in a large number of observations and from careful checking of the music as actually produced in the studio with the results obtained on a receiving set, a series of charts was worked out by Mr. A. G. Popcke, one of the Westinghouse Electric and Manufacturing Company's engineers, showing the proper location of soloists and piano, also the proper grouping of instruments of various combinations such as quartets, orchestra, band, and so on.

CHART STUDIO ACOUSTICS

Of course, these charts were related to the acoustics of the studio and also to the type of microphone used. For this reason, as the art progressed, it was necessary to make changes in the placing of artists before the microphone. Greater distance from the microphone is now possible because of the improvements that have been made in the microphone and in the amplifiers used. The old-time carbon microphone had a strong "frying" undertone, or "ground tone," the volume of which was a considerable percentage of the volume of music to be broadcast. Up-to-date apparatus has reduced this ground tone to a very small percentage of the sound to be broadcast, and consequently greater amplification is used, which results in greater possible distance between performer and microphone, a factor which has greatly facilitated fine program work.

This has simplified the problem of the proper placing of an orchestra, for example. The musicians are not crowded about the microphone but are seated comfortably at predetermined distances from it. The increase in distance has decreased the percentage of error due to slight departures from the proper placing of performers. In fact, the music in an auditorium can be picked up successfully with the regular seating of the orchestra by locating one or more microphones at the proper points, these having been determined by a careful study and experiment.

The results accomplished by this kind of work, together with the work done on microphones and improvements in design of transmitters, have brought about much improvement in transmitting programs of the higher quality with greater fidelity; if the radio audience use receiving equipment, particularly amplifiers and loud speakers, which will successfully reproduce all the frequencies that are transmitted, nearly perfect reception is possible.

SHORT-WAVE WORK

Meanwhile, KDKA was reaching out and pioneering in a branch of development of the radio art which now bids fair to be the most important in the science of communication. I refer to the work that the Westinghouse company's engineers have done in short-wave transmission, from which much is expected by radio engineers.

Early in 1922 we were convinced that there were wonderful possibilities which were being overlooked in the then unused and rather despised short-wave bands, considerably lower than those then in use for broadcasting and for communication. An experimental station known as KDPM was installed at the Westinghouse company's plant at Cleveland, Ohio, and serious work was undertaken between KDKA at East Pittsburgh and this station in an investigation of the subject of short-wave transmission and rebroadcasting. Since that time, research and development work in this branch of the art have been carried on continuously and vigorously.

In the fall of 1923 the Westinghouse company located a rebroadcasting station at Hastings, Nebraska, the well-known KFKX. At this point short-wave transmissions from KDKA were nightly received and rebroadcast on the Nebraska station's assigned wave length.

GREAT BRITAIN RELAYS KDKA

On New Year's Eve, 1923, through previous arrangement, KDKA transmitted a short-wave program to Great

Britain. This program was rebroadcast to British listeners through a station operated by the Metropolitan Vickers Company at Manchester, England, and was the first internationally broadcast program, as well as the first to be rebroadcast.

This work in short-wave transmissions led us to continue striving for distance. On December 12, 1924, KDKA's short-wave program was received and retransmitted in Johannesburg, South Africa, by a newspaper there—the *Johannesburg Star*—and a few weeks later, January 25, 1925, we transmitted a program to Australia. This transmission marked the ultimate in distance transmission since it was half-way around the world. Two days later, our short-wave programs were received and rebroadcast in Melbourne, Australia, completing the record of our achievement. In every event so listed, the event marked the first time in history that such an achievement had been accomplished. The records show that KDKA's short-wave transmissions have been heard in every part of the world.

FAR NORTH BROADCASTS

One important phase of the Westinghouse company's broadcasting activities has been its so-called Far North broadcasts, initiated through the foresight of Mr. George A. Wendt, of the Canadian Westinghouse Company, Limited. These programs now consist of a most fascinating list of letters from employees, relatives, and friends of that band of adventurous folk whose lives are spent in small habitations, for the most part, above the Arctic Circle. The activities that resulted in the Far North broadcasts began in the summer of 1923, when a number of receivers were distributed by the Canadian Westinghouse Company to the Far North posts of the Royal Canadian Mounted Police. Because of these receiving sets we were enabled to transmit messages to them, at first by KDKA, then later by means of short-wave transmitters of the other Westinghouse stations. As season after season of transmitting has been conducted, more and more of the companies operating posts in the North of Canada have supplied receiving sets to their representatives.

Among the organizations which have so equipped their posts are the Royal Canadian Mounted Police, the Hudson's Bay Company, the Revillon Frères, the Oblate Fathers, and others. To this host of listeners, the Westinghouse stations each winter send a series of messages, most of which are of unique importance to those living out of reach of all civilization save that which comes to them from the ether. We have sent messages that have saved lives, have rearranged winter plans, have caused heartache or happy reunion—all over that great area starting from Greenland in the east, thence over the coast of Labrador and all the way across Northern Canada. These Far North broadcasts are among the most important things that broadcasting has ever accomplished.

The radio messages sent into the Far North were often the only communication those people had with the world for six months; often it took many months for the acknowledgments to reach us.

THE PIONEER IN SYNCHRONIZING

Again, in later years, another pioneering step was taken. I refer to synchronizing. We were operating Station WBZ at Springfield, and another station, WBZA, at Boston. WBZA was necessary because the Springfield Station, WBZ, could not be heard in certain sections of the Boston territory. WBZA, a small relay station, was installed in Boston to overcome this difficulty. At first it was operated on a different wave length from WBZ, but it was realized that if these two stations could be synchronized and the program transmitted on a common wave length from both stations, a much better distribution of the broadcast would be possible; to the listener, of course, it would be as one station.

After some months of experimental work and development, this was accomplished, and now for a considerable time these two stations have been run in synchronism with much more general satisfaction to the program listener.

FREQUENCY MODULATION

Another pioneering step occurred at East Pittsburgh, where KDKA had been operating for some time with a different type of modulation called "frequency modulation," by means of which we are able to eliminate three-quarters of the number of transmitting tubes that are required in the ordinary manner of transmitting. Further, the wave band is greatly sharpened and eliminates side band interference. Much is expected from this innovation later.

HUGE SIZE OF THE RADIO INDUSTRY

The business of the radio industry in 1920 did not amount to more than $2,000,000 for the year. In 1927, this had grown to an annual business approximating $500,000,000—all due to broadcasting.

Broadcasting, therefore, means everything to the industry since there would be nothing without it. Broadcasting itself would be nothing without the listeners, of which it is now estimated there are 40,000,000. The problem of the broadcasters, therefore, is to constantly strive to hold and increase the interest of the listening public. Nothing could be more useless than a broadcasting station without listeners, or a receiving set without a broadcasting station.

In the year prior to the appointment of the Federal Radio Commission the entire industry was threatened with destruction by the chaotic condition existing in broadcasting. Happily the Commission was appointed in time, and through its efforts very great improvements have been instituted.

Broadcasting, however, is still an infant. Much remains to be done in the way of research and development. This, I think, is quite evident from the facts which I have recited of the step by step pioneering and epochal steps taken at KDKA. Work of this nature requires the highest kind of engineering and research skill. It requires expensive and extensive facilities and the expenditures of large sums of money. There are, therefore, only a few organizations in the world that are in a position to undertake work of this kind.

START OF NATIONAL BROADCASTING COMPANY

Mr. Owen D. Young, chairman of the Board of Directors of the Radio Corporation of America to whose foresight and wonderful organizing ability is due much of the present development in the radio field, realizing this condition, proposed a plan of cooperation between the Radio Corporation of America, the General Electric Company, and the Westinghouse Electric and Manufacturing Company whereby this important field of broadcasting could be organized and developed. This resulted in the formation of the National Broadcasting Company, an organization to devote its whole effort to the building up and developing of the broadcasting service through improved methods and programs, and to furnish a service throughout the country to properly located and selected stations in a manner similar to the service furnished to newspapers by the various press associations.

Nothing, in my opinion, could be more fortunate for radio's future than this. The participation of these important electrical organizations in the work of the National Broadcasting Company guarantees to it adequate financial strength and permits an organization and equipment to be provided that will be capable of coordinating and presenting program material of the highest order, backed by the vast technical resources of these large companies. Certainly this guarantees to the listening public that broadcasting is now on a firm and lasting basis, and that it will become increasingly better as time goes on.

A NATIONAL SERVICE

As the name implies, the National Broadcasting Company is a national service. It is not limited to east or west, north or south. It covers the entire nation through several networks and groups and individual stations. Its programs, therefore, have the widest possible appeal to all classes, localities, and interests. This organization has, in fact, been charged with the stewardship of national entertainment and enlightenment—the greatest task ever assigned to any commercial enterprise.

Mr. Young further indicated the high purpose he had in mind in the organization of the National Broadcasting Company and guaranteed its good faith to the public by inviting eighteen recognized leaders in public life in this country to serve as an advisory council. This was done so that the National Broadcasting Company might have the guidance of men and women prominent in all phases of public life, and it is believed that from their advice will come the highest utilitarian development of this wonderful service.

Improvement and expansion in program offerings and in program technique, under the able leadership of Mr.

Merlin Hall Aylesworth and his staff, have been very marked since the formation of the National Broadcasting Company.

No history of broadcasting can be complete without reference to Mr. David Sarnoff, vice president and general manager of the Radio Corporation of America, an early pioneer, whose fine judgment, clear vision and high executive ability have made him the guiding genius of the entire radio industry. Many times in our early days have we gone to him with our problem and have never failed to be encouraged by his unbounded confidence and enthusiasm, and sound advice.

WHO IS TO PAY?

From the very beginning the question of "who is to pay" has been constantly raised, and one plan after another has been proposed and abandoned.

I can truthfully say that I have never felt concerned about this point, firm in my belief from the beginning that this service was so necessary in our daily lives that ways would develop to make it self-supporting. Its advertising value has always been recognized, and I have felt from the beginning that sooner or later this would be realized and would be the answer to the question.

It is a distinctive and encompassing medium. It is the greatest and most intimate contact that has ever appeared, and is wholly personal in its appeal. It has now become the key to millions of homes, and the individual or firm that can bring the subject of its activities in an adroit and satisfying way to the listening millions is employing a means for great commercial possibilities in the disposal of its product, and can justify the expediture of large sums of money in its development.

OTHER FORMS OF AMUSEMENT SAFE

It is apparent, therefore, that so far as this advertising appeal can be effectively developed we need not worry about the source from which the money to pay will come. In the industrial development of this age, as one innovation succeeds another, there always arises the spectre of obsolescence, but its baneful influence extends only to those industries or organizations that have become sterile and impotent. If they have the energy and ability to accept the new and to reconstruct the old, the combination means new life and development in general.

I see no danger to other sources of amusement and entertainment in the development of radio except to those that are decadent enough to deserve death, but radio certainly will be a stimulant for what is novel and new and better, and will educate people in that direction and stimulate their interest and desire for the better things of life. So far as amusement and entertainment cater to those desires and instincts, they have nothing to fear and everything to gain from radio.

WHAT OF THE FUTURE?

But what of the future? Great innovations come in-frequently, but often unexpectedly. No one ten years ago would have envisaged the actualities of today, yet we, who are closest to it, may presume to predict that in spite of the great developments to date the ground has scarcely been scratched, and that even more wonderful advances and possibilities are near at hand. Radio vision, whereby we shall see as well as hear by radio, is an accomplished fact. No more visionary than some of the actualities of today were a dozen years ago, is the possibility of the transmission of power by radio.

We who are now active may have to leave much of these future developments to others; still we can feel content, ourselves, to have been pioneers whose dreams and struggles have borne the cherished fruits of successful accomplishment —usually a sufficient reward, but in this instance many times amplified when we contemplate the greatness of the service and industry that has developed from the modest beginning I have so inadequately recited to you today.

VIII

THE NATIONAL MAGAZINE OF THE AIR

THE PROBLEMS OF NATIONAL BROADCASTING AND HOW THEY HAVE BEEN SOLVED IN SPONSORED AND SUSTAINING PROGRAMS

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THE STORY of broadcasting is the story of an experiment which became an art, and an art which became an industry. The transition from mere experiment to permanent institution was an astonishingly rapid one, and posed a question which demanded a supremely rational and intelligent solution: who shall pay for broadcasting? In answering this question, we have uncovered not only the economic solution of the broadcasting problem, but also a new and virile force in public relations, and a potent medium of supplementary advertising which offers untold possibilities to the industrialist of today and tomorrow. A new day, indeed, is dawning in the realms of commerce, industry, and national affairs.

Before we discuss present-day broadcasting activities and their import, however, we must turn in retrospect to the obscure beginnings of the broadcasting art, in order that we may be in a better position to appreciate and appraise what has been done.

Radio telephony, originally developed for private, point-to-point communication, proved itself a glorified party-line. Everyone who wished to listen in could do so. Furthermore, because of the common medium employed, it was soon found that there was room for only a very limited number of communication channels. Fantastic pocket radio telephones for every man, woman, and child existed only in the nimble minds of the unscrupulous promoters who exploited them. Gullible persons who eagerly embraced them as a means of doing away with the trouble and the cost of the time-honored wire telephone were speedily disillusioned.

Prior to 1920, various amateurs had undertaken experiments in the field of wireless telephone transmission. Among these was Dr. Frank Conrad, an engineer of the Westinghouse Electric and Manufacturing Company, of East Pittsburgh. Conrad, while experimenting with a wireless telephone transmitter installed in a garage in the rear of his home, sent out crude programs featuring phonograph records in addition to the usual voice transmission. His impromptu concerts covered a wide range and were enthusiastically received by the mere handful of persons equipped with radio receivers, whose main function, up to this time, had been the interception of the dot-dash messages of radio telegraph traffic.

Mr. H. P. Davis, the vice president of the Westinghouse organization, who was watching these experiments, sensed the enormous possibilities of this medium for mass communication and public service, and inaugurated a regular broadcasting service by a radio telephone transmitter installed at the Westinghouse plant. Thus came into existence that station which has become famous as KDKA, "the pioneer Broadcasting Station of the World." The new idea was first introduced to an amazed public with the broadcasting of the Presidential election returns of 1920.

To indulge in a statistical survey of the rapid growth of broadcasting would be mere reiteration. Suffice it to say that KDKA was followed by other broadcasting stations which sprang up like the proverbial mushrooms in our various centers of population. Newspapers, manufacturing concerns, retail organizations, universities, municipalities, state governments, and even private individuals, thrilled at the prospect of making an entrance into countless thousands of homes, rushed pell-mell into the new enterprise. There was no lack of program material, and microphones throughout the country were daily fed on an endless stream of talks, phonograph and automatic piano music, selections by amateur vocalists and musicians, and abstracts from books and newspapers. The mere novelty of hearing words or music come through the air and into the four walls of the home was sufficient to justify any program feature.

And so broadcasting, like Topsy, just "growed" in a rambling, aimless way. It was merely an experiment, and little thought was given to its future or to the problems which it might entail.

But the inexorable laws of economics soon brought themselves to bear upon the situation. The radio audience which, in 1922, was a scant 100,000, had increased to several millions by 1924. And with increased size had come discrimination. Having outgrown the pristine thrill which always attaches itself to the novel, the audience became blasé and insisted on genuine entertainment. It was no longer willing to waste its time and power on amateur talent, but came to expect of the broadcasting station the same quality and perfection of entertainment which the stage and screen were wont to furnish. Then, too, the financial perquisites of broadcasting were growing by leaps and bounds, with no direct and adequate financial returns in sight. Foreign countries, in their solution of the economic problem of broadcasting, had shifted the burden to the listener-in, requiring him to pay a license fee. But the United States, having started to give broadcasting service away free, could not logically begin charging for it. Thus broadcasting, as practiced in this country, achieved a distinction unique in the annals of the world's history—it gave something for nothing.

Nevertheless, the number of active broadcasters continued to increase. Mere imitation proved to be a potent factor in overcrowding the field, and the number of broadcasters on the air rose from a meager handful in 1922 to a high-water mark of 722 in 1927. Congestion and chaos menaced the nascent art, since the ether could accommodate but a limited number of broadcast programs at one time.

The radio public of this country owes a sincere debt of gratitude to the American Telephone and Telegraph Company. To this organization must go the credit for the organization of network broadcasting to a group of radio stations through the use of wire facilities equipped for the purpose. The Western Electric Company, in its capacity as one of the foremost producers of radio telephone transmitting apparatus, found itself in receipt of many requests for equipment from those desiring to broadcast. As a matter of fact, in 1922, over 100 such requests were received from New York City alone. It seemed that those who felt themselves "called" were, like the sons of Abraham, "numberless as the sands of the sea and the stars in the firmament." The fact that the "air" was already crowded to overflowing did not discourage these zealous crusaders in the least. The American Telephone and Telegraph Company, through its close affiliation with the Western Electric Company, was in a position to sense the growing demand for broadcast transmitting facilities.

Accordingly, as a means of presenting the situation in its true light, the American Telephone and Telegraph Company approached the individuals and groups who were clamoring for a place on the air, and in a friendly way, put the following questions to them:

1. Do you really appreciate the cost of broadcasting? Considerable though the initial cost may be, it is but the first item in a geometrically increasing series of expenditures.

2. Do you actually need a broadcasting transmitter? Have you a real message to convey? Analyzed in the cold light of reason, your desires are perhaps intangible and unsound.

3. Do you realize the congestion which even now obtains? Have you ever considered how much greater this would become if restriction were thrown to the winds? Submerge your own plans, for the nonce, in a consideration of broadcasting as a whole.

But the American Telephone and Telegraph Company did not content itself with a mere academic presentation of the problem confronting broadcasters. It went a step further and offered broadcasting facilities to those who, undaunted by a clearer realization of the magnitude of the enterprise into which they had wished to rush blindly, were still desirous of utilizing this new medium of mass communication.

The broadcasting and publishing fields present a parallel altogether too striking to be ignored. Both the director of a broadcasting studio and the publisher of a national magazine are faced with a problem which is basically the same, although its denouement is, of course, totally different. The problem is one which Walter Lippman has aptly called the "enlistment of interest." In order that he may sell his magazine to as wide a public as possible, the editor must see to it that his editorial content, or text matter, is of high quality and wide appeal. It is on this, and this alone, that his circulation depends. When he has achieved in this way extensive "coverage," then he is in a position to sell space in his publication to such individuals and corporations as have a message which they wish to bring before the public. In other words, he is in a position to sell advertising space.

Now the broadcaster is in a similar situation. It is only when, through the intrinsic excellence of his programs, he has built up a clientele, or radio audience, that he can sell his "space," which happens to be time, to those who wish to come before the public with a message, a product, or an idea.

Station WEAF, in New York City, establishing at the very outset of its career a high form of efficiency and artistry in its programs, commanded a far greater audience than any new station could possibly aspire to. And now, "space" or time on the WEAF programs, which had become a national institution, was being offered to those who had expressed a desire to engage in broadcasting on their own account. Thus the idea of toll broadcasting came into being, marking a definite step forward in the economic solution of the problem. Facilities for broadcast transmission, and more important still, an assured audience, were now made available for those who wished to utilize them.

The first commercial feature undertaken by WEAF took the form of a ten-minute talk under the auspices of the Queensborough Corporation, a reality organization interested in the development of Jackson Heights in Long Island City. Talks at that time still bulked large in the radio program, for the listeners had not reached the degree of sophistication where they fought shy of them in favor of musical programs. It soon became painfully apparent, however, that these talks, unless they were on subjects of absorbing interest, were poor broadcast material. Accordingly, good music, sponsored by the organization seeking good will and recognition, came into vogue as part of the *modus operandi* of toll broadcasting.

Among the first advertisers to recognize this salient fact was Browning, King and Company, a well-known clothing house of New York City. It introduced the sponsored musical program, and listeners soon grew accustomed to hearing their announcer say: "You will now have an hour of dance music by the Browning, King Orchestra, coming to you through the courtesy of Browning, King and Company of New York City." The Lucky Strike Orchestra, sponsored by the makers of Lucky Strike cigarettes, was another pioneer in this type of program designed to establish good will and featuring the ultra-conservative "courtesy" announcement permitted by the stringent broadcast policy of the telephone company.

All this early toll broadcasting was handled exclusively through Station WEAF. It soon became apparent, however, that the nation-wide organizations which had taken up this new medium for catching the public ear were desirous of reaching, not only listeners within the range of the New York City station, but those in other metropolitan areas as well. It was natural that the American Telephone and Telegraph Company, equipped as it was with the requisite telephone line facilities for linking scattered stations, should introduce network broadcasting when the demands of the advertisers warranted it. This was done in due course of time, with a two-fold object in view: First, to make the program features in New York City, the amusement center of the nations, available to stations in other and less favorably situated communities; and second, to secure for the toll broadcasters a greater "coverage" or radio audience.

The network broadcasting system of the American Telephone and Telegraph Company, with WEAF for its key station, enjoyed a remarkable growth. Soon it covered New England; then it reached southward into Philadelphia and Washington, and west through Buffalo, Pittsburgh, Cleveland, Detroit, Cincinnati, Chicago, St. Louis, Davenport, Minneapolis, and Kansas City. This group, at the time the National Broadcasting Company purchased WEAF and assumed the management and operation of the existing network, comprised approximately 3,600 circuit miles of special telephone lines, with Boston, Hartford, Providence, Worcester, Philadelphia, and Washington linked by permanent wire facilities, while the remainder of the stations were on a temporary wire basis.

The first feature handled on a national basis was the Victor program on New Year's Night of 1925. So many stations had requested this program that all the permanent and many of the temporary stations were linked together for the occasion.

The American Telephone and Telegraph Company had now proved to its satisfaction that network broadcasting was feasible from a scientific standpoint and decided to retire from the field of radio broadcasting. The telephone company then sold WEAF to the Radio Corporation of America and made a non-exclusive contract with the Radio Corporation for the leasing of permanent telephone wires for national service.

Late in the year 1926, the National Broadcasting Company was organized by the General Electric Company, the Westinghouse Electric and Manufacturing Company, and the Radio Corporation of America. The new company purchased Station WEAF, which, incidentally, is the only broadcasting stationed owned by the National Broadcasting Company today. The company also purchased from the Radio Corporation of America its rights for broadcasting and leased radio telephone lines.

Early in 1927, the National Broadcasting Company assumed the management and operation of stations WJZ in New York City and WRC in Washington, both of the Radio Corporation of America, together with a considerable network which had been built up by that organization in collaboration with its associates, the General Electric Company and the Westinghouse company. With WJZ as the key station, this group became known as the Blue Network, offering an alternative program in virtually the same territory as the Red Network. Still later came the more complete development of the Red and Blue networks, as well as supplementary networks available for use with either. This was followed by the formation of the Pacific Coast network, with seven leading stations receiving service from San Francisco. In this manner, the National Broadcasting Company outgrew its early sectional limitations and became a national organization in the fullest sense of the term.

One of the first problems recognized by the young organization was the crying need of a more definite and specific broadcast appeal. The National Broadcasting Company was established with the twofold purpose of sustaining interest in broadcasting and of insuring the permanence of the infant radio industry. It was keenly alive to its responsibilities to the American public, which had invested millions in radio equipment, believing broadcasting to be a permanent institution. It had to evolve an industry out of the nascent broadcasting art, which, in many respects was still an experiment. The economic phase of broadcasting continued to be a prime consideration.

The sponsored program has helped to solve the economic problem of broadcasting. It has developed broadcasting from an experiment to a legitimate branch of advertising and publicity whose manifold possibilities are capable of great development. The purchase of a magazine of national reputation brings to the buyer, at a ridiculously low cost, the writings of the leading authors and the illustrations of the leading artists. And the reason for it all lies in the generous support of the national advertiser.

We who are in a position to know, feel that it can do these things for the sponsor:

1. It can create a *consumer acceptance* of the product and a better appreciation of the manufacturer. The quality of the product can be suggested by the quality of the program, and good will, hitherto the great desideratum of the broadcast appeal, can still be retained.

2. It can increase *dealer cooperation.* Dealers are radio listeners just as much as are customers. In fact, it has been shown that some dealers are more partial to this form of advertising than to any other. It is therefore in many cases most effective in securing the desired cooperation.

3. It can *increase the value of space advertising.* The broadcast feature, with its constant appeal, promotes a pseudo-friendship, idyllic in nature, between the listeners and certain perform-

ers whom they have come to associate with a definite company or product. The listener reads the printed advertising of these organizations with increased interest because he feels a sort of phantasmagoric contact between them and him.

Having determined what broadcasting *can* do for the sponsor, let us examine a still more pertinent proposition, to wit: *does* broadcasting really do what it is supposed to do?

The accurate analysis of so intangible, so impalpable a thing as a radio audience might seem, at first blush, a well-nigh impossible task. There are so many variables, so many things beyond the pale of normal existence. Yet we have succeeded in solving the problem and resolving it into understandable factors. Thousands of questionnaires, intimate contact with local newspapers, and statistical procedure applied to census figures, have given us a reasonably accurate cross section of the radio audience. The "blue sky" days, when the whole world was held temptingly before the dazzled eyes of the sponsor, have evanesced into thin air.

It is estimated that each broadcast receiver serves an average audience of five persons. In addition, a conservative estimate places the average reliable service range of each of our network broadcast stations at 100 miles. Again, there are approximately 7,000,000 receivers within the effective range of our Red, Blue, Pacific, and supplementary networks. Thus, the total audience available through our networks would be in excess of 30,000,000—*if* every receiver were tuned in on our program.

The fact is, however, that many other broadcasting stations are also trying to catch the ear of the listener. Making allowance for sets tuned to these other programs, sets not in use, sets out of order or in need of new tubes or batteries, we delete 75% of the grand total of 30,000,000 possible listeners, leaving us a residue of 7,500,000. These we claim as our reasonable minimum audience.

Continuing the analysis, it is essential that we know the *kind* of people we are reaching. Is the radio audience a sound market? Do the listeners, as a group, represent sufficient purchasing power to make it worth the sponsor's while to reach them?

In the first place, it must be obvious that the mere possession of a radio receiving set, averaging in price $75, bespeaks a willingness to spend money for luxuries, and when we learn that 45% of our radio audience own cars, 50% of them own their own homes, and 40% of them own pianos, we realize at once that the possession of a radio set has given us the means of picking out the better class of families in a community.

Nor can we overlook the editorial phase of broadcasting. Both broadcaster and publisher must face virtually the same problems. First is the creation of an editorial policy of maximum appeal to the public. Next, the securing of public response in the form of subscriptions. Third, the acceptance of the medium by industry and commerce seeking an outlet for their message.

The ideal daily broadcast program, like the ideal magazine, should be of sufficient variety to interest the largest possible number of people. Although the publisher cannot expect to make a magazine that pleases everybody, nevertheless he confidently expects to have at least one article in each issue which will meet with universal approval. Likewise the broadcaster must adapt his program to the widely divergent tastes of the radio audience. And so it has come to pass that this national magazine of the air has as its make-up news items, religious messages, services for discussion of public affairs, weather forecasts, sporting events, health talks, household hints, cooking recipes, art, bridge lessons, fashion talks, music, romance, fiction, light entertainment, and so on. In short, broadcasting has all the fundamental requirements of a great national medium.

It is often asked whether broadcast advertising can include enough copy to do a good selling job, thereby justifying the not inconsiderable expenditure it involves.

It is quite generally admitted that 85% of all sales are made because the public has a previous acquaintance with the product involved. The American public has accustomed itself to buying definite brands, products, reputation or prestige. Furthermore, an analysis of modern merchandising discloses that 85% of all goods sold owe their popularity to the prior creation of a desire in the public consciousness for the product. This desire ultimately blossoms forth in the form of actual purchase.

In the field of advertising, these conclusions have been quite fully substantiated in actual practice. Copy is being condensed, intensified, "high-powered," if you will. In the rush and whirl of modern life, advertising must tell its story as quickly, as concisely, and as intelligently as possible. Broadcast tempo, therefore, is quite in keeping with modern advertising trends.

Broadcast advertising is unique in that its advertising and editorial copy are combined in the sponsored program. The two are blended in a perfect union. Thus we speak of the Goodrich Hour, the Ever Ready Hour, the Clicquot Club Esquimaux, and the General Motors Party, tacitly and unconsciously coupling the editorial or program features which appeal to us with the advertising message they contain. Space advertising is totally different. The advertising copy appears in one place and the editorial matter in another. There is no mutual absorption of the two interests for undivided attention of the reader.

Broadcasting is a great coordinating factor. No comprehensive scheme of national advertising is complete without it. Broadcasting, basically indirect in nature, can never supply "reason why" copy. This is the province of space advertising, which must always form the basis of the campaign. But broadcasting can do much to stimulate interest in the product and to help to sell more completely the space copy appearing in newspapers and magazines. The present-day trend is towards the fullest cooperation between broadcast advertising and space copy, each emphasizing and complementing the other. Many broadcast advertisers are merchandising their programs with quite as much thoroughness and care as they merchandise their products or resell their magazine advertising in reprint form.

Broadcasting has been named "the fourth dimension of advertising" and is now a definitely established force in the advertising world. Today the advertiser and the advertising agency are investigating broadcasting just as critically as they investigate newspapers and magazines. Circulation, or "coverage," and type of audience are carefully checked with broadcast rates; program material is critically judged; the place of broadcast advertising in the campaign is determined in advance; and all the factors are cut to produce the most perfect design possible. Jobbers and dealers are appraised of broadcasting arrangements, just as they are notified of nation-wide advertising campaigns.

Broadcast advertising has made room for a type of advertising specialist—the "continuity" writer. These specialists make a study of program features that have the maximum appeal for a radio audience, and devise means of weaving the advertising motif into the warp and woof of entertainment. Their task is infinitely more complicated than that of the copy writer, since advertising and entertainment must each complement the other.

In conclusion, we present a statement touching the facilities of the National Broadcasting Company as of today.

The Red Network comprises some twenty permanent outlets (associated radio stations) connected by 3,370 miles of permanent lines.

The Blue Network has eleven permanent outlets, (associated radio stations) connected by 2,890 miles of permanent line.

The Pacific Coast Network includes six permanent outlets connected by 1,700 miles of permanent line.

The supplementary cities, available for either Red or Blue network programs, have three permanent outlets with 1,100 miles of line. The Southwestern Group has two permanent and two temporary outlets connected by 580 miles of permanent and 550 miles of temporary line. The Southeastern Group has four permanent outlets with 800 miles of wire and one temporary outlet with 250 miles of line. Stations at Jacksonville, Fort Worth, and Richmond are available as special additions and are connected respectively by 330, 40, and 150 miles of temporary line.

Thus we have forty-nine associated radio stations connected by radio telephone wires with a total mileage of the Red, Blue and Pacific Coast networks of 11,770, and 530 miles for special service to three additional stations.

This, briefly, is the story of the sponsored program. Broadcasting, seeking for a solution of the economic problems facing it as the "Magazine of the Air," has very naturally patterned after the publishing field, adopting its best and most acceptable methods of approach to the public, including the admission of the advertiser to this audience under proper regulation and through the sponsored program. We already have assurance that the American people, recognizing the basic principle that value received must be obtained for the value given, will continue their enthusiastic approval of the sponsored program. This answers the question "Who shall pay for the broadcasting of the future?" making possible still greater and more important developments, with satisfaction to all and with the burden of expense equitably distributed.

My address on the subject of sponsored broadcasting has necessarily held me to the business development of the National Broadcasting Company and to our relationship to fifty-two associated stations. Scattered throughout the United States, these associated radio stations are connected by the wires of our system.

With the exception of WEAF owned by the company, and WJZ and WRC managed by us, these radio stations are independently owned and operated. The service of the National Broadcasting Company and sixty or more national industrial institutions may well be compared to the Associated Press, the United Press, the International News Service, and to the city newspapers. These associated radio stations have the full power to accept or refuse the programs of the National Broadcasting Company or our national sponsors.

The Columbia Broadcasting Company, with sixteen associated stations, also occupies a field in sponsored broadcasting. Several hundred other radio stations operate in all parts of the United States. The listener may tune in on the programs of his choosing or listen not at all. A movement of the dial shuts out the objectionable program.

The new National Magazine of the Air, as I term the National Broadcasting Company, has its editorial section composed of religious talks and services, discussions of public affairs, fiction, plays, news, sporting events, symphony and so-called popular orchestras, vocal performers, and children's entertainment. Ninety-nine percent of the actual program time is unrelated to the message of the advertiser.

A public advisory council of prominent men and women assures fairness of policy on all matters of public interest.

Ever changing programs day and night; the end to isolation of remote places; a new interest for the shut-ins; great music, the universal language of the rich and poor of all races in the cities and on the countryside; a Sunday congregation numbering millions for great preachers —a new era in religion; the voice of the President of the United States in the homes of our people; great celebrations in honor of the heroes of the world during which the entire nation listens; Senators and Congressmen debating from Washington; the national conventions with the actual voices of the statesmen in action; all made radio broadcasting in the United States a new and constructive force for national understanding and steadily increasing literacy.

The aid and cooperation of the press has brought to every home advance information of the radio programs, with appropriate previews and reviews of the best in radio, encouraging and inspiring this new national voice to greater effort.

Radio broadcasting provides a great medium for religion, music, debate, drama, and information. Public opinion controls its destiny and guides the way to greater public service.

IX

THE DISTRIBUTION AND MERCHANDISING OF RADIO EQUIPMENT

J. L. Ray
General Sales Manager,
Radio Corporation of America

IT IS undoubtedly true that as the world grows older, the pace of civilization becomes more and more rapid. Our fund of empirical information gradually grows, and each time something new is discovered its development and exploitation is accomplished more rapidly. The radio industry is a good example of this truism. It is barely seven years old, and yet into this short period has been crowded an expansion which in all other industries has taken many times as long. The automobile and phonograph industry took over twenty years to reach the degree of acceptance the radio industry was able to reach in seven. This rapidity of development was made possible by the public demand which sprang into being almost fullformed, with a resultant acceleration of technical progress.

The foundation of the radio industry is, of course, broadcasting. The first regular broadcasting was started in November, 1920, when station KDKA, owned by the Westinghouse Electric and Manufacturing Company, at

East Pittsburgh, began sending nightly programs over the air. It was not until a year later, however, that the public came to the realization that there was music in the air and that it might be obtained for the taking.

Previous to this time there were only a few radio manufacturers, probably not more than half a dozen in all, whose products were component parts of radio receiving sets and low-power radio telegraph transmitters, and whose customers were the some 30,000 radio amateurs and experimenters located throughout the country. There was little merchandising needed in those days. Manufacturers sold to a consumer, or a jobber, or a dealer, or to whoever would send in an order for merchandise. Advertising was naturally directed at the small group of consumers available and appeared mostly in mail order coupon form in the few "radio fan" papers of that time.

Late in 1921 the picture was changing rapidly. On January 1, 1922, it is estimated that there were approximately 60,000 radio sets in use in the United States for listening to broadcasting. By the end of that year it is believed that the total had reached 1,500,000, approximately 75% of which were constructed by the public from component parts. The number of manufacturers had grown to about 1,500, most of whom were manufacturing parts which were assembled into radio sets by the consumers. True, many of these manufacturers had had some years of previous experience in the production of electrical supplies and therefore readily geared themselves to this new demand.

The manufacturers' original consumers, the amateurs and experimenters, helped a great deal in this expansion. They knew how to build radio sets from these parts and they taught their friends, and their friends taught other friends.

So much for the parts business. There was very little merchandising done in connection with it, and public demand for parts reached its peak probably in 1924.

Throughout 1922 and part of 1923 there was a wild scramble of all the jobbers and dealers in the country who were attempting to obtain agency appointments from the ever growing list of manufacturers. Nearly every retailer in the country who was not doing well in his regular business tried to sell radio. Plumbers, florist shops, drug stores, candy stores, blacksmith shops, and even undertakers, clamored for franchises. Most of them were accepted by one manufacturer or another.

This chaotic condition and uncontrolled expansion continued throughout 1924. During this period the seasonal cycle in the industry generally went this way: New models, embracing startling improvements and radical changes, were introduced in the summer or early fall. Encouraged by the initial enthusiasm of the trade, most of the manufacturers built too many sets. Sales dwindled through the late winter months, and spring generally brought about liquidation with radical downward revision of prices. One department store in New York sold in a few weeks, in the middle of summer in 1923, over 20,000 receiving sets at half the former price, and the public clamored for more. Until early 1925 the public bought anything and everything without much evidence of discrimination.

The prestige caused by fundamentally sound merchandising policies and constant national advertising of a few manufacturers now began to be felt. The public had had enough of over claims and under performance. No longer was it necessary to have an ambulance and a surgeon attend the liquidation sales of department stores. The roster of radio manufacturers became shorter. The industry was approaching stabilization.

Various methods of distribution are still used by different manufacturers. Selling through jobber to retailer has been used by the largest companies in the industry, such as Radio Corporation, Atwater Kent, Kolster, and Crosley. Direct manufacturer-to-dealer distribution has been employed by various concerns, such as Freshman and Stromberg-Carlson, while some few manufacturers have even set up their own retail stores to sell to the public.

It is our belief that good jobber distribution is best suited to the purpose. Radio is a seasonal business, the activity in which starts in the wholesale trade in August and in the retail trade in September, and runs through until March or April of the following year. There is, and possibly always will be, a noticeable slump in public buying from April until August. With electrical jobber distribution, the slack period in radio can be profitably employed by the jobber's salesmen in devoting themselves to electric fans and other summer season merchandise, as well as to the staple electrical lines with an all-season demand. Another important consideration in which the advantage lies with jobber distribution is the question of credit. National dealer distribution by a large manufacturer involves the keeping of thousands of accounts with small outlets, many of which have low or doubtful credit ratings, while on the other hand, jobber distribution involves, at the most, only a few hundred accounts with much larger and more stable concerns, and tends largely to eliminate credit risk from the business.

When dealer distribution is used, it is necessary for the manufacturer to maintain a much larger sales force and to carry this force through the quieter season of the year without adequate return. Direct distribution to the public presents to the radio manufacturer approximately the same problems he has to face with distribution direct to dealers, except that these problems are greatly intensified. It is interesting to note that no large radio manufacturer with national distribution has used the "direct to the public" method.

Viewing the question solely from the point of view of the data on hand and gauging it by the financial success of the manufacturers who have used the different methods of distribution, we must come to the conclusion that, up to the present, jobber distribution has been the most successful in the radio industry. The argument of jobber versus dealer distribution, however, is many years old and has been argued by leading economists, so I shall not go into it further at this point.

Perhaps a specific account of the method of distribution employed by the Radio Corporation of America in the development of its business will serve as an illustration for the purpose at hand.

In the rush of 1922 and 1923, the number of distributors selling our products was built up to about 200. These distributors all handled the two main divisions of merchandise sold by the Radio Corporation of America, namely, sets and loud speakers and tubes, or as we say, Radiolas and Radiotrons. These 200 jobbers in turn sold to about 15,000 dealers. Complaints began to come in from many of our retailers that too many outlets were handling Radiolas. Fearing that in time this might drive some of the better Radio Corporation dealers to specialize in other makes which had more restricted distribution, the Radio Corporation of America took a step toward the reduction of the number of these retail accounts. In the summer of 1925 announcement was made to the effect that on January 1, 1926, the Radio Corporation would appoint certain dealers throughout the country as authorized dealers and that these dealers would be appointed on the basis of their performance during the latter part of 1925 on three counts, namely credit, volume, and service—credit sufficient to carry in stock a representative selection of the Radio Corporation's products, a volume of business commensurate with the normal trading area, and the equipment and personnel to install sets and service them after they were sold.

Careful records were kept of the purchases and sales of all our dealers for the last five months of 1925, and shortly after the first of January, 1926, approximately 8,000 dealers were appointed. This number has been gradually increased as local conditions demanded until we now have between 10,000 and 11,000 dealers selling Radiolas.

These dealers are appointed by the Radio Corporation of America, and a list of them in each trading area is sent to all the jobbers in that area, with the recommendation that they confine their sales to these authorized accounts. Under the law, of course, when we have sold our merchandise to a jobber, our title in that merchandise passes and we cannot control to whom the jobber sells or at what price he sells. However, we are free to recommend and suggest that our jobbers sell Radiolas only to these authorized dealers and endeavor to build them up as successful merchants, reflecting credit on our goods and assuring a proper attitude toward the service requirements of the public. Realizing that the policy is sound in the long run, our jobbers in general follow these suggestions.

It was feared that this step of reducing the number of Radiola outlets would create a great deal of ill will for the RCA on the part of the retailers removed from our list. It is interesting to note, however, that in the majority of cases the reason for our action was understood and very little ill will was encountered.

The problem of the distribution of our vacuum tubes was entirely different in its nature and was handled in another way. Primarily, tubes are a combination of convenience article and package goods. Realizing that the widest possible distribution of tubes would be the most profitable, we placed no suggested restriction upon the resale by jobbers. We expanded our tube jobber list from 200 to approximately 500 and urged these jobbers to sell tubes to practically anyone who would be willing to test them before sale. We have no exact list of number of retailers handling our tubes, but we estimate that our tube jobbers have more than 30,000 accounts.

We concluded about a year ago that tubes would lend themselves to sales treatment as branded package goods and we therefore changed our container for the tube from a plain package without display value to a decorative and highly colored box. We are now using pictures of the new package in our national advertising.

The question has been asked many times what type of retail dealer constitutes the best radio outlet. The question has never been answered and perhaps it is too broad and general ever to be answered fully. We do know, however, that the music and phonograph dealers constitute a very successful group. At first the music dealer was rather slow in taking on radio, but the phonograph business became so depressed in 1922 and 1923 that he was almost forced to take it on. Many of them, having had a considerable experience in the merchandising of comparatively high-priced articles, made a very profitable job of it both for themselves and the manufacturers. Practically every music house in the country now handles radio.

The electrical dealer and the electrical contractor-dealer together constitute the biggest group of radio retailers. They quite naturally came into the picture in the beginning of the industry when the installation of the radio set was an engineering job and when the maintenance of a radio set required the same type of experience. Their previous merchandising experience in selling washing machines, vacuum cleaners, and kindred articles has been an assistance to them in merchandising radio.

The automotive accessory dealer furnishes another comparatively large group of radio retailers. Many hardware dealers are important cogs in the industry.

The department store has played an important part, not only in keen and active merchandising of current products, but in assisting the manufacturer who, from time to time, has overproduced, in disposing of sets at reduced prices to the public.

I have been asked to give some statistics on the radio industry. Most figures are dry and apt to be uninteresting, but the tremendous growth of the radio industry reflected in the industry's statistics have always been fascinating to me. I am indebted to the McGraw-Hill Publishing Company for much of these data.

As I mentioned before, it is believed that there were approximately 60,000 sets in use on the first of January, 1922. These sets were serving an audience of approximately 75,000 people. It is now estimated that 7,500,000 homes are equipped with radio sets and that the listening audience has grown to nearly a third of the total population of the United States.

More than 100,000,000 vacuum tubes, for use in radio sets, have been purchased at a cost to the public of at least $224,000,000. There are now 1,200 manufacturers engaged in the construction of radio sets and radio parts. There are 1,100 wholesalers and distributors, and there are 28,000 dealers carrying a stock of sets and accessories.

In 1922 the public spent $60,000,000 for radio. In 1927 they spent approximately $446,000,000. Their total expenditures for the six years amount to $1,936,000,000.

I previously mentioned something about the rate of growth of the radio industry as compared to other industries. In three decades the phonograph industry of this country has equipped 13,000,000 homes with phonographs. After something over a quarter century of automobile history, there are slightly more than 19,000,000 passenger automobiles in use. In the 52 years since Alexander Graham Bell first spoke over a telephone circuit only a few miles from here, the number of subscriber stations connected to telephone exchanges in the United States has grown to a total of over 18,000,000. Contrasted with the rate of growth and approach toward saturation in these older industries, the performance of radio in reaching something over 7,500,000 homes in seven years doubtless reflects some degree of credit upon the merchandising methods employed, even if the profits retained to date in the industry have unfortunately been inadequate.

We believe, however, that the day of at least comparative stabilization is with us. The number of set manufacturers with more than a local market has dwindled down to about 30 or less. Integrity of product, consistent national advertising, careful selection of distribution, and the other elements of sound business policy have had their definite effects, and the public has responded accordingly. The future may perhaps bring a further slight decrease in the number of manufacturers, some perhaps through inability to make a net profit, and some perhaps by the ever present tendency in American industry toward consolidation.

It is true that the radio set does not wear out very rapidly and thus the more pessimistic may look forward to saturation. Let us look at some figures for a moment, however, and see what kind of saturation we might possibly have in the industry.

There are 27,850,000 homes in the United States. Let us be conservative and say that only 15,000,000 of these homes will ever own radio sets. Let us again be conservative and say that each one of these set owners will keep his set for ten years before he buys another one. This still leaves an annual business of 1,500,000 sets, which is approximately equal to the present rate of purchase by the public. Add to this the accessory business of tubes, loud speakers, batteries, and other equipment, and we have an industry of a half billion dollars a year.

Radio has passed the novelty stage and can be classed now as more than an amusement—it is an economic and an educational force. As such, it cannot help being one of the great and permanent industries of the country.

I would like to say just a word more about the merchandising methods of the future. There has been much talk, some thoughtful and some thoughtless, to the effect that the wholesaler is rapidly going out of the picture. Certainly, as the situation stands now, I do not concur in these thoughts. The distributor's position as local warehouse, local service station, and local salesman is important both to the manufacturer and to the retailer, and as far as we can see the question at this date, this time-tried method is economically sound.

The radio dealer of tomorrow will probably be faced with fewer service problems, but with more merchandising problems. His sales will be largely replacement sales. His merchandising tactics will approach the methods used in automotive retailing today.

As a whole, there should be more profit in the industry in the future than there has been in the past. More care in gauging production and more intensive merchandising should eliminate the necessity of the liquidations which have reduced the over-all profits of the industry to such an extent in the past.

There is a modernity about radio that has a peculiarly strong appeal to this age. Its speed in disseminating news is almost inconceivable. Its ultimate value as an instrumentality of entertainment to the masses is beyond estimate. The variety of its applications to the business and social life of modern man appears inexhaustible. I know of no industry other than radio that has taken its place among the leaders of the country in so short a space of time. And because the growth of radio has been sound, as well as phenomenal, I firmly believe that it will continue faithfully to serve the public in ways that no other agency can, and to gain the rewards which this service merits.

X

ADVERTISING RADIO TO THE AMERICAN PUBLIC

PIERRE BOUCHERON
Advertising Manager,
Radio Corporation of America

THE QUICK response to the appeal of radio has been due in large part to the fact that radio could bring to the home entertainment and information more quickly and economically than any other device known to mankind. Besides, there was the romantic appeal of being able to pluck all manner of music and speech out of the air. Here, indeed, was the modern Aladdin's lamp, the sheer magic of which readily caught the fancy of every man, woman, and child who first heard the strains of music and the voices of entertainers over the crude broadcasting stations of 1920 and 1921.

For these reasons, the radio industry did not face the problem of having to "sell" itself to a skeptical public. It did not have to engage initially in cooperative advertising and sales promotion campaigns that other less spectacular industries have had to employ in their pioneering periods. On the contrary, as soon as several thousand radio amateurs had shown their friends and neighbors that music could actually be gleaned from the

RADIO • DEPARTMENT

RADIO IN THE HOSPITALS

"HAVE YOU EVER BEEN ILL in a hospital?" asks Ward Seeley, in *The Wireless Age* (New York). He goes on to explain that he means just ill enough to be kept in your bed, not ill enough to be oblivious to your surroundings; and he recalls to your mind how bored and disgruntled you were, how slowly the hours passed, how you slept

possibilities, as it already has an annunciator system with loud speakers in all wards and corridors, for calling the doctors. Reuben O'Brien, superintendent, now has a regenerative set with two stages of audio frequency amplification, and the sum of $100 has been provided for the purchase of a loud speaker. This is to be placed in front of the main transmitter of the annunciator system, which thus will spread radio concerts, news

made in the new building for which the hospital recently secured funds. 'We want to do anything that will add to the patients' happiness,' said Dr. Savage, 'and radio will do it as nothing else can. I am very much in favor of it.' The hospital is located in the financial center of New York City, and its list of directors is an imposing one, including some internationally known names of prominent financiers. The expense of the radio equipment will be borne by the directors, who pledged their support after listening to a vigorous plea by Dr. Savage.

"Many of the Government hospitals in which are wounded and disabled veterans consider radio to be vital in improving the mental condition of their patients. The Fox Hills Hospital was one of the first to utilize radio, securing a Signal Corps set, and other hospitals in all parts of the country followed suit. The local posts of the American Legion in many cases raised the funds for the radio equipment. In El Paso, Tex., the Veterans of Foreign Wars only recently provided the William Beaumont Hospital there with receiving equipment.

"Probably there is but one handicap to radio from the doctor's point of view. That is the fact that the best and most interesting concerts are broadcast after eight o'clock at night. Several doctors told me that this was just the hour when they expected their patients to be settling for a long sleep.

"'Give us more concerts in the afternoon,' they pleaded, in substance. 'The phonograph records are fine, and they come over well, but the major interest is in the personal performances that take place in the evening. In many cases the effect on the patient is well worth an extra hour or so of sleep, but if that effect could be had in the afternoon instead of the evening it would be even greater.'"

PITTSBURGH'S BROADCASTING PIONEERS

AN ARTICLE in the *Radio Review* of the New York *Evening Mail* credits Mr. Harry Phillips Davis, vice-president of the Westinghouse Company, with being "the father of the present-day development of wireless, of the concerts on regular schedules, advance programs, the broadcasting of information of a thousand varieties, the marshalling of world-famed singers and artists behind the radio transmitters of great stations, and the consequent entertainment of millions of persons throughout the nation."

Mr. Davis has been associated with the engineering department of the Westinghouse Company since 1891, becoming manager of the department in 1908. Here is the account of the way in which he became interested in the broadcasting problem; and of the decisive action that led to the establishment of KDKA, at Pittsburgh, as the pioneer of present-day broadcasting stations:

"In September, 1920, radio was mainly the subject of scientific research and experiment. The devices and instruments necessary for transmitting and receiving wireless messages were not obtainable in the general market. There was practically no popular demand for them, and they were hard to obtain. Prior to the war interest in radio had been growing slowly, but the exigencies of the great struggle stifled it. But in September, 1920, Mr. Davis saw in a newspaper advertisement that Frank Conrad 'would send out phonograph records this evening' for amateurs. Mr. Davis envisioned then the future of radio.

"Mr. Davis pondered over the matter for several days. He saw that the true field of wireless for a long time to come would not be private communication, but broadcast communication, and the entertainment of hundreds, indeed, millions of persons all over the country. He saw that a station sending out entertainments, concerts, records of current events on regular schedules, was the key to the future. He believed that once such entertainment was broadcast, persons would demand 'ears' with which to hear it. He sent for Frank Conrad, who had been in charge of wireless experiments for the Government in Pittsburgh during the war. He succeeded in closing the Conrad station, and in November, 1920, put into operation, under direction of Mr. Conrad, the KDKA station at East Pittsburgh, as a broadcaster of programs of popular entertainment."

A BROADCASTING PIONEER.

Harry Phillips Davis, who saw in 1920 that the true field of wireless "would be broadcast communication and the entertainment of hundreds, indeed millions, of persons all over the country."

MEASURING INSTRUMENTS FOR THE RADIO AMATEUR

IN AN ARTICLE IN *QST* (Hartford), Mr. John H. Miller asserts that almost any amateur will find more interest in his work if he is able to measure the electrical quantity that he is using, and that the results will justify the use of instruments wherever possible. He especially cautions the novice to use care in handling the measuring instruments. They will stand a remarkable amount of rough handling, he declares, considering the delicacy of their construction, but if the best results are desired, the instruments should be treated with the same care and consideration that is given a fine clock or any other delicate piece of machinery.

Here are some practical points which, even if somewhat technical, should be of interest to every amateur who likes to have reasonably full knowledge of the apparatus he is using:

"It was recognized very early that when we wanted to measure current at a high frequency, ordinary electro magnetic instruments were practically valueless, since impedance became a determining factor in the readings and varied along with the frequency. Pure resistance necessarily had to be used if frequency variations were to be eliminated and about the only thing that a current in a pure resistance does is to heat it up. Heat then became a medium through which we could measure current of any frequency. Going further, we know that heat causes most metals to expand and this mechanical expansion we can cause to move an indicator over a scale graduated in amperes. Many ingenious methods have been used to magnify the slight expansion of the hot metal strip, but they are all essentially lever systems which increase the amount of motion until it is indicated on the scale of the instrument as amperes. This type of instrument has been highly developed by the Germans, and before the war practically all of the expansion type of hot wire meters were imported.

"A hot wire meter, while very valuable when nothing else was available, has a number of faults which we must recognize if we are to take such an instrument at its face value. It is frequently sluggish, and the pointer quite often refuses to return to zero, due to the permanent set of the expansion element. As the expansion element takes a permanent set and we return the pointer to zero by means of its adjustment, the ratios of the lever system are sometimes changed and we get a false reading when we again use it. The actual expansion of the metal strip is very small, usually only a few thousandths of an inch. In multiplying this expansion so that the pointer moves over several inches of scale we introduce a great many factors which are usually somewhat variable. The net result of these facts is that the expansion type of hot wire meter is liable to have glaring inaccuracies and to be unreliable.

"Another way in which we can utilize the heat-developed in a resistance wire to indicate amperes on a scale, is to attach a thermo-couple, formed of two dissimilar metals, to the heating wire and measure the thermo-electric voltage generated on a standard D'Arsonval type of meter. The instrument which measures the direct current thermo-electric voltage may then be calibrated to read amperes flowing through the heater wire itself. This type of instrument is now being manufactured by the majority of reputable American instrument manufacturers

Figure 1: The above pages, taken from the *Literary Digest*, are representative of the type of publicity given the radio industry during 1920,

skies, a demand was created for radio that taxed the facilities of those engaged in the production of equipment.

The newspapers, ever on the alert for service to their readers, soon began to take notice of this new toy of science. At first they carried news accounts of what radio was doing experimentally; how KDKA at Pittsburgh had broadcast the Harding election returns to several thousand earphone listeners; how a certain amateur had built a set in his home capable of receiving signals a thousand miles distant; or how an experimental station had broadcast for the first time in history part of an opera. The more progressive publishers, with an eye to circulation, conceived the weekly radio page or section devoted to detailed directions for building homemade receivers. Later, when broadcasting stations began to dot the nation, daily program schedules were published for the benefit of readers who had radio sets.

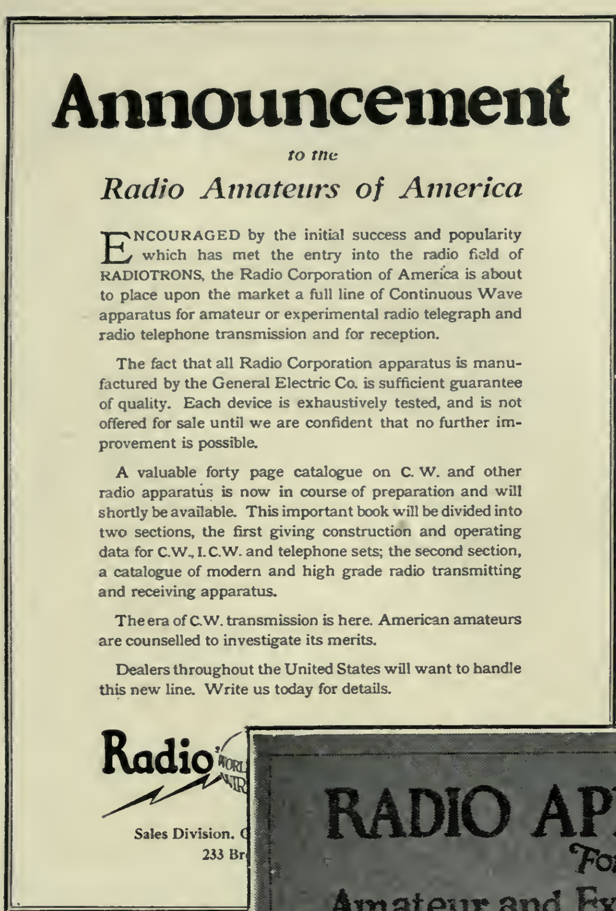
This popularizing of radio by the newspapers was further promoted by numerous monthly and weekly radio magazines of national circulation which devoted their entire editorial content to the development of radio circuits and apparatus and to directions for the building of homemade equipment. By 1924 there were nearly 30 such "fan" magazines in publication with a combined circulation of over one million copies. In addition to this, semiscientific, technical, and class periodicals of every description started radio sections also devoted to the construction of homemade apparatus.

Because of the rapidly accumulating publicity influence of newspapers and magazines, combined with the effective word of mouth advertising of the many thousands of enthusiasts who already owned sets and who, proudly, took pains to show them to the populace, it is easy to conceive how the overwhelming demand of 1922, 1923, 1924, and 1925 was created for radio apparatus.

Up to this point, radio had been a veritable bonanza. So eager were the public to purchase devices that would enable them to produce music from the air as if by magic that their demands far outran the production possibilities of the early manufacturers. As might well be imagined, this situation could not last in a country as "production-minded" as ours. The apparently insatiable radio market attracted thousands of manufacturers of all descriptions to convert at least a part of their production to the manufacture of radio devices. They sprang up like mushrooms, and for a time the public absorbed their outputs to an astounding degree because of the accumulated demand created by the first surge of the thousands who would have their radios quickly and at any price.

And so within a comparatively short time, this public demand for radio, which so recently had danced far ahead of production, beckoning manufacturers to produce, was overtaken and passed. Indeed, the accumulated momentum of these manufacturers carried them far beyond the danger signals, and many of them did not come to rest until they collided with the necessity for liquidation. Naturally, this hectic competition soon began to call for advertising and merchandising skill.

Let us at this point examine the story of this production race as it was reflected in current advertising.



Announcement

to the

Radio Amateurs of America

ENCOURAGED by the initial success and popularity which has met the entry into the radio field of RADIOTRONS, the Radio Corporation of America is about to place upon the market a full line of Continuous Wave apparatus for amateur or experimental radio telegraph and radio telephone transmission and for reception.

The fact that all Radio Corporation apparatus is manufactured by the General Electric Co. is sufficient guarantee of quality. Each device is exhaustively tested, and is not offered for sale until we are confident that no further improvement is possible.

A valuable forty page catalogue on C. W. and other radio apparatus is now in course of preparation and will shortly be available. This important book will be divided into two sections, the first giving construction and operating data for C.W., I.C.W. and telephone sets; the second section, a catalogue of modern and high grade radio transmitting and receiving apparatus.

The era of C.W. transmission is here. American amateurs are counselled to investigate its merits.

Dealers throughout the United States will want to handle this new line. Write us today for details.

Radio

Sales Division. C
233 Br

Figure 2: Example of first advertisements published in the "fan" magazines in 1921.

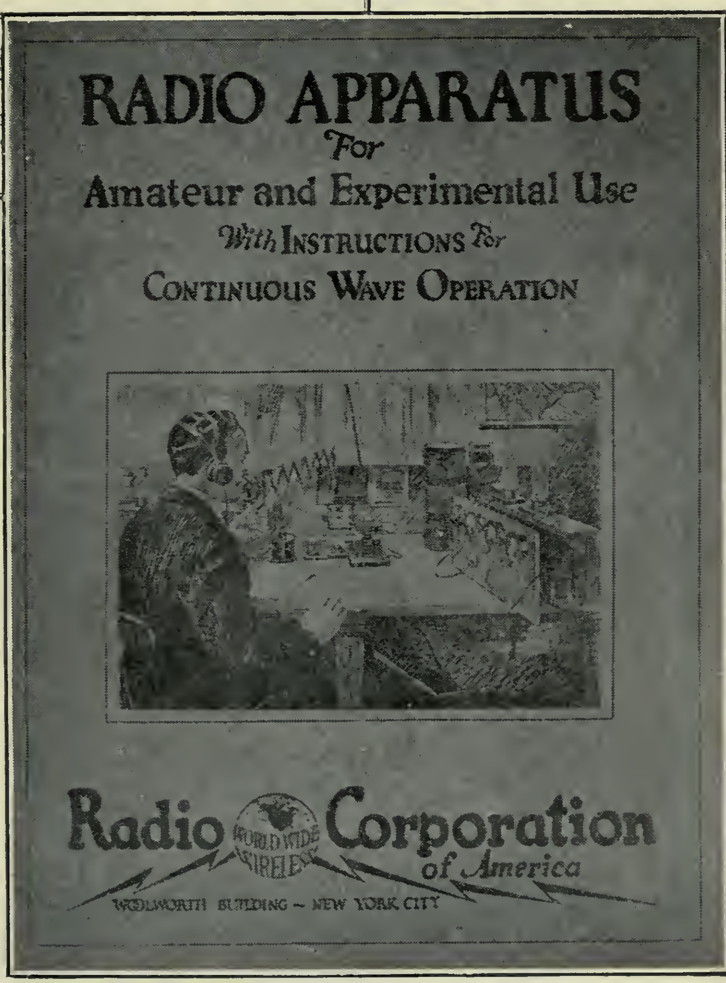


Figure 3: Instruction book and catalog distributed in 1921.

Figure 4: Testimonial advertisement in "fan" magazines featuring amateur radio telephone equipment.

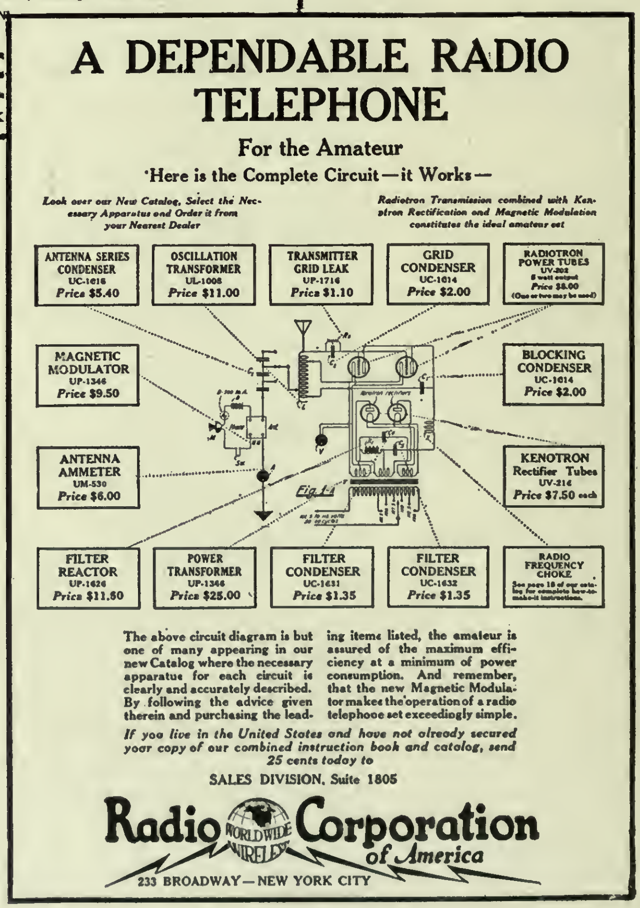


Figure 5: Another technical advertisement of the radio telephone published in 1921.

A critical study of magazine and newspaper advertising of radio equipment during 1924 and 1925 disclosed a mass of claims and counterclaims. Everyone was shouting "superior performance at a new low price." Manufacturers were naively telling the public through the medium of the printed word that their sets were the best, that they were revolutionary in principle, that they would outperform other sets on the market. Such advertising could have no effect on the buying public other than one of confusion.

How these problems were met and solved may well be traced by a résumé of the experiences of one of the pioneering leaders in the industry, the Radio Corporation of America, whose advertising and publicity activities date back to 1920.

The methods employed by the Radio Corporation of America were the same, fundamentally, as those employed by other large and successful merchandising organizations. Like other industries which have had to pioneer in a new field, radio advertising passed through five stages of development as follows:

1. Initial announcements to the public by means of newspaper releases and general publicity
2. Advertising and displaying early products to amateurs and experimenters
3. The use of "fan" and trade papers to secure trade support and dealer outlets
4. First attempts at national advertising to seek public acceptance; introduction of trade marks and names
5. Period of comparative stability and acceptance by industry of sound advertising practices, campaign procedure, and use of all forms of media

Best Radio Magazine Published by Any Newspaper

RADIO THE EVENING MAIL REVIEW AND HOME MECHANICS

SATURDAY, JULY 22, 1922 SECTION TWO

When Madame "Do-Re-Mi" Sings at WJZ

By RAYMOND FRANCIS YATES

Back-Stage Glimpses of Broadcasting

Engineer, Operator and Performers All Play Equal Parts.

Soundproof Rooms Check Distortion

Proper Voice Modulation Necessitates Special Apparatus.

THE EVENING MAIL RADIO REVIEW AND HOME MECHANICS

Plenty of "Pep" in Electrolytic Detector

Much in Use By Amateurs In Europe

Local Battery Must Be Connected In to Get Results.

By LLOYD JACQUET, I.R.E.

Signals Are Louder Than With Crystal

Platinum Point in Nitric Acid Takes Place of Cat-Whisker.

RADIO'S GREAT FUTURE

ROMEO—AND RADIO : : Pie Crust Unexcelled—As Armor Plate : : BY JAEGER

Figure 6: Example of newspaper section devoted entirely to radio during 1922.

Figure 7: Early advertisement in "fan" magazines featuring some of the first factory-built crystal receivers to the general public.

Stage number one in the publicising of the radio art and industry began late in 1920. At this time several amateur and experimental stations of low power began to broadcast at spasmodic intervals music and speech that immediately attracted the attention of several thousand amateur receiving stations, with resultant press notices in the newspapers. A signal incident of this nature was the broadcasting of President Harding's election returns on November 2, 1920. This was a major news event, and hundreds of editors were quick to catch the true meaning of radio as a disseminator of news of national import. The event was the forerunner of many others, especially in the field of sports, such as the broadcasting of prize fights, baseball scores, and races. Such publicity, as distinguished from pure advertising, shortly resulted in a keen interest and a demand for apparatus capable of receiving "air" programs. Thus the industry was quickly brought into the next stage, which was the advertising of the product.

Stage number two was initiated about the middle of 1921. The industry then advertised directly to the amateurs and experimenters rather than to the general public. Such advertising took form in two specific ways.

First, by means of advertisements of what would now be considered highly technical laboratory apparatus for both transmission and reception with such awe-inspiring names as kenotron rectifier, oscillation transformers, transmitting grid leaks, filter reactors, magnetic modulators, triode amplifiers, impedance audibility meters, shortwave regenerative receivers, crystal detectors, and

Figure 8: One of first advertisements of radio receivers to appear in national magazines during 1922.

so on. These advertisements were placed in the so-called fan magazines such as *QST*, *Radio News*, *Wireless Age*, and other contemporary periodicals catering to amateur radio telegraph and telephone experimenters.

Secondly, instruction booklets and catalogues of elaborate make-up with detailed and complete data on the building of radio transmitters and receivers for amateur and experimental use were issued in quantities running into hundreds of thousands of copies. These were distributed through the existing trade channels, but principally through the medium of fan magazine advertisements, which were keyed with coupons offering these valuable textbooks at prices ranging from 25 cents to $1, depending upon the size and scope of the book.

The primary purpose for charging the amateur these nominal sums was not one of profit but more to eliminate "free catalogue" seekers and juveniles of little or no purchasing power.

These instructional catalogues, which were prepared by highly trained commercial engineers, performed a most important function in the early days of radio merchandising by furnishing to an eager public much needed technical information on how to build and operate sending and receiving apparatus. The Radio Corporation of America performed this necessary service at that time because few if any manufacturers were prepared to supply the amateur, much less the general public, with ready-made and dependable equipment. Otherwise public interest might have waned and the progress of the radio art been retarded.

Meeting the Demand That Grew Overnight

April production of the Radio Corporation of America in vacuum tubes, used in radio transmitting and receiving sets, will reach 150,000.

The production schedule for May calls for a total delivery of 175,000 vacuum tubes.

Program will reach 200,000 a month or more in June, according to public and trade requirements.

CRYSTAL detectors served the purposes of the larger number of amateurs in the early days. The great demand for vacuum tubes is a development of the past six weeks, due entirely to the sudden popularity of broadcasting.

Although machines play a part in the major processes of manufacture, tubes are still largely made by hand. The hand work plays a far more important part in making vacuum tubes than in any other piece of electrical apparatus with which the public is familiar.

Manufacture of the delicate vacuum tubes used as detectors, transmitters and amplifiers, has been subject to the usual difficulties in bringing about quantity production.

During the first eleven months of 1921, the factories produced for the Radio Corporation of America an average of 5,000 tubes per month. This rate of production, small as it seems now, was gradually producing a surplus. Then, suddenly, in one or two territories, broadcasting jumped into popular favor over night. On December 30, the production schedule was increased to 40,000 tubes per month. In January of this year, the Radio Corporation of America pushed the schedule to 60,000 per month—a figure largely in excess of the demand at that time.

Setting the Production Pace

The present concerted demand, due to the further expansion of broadcasting, came early in February. On February 3, the factories were asked to do everything in their power to reach 75,000 vacuum tubes—to try to reach it during that month. They did their utmost. They came close to the production goal, and the following month, March, they not only reached 75,000, but bettered it by several thousand. April calls for 150,000, and May for 175,000.

In the event that no surplus results from the present expanded program, facilities will be further increased. It is easier to increase production now than it was four months ago, because it is easier to increase the size of a large and well trained organization than to build a new one. Technically trained forces are required in the factories, which are working with skill and energy. The factory forces are fully conscious of the present public interest in their work and their own important function in the program of the Radio Corporation of America — a program based upon the sound business policy of serving the public faithfully and intelligently.

The production program of the Radio Corporation of America is set higher than the existing demand during the month the orders are placed at the factories. It is frankly recognized, however, that one prospective purchaser may inquire at five stores, thus creating the impression that five sales would be made if the tubes were in stock, wherers only one would be made.

Radio Corporation of America
WORLD WIDE WIRELESS

Sales Department
233 Broadway, New York City

Figure 9: A newspaper advertisement frankly stating the facts of production to the public during 1922.

Thus it will be seen that the pioneer publicity efforts of the Radio Corporation of America were designed to develop a deep and lasting interest in the radio art; the sincere amateur and experimenter was given every opportunity and privilege of assembling the various patented parts and circuits produced by the company in the early stages of the art.

The accompanying illustrations show several examples of advertisements, catalogues, and instructional data published and distributed by the RCA during 1921 and 1922 which were instrumental in the rapid promotion of later developments.

Stage number three took form early in 1922 immediately after the effect of preliminary fan magazine advertising and booklet circularization had taken hold and the demand for radio products began to increase. Like the early advertising, our trade announcements were made in the fan magazines, which at that time were also functioning as trade papers. Shortly after this some of the accepted electrical trade papers such as *Electrical Merchandising* and *Electrical Record*, were also used.

The problem here was not one of seeking trade connections, for every conceivable type of distributor and dealer seemed intent on handling radio products, but for the most part was confined to special announcements and to the introduction of new apparatus and accessories as they issued from the factories. Next, a genuine attempt was made to seek the better type of dealer merchant and to interest him in the handling and proper servicing of radio. To this end, most trade paper advertisements incorporated specific copy asking the prospective dealer to "write for special proposition."

The illustrations shown here are typical of advertisements in fan and trade papers published during this stage. They feature radio apparatus to both the trade and the amateur.

Stage number four, which developed late in 1922 and early in 1923, marked a definite trend on the part of radio manufacturers to promote the sale of complete factory-built receivers and coincidentally to pursue known standards of advertising. Up to the end of 1922, few advertisers did much more than sporadic advertising in the fan papers of limited circulation. They advertised mostly parts to home set builders.

At this period it became obvious that the average readers of these radio magazines, who for the most part already owned radio sets, were no longer prime prospects for radio sets. Eyes turned toward the general public, and it was thereafter considered more advisable to adopt sales and advertising measures designed to capture the popular market among the 26 million American families. The Radio Coporation of America led the way in this trend and organized what was probably the first advertising campaign in national magazines, reaching millions of readers, among whom were many thousands of potential prospects for radio sets. This national campaign first took form in an October, 1922, issue of the *Saturday Evening Post.*

It was but logical that this advertising should be confined solely to complete radio sets. The first flush of the

RCA

To Protect The Dealer and The Public

A new trademark; a symbol of quality, has been adopted by the Radio Corporation of America. It appears at the top of this page, and soon it will be affixed to all Radiolas, Radiotrons and other products.

The new symbol is more than a trademark. It is the dealer's and the purchaser's guarantee that the apparatus to which it is applied is the result of research conducted by the foremost scientists and engineers; is the product of the most reliable and well equipped manufacturing organization in the country; and is marketed in accordance with methods approved by experienced business men.

Like the R C A apparatus still on sale, bearing the old symbol — the letters R C. in a circle — the newly marked R C A apparatus will embody the same high standard of quality and will be backed by the same protection which R C apparatus has enjoyed during the past.

The new monogram has been adopted to render apparent, instantly and unmistakably, the products of the Radio Corporation of America. Henceforth, this symbol R C A will appear on all apparatus and Radiolas — from the simplest crystal receiver to the Cabinet type. It testifies to the constant striving of the R C A organization — research engineers, factories and sales force — to produce and sell only the best, and to develop types of Radiolas which will keep pace with the advancement of broadcast reception and which will apply the new discoveries made in the R C A research laboratories.

Teaching the Public What R C A Means Through Advertising

The new symbol R C A will be widely advertised throughout the country. In an art which is so rapidly developing and which offers so many opportunities for the marketing of unreliable apparatus, it becomes more and more necessary to drive home the importance of the highest engineering and manufacturing standards. The symbol R C A is a guarantee that these standards have been insisted upon in the manufacture of Radiolas.

Write for Display Cards

R C A dealers will be supplied with R C A symbols for store display. By writing to us and stating whether a decalcomania window sign or a wall card is desired, we shall be glad to meet their wishes.

Radio Corporation of America

WORLD WIDE WIRELESS

Sales Department
233 Broadway,
New York, N. Y

District Office
10 South La Salle St.,
Chicago, Ill.

Figure 10: Announcing a new trade mark to the public during the latter part of 1922.

new industry has passed, and the public no longer had to resort to the assembly of parts as a means of assisting production in satisfying the early demands.

Stage number four may be said to have been kaleidoscopic in character. The years 1922 and 1923 were critical years for the radio industry, and the art of advertising was called upon to assist in meeting its rapidly changing conditions. First the problem was one of introducing the radio idea to the public. It has been shown how the press performed this task in a remarkably short time. But almost immediately the radio industry found itself in a greatly oversold market. The public clamored for radio apparatus of all types which demand could not be met by the existing production facilities of several hundred manufacturers. One of the advertisements illustrated in the accompanying pages, entitled "Meeting the Demand That Grew Overnight," shows how advertising was used to explain frankly the situation to the public in order to insure future consumer good-will.

By the end of 1923, so many mushroom manufacturers had entered the radio field that the seller's market turned into a buyer's market. The public began to discriminate in their purchases of radio. No longer did they buy simply because it was radio, but instead began to look for performance and the reputation of the maker.

Coincident with this new public consciousness, the Radio Corporation of America (as well as other companies) began to give thought to brand and prestige advertising by adopting a standard trade mark (the ini-

— the miracles of Radio within the farmer's reach —

Radio can serve the farmer today because it will bring to him

(a) Short resumés of the day's news.

(b) Crop reports, market reports, weather forecast, time signals, and other timely agricultural information, as well as agricultural extension courses.

(c) Speeches by prominent public officials, any variety of subjects of special thought to the farmer, religious services, lectures by the country's foremost scientists, doctors and politicians.

(d) Songs from world-famed singers who sing in person, musical recitals of the highest order, and occasionally, in some locations, complete plays and operas.

No expense has been spared by the Radio Corporation of America to carry the benefits of radio into the home. It was early realised that receiving sets for the home would end isolation—that the Nation would be brought closer together, that education, health, happiness and progress would be furthered. America's greatest scientific and engineering talent has been employed; research has become organised; expensive machinery set up and torn down, replaced at once by other machinery which experiment has proved more suitable; skilled men have been trained to meet this new, delicate and costly manufacturing problem. The result has been the development of the Radiola, the trade-marked product of the Radio Corporation of America.

• • •

In general it may be said that there are four classes of radio receiving apparatus, each one designed at a specific price and for a specific use. These are:

(1) The simple circuit crystal type Radiola which may cost from $25 to $40, and which may receive effectively from five to twenty-five miles, according to atmospheric conditions.

With the use of crystal detector apparatus reception is accomplished by means of head telephone receivers.

(2) This class of apparatus may be said to be practically the same as Class 1, except in this instance we depart from the simple detector to the Radiotron vacuum tube detector, with an improvement in receiving qualities. The cost in this instance may range from $65 to $75.

With this type it is also necessary to employ the head telephone receivers.

(3) In this class, much greater efficiency is obtained because one or two stages of vacuum tube amplification is employed. It will function quite well up to 100 miles, although under exceptional receiving conditions, as much as 1000 miles may be obtained, employing the head telephone receivers. The cost in this instance may range from $125 to $250.

It is also possible in this instance to employ a loud speaker and thus eliminate the head telephone receivers, *thereby permitting a roomful of people to enjoy radio.*

(4) This type of radio receiver is usually embodied in a complete cabinet, similar to that of the phonograph. All necessary instruments are enclosed in the cabinet and the tuning and adjusting devices are greatly simplified. In this class is the Radiola Grand, price $350.

• • •

All these sets are described in the general hand book of radio information, "Radio Enters The Home," price 35 cents. If you desire this book, the coupon is available for this order

The Radiola, which is the registered trade-marked product of the Radio Corporation of America, gives more at a smaller expense than any other known communication service now available to the farmer. It brings into the home at small cost many things which cannot be furnished by other means except at greater cost. It brings other things which cannot be brought by other means at any cost.

Radio Corporation of America

World Wide Wireless

233 Broadway, New York

MAIL THIS COUPON TODAY

RCA

This symbol of quality is your protection

Sales Department
RADIO CORPORATION OF AMERICA
233 Broadway, New York, N. Y.

I am enclosing 35c for the book "Radio Enters the Home."

Name..

Street Address........................ R.F.D...........

City.................................. State.............

— firmly to establish America's leadership in Radio —

WE want the farmers to know something about radio and the Radio Corporation of America. As a corporation formed at the suggestion of representatives of the United States Government, we feel a sense of responsibility to the public and are especially desirous that the farmers of the country correctly understand our policy, service and future hopes.

The war forcibly brought home the knowledge that foreign nations largely controlled the international communications of America. Nearly all cablegrams cleared through London. Even when there was more direct contact with other European points, the cables could be cut.

Several of the great scientific and engineering organizations of America had made progress in radio development work, but foreign interests were closely identified with the radio communications business even in America. These foreign interests, therefore, were the only ones in a position to buy the expensive apparatus developed in America.

Realising the effect of such a situation upon the future of this country, representatives of the Navy Department appealed to American interests to establish an American-owned, operated and controlled radio communications company, powerful enough to meet the competition of radio interests of other nations—to set up for America a world-wide wireless system that would give this country contact with the rest of the world, free from interruption or tampering.

The task required vast capital because powerful radio stations cost millions. In order to do the job for the Nation, corporations had to forget their rivalries and work together. The Radio Corporation of America was formed. In order that America might work as a unit in radio and present a single front to the rest of the world, the General Electric, Westinghouse, United Fruit, and American Telephone and Telegraph Companies, after long negotiations, exchanged patent rights and research facilities, so that the best apparatus could be developed for the Radio Corporation of America, quickly and free from pertinent patent restriction.

It is because of this generous cooperation that the Radio Corporation of America was able to acquire the patents which cleared the way for the building of a world-wide wireless system with powerful connecting stations in all parts of the world.

In achieving the major national purpose assigned to it, the Radio Corporation of America has developed an effective radiogram traffic between the United States and foreign countries; marine radio communication, including the erection, maintenance and operation of radio telegraph apparatus on American vessels, and the transmission of broadcasted concerts, information and other forms of intelligence, as well as the manufacture and distribution of home receiving sets, known today under the registered trade name of *Radiolas.*

In the continuance of this series of messages to the American farmer, the Radio Corporation of America will present, as simply as possible, the principles of radio, the manner in which wave lengths are used, and *the way in which the farmer can gain the most benefit from radio generally.*

The Radiola, which is the registered trade-marked product of the Radio Corporation of America, gives more at a smaller expense than any other known communication service now available to the farmer. It brings into the home at small cost many things which cannot be furnished by other means except at greater cost. It brings other things which cannot be brought by other means at any cost.

RCA

This symbol of quality is your protection

Radio Corporation of America

World Wide Wireless

233 Broadway, New York

MAIL THIS COUPON TODAY

Sales Department
RADIO CORPORATION OF AMERICA
233 Broadway, New York, N. Y.

Farm & Home Dec. 1922

I am enclosing 35c for the book "Radio Enters The Home."

Name..

Street Address........................ City...........

R. F. D.............................. State.............

Figure 11: Two advertisements of a series of six specially designed to reach the farmer and published in national farm magazines during 1922 and 1923.

tials RCA within a circle) and the trade names Radiola and Radiotron. The following excerpt is taken from one of the advertisements that announced the new trade mark to the public.

"TEACHING THE PUBLIC WHAT RCA MEANS THROUGH ADVERTISING

The new symbol RCA will be widely advertised throughout the country. In an art which is so rapidly developing and which offers so many opportunities for the marketing of unreliable apparatus, it becomes more and more necessary to drive home the importance of the highest engineering and manufacturing standards. The symbol RCA is a guarantee that these standards have been insisted upon in the manufacture of Radiolas."

The advertisements reproduced which appeared during 1922 and 1923 are typical of the procedure followed.

The fifth, or present, stage in the advertising of radio includes the period from 1924 to 1928. Although during this time changes have taken place in the type of appeal and although constant improvement has been made, advertising of radio products has now reached the stage of sound advertising practices as distinguished from the early claims and counterclaims of competing manufacturers. From the period in which the truth was frequently stretched to the breaking point, radio has entered the same stage of advertising and merchandising its products in which the older industries are to be found.

Not only has the industry reached the period of comparative stability, but its advertising is now in general keeping with established standards advocated by the Better Business Bureaus and other advisory bodies. No

When shall I buy a Radio Set?

SOME four million people in the United States decided, in the exciting three years that have just passed, that they would not wait. They bought radio receiving sets of different types and at different prices.

Look from the window of a railroad train, or bus, or trolley car, as you ride past city homes or farms, and you will see, again and again, the aerial symbol of the miracle that has become an American commonplace.

American homes have been knit closer together. Families that scattered each evening now make a circle around the radio set at home. Some of them bought their sets just before the Dempsey-Firpo fight; some before the three national political conventions were broadcasted; some just to hear the memorable speech of the President of the United States that closed his successful campaign for election.

Those who received the greatest return from their radio sets were those who delayed the shortest time in making up their minds that some sort of a radio receiving set was better than none at all.

•

No longer, as you count the aerials on the housetops, can you get even an approximate estimate of the number of radio sets in any neighborhood. The sensation of the past ten months has been the RADIOLA SUPER-HETERODYNE, which required no aerial or connection of any kind.

And the radio art has progressed to a point where the famous scientists of the Radio Corporation of America are willing to say that it is doubtful whether any basically better reception circuit is apt to come from the laboratories.

Fundamentally the SUPER-HETERODYNE marked the location of rock beneath the sand and gravel. It is the foundation on which future RADIOLAS will be built.

And there are other good Radiolas—Radiolas requiring aerials, but which bring the full miracle of radio into your home—selling for as low a price as $35, and the reputation and skill of RCA are behind them.

Not only the scientists and engineers of RCA itself, but the laboratories and factories of the General Electric Company, Westinghouse Electric & Manufacturing Company, and Wireless Specialty Apparatus Company, as well, are behind Radiolas and Radiotrons.

•

ONE of the foremost engineers of the Radio Corporation of America will shortly be in Europe arranging for the completion of details connected with the broadcasting in America of events from Paris, London and other world capitals.

International broadcasting, as a regular feature, is now merely a matter of months. The stride of broadcasting has been, and probably will continue to be, rapid.

Because of the responsibilities of its leadership, its identification with world-wide circuits of wireless telegraphic communication and the broadcasting service through WJZ, WJY, WRC, and associated stations KDKA, WBZ, KYW, KFKX, WGY, KOA and KGO, the Radio Corporation of America can give an assurance of stability, a guarantee of the permanence of radio and broadcasting hardly possible from any other source.

•

THE gates of what may be a wonderful summer for you are opening. Days that are lost in dullness are lost forever. Nothing will ever bring this summer back again. But the pleasure, the music, the laughter; the reports of stock markets, baseball and other events; the church services and educational features, that your Radiola will bring you at home, or in your seashore bungalow, or in camp on the mountain-top, may make this summer live forever in your memory.

And so we say *buy your Radiola now.*

All RADIOLAS, as well as RADIOTRONS, the trademarked vacuum tube of RCA, represent sound values, and insure complete enjoyment of radio's entertainment and educational advantages.

Provided the set is a genuine RADIOLA on which the name of the Radio Corporation of America appears, you run no risk of disappointment.

This is the third of three advertisements by the Radio Corporation of America. The first—"What Radio Set Shall I Buy?"—appeared in *The Saturday Evening Post* of May 23. The second—"Where Shall I Buy a Radio Set?"—appeared in the issue of May 30.

Write for the booklet "What, Where and When in Radio." Address RCA, 233 B'way, New York.

Figure 12: One of a series of three advertisements published in the newspapers of leading cities during 1924 designed to guide the public in the selection of dependable radio receivers.

longer do we see "revolutionary" announcements and claims that tend to disorganize the industry and make the public wonder what is coming next and cause it to stop buying in anticipation of something "bigger, better, and cheaper." No longer do we have wholesale liquidations by mushroom manufacturers of questionable products closing out at half cost prices. The industry has cleaned its own house, and the field is fairly clear to reputable manufacturers whose self-imposed responsibility is not only to produce a dependable product at a fair price, but also to furnish a broadcasting service to the listening public.

During the past four years the radio industry has more than repaid the newspapers of the nation for the wonderful reception they gave radio in the first stage of the art. It has repaid in the form of millions of dollars of advertising space. Today, practically every newspaper of any importance publishes a daily page with the broadcast program of the day and other radio news, flanked with a generous amount of paid advertising space from manufacturers and dealers. Some of the leading newspapers back this up with weekly radio sections which contain large-size advertisements from manufacturers that represent an aggregate of many millions of lines of additional revenue each year.

The use of newspapers as advertising mediums has been on a constant increase. National advertisers have found it advisable and indeed profitable to strengthen their national magazine schedules with seasonal newspaper space, particularly during the active selling period

Figure 13: Magazine advertisement of 1925 illustrative of the advertising technique adopted to create consumer acceptance for a name and a product.

of the year. The radio industry, like other seasoned industries, has found that no selling plan can endure long without the consistent use of generous newspaper space as well as magazine advertising.

Moreover, the radio industry has passed through a process of evolution in its advertising and merchandising activities very similar to the evolution of older industries, with the exception that this industry, because of its early growing pains, had to adapt itself more quickly to the use of existing known standards of advertising already in effect with older industries. We refer to such definite standards as:

1. The advertising agent and counselor, who provides a type of service to the national advertiser which is invaluable and not available from any other single source except at tremendous additional expense.

2. The ABC (Audit Bureau of Circulations), which may be said to be the yardstick of space measure, insuring circulation, prestige, and practices of both magazines and newspapers.

3. The research and merchandising facilities of not only the advertising agent but of the great newspapers and magazines of the country and of such organizations as the Association of National Advertisers, the American Association of Advertising Agencies, and the like.

Thus during the past four years the radio manufacturer has pursued campaign procedures that utilize every previously known advertising factor. For good measure it has added another, of its own creation, namely, broadcast space advertising.

A typical campaign and the reasons for the use of its elements may be set down here for the possible analysis of the student of modern business methods.

Figure 14: Special copy appeal and illustration employed in the boy magazines and published during 1925 and 1926.

THE RADIO CAMPAIGN

The success of an advertising campaign presupposes, first, that there is a market and public demand for a given product, second, that the prospective advertiser has produced such a product and that it is dependable and properly priced, and, third, that it is adequately distributed. These three factors are fundamental requirements of the successful radio campaign, as they are of the campaign for any other product.

As to the extent of the advertising budget, this is generally a flexible arrangement depending upon the problem at hand. The amount appropriated for the average radio advertising campaign has varied between three and six per cent of the manufacturer's yearly gross sales for all forms of advertising and sales promotion.

1. Use of Magazines

When radio set out to capture the general public, it found at its disposal an already established and powerful medium in the national magazines of the country. By judicious use of the leading weeklies and monthlies of both general and farm circulation, the Radio Corporation of America published its advertising messages each month of the year in about 10 million copies of various classes of magazines estimated to reach the best of the known 26 million families in the United States. There is no other force available with so powerful an advertising effect and at such an economical cost as the great magazine group of the country. Perhaps the greatest

Figure 15: Announcing a new authorized dealer plan of distributing radio receivers through the better type of merchant. This advertisement and similar ones appeared in national magazines and newspapers during the first part of 1926.

function of the magazine as an advertising medium is to create *consumer acceptance* for the product by constantly reminding and indelibly stamping in the memory of the prospective purchaser:

1. The name of the product
2. The shape, size and style
3. Its outstanding features and uses
4. The price.

This is called consumer acceptance because the advertiser does not necessarily expect *any one* advertisement to ring the dealer's cash register immediately it has been published, although that of course is the eventual result hoped for. What national magazine advertising on a year-round campaign basis expects to accomplish is the creating of consumer good will and familiarity with the product so that if and when Mr. Consumer is ready to consider replacing his old radio set or to buy a new one, he will have in mind and *ask by name* for the product that has most effectively stamped itself in his mind. Whether or not the prospect will actually buy that particular product depends on how well advertising has done its job and on how the retailer backs up the advertising message with selling facts and proper demonstration. These conditions take form in the following supplemental advertising factors.

2. Use of Newspapers

In the early stages of advertising radio products, it was soon found necessary to amplify the effect of magazine space by the use of newspapers especially in the

Figure 16: Introducing a new line of receivers to coincide with the opening of the New York radio show in the Fall of 1926.

key city markets such as New York, Chicago, Philadelphia, Detroit, and Boston. The newspapers furnish a medium flexible enough to permit important announcements and the introduction of new products almost overnight. The newspapers also permit radio manufacturers to tie in more closely with the advertising activities of retailers and thus furnish the *where-to-buy* link of the selling chain.

By taking frequent and large-size newspaper space the national advertiser encourages the retailer to run advertisements over his own name and address on the same product and in the same newspaper, especially during the most active selling period of the year. Thus while magazine advertising creates consumer acceptance, newspaper advertising creates consumer demand, although in other merchandising situations either medium may perform both functions. In a word, the newspapers bring to a successful conclusion the good work already started by the magazine. If the prospect is in the market for the product, newspaper advertising, first, reminds him of the product by name, second, associates the product with a timely event, such as the purchase of a radio set as a Christmas gift, or to receive a major sporting event, a star program, the President's address, or the like, and, third, gives him a dealer's name and address.

Again, the Radio Corporation of America was one of the first radio manufacturers to make use of the newspaper on an extensive national basis as an advertising medium. Starting first with a schedule covering a few of the principal cities on a once-a-month basis, it grad-

Let the wonderful Radiola 16 take you to the great National Conventions

YOU can sit in your living room, with a Radiola 16, and hear every word from the platforms and the floors of the big political conventions at Houston and Kansas City.

You will hear the nominating speeches and the cheers and uproar that will greet the names of the "favorite sons." You will hear the balloting by states, from Alabama to the Philippines. You will know the names of the successful candidates at the same instant they are announced in the convention halls.

Every day of the year a Radiola 16 keeps you in touch with the world.

RCA LOUDSPEAKER 100A. The leader in its class. Ideal to use with Radiola 16. You can tell it by its rich, mellow tone. $35

RCA RADIOLA 16. 6-tube, tuned radio frequency receiver. A big performer for a little price. Can be operated with storage batteries; or, by the addition of socket-power devices, with A. C. electric current. Equipped with Radiotrons. $82.75

RCA HOUR every Saturday night through these stations associated with National Broadcasting Company:

8 to 9 p. m. Eastern Time	8 to 9 p. m. Pacific Time	7 to 8 p. m. Central Time
WJZ WBAL WEEI WRC WTIC WHAM WJAR KDKA WTAG WLW WCSH WJR	KPO KGO KFI KHQ KGW KFOA-KOMO	KYW WDAF KSD WOW WCCO WHAS WOC WSM WHO WMC WSB

Buy with confidence Authorized Dealer RCA *where you see this sign.*

It brings the news of great events; crop, weather and market reports; the voices of famous singers and the music of great orchestras; opera and drama direct from the metropolitan stages—programs for which millions of dollars a year are spent.

Radiola 16 is one of the latest receiving sets developed in the research laboratories of General Electric, Westinghouse and the Radio Corporation of America. There are other Radiolas ranging up to $895, but none that gives more per dollar than the compact Radiola 16.

RADIO CORPORATION OF AMERICA

RCA Radiola

MADE BY · THE · MAKERS · OF · THE · RADIOTRON

NEW YORK · CHICAGO SAN FRANCISCO

Figure 17: Special art treatment and copy designed to appeal to the great farm sections of the country and published in the leading state farm papers during 1926, 1927 and 1928.

Figure 18: Recent advertisements in two colors published in the general magazines of large national circulation tying up the product with the major broadcast events of the day.

ually extended its list over a period of several years. To-day it employs nearly 200 newspapers in almost as many cities and carries an active campaign for all classes of its products every week during the major portion of the year. The weekly circulation is over 18,000,000 copies.

3. Use of Radio Broadcasting

The universality of radio as a disseminator of information and entertainment soon became apparent to the national advertiser and it is but natural that the radio industry turned to this great force as an advertising medium for its own products. The Radio Corporation of America, Atwater Kent, Philco, Eveready Batteries, Crosley, Balkite, and other radio manufacturers have sponsored radio programs with remarkable results in popularizing their trade names while at the same time furnishing a high class entertainment service to (1) purchasers of their products and (2) prospective purchasers.

Radio broadcasting as an advertising medium has become a valuable supplementary advertising force in creating and maintaining public good-will in the successful merchandising of radio products as well as of countless other nationally advertised products. Not only does it "sell" while it entertains, but, for the first time in advertising history, it supplements the printed message with the spoken work. Indeed, it may be said to duplicate, on an incredibly larger scale, the work of the original town crier, who heralded important announcements, news, and, on occasion, the merits of a given product, service, or individual.

Broadcasting as an advertising medium does not supplant nor does it encroach upon the fields of other mediums such as magazines, newspapers, or billboards. On the contrary, in many cases its use has resulted in substantial increases in the use of white space by the advertiser. Although it may seem apparent that the introduction of radio broadcasting in an advertising campaign must of necessity result either in an increased budget or in the diversion of advertising monies from other mediums, actually this is not proving to be the case. For experience proves that the more a national advertiser resorts to advertising in its various forms, whether visual or oral, the more is sales resistance reduced with consequent decrease in direct sales expense. In fact, in the merchandising of certain low unit cost products, advertising alone is called upon to do the entire selling job and at a much smaller cost than was the case when direct selling by the field force was relied upon to do most of the selling.

Unlike magazines and newspapers, no exact circulation figures are available in the use of broadcast advertising, but the National Broadcasting Company estimates that an average sponsored program over one of its national networks of 28 stations is heard by more than 10,000,000 listeners, and on occasion, depending upon the advance publicity given, may be heard by 30,000,000 listeners.

4. *The Use of Outdoor Advertising*

When a product has been extensively advertised to the public and has come into general use, as radio has,

Figure 19: Recent newspaper advertisement featuring the introduction of a new model. Dealers are urged to capitalize on these advertisements by inserting their own copy in the same newspapers.

Figure 20: A direct mail campaign produced by the manufacturer and sold the dealer at half cost for local circularization and stimulation of sales.

an advertiser may well consider the consistent use of outdoor billboards and posters. In our complex mode of living, no advertiser can afford to confine his advertising to one medium. It is important always to keep a name and a product constantly before a restless public. With the rapid increase in the use of the automobile, the average American family is apt to spend a great deal of time outdoors, especially during the summer season. Outdoor posters furnish an ideal medium to the national advertiser intent on "keeping everlastingly at it." Perhaps the greatest force of outdoor advertising is in its reminder effect so that he who runs may read, and as an effective tie-in to magazine, newspaper, and broadcast advertising.

Several prominent radio manufacturers have employed outdoor space on an extensive national scale, notably Atwater Kent and the Radio Corporation of America. No definite unit of circulation can be guaranteed the national advertiser as in the case of magazines and newspapers, but a so-called full showing in the leading cities of the country easily runs into many millions. The National Outdoor Advertising Bureau estimates that a half showing of about 4,000 locations in 30 key cities can be so placed with respect to main traffic arteries as to insure reading by a large majority of the cities' purchasing power.

5. *Use of Sales Promotional Helps*

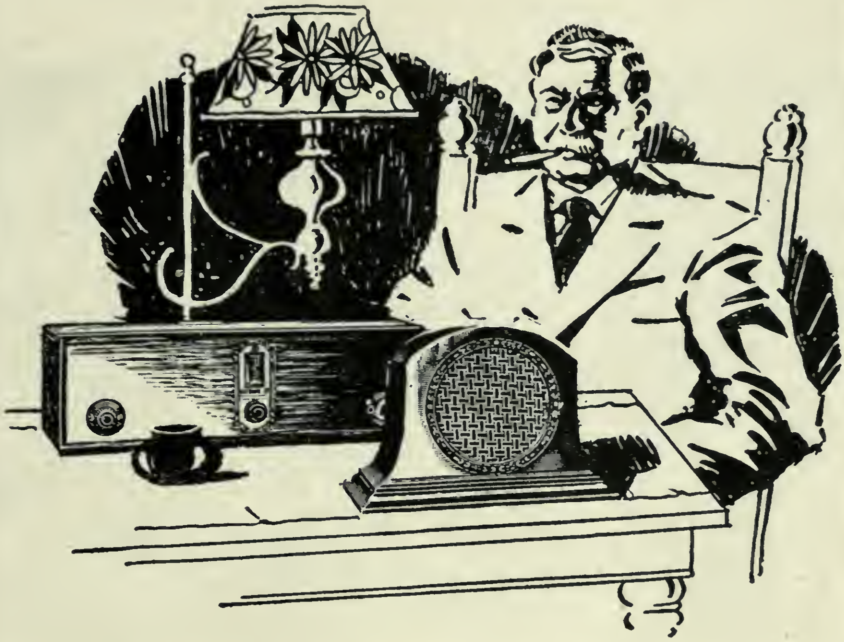
Not only have radio manufacturers applied known standards and mediums of advertising already in use by other industries, but they have from the very beginning pursued intensive sales promotion campaigns that called for considerable skill in their preparation and execution.

In the merchandising of products of high unit cost, such as radio receivers and accessories, it is necessary to assist the retailer in every possible way to move the merchandise rapidly so that his turnover will be sufficiently great to insure him a normal profit. In fact, a manufacturer's success depends in large measure on how successful he can make his retail organization. Otherwise the retailer is apt to become uninterested in the line so that while not actually refusing to sell the product, he will make no serious effort to push it and will instead concentrate his sales effort on competing products. Thus it becomes exceedingly important that no sales help be overlooked that will assist the retailer to conclude the sale *after national and local advertising have brought the prospect into his store.*

While there are many definitions and applications of sales promotion, the writer will confine himself to a brief review of successful helps used by the Radio Corporation of America.

1. *Direct Mail.* A series of one or more post cards or letters individually stamped and addressed to a selected list of prospective purchasers of radio sets. These campaigns are originated and executed by the manufacturer and sold usually at half cost to the retailer who, after the pieces are mailed, follows up the prospect with telephone and personal calls.

2. *Window Display.* A monthly service of display cards, streamers, and other devices that feature the product and which are used to help display the merchandise in an attention arresting manner in the dealer's windows and inside the store.



We Want To Be Your Radio Advisors

WHEN you have purchased a radio set here our interest in you does not end. We want you to enjoy it—to come to your home if anything interferes with its reception. Day or night, we're at your service.

Come in today and listen to the new Radiolas. Six splendid models built to fit every purse and purpose.

We particularly recommend Radiola 17 with the new RCA Loudspeaker 100-A. A most amazing value on our most liberal terms.

DEALER'S SIGNATURE

Figure 21: Type of complete advertisements prepared and distributed in matrix form to authorized dealers for use in their local newspapers under their own names.

The
NICKEL-A-DAY
Art Display Service
with New Features

New Ideas and Novel Cut-outs are Coming Every Month

No RCA Authorized Dealer should be without this Service, which lends so much beauty, prestige and RCA identification at so small a cost.

RCA has invested a lot of money to make the "Nickel-a-Day" Art Display Service the finest example of window and store advertising ever offered to retail dealers. And RCA is never going to miss an opportunity to increase the value of this investment to itself by improving the value of this service to its dealers. For example, right now our artist is working on some exceptionally attractive cut-out displays that will feature each model in the entire line of Radiolas.

On this page you see reproductions of some of the displays that are being sent to the RCA Authorized Dealers who have already subscribed to this service. Of course, these small reproductions without color do not begin to do justice to the actual posters.

Just try to visualize these displays in black frames three feet high and then add some vivid colors—then keep right on adding colors to the limit of your imagination—even then you cannot visualize the striking beauty, the daring design and splash of colors that the artist, C. L. Millard has achieved with his brush.

During the next twelve months many new features in the form of striking cut-outs and novel cards will make this display campaign attract more interest and more sales than ever before.

The TOWN CRIER

Figure 22: Large window posters in attractive colors are prepared each month for dealers' use with instructions for proper display in order to feature the product in an attention-arresting manner to the public.

Figure 23: Single column advertisements which serve to create and maintain brand acceptance.

SALES HELPS

FOR DEALERS

¶ The last seven of the accompanying illustrations show a few examples of the various sales promotional devices produced by the manufacturer to help the dealer stimulate local sales.

Figure 24: Title page of booklet.

Figure 25: Folders and booklets for dealers' use.

Figure 26: Recent examples of sales literature that describe the product in detail.

3. *Sales Literature.* Catalogues, booklets, and folders describing the product and its uses in a more descriptive and elaborate way than is possible in the limited space of a magazine or newspaper page. This literature is used by the retailer to back up his oral sales arguments and is handed to the prospect who may not be prepared to make an immediate purchase.

4. *Local Advertising Helps.* Electrotypes, matrices, moving picture slides, posters, and other devices that feature the product in connection with the dealer's name and address and which he employs in his own local advertising at his own expense.

5. *Store Identifications.* Metal, card, decalcomania, and illuminated signs and slogans featuring the product and which the dealer hangs or places in a conspicuous position inside the store, in the window, or outdoors so that his store may be readily identified by the public and the manufacturer's national advertising of trade-marks and names.

6. *Trade Organ.* A well-rounded sales promotion campaign requires frequent "selling" to the trade and constant reiteration. This is accomplished by a trade organ sent out at regular intervals to all wholesale distributors and retail dealers. The *Town Crier* published monthly by the Radio Corporation is a typical example. It serves as a contact and builder of good-will by furnishing trade news, special announcements on product advertising, sales promotion and service information available, and also by acting as an exchange for information and success stories to and from the dealers themselves.

CONCLUSION

From the foregoing, it will be obvious to the student of business that every important facility employed in the successful merchandising and publicising of radio is already well known and extensively used by other industries.

The unique difference with radio, however, was that whereas it took other industries from 5 to 20 years to reach a stage where all these facilities could be successfully employed on a national basis, radio found it necessary to adopt one after the other and, in the space of barely two years after its inception in 1920, it employed all these forces. In addition, it introduced a new medium —radio broadcast advertising—that bids fair to become a powerful supplemental aid in lowering sales costs.

Touching briefly on the cumulative power of advertising as a business builder, it is interesting to note that every one of the pioneers of the radio industry who has pursued a consistent, year-round, uninterrupted advertising campaign since the beginning, is today highly successful without exception. On the other hand, one-time successful manufacturers who advertised solely during the selling season and who stopped when business slowed up, or who did not advertise on a year-round basis continuously, are today either far down the list of leaders or in most instances out of the running entirely. *It pays to advertise.*

In conclusion, the writer wishes to acknowledge with deep appreciation the assistance given in the preparation of this paper by the late Thomas F. Logan, president of Lord and Thomas and Logan, Inc., advertising counselors for the Radio Corporation of America since its inception in 1920, whose execution of the advertising campaigns described in the foregoing text have been in great measure responsible for the growth and success of RCA products and communication service.

Figure 27: Large 24-sheet posters for outdoor use are distributed for local showings over the dealer's name and address.

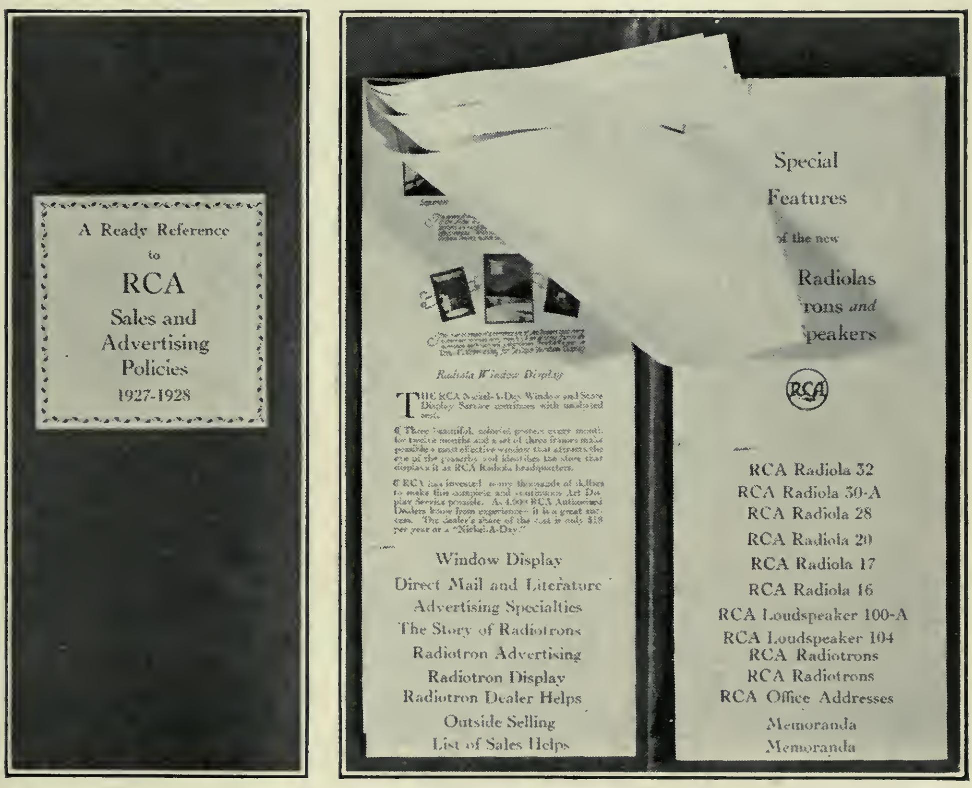


Figure 28: Small pocket size handbook for ready reference of dealer in visualizing the manufacturer's sales campaign.

Figure 29: Special advertisements are published in the trade papers to remind the dealer of the various forms of sales helps that are always available to help him develop local sales and thereby increase his profits.

XI

APPLICATIONS OF RADIO PRINCIPLES AND DEVICES IN INDUSTRY

HAROLD C. WEBER
Massachusetts Institute of Technology

THE principles of radio frequency currents and the applications of three-electrode vacuum tubes are without doubt considered by many as most important to those interested in communication work. This is probably due to the fact that radio has developed primarily as a means of communication. It is interesting, however, to consider the various applications of these ideas to fields where no communication features are involved. There can be no doubt that the uses of radio principles in engineering work would be much more widespread, could we but bring about a closer cooperation between the man in industry and the radio engineer. Unfortunately, the two, up to the present, have met rather seldom, but perhaps this condition will be slowly rectified as time goes on.

HIGH-FREQUENCY FURNACE

One of the first industrial applications of radio was the development of the high-frequency induction furnace. The principle of operation may be briefly outlined.

Losses occur in all conductors and most nonconductors when they are subjected to the action of a high-frequency electric field. Lost energy will show up as heat. In the induction furnace, the charge, placed in a crucible, which may even consist of an evacuated container, is so placed that it is in the most intense part of a high-frequency electric field. The field itself is set up by merely winding a spiral conductor, usually consisting of copper tubing, into a solenoid of about 15 or 20 turns. Through this winding passes the high-frequency current, generated by a simple apparatus consisting only of a transformer, an electrostatic condenser, and a spark gap. Since the container holding the charge needs no external connections, the possibility of performing high temperature work either in a vacuum or in an atmosphere of any chosen gas is easily realized. This type of furnace, going under the trade name of the Ajax Northrup Induction Furnace, is in common use.

One interesting use to which this principle is put is in the evacuation of high vacuum tubes, such as radio tubes. Mere pumping cannot remove all the gas from such a device, as a considerable portion sticks to all the interior surfaces. We usually call this occluded gas. A combination of high temperature and simultaneous pumping will effectively remove most of the gas. The heating is often brought about by placing the completed tube connected to the vacuum pump in a high-frequency field and inducing sufficient losses into the interior metallic parts of the tube to heat them to a high temperature. This is a case where direct heating with torches or electric heaters applied to the outside surface would be very inefficient.

The preparation of certain alloys requires that all fusion and heat treating be done in a special atmosphere with air excluded. Such heating is easily accomplished in the induction furnace.

COLOR MEASUREMENT AND MATCHING

There has always been a need for some device to accurately match and duplicate colors. An instrument has been developed consisting of a sensitive photoelectric cell feeding into a radio amplifier, which in turn delivers an electrical current whose value is dependent upon the color to which the photoelectric cell is exposed. In this way, it is possible to get an electrical picture of any color and either transmit it over telegraph lines or make a printed record of it in such a way that the original color may be duplicated at a distant point, without the aid of the human eye. Such a device eliminates all difficulties due to color fading in the case of color standards which it may be desired to keep unchanged for considerable periods of time.

MEASUREMENTS OF TIME AND TIME INTERVALS

The synchronous motor is the basis of practically all the electric clocks which are sold for household use. Under correct conditions the speed of this motor is dependent only on the frequency of the current with which it is supplied. Vacuum tubes, especially when controlled by means of quartz crystals, are capable of generating alternating currents whose frequency can be maintained constant with an extremely high degree of precision. Some of the most accurate clocks used for scientific purposes are run by high-frequency synchronous motors, which in turn derive their electrical energy from what is probably the simplest and most dependable constant frequency source known, the oscillating vacuum tube. By auxiliary apparatus it is possible to record individual impulses from an oscillating vacuum tube, and such a combination of apparatus enables us to time events taking place over such short intervals as one hundred-thousandth of a second or less. Since we can accurately determine and maintain the number of pulses sent out by a given oscillating vacuum tube set-up, it must be evident that the vacuum tube enables us, in this case, to measure with high precision in a comparatively simple manner extremely small time intervals. Thus we have radio devices capable of accurately determining long time intervals (synchronous motor clocks) and extremely short time intervals (high-frequency oscillators).

SOURCE OF ALTERNATING CURRENT FOR PRECISION LABORATORY WORK

Laboratory workers doing work of a chemical, electrochemical, or electrical engineering nature have long felt the need of some device for generating in a simple, reliable way alternating currents of various frequencies.

This need has been especially felt by those doing work on the conductivity of solutions. The oscillating vacuum tube gives a current practically perfect for all these uses and it is being widely used in various laboratories throughout the country for such purposes.

VACUUM TUBE VOLTMETER

The engineer often feels the need of a voltmeter which can be used on either high or low voltage circuits. Inasmuch as voltages applied to the input circuit of a vacuum tube are reflected in the output circuit in amplified form, a vacuum tube circuit may be readily used as a voltmeter, and since no current has to flow in the grid circuit of the tube in order to actuate the device, there is immediately available an instrument for measuring voltages without drawing any current. If, instead of applying the voltage to the input circuit of the tube, it be applied to the output circuit and then the resulting change in the input circuit be measured, we have available a method of reducing a high voltage to a low one. The relation between the two voltages is accurately determined by the tube characteristics. With the use of vacuum tube circuits in this way, a simple, easily obtainable voltmeter is available for measuring extremely high voltages.

CHEMICAL APPLICATIONS

The chemist and the chemical engineer have found several uses for three-electrode vacuum tubes. The frequency of a circuit made up of coils and condensers is dependent upon the size of these units and the capacity of a condenser is dependent upon the size of the plates, the distance between the plates, and the insulating material which is placed between them. It is possible to determine accurately the frequency of an oscillating circuit. If the space between the plates of the condenser of this circuit be filled with air, the circuit will have a certain frequency. If this air be replaced by another gas such as carbon dioxide, which has a dielectric constant different from that of air, then the frequency of the circuit will be changed. Various mixtures of carbon dioxide and air will cause various changes in this frequency. Such a set-up will constitute an accurate apparatus for the analysis of gases.

The fact that voltages applied to the input circuit of a tube cause amplified changes in the plate circuit is utilized for the measurement of acidity and alkalinity by the chemist and chemical engineer. It has long been known that a voltage is set up when two dissimilar electrodes are placed in a solution. The magnitude of this voltage may be made to depend on the concentration of the alkali or acid in the solution. A combination of such a pair of electrodes together with a vacuum tube and its circuit is commercially available for the direct determination of acid or alkali content in solution without the necessity for performing chemical analysis. This device is accurate, direct reading, and portable. It also has the decided advantage that no specially trained man is required for its operation.

ENGINEERING APPLICATIONS

Distance is one of the important things which we measure in engineering work. The vacuum tube is excellently suited for the measurement of small distances and minute changes in distance. Since the frequency of a vacuum tube circuit is altered by changing the distance between the plates of the condenser in this circuit, a device for measuring length can be built up utilizing an oscillating tube circuit. The sensitivity of such a measuring instrument may be judged by the fact that one English scientist could easily measure the deflection in the top of an oak table an inch and one-half thick when it was subjected to the load of one English penny. Distances of the order of magnitude of one two-hundred-millionth of an inch have been measured with such a device.

A great many other general engineering applications have been made. The voltage set up by thermocouples, which are so extensively used for determining temperatures, may be very precisely measured by means of vacuum tube voltmeters. In this way radio principles become an aid in the determination of temperature.

One device commercially available has the condenser plates in its oscillating circuit held a fixed distance by a strip of rayon silk which is sensitive, as regards length, to changes in humidity in the air surrounding it. Any change in length of the sensitive strip is immediately reflected by a change in frequency in the oscillating circuit associated with it. This combination gives us an extremely sensitive and accurate method, not only of determining humidity in the air surrounding the strip, but also of determining the moisture content of any material placed near the strip. These instruments have found quite wide use for the control of the moisture content in a sheet of paper pulp as it leaves the drier of the pulp making machine. In this particular case, the device is usually connected to other mechanism controlling the moisture content of the pulp in such a way that absolutely constant water content is automatically maintained. Of course, by the substitution of strips of material sensitive to other kinds of vapor the device may easily be adapted to the drying of materials where vapors other than water are involved, such as the drying of rubber goods containing hydrocarbon vapors.

Pressure is a fundamental quantity which the engineer determines over and over again. The vacuum tube offers a method of measuring practically all pressures from the highest to the lowest. When a quartz crystal is subjected to pressure, an electrostatic charge collects on its surface and the size of this charge is dependent upon the pressure applied. The vacuum tube offers the simplest and probably the most accurate method of determining this charge. This type of apparatus has been used for measuring very high pressures, such as those obtained during an explosion in a closed space. The dielectric constant of a gas is a function of the pressure, and since the dielectric constant of the gas in the condenser of an oscillating circuit is one of the factors determining the frequency of the circuit, it is possible to build pressure gauges utilizing this principle. Several such gauges have been successfully used. If one so desires, the pressure to be measured may be made to move one of the plates making up the condenser, which is necessary for all oscillators, and since extremely small movements of either plate may be accurately determined, a very delicate pressure gauge results. Such a gauge has recently been built, in rugged form, for plant use, which easily measures the pressure exerted by a column of water four ten-thousandths of an inch high. Such small pressures are often met in the determination of gas velocity, and any simple device for determining them with any degree of accuracy has been lacking up to the present time.

For those extremely low pressures existing in highly evacuated devices the ionization manometer utilizing the principles of the three-electrode vacuum tube has often been used.

CONTROL OF PROCESSES

At least one rubber company has done considerable work on the control of its vulcanization, utilizing, through the aid of vacuum tubes, the change in dielectric constant of the rubber goods as vulcanization proceeds.

The Atlantic weight meter is a commercially available device for controlling the thickness of any continuous sheet material such as paper, oilcloth, or rubber-coated fabrics, and it depends for its action entirely upon the change in frequency of a vacuum tube circuit when the condenser associated with this circuit has placed between its plates the samples to be analyzed.

Considerable work is being done at the present time on the control of chemical reaction by means of high-frequency oscillation. As yet no commercial developments have resulted, but the experiments thus far offer great promise.

LOCATION OF OIL AND MINERAL DEPOSITS

Some of the large oil companies have been using a device embodying a sensitive radio receiver and a transmitter so arranged that the two constitute a fairly accurate method of locating oil deposists. There seems to be no reason why similar devices cannot be built to aid in locating various kinds of mineral deposits.

USES BY MEDICAL PROFESSION

The medical profession has been able to find some uses for radio principles. An extremely sensitive and reliable cardiograph for studying the action of the human heart and for the diagnosis of heart disorders has been developed using three-electrode vacuum tubes.

In therapeutic work involving X-rays such as the treatment of cancer and similar disorders, great confusion and difficulty have existed because of the lack of a suitable device for accurately measuring the X-ray dosage. The Siemens and Halske Company in Germany have on the market a device consisting of a cell sensitive to X-radiation whose changes are accurately recorded on an indicating instrument through the use of a single three-electrode vacuum tube. The principles involved are similar to those used in the simple one-tube radio set, and the entire action of this extremely valuable medical aid is dependent upon the apparatus and ideas developed for radio communication.

The use of extremely high-frequency currents, that is, of the order of fifty million cycles, for the treatment of various types of disease offers great promise. A single example may make one of the possible uses clear. During a fever the temperature of the human body rises. This rise is an attempt by nature to counteract some disorder in the body. Most germs die quickly unless they are kept almost exactly at body temperature. To artificially raise the temperature of the human body even a few degrees, without serious injury to the patient, was difficult, if not impossible. The General Electric Company has done some experimental work in changing body temperatures, and it is found that if the person undergoing the experimentation be placed in the field of a high-frequency current, the losses, caused by the fact that the body fluids are conductors of electricity, will cause a rise in body temperature of several degrees in a very short time, without any discomfort at all to the person undergoing the test. Of course, such a method of treatment requires a great deal of development and cooperation between the radio engineer and the medical profession before it can come into widespread use. This treatment seems to offer promise as a method of combating cancer, as well as most of the more common diseases.

CONCLUSION

As yet we know comparatively little in regard to the action of radio frequency oscillations, especially those in the range of 30 million cycles to 300 million cycles. There can be no doubt that further study of these vibrations will yield results fully as important as those obtained from the use of X-rays and ultraviolet rays. This seems especially probable because these latter types of radiation are fundamentally the same as radio frequency radiation, only of enormously higher frequency.

The engineer and the scientist should consider the three-electrode vacuum tube as a new tool and as in the case of any new tool they must learn its various uses and methods of control. The already large number of varied uses of this device is probably but an indication of the many applications that will be found for it in the future. There seems to be practically no field where it cannot either perform some operation better than it is now performed, or do things which at present are impossible. The developments of DeForest, or if you wish Armstrong, have been of far-reaching importance in the everyday life of almost every one of us, and as yet we have only begun our exploration of the field of controlled electron streams.

APPENDIX

RADIO PRINCIPLES*

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MOST persons who have never made a study of the subject believe that wireless telegraphy started with the developments by Marconi. As a matter of fact, a great many years before Marconi built his first radio transmitter much of the mathematics and the theory connected with radio had been worked out by such men as Hertz, who actually set up receiving and transmitting equipment capable of working over a few hundred feet, Maxwell, who did so much to develop the electromagnetic theories on which all radio work is based, Faraday after whom one of the fundamental units of capacity, the farad, is named, and Helmholtz, the great German scientist, not to mention a score of others.

FUNDAMENTAL CONCEPTS

In order to understand the mechanism of radio transmission and reception, certain fundamental concepts are necessary. If an electric circuit be set up consisting of an inductance, that is, a coil of wire, and an electrostatic

* The author does not claim to have covered the subject of radio principles completely or exhaustively in this paper. It has been his intention to explain in simple, nontechnical language some of the fundamental concepts and to trace roughly the technical development of radio apparatus. He has tried to keep in mind the fact that his readers are, for the most part, not technically trained and probably have a very slight understanding of radio principles.

capacity (any two conductors which are insulated from each other constitute an electrostatic capacity), it will be found that the circuit has a very definite time interval, or frequency. In this connection consider Figure 1. C is the electrostatic capacity and L is the inductance. Let us put a negative charge (a quantity of electrons) on one of the conducting plates of the capacity. If now this swarm of electrons be set in motion, it will flow around through the inductance to the other side of the condenser. Arriving at that point, the electrons, because of their inertia, will, so to speak, be bounced off the plate

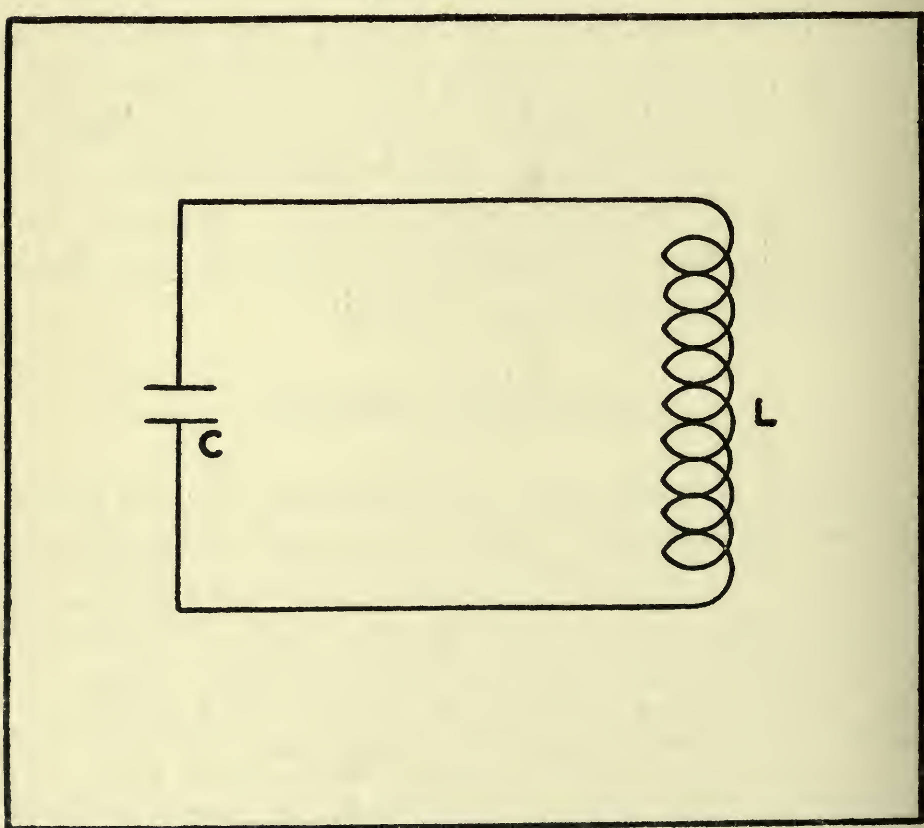

Figure 1: Electric circuit.

they have just arrived at and will start back again on a return journey to the plate whence they came. The time it takes the swarm to go from one plate to the other is determined by the electrical size of the condenser and the inductance only.

The number of times per second this electron swarm retraces its path is called the frequency of the circuit, and the circuit is called an oscillating one. For radio work this frequency is very high. For currents in the broadcast range it is over a million times a second. The frequency of a circuit is related to the wave length by a simple equation. The velocity of light (300 million meters a second) divided by the frequency is always equal to the wave length in meters. The wave lengths used in radio work range from those of approximately 1 meter to those of 20,000 meters. It must be evident from the nature of wave length and frequency that the higher the frequency, the shorter the wave length. We ordinarily speak of those waves between 1 meter and 150 meters as the short waves, of those between 200 and 600 meters as the medium waves or the broadcast waves, and of those from 600 to 20,000 meters as the long waves.

Let us go back again to our fundamental circuit consisting of the capacity and the inductance. Although the length of time it takes the swarm of electrons to get from one end of the circuit to the other does not vary, it is a fact that unless we supply energy to keep the electron swarm moving the amount of energy tied up in the moving electrons will get progressively smaller because of losses in the circuit, resistance losses, dielectric losses, and so on. Such an oscillating current where energy is not continuously supplied is called a damped, as contrasted with the case where energy is constantly supplied, in which case we have undamped oscillation.

All the early radio transmitters, the so-called spark transmitters, supplied damped oscillations. For radio work the undamped oscillation has distinct advantages over the damped type, among which may be mentioned the ability to distinguish between two sets of oscillation having almost the same frequency (that is, we may tune more sharply), and also the ability to cover greater distances with a given expenditure of power in the transmitter. Furthermore, radio telephony is practically an impossibility with damped oscillations. Before the advent of the three-electrode vacuum tube, which, by the way, is the modern method of generating undamped oscillations, high-frequency alternators and oscillating arcs of the Poulsen type were quite extensively used, especially for transoceanic communication. The first practical high-frequency alternator was developed by Alexanderson in 1906. It was of the induction rotary disc type, had an output of two kilowatts and a frequency of about 200,000 cycles, and was really one of the first distinct steps towards the elimination of those systems employing damped waves.

EARLY RECEIVERS

Early receiving sets were comparatively simple. They consisted for the most part of an inductance, either variable or fixed, and a capacity, which was usually adjustable, together with a rectifier and some device for making the received signal audible, usually a pair of telephone receivers. The rectifier or detector is an important and necessary part of any radio receiver.

The high-frequency impulses picked up from the transmitting station cannot actuate the telephone receivers directly, but must first be rectified or changed to pulsating direct currents and then either reduced in frequency in the case of most telegraph signals, or demodulated in the case of telephone messages. As will be explained later, the voice pulses really ride on a carrier wave, and it is the purpose of the detector, among others, to separate the carrier from the voice wave. The voice wave then passes on through the audio amplifier and is finally made to actuate the speaking device. The early receiving sets differed mainly in the type of rectifier used. Probably the coherer was the first detector used for radio purposes. Then followed in rapid succession the microphone detector, the magnetic detector, the electrolytic, and eventually, the several crystal detectors going under such trade names as the Silicon, the Perikon, and the Carborundum detector, and finally the three-electrode vacuum tubes.

EARLY VACUUM TUBES

About the same time that the Alexanderson high frequency alternator was developed, the Fleming valve made its appearance as a rectifier. This device consisted of a filament, similar to an ordinary incandescent lamp filament, sealed into an evacuated tube with a second electrode called a plate. Connections were brought out from the two ends of the filament and from the plate. The action of this device is interesting. In use the filament is heated by means of a small battery. Practically any material when heated will throw off electrons. Electrons are negative charges of electricity having a mass of about one eighteen-hundredth the mass of the hydrogen atom. If there are no gas molecules in the way, these electrons as they are thrown off will travel for considerable distances. To give them an unhindered path, the Fleming valve and the modern vacuum tubes are exhausted as completely as possible. If the plate in the Fleming valve be positively charged, the electrons will be attracted to it, while if it be negatively charged, they will be repelled. Thus, if an alternating voltage be applied to the plate, electrons will pass from the filament to the plate whenever the plate is positive but will be unable to pass when the plate is negative. The device acts as a rectifier, and as such was used a great deal in early radio receiving sets for receiving damped waves.

DEVELOPMENT OF THREE-ELECTRODE TUBES

The coming of the high-frequency alternator and other devices for generating undamped waves made practically useless most methods of radio reception developed up to that time. Although these early sets were capable of receiving and delivering to the telephone receivers the energy picked up from stations using high-frequency undamped transmitters, it was impossible to produce audible sounds in the receivers because the frequency was above that to which the human ear responds.

Very fortunately new ideas were introduced into radio work about this time. DeForest added a third electrode, the so-called grid, to the Fleming valve, giving us essentially the modern three-electrode vacuum tube so commonly used in most radio sets today. This grid or control member is usually located between the filament and the plate, and its name suggests its construction. In operation the received voltage is allowed to flow onto this grid or control member, while the plate is kept continually positive with respect to the filament. Thus a constant stream of electrons is always moving from the filament to the plate, that is, a current is flowing in that circuit to which the filament and the plate are connected, and incidentally this circuit always contains the mechanism for transforming this current into audible sounds. The presence of the electrons on the grid interferes with or lessens the number of electrons which can get from the filament to the plate. Not only is this true, but the effect is an amplified one. The voltage amplification in modern tubes ranges from about three to two hundred times. Thus for the first time we see electron tube devices being used as amplifiers.

REGENERATION*

If some of the amplified energy in the plate circuit be fed back into the grid circuit to be reamplified, it must

* Both Armstrong and DeForest claim to have developed regeneration, and a court battle over the patent has been carried on for several years.

be evident that an even greater effect will be realized. Thus a very small received voltage may be fed through the tube, part of the amplified output fed back into the tube, and the process continued over and over again until a very large output is built up. The action is entirely analogous to the continued singing sound which one obtains when the receiver of a telephone is placed against the transmitter. This is the general idea behind the so-called Armstrong regenerative principle over which there has been such a long court battle. One might think that outputs depending only on the power of the tube might be built up in this way from comparatively small inputs, but it is found that if too much energy is fed back the whole circuit gets unstable, and instead of being controlled by impulses picked up by the receiving set and fed onto the grid, the tube merely continues operating of its own accord, generating an alternating current of a frequency determined by the size of the inductances and capacities contained in the circuit. In short, we say the tube oscillates. The oscillating vacuum tube is the basis of all modern methods of wireless telegraphy and telephony.

The use of the three-electrode vacuum tube and the regenerative idea enormously increased the distance over which communication could be carried on. Transmitters having a range of 25 to 100 miles were found capable of transmitting from 1,000 to 1,500 miles when using regenerative receivers. It was found that if the regenerative receivers were allowed to oscillate and at the same time pick up a signal from an undamped transmitter, a beat note would be generated by the interference of the two frequencies, and that if the oscillating receiver were made to oscillate at a frequency which differed from the frequency of the energy being picked up enough so that the beat note were of an audible frequency, then the oscillating detector offered a simple means of receiving undamped telegraph signals. In this condition it is still much used, especially by the amateurs working in the short-wave part of the spectrum.

TRANSMISSION USING VACUUM TUBES

In using the oscillating tube as a transmitter of wireless telephone messages, the tube is first made to oscillate at a frequency determined by the constants of the circuit. This frequency determines the wave length at which the message will be sent. Superimposed on this current is a second one, which is made to vary in accordance with the sounds which it is desired to transmit. One way of looking at this is to say that the voice wave rides on the high-frequency or carrier wave. This mixing of the carrier and voice wave is called modulation; the exact mechanism of how it is done will not be entered into here.

AMPLIFIERS

From our discussion of the action of the three-electrode vacuum tube it can easily be seen that the output of one tube may be fed into the input of a second tube, thus building up what is known as a vacuum tube amplifier.

Several tubes may be arranged in a train. It is with the design of these amplifying trains that the radio engineers have busied themselves, to a great extent, during the last five to eight years. If the amplification takes place before the signal gets to the detector or rectifier, it is called radio frequency amplification because we are then amplifying oscillating currents lying in the radio frequency range, the exact frequency being determined by the wave length.

Since such amplifiers operate over a comparatively narrow frequency band, it is necessary to make them adjustable if we wish to operate efficiently over a very wide range of frequencies. This operation of adjusting the circuits to respond to the frequency desired is called tuning, and the narrowness of the band over which the amplifier will respond at any given setting determines the selectivity of the receiver. Sharp tuning or high selectivity is desirable, but in a radio telephone receiver, unless the amplifier can respond to a band of frequencies at least 10,000 cycles wide, distortion will be introduced due to the fact that some of the frequencies present in the original sounds will be missing in the received sounds. This is the reason why there is a very definite number of broadcast channels available between 200 and 600 meters, and why it is impossible with our present methods of transmission and reception to get more than this number into the range between 200 and 600 meters without causing them to overlap and interfere.

One cannot go on amplifying radio frequencies through tube after tube without getting into difficulty. In fact, unless precautions are taken, one stage of radio frequency amplification will give difficulty due to the fact that such a stage will usually involve two tubes and their associated circuits. The circuits associated with these tubes must be turned to the frequency that it is desired to receive, and when this is done it is usually found that the two circuits interact so badly that continuous oscillation, either with or without beat notes, results, and badly distorted signals, or no signals at all, are received. This difficulty, of continuous uncontrolled oscillation, can be obviated by isolating each circuit and its tube from all other circuits by shielding, and also by some device which either introduces high enough losses into the various circuits so that they cannot oscillate or by feeding back from each circuit to its neighbor just enough energy, properly chosen, so that it bucks the currents flowing and thus prevents oscillation. The Hazeltine and Rice methods are those commonly used for feeding back the necessary voltage. Sets using this method of controlling oscillation are usually called neutrodynes.

By proper design it is possible to build sets of this type having as many as five stages of radio frequency amplification, although commercially not more than two or three are usually attempted. The gain from each stage varies from 4 or 5 up to 15 or 20, and since the over-all gain is the product of the individual stage gains, a three-stage radio frequency amplifier having a gain of 20 for each stage will have an over-all amplification of 8,000.

Radio frequency amplification becomes increasingly difficult as the frequency is increased. It is comparatively easy to amplify at a frequency of 30,000 cycles, or 10,000 meters, but very difficult to amplify at a frequency of 3,000,000 cycles, or 100 meters, and practically impossible to amplify directly at frequencies greater than this. This fact, coupled with the fact that there was dire need during the World War of amplifying signals of wave lengths less than 100 meters, led Armstrong, one of the original discoverers of the regenerative circuit, to develop the so-called superheterodyne method of reception.

The idea of the superheterodyne is to pick up the signal at, let us say, a frequency of 3,000,000 cycles with the first tube in the set and then to mix this 3,000,000 cycle signal with a second signal, generated by another tube in the set, this second signal being at a frequency of, perhaps 3,030,000 cycles. From the interference of these two signals a beat note signal of 30,000 cycles will result. This beat note signal is then fed through a radio frequency amplifier adjusted to respond to exactly 30,000 cycles, at which frequency highly efficient amplification can be obtained. Finally, the amplified 30,000 cycle signal is rectified and fed either into an audio frequency amplifier or directly to the telephone receiver. The superheterodyne method of reception offers what is probably the most sensitive method of reception so far developed. It requires a large number of tubes, usually six not including the audio amplifier, but this is no serious drawback. One tube may be made to serve two purposes as in the case of the second harmonic superheterodyne.

AUDIO FREQUENCY

Let us turn our attention now to audio frequency amplification. Radio frequency does but little to increase the volume of sound energy from a receiver, but does have an enormous effect in increasing the distance over which signals may be received. For increased sound volume we must depend on audio frequency amplification or, saying it in another way, amplification after rectification. It is here that most of the progress has been made during the last three or four years. Essentially, the audio amplifier is the same in principle as the radio frequency amplifier except for the fact that it must respond with equal efficiency over all audio frequencies from about 60 to about 5,000. It is comparatively easy to build an audio amplifier to cover the higher frequencies, but the job becomes increasingly difficult as we go toward the lower end of the audible range, and very few audio amplifiers at present in use will cover the entire range. It is lack of the lower frequencies in the audio amplifier that gives to most cheap radio sets the characteristic tinny note.

Most sets in use today use two stages of audio frequency amplification. As long as we are concerned with amplification from tube to tube, we need worry little about the power that the tube can handle, because intertube amplification is mostly a question of voltage amplification. The last tube in almost any radio set, however, feeds into some kind of a loud speaker. All loud speakers are really electric motors built in such a way that they transform electrical energy into sound energy and, being motors, require not voltage for their operation but power, which is the product of voltage times current. Thus we see that the last tube in any radio set must be a tube capable of delivering considerable power in its output circuit, and this is the position always occupied by the so-called power tube in the modern radio set. Lack of power from the output circuit of the last tube practically always means lack of the low notes and a tinny characteristic.

Thus high-quality reception of music and voice means high-quality transmission, proper design in the radio frequency amplifier of the receiver, followed by an audio amplifier capable of responding equally over the entire audio range and delivering sufficient electrical energy to the loud speaking device to properly operate it, and finally, a loud speaker which is capable of reproducing, as sound, all frequencies in the audible range equally well. High-quality amplification is thus seen to be made up of a large number of factors all of which must be given due consideration in order to obtain a satisfactory final result.

DEVELOPMENT OF VACUUM TUBES

The development of vacuum tubes has kept pace with the development of radio transmission and reception. The early DeForest and Fleming tubes, although they were evacuated, were of the so-called low vacuum type as contrasted with the high vacuum tubes in use today. This high vacuum is obtained by the use of modern vacuum pumps, the tube being heated as hot as the manufacturer dares during the process of removing the occluded gases. Finally a small quantity of some material, such as metallic magnesium or phosphorous, is added to the interior of the tube in order to chemically combine and thus hold any gases which may be left after the pumping process. The silver coating on the inside of the radio tubes is due to the presence of this chemical clean-up agent, or getter, as it is called.

Improvements in the filament have been very noticeable. Originally a plain tungsten filament was used, and the ordinary receiving tube with this type of filament had a filament current consumption of about one ampere. It was soon discovered that a small quantity of metallic thorium mixed with the tungsten gave a filament which would emit electrons plentifully with a current consumption of one-fourth of an ampere. Finally it was found that tungsten or platinum wires coated with the oxides of certain metals would give off electrons with even lower filament current. Both the thorium and the oxide coated filaments are used today. The common 201A type of tube is the thorium type, while the WD11 and 12 and 112A and 171A types are of the oxide coated variety.

For a long time it was impossible to make three-electrode tubes having outputs greater than 250 watts. The output was limited by the rate at which heat could be taken away from the elements sealed into the tube. This was a serious disadvantage in radio transmission work because results from using a large number of tubes operated in parallel are seldom as good as results obtained from a single high-powered tube. The expense of the multiple tube set-up is also very much more than the expense of the single tube outfit. The General Electric Company, a few years ago, developed the Waterhouse seal between glass and copper, thus enabling the tube manufacturer to allow the plate, where most of the heat is generated, to protrude out through the tube and into a tank of cooling water, where the heat can be liberated as rapidly as desired. Tubes having an output of 100,000 watts were immediately made available. This marked a distinct step in the construction of high-powered tubes.

The current used for heating the filament of a vacuum tube serves no purpose except to drive off the electron and in receiving sets manufacturers have been handicapped by the fact that unless direct current, usually obtained from batteries, was used in heating this filament, undesirable noises were introduced into the circuits. The use of alternating current obtained directly from the house supply line entirely eliminates filament battery but necessitates the use of the so-called alternating current type tubes, having as their source of electrons not the hot filament but a refractory surface covered with the electron emitting oxide and indirectly heated by a filament obtaining its current from the alternating current main but serving no other purpose than that of a heater.

Recently a fourth electrode has been added to the vacuum tube, taking the form of a screen between the plate and the grid. The addition of this fourth electrode makes possible amplifications as high as 300 per tube and enables one to get fairly high amplification even on frequencies below 100 meters. There are some difficulties connected with the use of these tubes, but no doubt these will be eliminated in a short time. These tubes seem to be most useful as radio frequency amplifiers, especially at the extremely high frequencies where no other type of direct amplification is satisfactory. This tube goes under the name of the "Tetrode," or screen grid tube.

The apparatus that has been developed for radio work together with the ideas involved in radio circuits have been applied to uses other than that of radio communication, and there can be no doubt that the modern vacuum tubes constitute some of the most valuable tools available both from a scientific and an industrial viewpoint.

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