HISTORY OF BROADCASTING:

RADIO TO TELEVISION

RADIO AND ITS FUTURE

EDITED BY

MARTIN CODEL

FOREWORD BY

SENATOR GUGLIELMO MARCONI

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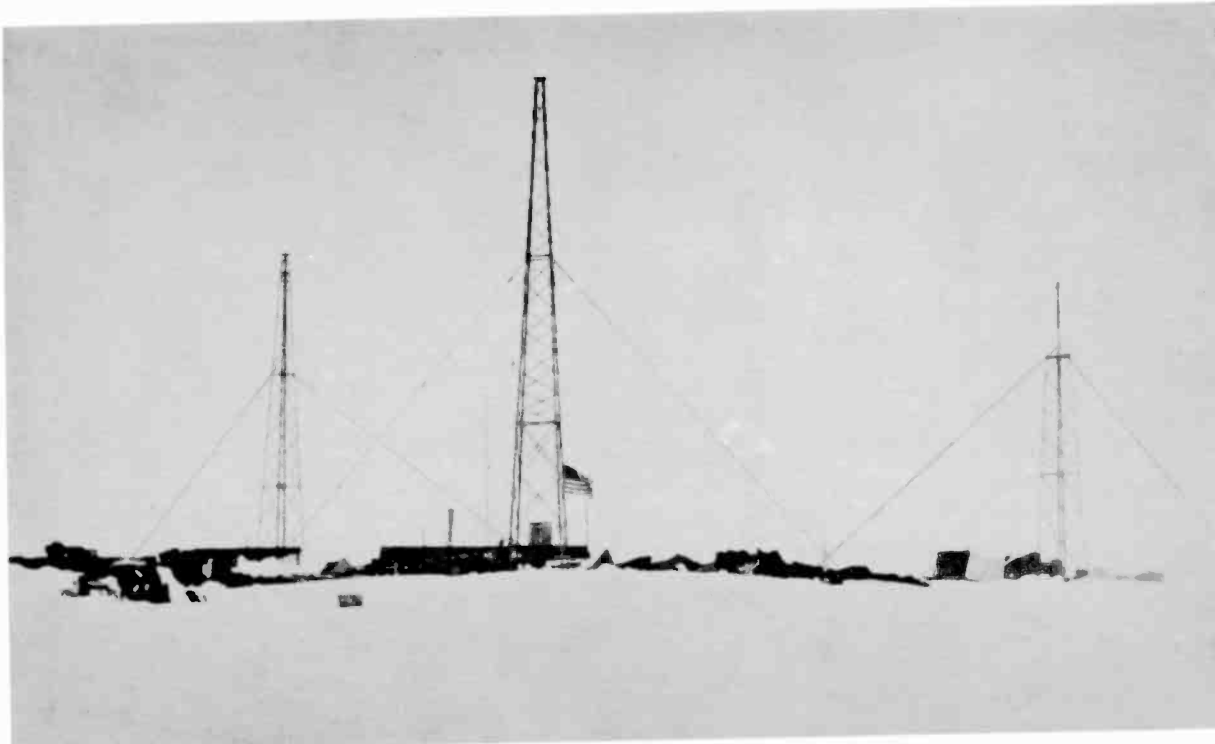

THE BYRD BASE AT LITTLE AMERICA, ANTARCTICA, SHOWING THE RADIO TOWERS THROUGH WHICH THE PARTY MAINTAINED CONSTANT COMMUNICATION WITH THE OUTSIDE WORLD.

Radio and Its Future

MARTIN CODEL, editor

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HISTORY OF BROADCASTING: Radio to Television

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INTRODUCTION

Radio, in its various branches of use, has become as commonplace in modern existence as the telephone and the automobile. Yet its essential structure has remained a mystery to most people. It is the purpose of this volume to review, through the medium of men who are authorities in their respective branches of the American radio art and industry, just what radio has accomplished and is accomplishing. Because radio's various services have attained their present prodigious proportions in such an amazingly short space of time—and are still making their own history day by day—it is also the object of this book to discuss what radio promises to accomplish in the immediate or far future.

It is manifest that prediction along any line is risky business. Yet the editor, in his experience as a newspaper correspondent, has found that most conservative of individuals, the engineer, the most willing to predict. If a note of conservatism does run through some of the treatments given the future of radio, it may be that the authors have not shown enough alacrity to record the views they so often reveal in conversation. It was a radio engineer who once exclaimed publicly, at a conference with the Federal Radio Commission, that anything man can imagine he can do in the ethereal realm of radio will probably be an actual accomplishment some day. Perhaps radio, or something akin to radio, will one day give us mortals telepathic or occult senses!

For the most part, however, the reader will find these chapters devoted to actual and probable prospective developments that he can comprehend as a layman. The effort has been to present the radio of today and tomorrow—with such historical discussion as seemed necessary to elucidate each subject—so as to afford a fairly complete picture of each branch of the radio art and industry. Many of the contributors are men who have placed and are keeping America ahead of the world in radio achievement. Although the possibilities of radio were perhaps first seen by foreign scientists, and a British subject, Senator Guglielmo Marconi, was the first to put radio to practical use, the story of American radio is really the story of radio as we use it today. Indeed, it was the invention of the audion tube by an American, Dr. Lee DeForest, that made modern radio possible, and it was an American invention, the Alexanderson alternator, which started this country on the way to its present leadership in the field of radio as a whole.

The divisions of this book are arbitrary. The arrangement of chapters is for the convenience of the reader only. The interrelation of the various branches of radio made it inexpedient to separate the chapters otherwise, unless there was no division at all.

The editor is indebted to the contributor of each chapter for the fine cooperation which made this book possible. He is also grateful for the many helpful suggestions furnished by Warren Bishop, managing editor of *Nation's Business*. A series of articles arranged for that magazine by the editor inspired this book, and several of the articles appear in revised form as chapters. Permission of the McGraw-Hill Book Company to reprint certain material from the Harvard lectures on radio, published in a volume, *The Radio Industry,* by the A. W. Shaw Company, is also gratefully acknowledged.

In arranging and editing these chapters the editor consulted frequently with many other authorities in the radio field, and he feels especially indebted to H. A. Bellows, former member of the Federal Radio Commission; George R. Putnam, U. S. Commissioner of Lighthouses; Sam Pickard, vice-president of the Columbia Broadcasting System; W. W. Winterbottom, Lloyd A. Briggs, and Emmet Crozier, of the Radio Corporation of America; Laurens Whittemore and John Mills, of the American Telephone & Telegraph Co.; Frank C. Page, vice-president of the International Telephone & Telegraph Corp.; Philip N. Schuyler, of the Postal Telegraph-Cable Co.; A. L. Budlong, of the American Radio Relay League; Lieut.-Comdr. T. A. M. Craven, of the United States Navy; Paul M. Segal, former assistant general counsel of the Federal Radio Commission; and Lieut. E. K. Jett, United States Navy (retired), and Gerald C. Gross, engineers of the Federal Radio Commission.

MARTIN CODEL.

WASHINGTON, D. C.
January, 1930.

PART I: BROADCASTING

AMERICAN BEGINNINGS

By H. P. Davis

Vice-President, Westinghouse Electric & Manufacturing Co.

LESS than a decade ago, an idea; today a billion-dollar industry, giving employment to hundreds of thousands of persons. Such is the amazing growth of that idea.

Radiotelephonic communication was not new in 1920. It was, however, primarily a research problem and a plaything, more or less, of the radio amateur. At best its range was limited. It was unsuited for telephone service, as it lacked secrecy. It seemed unfit for long-distance use. Apparently it had no commercial future.

But an idea to be of value must be translated into action. This action developed a commercial use for radio that would take it out of the scientific laboratory and capitalize its handicap—lack of secrecy. Thus was born a new public service which we now term radio broadcasting because of its mass communications character.

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. Though broadcasting is little more than nine years old as this is written, most of us look upon it in a matter-of-fact way, as we do the electric light and the telephone. The temper of the times, perhaps fortunately, is to take miracles of science for granted. Consider how we have changed our attitude in the period of about sixty years since this article appeared in a prominent Boston newspaper:

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 telephone did come; then the radiotelegraph, spreading, unlike the telephone's guided communications, its "signals" in all directions. When voice could be transmitted without the use of wires, it promised a means of mass communication. What use, however, would this one-way method of communication serve?

Attempts were made and some successful results accomplished prior to the World War in adapting telephonic principles to radio communication. Reginald Fessenden, probably the first to attempt this, broadcast a program on Christmas Eve of 1906. Later, Dr. Lee DeForest did the same in the development of his inventions. Various other experimenters and amateurs worked along the same lines. 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.

This activity took form in several fields. One 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 & 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 at its plant at East Pittsburgh, Pennsylvania, and the other at the home of Dr. Frank Conrad, one of its research engineers, in the Pittsburgh residential district, a distance of four or five miles separating the two stations. Their call letters were 2-WM and 2-WE. I was in charge of this part of the company's war activities, Dr. Conrad serving as one of my assistants and coordinating our work with that of the Army Signal Corps.

A considerable amount of money was invested in this equipment and a large staff of experts handled the details of our complex activity. At the end of the war, the company found itself with this investment and organization on its hands. The reestablishment of patent restrictions, most of which were adversely held, placed it in a position of considerable difficulty in continuing this work. In casting about for a way to establish itself in the industry, negotiations were undertaken and concluded whereby controlling interest was purchased in the International Radio Telegraph Company, which owned many important fundamental radio patents. This company owned and operated several ship-to-shore stations and was a pioneer in this field.

The large sum of money expended for the control of the International Radio Telegraph Company emphasized in our minds the necessity of developing our new acquisition into a service which would broaden, popularize, and commercialize radio to a greater extent, 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 us to broadcast a news service from our stations to ships. This idea was followed up, but nothing was accomplished because of the negative reaction obtained from those to whom we desired to supply this service. However, the thought of accomplishing something of this sort persisted in our minds.

During this period Dr. Conrad continued his experiments with the station at his home, greatly improving his radiotelephone transmitter. When government restrictions on radio stations were removed, Dr. Conrad operated his telephone transmitter quite regularly to send out programs of one kind or another. Amateurs and others with receiving sets—and they were very few—were interested enough to listen. The program material available was largely phonograph records, but there were some talks, and baseball and football scores were reported. Dr. Conrad's amateur station, designated as 8-XK, became one of the best known in the country.

We watched this activity and the activity of various others who were experimenting with radiotelephony very closely. Soon came the idea which led to the initiation of a regular broadcast service. An advertisement of a local department store in a Pittsburgh newspaper, calling attention to a stock of radio receivers which could be used to hear the programs sent out by Dr. Conrad, led me to the conviction that efforts then being directed to develop radiotelephony as a confidential means of communication were wrong, and that this field instead offered one of widespread collective publicity. Right in our grasp, therefore, we had the service we had been groping for. A little study developed the great possibilities. We became convinced that we had in our hands the instrument that would 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 of application. It offered the possibilities of service that could be rendered without favor and without direct cost to millions.

The result was my decision to install a broadcasting station at East Pittsburgh 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. The Westinghouse Electric & Manufacturing Company, on November 2, 1920, put into operation the first permanent radio broadcasting station in the world, now known as KDKA.

Its first program consisted of the returns of the presidential election which elected Warren G. Harding to office. There were perhaps less than 100 people equipped to listen to this initial broadcast. Contrast this with the nation-wide and world-wide broadcast of the Hoover election of 1928!

Following the election-night broadcast, a daily program was instituted to last from 8:30 to 9:30 o'clock each evening. Our daily schedule, expanded to most of the hours of the day, of course, has continued uninterruptedly up to the present time.

A broadcasting station is a rather useless enterprise unless there is some one to listen to it. Here was an innovation, and even though it was advertised, few other than amateurs with receiving sets could listen to us. To meet this situation, we had a number of receiving sets manufactured and distributed among officers of the company and friends. Thus was the first broadcast audience drafted.

After nine months of continuous operation of Station KDKA, the Westinghouse Company, encouraged by the increasing demand for receiving equipment, opened WBZ at Springfield, Massachusetts, in September, 1921. A month later it opened WJZ at Newark, New Jersey. A month after that we installed KYW at Chicago. It was not until the summer of the next year that other stations of prominence were placed in operation, and very few then.

History holds no parallel for the developments that have followed. In only a few years a new and all-embracing service was given to the world and an industry developed to a place of first magnitude. No one who heard the first radio broadcasts of KDKA, or even of the host of other stations that first experimented and then sprang into commercial being, would then have had the temerity or the optimism, no matter how obsessed with the idea, to venture the prediction that the whole world would be brought under the spell of this service.

When radio broadcasting caught the public mind, it became a conversational topic as commonplace as the weather. It is probably a fact that, when the response came, no idea, no facility, no service, ever received such a reaction from the public or grew so fast in popularity. A scientific novelty and a—financially, at least—hazardous experiment was transformed into a widespread and popular public service.

We attribute much of this original public response to the press work we had been doing. From the start, we had sent out announcements and copies of our programs to a list of representative newspapers. Then we organized a magazine known as *Radio Broadcasting News,* which we sent to about 2,000 newspapers. It was not long before KDKA's programs were published in newspapers throughout the United States and Canada.

A factor that also contributed much to the success of broadcasting was the fact that it was done continuously and regularly at well-heralded times of night and day, with programs of general interest. At KDKA we endeavored to render a real public service with regularity, presenting well-planned, high-grade, interesting and timely advertised programs.

Our first pickup or "remote control" service was from the Calvary Episcopal Church of Pittsburgh. We had been sending out music and entertainment from phonograph records every day, including Sunday. Our week-day form of program material did not seem quite suitable for Sunday evening purposes. Accordingly, we hit upon the idea of broadcasting a church service. As music was the principal content of our programs, our thoughts naturally turned to the Episcopal service. It happened that one of our engineers was a member of the choir of the Calvary Episcopal Church. He enlisted the cooperation of the rector, Dr. E. J. van Etten, who worked with us willingly.

The broadcasting of a church service alone was 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. It has proved to be one of the greatest, most popular and beneficent features ever offered by radio broadcasting. Even today, the broadcasting of religious programs is doing more to enlarge the church's sphere of influence than any other medium employed through the ages.

As part of the pioneer records we have the honor to record that the Hon. Herbert Hoover's first radio broadcast address was transmitted over KDKA—a speech before a dinner of the Duquesne Club of Pittsburgh on January 15, 1921, in which he appealed for funds for European relief work. On February 18, 1921, KDKA transmitted addresses by Miss Alice M. Robertson, then Congresswoman-elect from Oklahoma, the first woman to sit in Congress, and by Colonel Theodore Roosevelt, Jr. One month later, three members of President Coolidge's Cabinet addressed the growing audience of KDKA, namely, Secretary of the Treasury Andrew W. Mellon, Secretary of Labor James J. Davis, and Secretary of War John W. Weeks. William Jennings Bryan also made his first radio address over KDKA.

In the ensuing months, KDKA rapidly developed and presented a series of "firsts" in broadcasting history. Among these were the re-transmission of Arlington time-signals at ten o'clock nightly. It is still one of the most popular and appreciated radio features. Then sports events began to be broadcast. On April 11, 1921, we carried a description of a boxing contest held in Motor Square Garden, Pittsburgh. Next month we broadcast from the stage of the Davis Theater in Pittsburgh the first theatrical program in history. In August we broadcast the Davis Cup matches, held at Sewickly, Pennsylvania, by a twenty-five-mile remote-control connection with the transmitter. The same month came a play-by-play account of a baseball game in the local National League Park.

These were the forerunners of the tremendously popular sports broadcasts which the American public now receives regularly.

One of the first broadcasts from WJZ consisted of a description of the world series in which one of the New York teams was contending. Station KYW had an auspicious opening, transmitting a performance of the Chicago Civic Opera directly from the stage. On May 19, 1921, KDKA was authorized to broadcast government market reports after it had initiated a farm broadcast service which included livestock, hay and grain reports, and weather forecasts.

At station KDKA there also took place pioneering in a branch of development of the radio art which promises to be one of the most important in the science of communication. I refer to the work that Westinghouse Company engineers have done in short-wave transmission, from which much is expected by radio scientists. Early in 1922 we were convinced that wonderful possibilities were being overlooked in the then unused and rather despised short-wave bands—the channels considerably below those in use for broadcasting and telegraphic communication. An experimental station known as KDPM was installed at the Westinghouse plant in Cleveland, Ohio, and serious work was undertaken between KDKA and this station in an investigation of short-wave transmission and rebroadcasting. In the fall of 1923 we located a rebroadcasting station at Hastings, Nebraska, known as KFKX. This picked up the transmissions of KDKA *via* short waves and retransmitted them on its own wave length. The Nebraska station was later moved to Chicago.

Since that time research and development work in this branch of the art have been carried on continuously. From these experiments has developed a world-wide service, which is treated elsewhere in this book by Mr. C. W. Horn, formerly with Westinghouse and now with the National Broadcasting Co. Suffice is to state here that the Eskimos of the Arctic still obtain and Commander Byrd and his exposition in the Antarctic did obtain radio programs, as well as telegraphic dots and dashes, by means of the magical short waves. During short-wave broadcasts there is sometimes practically 100-per-cent coverage of the globe.

It is a fact, which I state in all modesty, that the history of KDKA practically records the achievement of American broadcasting. And the history of American broadcasting records not only the growth of radio as a means of mass national communication, but its establishment as a factor of vast possibilities in world relations. Broadcasting has introduced an instrumentality of personal contact whereby one can talk to others in an understanding manner under conditions of widest diversity of location, custom, and language. It will, I believe, develop a universal speech as time goes on.

THE RADIO STRUCTURE

By Martin Codel

North American Newspaper Alliance

Rival candidates for political office are declaiming their parties' several and their own special virtues. A favorite announcer is describing a great sporting event. A battery of voluble young men is rendering a verbal account in veriest detail of a presidential inauguration, a triumphant return of a national hero, or some other interesting current happening.

In all these notable broadcasts the owner of a radio receiving set and his friends and neighbors can enjoy a vicarious participation. Of an average evening, he can turn the dial to tune in a symphony, an opera, dance music, vocal and instrumental entertainment of all sorts. There is also a choice of educational features and there are news flashes furnished by the press associations and newspapers. Always, or almost always, there is something "on the air" to interest and entertain.

Whence comes this service, and who pays for it? It is the object of this chapter to present a general picture of the American radio structure as a whole, with particular attention to broadcasting, which is its keystone.

Considering the latter part of the question first: You paid a big part of the radio bill when you bought your radio receiving set. You pay part of it when you purchase a new tube or accessory. The rest—no one can possibly say how much—you continue to pay when you smoke a widely publicized brand of cigarettes or bathe with a popularly advertised soap or brush your teeth with an oft-mentioned tooth paste. You pay intangible installments, too, when you elect to trade with a local merchant whose commodities or services you have heard extolled through your loud speaker between periods of music or dialogue.

Buying a radio set, in the American manner, is something like buying an automobile, except for the obviously wide variance in initial investment and cost of upkeep. There is a vast amount of difference, however, in the character of the radio and automobile business. Peculiar unto itself is the economics of the radio broadcasting structure. Upon it rests an industrial superstructure now approximating the billion-dollar class in retail distribution values.

A broadcasting station is analagous to a daily newspaper. The newspaper seeks to inform and incidentally to entertain, maintaining itself as a going business institution mainly by revenues derived from advertisers. A modicum of revenue may come from circulation. The radio station seeks to entertain and only incidentally to inform, maintaining itself also by revenues derived from advertising. There is no income from the unseen and uncounted "circulation." The only guaranty of circulation the station can offer is its reputation for maintaining a continuing public interest in what it broadcasts.

We find broadcasting stations owned by newspapers, radio shops, music stores, hotels, restaurants, theaters, manufacturers, department stores, public utilities, insurance companies, and a score of miscellaneous other commercial enterprises. We find them also owned and operated by states, municipalities, schools, churches, labor unions, and fraternal orders. The trend is now to maintain stations as separate business entities; among the 611 broadcasting stations listed in a compilation prepared for the United States Senate in December, 1929, there were 229, or 37.4 per cent, which showed their business to be broadcasting *per se.*

Most stations, however owned, were losing financial propositions until the business of broadcasting was more or less stabilized by the recognition of radio's possibilities as a medium of advertising. Many have had and some still are having all or part of their original and maintenance costs charged off to accounts other than the business of broadcasting itself. Good will for their owners was often the only original reason for being for stations. Now the effort is to capitalize this good will in the form of indirect, and sometimes direct, advertising of products or services.

The business that makes perhaps the most substantial profits from broadcasting is the manufacture of radio apparatus; the highly developed broadcasting services of today, in fact, largely sprang from recognition of this peculiar feature of the radio industry. Demand for the manufactured product,—that is, sets, tubes, and parts,—varies directly with the type and quality of programs broadcast. Thus a political campaign, a world series, a football match, or a championship prize fight marks a seasonal or sporadic marketing boom. Yet it is worth noting that relatively few radio manufacturers operate broadcasting stations themselves, although they lead all other industries in the sponsorship of radio programs.

The broadcasting structure, for general purposes, may be divided into two classes, local and national. In the local classification may be included the high-powered as well as the medium and low-powered stations. High power often carries programs over widespread areas, but usually the consistent service range of even the highest powered broadcasting station does not exceed a few hundred miles. Its service is at least regionalized, if not localized to the narrow radius of the stations of the lower powers.

National broadcasting is made possible by linking these local broadcasting stations, irrespective of their powers, by means of telephone lines. The station studio in which the national program originates is known as the "key" of the network, or hook-up, and this system of broadcasting is known as "chain" broadcasting. The individual stations obtain the programs over the leased wires and broadcast them to their own audiences on their own wave lengths. Sometimes only part of the country will be covered by a network. At other times—almost always for great national events like an inauguration, and increasingly for the programs sponsored by nationally advertised products—the whole country is covered by the stations linked for chain broadcasts.

The operation of each broadcasting station, or unit, reveals a peculiar individuality which can only partially be inferred from the character of its ownership. The listener himself measures in his own mind the relative merits of the stations within his set's tuning capacity, and chooses those whose programs he prefers. About three-fourths of the country's stations are operating with low or medium power on wave lengths which necessarily are crowded because only ninety so called "channels" are available for broadcasting purposes; the rest of the radio spectrum is largely used for directed communications of various kinds. When a station has the exclusive use of a wave length for a given period, this is known as "cleared channel" broadcasting. Such channels are the most highly prized, for they are free from the wave clashes known as heterodyne interference that result from the use of a single channel by more than one station. It is plain that only a few stations can be given "cleared channel" privileges; if other stations sometimes share these prized wave lengths during daylight hours, it is because the day offers less likelihood of interference than the night.

The manager of any station seeking to maintain a general appeal and hold an audience faces the task of keeping that station in constant operation during the hours of operation for which it is licensed by the Federal Radio Commission—from early morning until midnight, or perhaps an hour later, in the case of full-time stations. He must diversify his programs and keep them of high order. He must have a complete and competent staff, including announcers, artists, directors, engineers.

In this country, most broadcasting stations support themselves by "selling time," the rates varying for various stations. In "selling time," the station, in effect, leases its facilities for a given period to an advertiser, who either stages his own performance or engages the station staff to stage one for him. Time that is not sold is occupied with features of the station's own selection. The first type of program is known as a *sponsored* program, the other as a *sustaining* program.

American broadcasting differs essentially from that of most other countries. Broadcasting almost everywhere else is supported by taxes imposed upon the possession of a receiving set. Many other countries operate their broadcasting systems as government monopolies, although there are a few exceptions where concessions are made to private monopolies. Departments or bureaus or committees administer the programs. The British Broadcasting Corporation is an example of a government-owned and departmentally-administered monopoly. The owner of a radio receiving set in the United Kingdom pays to the government an annual license fee of about $2.50. The German Broadcasting Company, also under government auspices, collects a fee on each set of about 50 cents a month, the collections being made by the postman. Fees in other countries vary from 5 cents a year in France (which is one of the few countries authorizing private operation) to $18 in Salvador (where the government holds the monopoly).

In most foreign countries there is no advertising sponsorship of programs. There are a few exceptions. The German system will sell a given hour of the day to advertisers, but keeps the rest of its broadcasting period free from advertising of any kind. The British Broadcasting Corporation will devote no time whatever to commercialism.

A typical American commercial station of high order is WMAQ, owned and operated by the *Chicago Daily*

News, which regards it as an invaluable good-will adjunct but conducts it on a business basis. Station WMAQ "sells time" at rates that vary with the period of the day desired and the fraction of the hour used. This station stipulates in all contracts with its time purchasers:

"The advertiser must pay for talent used in his radio programs. The *Chicago Daily News,* through its program department, will assist the advertiser, at his request, in obtaining talent and arranging programs, but acts only as the advertiser's agent. The cost of installing and leasing special telephone or telegraph wires and amplifier equipment [such as the "remote control" connections from dance-halls, dining-rooms, or theaters to the transmitter] for transmission of a radio advertising program must be borne by the advertiser.

"The *Daily News* reserves the same general right of censorship over the nature of an advertiser's radio program as is exercised by the *Daily News* over newspaper advertising accepted from newspaper advertisers. The advertiser's program must be of high quality, in content and in performance, and is subject to approval in advance by the *Daily News* in every detail. Any contract for radio advertising is subject to all authorized requirements, regulations and acts passed by the various states or by the United States Government or its departments and bureaus with regard to radio broadcasting control."

For all practical purposes, this station and its commercial rules afford a typical example of the management of the higher grade of stations in the United States whose powers may range from 500 to 50,000 watts. Commercial rates, of course, vary with the stations; there is no fixed standard. They range from a few dollars an hour charged by the local stations of extremely low powers, sometimes simply one-man affairs, to the $1,000 an hour which a high-powered, "cleared channel" Middle Western station announced it would charge for its choice time in 1930 because of its extraordinary wide range of listeners. As a general rule, it may be said that advertising rates vary according to the power employed, the marketing area covered, and the station's reputation for attracting and holding an audience.

Like a newspaper, the broadcasting station must seek to attract the greatest possible "circulation." Therefore, its life blood is the day-by-day and hour-by-hour quality of its programs. It is obvious that certain communities cannot produce enough talent to supply their broadcasting stations with good performance material. It is impossible to make the programs of remote local stations attractive enough throughout the day to keep the listeners' dials pointed to that station. Even phonograph records, with all the diverse and high-grade features they can carry and the excellent tonal reproduction that is possible in broadcasting them, will not satisfy—although it should be noted here that more and more full continuities, especially transcribed on disks or films for local broadcasting, are being made available to stations throughout the country.

The need for additional talent, obtainable only from the centers of amusement, which almost invariably are the centers of population, accounts largely for the existence of the great broadcasting chain organizations. These have "key" stations and studios of their own in New York City and studios in Chicago and other cities, and they can pick up programs from virtually any point to which a telephone wire can be stretched.

The chains are to local broadcasting stations what news services like the Associated Press and the United Press are to local newspapers. They syndicate the best program material available. They stage their performances largely where the talent is concentrated—Broadway is the most important American center, but places like Chicago and Hollywood have grown to great importance. Like the local stations, the chains, too, must "sell time" for financial support. Their saleable hours are generally occupied by advertisers of nationally distributed products or services.

The United States has two chain organizations of national scope, the National Broadcasting Company and the Columbia Broadcasting System. Each has subscribing stations throughout the country, so that their programs can be broadcast to every corner of the land. The stations, like the newspaper subscribers to the Associated Press and United Press services, are almost invariably independently owned; the chains themselves own or control only their New York "key" stations and a few others. The chains undertake to provide the announcers who are on the spot to describe great current events. They contract to furnish the great artists, operas, recitals, lectures, speeches, sermons, and other features of national interest.

Advertising rates for such hook-ups of stations, of course, are commensurately higher. The chains pay flat rates to the stations they use as outlets for the program periods they have sold to advertisers. They pay the telephone-line tolls for the advertising or *sponsored* periods, and the station gets a flat sum (not always equal to its local time rate) for subscribing to them. And the stations pay a similar fee to the chain, as well as the line tolls, for the *sustaining* features, which generally are special hours by the chain's own artists, educational features, and descriptions of current news events as they occur.

Network rates depend upon the size of the network; the cost of time alone—that is, excluding the performance material—on a basic net of twenty stations extending from New York to Kansas City is around $5,000. Each chain has such a basic net, to which may be added more stations, as demanded by the advertiser and provided the stations are willing to subscribe to the program. Chain broadcasting is treated elsewhere in this book, as is the business of broadcasting from the point of view of the individual station operator. Only a hint has been given heretofore in this discussion as to how the American networks came to be formed, and it may be pertinent to review the relatively short history of the two major chain organizations.

The National Broadcasting Company was organized late in 1926 at about the time the American Telephone & Telegraph Company, which had developed many radio patents in its research laboratories and owned several stations, had decided to forsake the broadcasting field entirely. The A. T. & T. had occasionally linked groups of stations with its wires for the broadcasting of important events like the Coolidge inauguration of 1924. But it proposed to leave the broadcasting field to others.

Owen D. Young, then chairman of the boards of the General Electric Company and the Radio Corporation of America, is generally credited with having conceived the idea of a great chain organization devoting all its attention to programs designed for widespread distribution.

The General Electric Company is one of the main factors in the combination of radio patents upon which the Radio Corporation of America was established and upon which much of its present strength rests. The Westinghouse Electric & Manufacturing Company is another important contributor of radio patents to the R. C. A. By their patent cross-licensing arrangement, radio sets, tubes, and accessories bearing the R. C. A. trade-mark formerly came largely out of the General Electric and Westinghouse plants under a scheme of production allocation and today are produced in centralized plants in which these corporations have direct interest.

Perhaps 90 per cent of the other manufacturers of radio sets in the United States are licensees of this patent combination, paying royalties for the use of its patents. It was naturally to the economic advantage of all concerned, and particularly to the R. C. A. and its affiliated companies, to stimulate the sale of radio apparatus. The best possible stimulus is the broadcasting of consistently high-grade programs.

The National Broadcasting Company was formed with 50 per cent of its stock owned by the R. C. A., 30 per cent by the General Electric Company, and 20 per cent by the

Westinghouse Electric & Manufacturing Co. It was anticipated there would be losses, and these were to be shared in like proportion.

Even Mr. Young's fondest expectations did not envision the acceptance of chain broadcasting as an advertising medium by so many makers of nationally distributed goods. Hopes that equipment sales would increase were fully realized. Mr. M. H. Aylesworth, the president of the National Broadcasting Company, told a Congressional committee at one time that every time a station joined the chain the sales of radio receiving sets in its immediate vicinity doubled in volume within a month.

The Columbia Broadcasting System entered the field about a year later, starting with a membership of fifteen stations. Its basis of organization was considerably different from its predecessor's. Having no such parental backing or patent holdings, its hope was and is to profit from the sale of time to national advertisers. It furnishes lively competition in the chain broadcasting field, all of which redounds to the benefit of the listener whose attention and good will are eagerly sought and whose preferences and predilections attract him to one station or another. Both chains have operated with large deficits, but both have potentialities of large earning power.

The reader may have wondered about the necessity of linking stations by means of telephone lines. This brings up a subject that concerns the future of chain broadcasting.

Telephone-wire connections are necessary because no station, however powerful, is able to furnish reliable service to the whole country. Static, fading, and the other vagaries of radio demand that programs intended for national audition shall be transmitted over wires to the redistributing points, where a reliable local or regional coverage can be assured on the several wave lengths used by the different stations. All the chain stations taking the same program cannot use the same wave length because they want to retain certain periods of time for their own local programs and to broadcast them as free from interference as possible. The synchronization of a multitude of stations on one wave length has not yet been accomplished technically, but high hopes are held for such a development. Its accomplishment will benefit both the stations, which will be freed from the blighting and restrictive effects of heterodynes, and the chains, which may be able to develop a new system of transmission thereby.

Chain broadcasting is evolving to the point where one wave length may be sufficient to carry a network program to the entire country. If and when such synchronization is accomplished, the establishment of chains of stations, possibly owned and operated by the chains themselves and devoted entirely to national programs, may be expected. This is the goal of synchronization tests that have long occupied the attention of many radio engineers.

If this goal is achieved, it may spell the end of chain programs from the independently owned stations. Or it may simply mean the establishment of new outlets for more chain programs. Such a revolutionary development in the broadcasting structure would undoubtedly effect an economy of the all-too-scarce wave lengths. It may also mean the establishment of additional competing chains. The listener stands to benefit in any event.

It would be as if the Associated Press and United Press established community newspapers to carry their national news reports only. All of the stations of one National Broadcasting Company chain, for example, would operate on one wave length. All on the Columbia Broadcasting System's network would utilize another channel. No more channels for national programs would be required unless new regional or national chains were started.

Presumably the chains would own these stations themselves. As for the independently owned stations, they would be devoted to programs of local origin, perhaps obtaining some supplementary services from the network studios.

Programs specially recorded for broadcasting have been mentioned. These have been quite successful so far, carrying announcements and programs from disks that are not unlike those of the chains. Records, of course, will never help the "spot" reporting of news event. This service can only be furnished over the wired networks. The chains have assiduously held to the policy of delivering to their member broadcasting stations only such programs as are actually staged in their studios by actual performers.

Another future development in program service which is closely akin to the radio art is aborning as this is written. It is "wired wireless," more often called "wired radio." This is the system whereby programs may be sent into the home on the carrier frequencies which follow the path of the house power or telephone lines. This method of transmitting voice and music has long been known, and is commonly employed today to afford a multiplex use of telephone wires for conversations.

"Space radio" took to the entertainment field first, however, and has captured the fancy of the great mass of population. "Wired radio" proposes to enter the field to furnish a supplementary program service, for which the chief *raison d'être* is that it will be free from the vagaries of radio reception, such as static, fading and interference, and will contain no advertising matter.

The programs would be transmitted from central studios to power substations and thence delivered to the homes served by the power lines. Subscribers would pay for the service on a monthly rental basis, the receiving sets being installed in their homes and serviced by the power company. Supporting revenues would come from the receiver rentals and from the additional electrical current consumed.

The North American Company, a large public utility holding company with operating subsidiaries in many large cities, has organized Wired Radio, Inc., as a subsidiary to exploit this system. Experiments have been conducted since

1922, when certain patents of Maj. Gen. George O. Squier, the former Chief Signal Officer of the United States Army, were acquired. Experimental trials have shown good results, and the North American Company has entertained high enough hopes for the future of "wired radio" to have invested large sums of money in the acquisition of hundreds of patents and thousands of musical copyrights.

It is evident from the foregoing discussion that we are only on the threshold of great new developments on the broadcast side of radio. The author has not gone into more detail on the phases here treated because they are covered in other chapters of this volume. If the development of broadcasting in a few short years has been remarkable, the future holds forth many more and more fascinating prospects, which the various authorities contributing to this book disclose.

The radio program the listener tunes in tonight is an accomplishment since 1920. Visual broadcasting, more commonly called television, is confidently promised for the future by eminent scientists; indeed, tremendous strides have already been made toward the technical solution of the problem of sending images along with sound into the home *via* radio and wire. The radio receiving set of the future may be one enabling its operator to see as well as to hear. Broadcasting and its industrial structure will then undergo a complete reorganization.

A substantial edifice, but one based on nebulous foundations and subject to whims and caprices as varied as human nature itself—withal, held at the mercy of the scientific laboratory—that is the American radio structure.

NATIONAL BROADCASTING

By Merlin Hall Aylesworth

President, National Broadcasting Company

THROUGHOUT the world the pace of life is rapid, and growing ever more so. But here in America life whirls by at a pace to set conservative brains dizzying at the aspect. We are told that no people live so rapidly as we do. We erect skyscrapers and five years later tear them down to be replaced by still larger buildings. Tearing, building, tearing, building—American industrial life is relentless.

Skyscrapers, tunnels, bridges, railroad lines, gigantic industrial plants—these are individual instances, examples of the rapid growth of industry. But the grandest example of our swelling, hurtling life is to be found in the growth of this thing called radio. Unlike the other instances mentioned, radio is at once a science, an art, and an industry, employing millions in capital and equipment, hundreds of thousands of workers, and serving one-half the population of the country. Being a combination of science, art, and industry, it would seem to be most unwieldly. Dependent on so many conflicting developments in these separate fields, it would seem to require centuries to develop into a unified whole. Radio is so much a part of our everyday lives that we take it for granted, little realizing that in 1930 it had only reached its tenth birthday.

The movies are about twenty-five years old. The automobile industry is the same age. Radio in 1930 is barely ten. Surely it may be called the infant industry. Still, young as it is—not one-half the age of the other two—it ranks with them in wealth and outranks them in the numbers of people affected in their daily lives by its existence. In ten short years radio has grown from non-existence to an industry approaching one billion dollars per year, employing more than three hundred thousand workers, and catering to an audience of well over fifty millions. Radio is the modern version of Jack and the Bean Stalk. Time has shrunk. A hundred years of development have been accomplished in ten. But the ten years of radio can no longer be considered a mere decade. This particular ten years marks an era—the Era of Broadcasting.

Early in 1920 a voice, speaking into a primitive microphone, broadcast over crude transmitting apparatus, heard by perhaps fifty people with home-made receiving sets and ear-phones, asked those who were listening-in on the program of phonograph records to oblige the broadcaster by telephoning or writing him to the effect that the signals were coming through, and commenting on the quality of reception.

"Will those of you who are listening in please phone me or write me at East Pittsburgh, Pa., telling me how the program is coming in. Thank you. Frank Conrad, station KDKA, signing off." Frank Conrad, radio pioneer, was speaking.

Today virtually the same message is spoken by the radio announcer of a sponsored program, spoken into a sensitive microphone which catches his every inflection, through a vast control room from which wire networks reach out to scattered broadcasting stations saturating the radio ether from coast to coast so that tens of millions may hear by means of perfected receivers manufactured by mass production at a cost well within reach of the most humble family.

Now some manufactured articles have intrinsic merit. The value of others depends upon their use. But in most instances the use of the article is limited only by the desire on the part of the owner to use it. Not so with radio. The radio receiver has no value of itself. Its sole value is derived from its ability to receive broadcast programs. The number and the quality of programs broadcast, however, is not in the hands of the set-owner. On the face of it, the purchaser of a radio set is taking a great chance. He buys the set with a view to obtaining programs. Supposing the radio stations stopped broadcasting? The purchaser's investment would be a total loss. That the purchaser has faith in the continuance of excellent programs is attested by the vast numbers of radio receivers he buys every year. That this faith has been realized and acted upon by broadcasters is also a matter of note. Radio manufacturers invest millions and build millions of receivers, purely on the assumption that broadcasters will continue to disseminate fine programs, by means of which the public interest in sets to receive such programs will be maintained. When broadcasters quit or lessen the quality of their programs, the set manufacturers will have to close shop. Under the tremendous strain of this responsibility, the broadcasters have done nobly.

But they have a responsibility far surpassing that to the radio manufacturer. They have a responsibility to the public. Catering to millions, influencing every part of their lives, from setting-up exercises at 6:30 A. M. to the bed-time hour of the latest night-life denizen, radio is a public trust. At first, broadcasting was not recognized as such. It was considered a powerful force which might serve the broadcaster. Shortly after the opening of KDKA, others stepped into the charmed circle. They knew not what to look for in broadcasting. To some it was personal egotism. To others it suggested the vague possibility of gaining a fortune. But all thought that by crossing the magic line, by stepping into the broadcasting ring, their lives would be charmed. Their number grew until, by the time the Federal Radio Commission was formed in 1927, there were 733.

The great stampede trampled over the ether waves, treading on each other, each shouting to be heard above the din of all the others.

Having stepped into the charmed circle, they waited for the charm to work. And they waited. Where was all this wealth for which they were fighting each other, crowded in the small circle of broadcasting wave lengths! Seemingly, it was all a dream. Expenses there were, ever mounting expenses. But of income there seemed to be no trace. Milling about in the broadcasting ring, nearly a thousand broadcasters looked to each other for aid. They stood about and shivered in the cold of financial loss. Was this wild scramble to enter broadcasting a mirage? They decided to wait and see.

After a little, having lost their all, a few timid souls dropped out. Then a few more followed. The pendulum had reached its extreme. It was beginning to retrace its course. It began slowly. By 1925 its speed was growing. More and more broadcasters were leaving the charmed circle. There had been no charm. They were through. Meanwhile, set manufacturers and radio-tube manufacturers, dependent on broadcasting for the sale of their product, were becoming anxious. Opinions were expressed that broadcasting was just a fad that was already beginning to die, for lack of sustenance. In the meantime, a few stations had developed such tremendous public acceptance that they dared not leave the field for fear of creating such ill will on the part of their public that the cost of discontinuing on the air would be more than the cost of broadcasting. The situation was growing desperate.

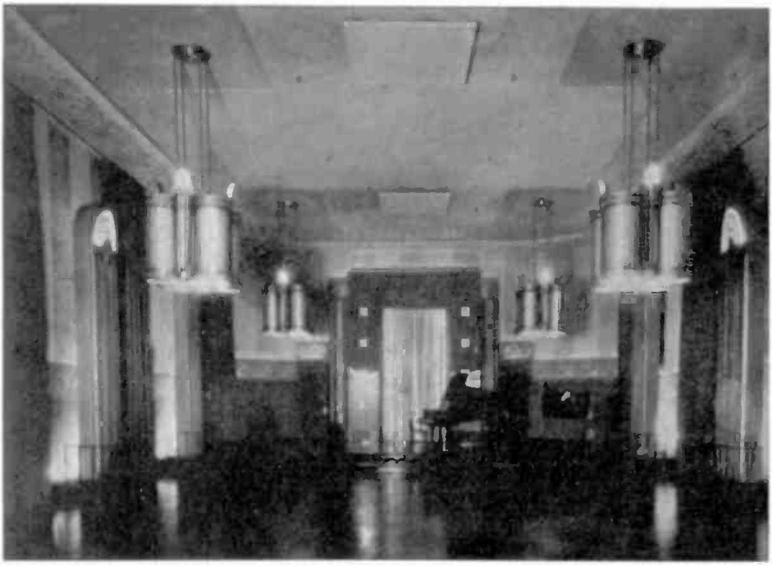
Among the broadcast experimenters—and that is precisely what they were at the time—was the American Telephone & Telegraph Company, operating station WEAF in New York City as an experimental station. Its prime interest was to learn how the radio telephone could be utilized in the furtherance of the Bell Telephone System's service to the nation. Naturally, the economic problem faced the telephone workers as it did the others. Before broadcasting could be considered a prospective customer, it had to find ways and means of making both ends meet. How could broadcasting be made to pay? The public could not be taxed. It would be unwilling to pay for what had been given free for many years. Obviously, the payment had to be imposed on the microphone end. That is the way the telephone company collected its fees. Why not the same thing in broadcasting? Toll broadcasting—that was the answer. Just as a person who had a message to deliver did not set up a telephone line of his own, but rather rented a line from the telephone company, so might various organizations, seeking to gain admittance into the homes of the land so as to introduce their good-will message, rent the broadcasting facilities. The organizations would thus be saved the expense of building and maintaining their own stations, together with filling in many hours each day with worthy programs in order to hold an audience together.

Thus WEAF became a toll broadcasting station, late in 1924. A few organizations came to the studio and broadcast their good-will messages. At first these organizations were anxious to talk to the unseen audience, firmly convinced that this medium was no different from the printed word. However, it soon became evident that broadcasting was a more intimate, more social, more delicate medium. Just as a high-powered salesman would hardly dare to engage in a hard-boiled sales talk when a guest of a family, so broadcasting, invited to the home fireside, could not "talk shop." The family were gathered about the broadcast receiver for just one purpose—to be entertained. Realizing that its first obligation was to the listeners-in, the WEAF station insisted that all program features contain maximum entertainment value. And so the sponsored musical program as a vehicle for the brief good-will mention came into being.

To the American Telephone & Telegraph Company must go the credit for first attacking the economic problem of broadcasting. In furtherance of its service to the public and also to the sponsors, the telephone organization soon sought to supply its programs to a few broadcasting stations, located in various centers. Realizing the meager program sources at their disposal, these stations anxiously turned to the key station, WEAF in New York City, which could bring them programs of the highest standards. As a syndicated program rather than as an individual offering, the network could afford to seek the highest professional talent in place of the erstwhile amateur talent. In addition, the sponsors could cover not just New York City, but many cities and their surrounding areas. And so grew up the WEAF network, covering New England, reaching southward into Philadelphia and Washington, and west through Buffalo, Pittsburgh, Cleveland, Detroit, Cincinnati, Chicago, St. Louis, Davenport, Minneapolis, and Kansas City. This group was woven together by approximately 3,600 circuit miles of special telephone line, with Boston, Hartford, Providence, Worcester, Philadelphia, and Washington linked by permanent wire facilities, and with the remainder on a temporary wire basis.

By 1926 the radio industry had grown to enormous proportions. The public had invested hundreds of millions of dollars in radio equipment, with the tacit understanding that broadcast programs would flow into every home provided with a radio set in an endless stream. Yet the broadcasters, who provided the very foundation for the radio industry, received no direct return for their efforts. They did the sowing, but others did the reaping. For the most part, they were supplying something for nothing. Broadcasters were in many instances ready to quit. The radio industry, indeed, rested on a crumbling foundation. Broadcasting was just an experiment.

Then it was that three organizations most concerned with the future welfare of the radio industry and the safeguarding of the huge investment made by the American



"Cathedral Studio" of National Broadcasting Company, Showing the Effect Created by an Indirect Lighting System Used to Create Atmosphere for the Artists.

A Corner of the "World Studio" of the Columbia Broadcasting System. Numbers and Letters on the Baseboards Are Used by Instrumentalists to Mark Their Correct Locations in Relation to the Microphones.

public in broadcast sets, decided that broadcasting was not keeping pace with progress in the radio industry. Broadcasting lacked stability and permanence. It was an experiment. There was no assurance of continued broadcasting. The quality of programs generally available limited the merchandising of radio sets. While the main centers might provide sufficient program material, the smaller centers were quite unable to keep up the necessary daily flow.

Once again, the radio industry in its hour of need turned to the astute leadership of Owen D. Young, preëminently identified with the founding of American world-wide radio communication. Under the leadership of Mr. Young, the organizations most concerned—namely, Radio Corporation of America, General Electric Company, and Westinghouse Electric & Manufacturing Company—decided upon the formation of a nation-wide broadcasting service to meet the immediate as well as the future requirements for programs of the highest standards.

In September, 1926, the National Broadcasting Company came into existence, as a realization of the ideal of nation-wide broadcasting service. It was charged with the preparation and presentation of the highest-type radio programs possible, together with the distribution of such programs *via* networks and associated radio stations throughout the country. As the starting point, the National Broadcasting Company took over the ownership of station WEAF and the extensive radio network developed by the American Telephone & Telegraph Company. WEAF became the key station for the first, or *Red,* Network. Shortly afterward, station WJZ of New York and station WRC of Washington, both owned by the Radio Corporation of America, which had developed a modest network of stations, were taken over on a management and operation basis. Station WJZ became the originating station for a second, or *Blue,* Network, thereby providing an alternative program in most territories already covered by the WEAF network. Still later, a third network was organized for the Pacific Coast, with San Francisco as the originating point.

Thus came into being an organization primarily devoted to indirect sales promotion for the radio manufacturing industry. Its basic principle of operation was obvious. In order to carry out the purpose for which it was organized, it must of necessity be, first of all, an institution of service to the listening public, for the listener is the economic basis upon which the broadcasting structure rests. In other words, in order to serve the radio manufacturing industry, the broadcaster must give the radio listener what he wants. The sale of a radio set, in the final analysis, is in reality the sale of a seat in the theater of the air. The buyer of that seat expects a continuous radio show throughout his waking hours, seven days a week, always different, always fresh, always interesting. Such is the sum and substance of the public's thought of an investment in radio.

It was a kind fate that caused commercial broadcasting to see the light of day in America—the New World—the Land of Opportunity—the haven of advertising and publicity. Having created a vast audience, and following in the footsteps of the American Telephone & Telegraph Company, whose experimental WEAF and associated station network had been taken over, the newly formed organization naturally turned to the sponsored program as the solution of its economic existence. Instead of looking upon the growing audience as a liability, this growing audience now became a valuable asset. Here, indeed, was the most numerous and attentive audience ever assembled. It could be reached in the quiet and intimate atmosphere of the home. It could be reached through the most natural channel for the exchange of human thought, namely, the speaking voice. And so the sponsored program received consideration.

Today, the radio station, as does its sister industry, the newspaper, depends for its financial support on advertising or the commercial message. A certain amount of time is set aside for broadcasting programs which include the messages of commercial institutions. The value of such advertising is its effect on the listener. So it is the listener who makes the programs. He is judge, jury, prosecuting attorney, plaintiff, jailer and lord high executioner. If the broadcasters will furnish him with what he wants, he will buy a radio set; if not, he will not buy. If nobody wants radio sets, there will be no value to advertising programs placed on the air, and the financial structure of the broadcasting business topples.

The expenditure of millions of dollars annually, the employment of hundreds of thousands of men and women, the use of thousands of miles of specially engineered wires to form networks—all these factors make possible the programs to which the entire nation listens every evening and during the day. Radio has had a most amazing public acceptance—indeed, the most unusual acceptance of anything new since the beginning of time.

It is to maintain that acceptance and the immense structure of the industry that the commercial program is cherished. It is the backbone of broadcasting, and as such, the foundation of every branch of the radio industry. It must serve industry and the public in general. And it does. To industry, the commercial program serves as the mouthpiece through which an organization may address the entire country. It serves the public by making possible programs of high quality such as would be impossible to attain were they to be financed in any other way.

Of course, not all programs are sponsored. There are, besides, sustaining and public-service programs. The sponsored programs are paid for by the advertiser, with the National Broadcasting Company acting as advertising solicitor for its associated stations, and the revenues received divided between NBC and the associated stations, which are paid uniformly without regard to location, power, or service area. Sustaining programs, on the other hand, are produced by NBC and distributed to the associated stations for payment by those stations that use the programs. They consist of entertainment of all kinds, produced mainly in the New York, Chicago, Washington and San Francisco studios of NBC. The public-service programs include educational, informative, religious, governmental programs, descriptions of important events, discussions of national issues, inspirational and cultural programs. The associated stations are independently owned and operated, and have no contractual or other obligations to accept or reject the programs. Just as newspapers receive material from press associations with full right to publish the material or throw it into the waste basket, so, too, the independent stations may feature the NBC public service programs or discard them. This being the case, the programs are judged individually, on their intrinsic merit, a fact which stimulates the broadcasting system to prepare consistently good fare for the associated stations. About 120 stations receive services from the National Broadcasting Company and the Columbia Broadcasting System, the two large American network organizations.

The network has solved the problem of the small-town station, far removed from the metropolitan centers of entertainment talent. With the use of network programs, the small station can provide its listeners with as fine programs as any station. Merely by connecting in on the network, it serves for eighteen hours a day the finest programs originating in the political, entertainment, industrial, and artistic centers of the nation.

We mentioned programs for eighteen hours of a day. These presentations affect the life of the nation from the time it rises until it retires after a strenuous day. Setting-up exercises start off the day. Then hints for the housewife, sewing, cooking, cleaning, the hundreds of matters affecting housekeeping, the purchase of food and clothing, the use of various household products. The afternoon listener may learn French or bridge, hear fashion talks, current events, politics, economics, literature, art, music, a debate, a meeting, or many other subjects. The evening gives programs of slightly less materialistic nature but perhaps more generally entertaining. Of course stock market closings and sports finals come over the air. The concerts, dance orchestras, political talks, opera, concerts, and so on, are featured. The entire field of man's and woman's interests is covered, every day with variations. For the farmer and rural folk there are special agricultural programs broadcast over those networks that reach into our vast farm sections during the day, for in the evening the farmer and the city dweller join in listening to the same entertainment.

The man at home may attend, *via* radio, the biggest political conventions and rallies. Detached from mob psychology, he judges logically the relative merits of the candidates. Fire-eating and arm-swinging are gone from the political arena. Common sense, facts and figures, and cool logic have taken their place. Eight million more ballots were cast in the 1928 presidential election than in the preceding one—proof positive of the political interest aroused by radio, to be sure.

Naturally, any agency whose influence is as great as radio's can be abused as well as used. Realizing to the full that broadcasting is a public trust, that upon its shoulders rests to a large degree how this country thinks and acts on the thousands of interests that affect our daily lives, those in charge of broadcasting have been most select in their programs. In a democracy, ruled politically, industrially, and culturally by the majority, public opinion is of vast importance to the national welfare. That radio has been an uplifting influence in the lives of the people is not the result of chance. Only by the most scrupulous attention to program material and production has this influence been created for the good and not for the ill of the country.

International broadcasting, done only sporadically before, started on a grand scale on Christmas Day, 1929, when the National Broadcasting Company interchanged programs *via* the short waves with England, Germany, and

Holland with complete success. What this means to international good will and the relations of mankind generally, I leave to the reader to contemplate. Certainly radio is affording a vehicle for realizing that "peace on earth, good will toward man" striven for, rather inadequately perhaps, these nineteen centuries or more that man has not known radio. International broadcasting will necessarily require that the policies of broadcasting companies be enlarged and more varied human interests considered.

Radio programs are primarliy entertaining. They should remain so. But as radio has concerned itself with more hours of the day and so with more of man's interest, it has had to offer more than entertainment. To the home-keeper it is a business asset, also to the farmer and industrialist. It has aided the great cause of education with the broadcasting of the Walter Damrosch musical appreciation hours. It has aided the schools with other features. Since radio stations function on Sunday as well as the rest of the week, it was only natural that radio should enter the field of religion. The religious and spiritual hours it has instituted are reported by the leading clergymen of the nation and of every denomination to have done more to bring religious thought and spiritual uplift to America than any other agency. Adult education has been fostered. Art has found not only a home in radio, but also an ally and disseminator of artistic work and interest.

All these and many other interests are served by radio. That it has been able to accomplish so much is due in no small part to the firm financial foundation on which it is based. Far in advance of its status in any other country, radio in America owes its preëminence to the revenue derived from advertising, advertising which is absolutely essential to the industrial life of the nation.

Returning to the commercial angle of broadcasting, radio advertising has made a place for itself in the field of merchandising. It is a recognized medium, highly organized, widely utilized, and with proved pulling power. Nor has it crowded out any other advertising media. Newspaper and magazine advertising has increased since the advent of the sponsored program. Broadcasting has not diverted funds; rather, it has earned additional funds for use on this new method of promoting business.

Essential to the manufacturer of radio receivers and associated products, radio has been placed on a solid business basis. It serves the industrial life of the nation as a powerful agency for the distribution of institutional messages. It serves the public by bringing the best entertainment, culture, information, and personalities into the home. Judging the merit of an institution by the quality of its service and the numbers it serves, radio may be said to give the highest service to the greatest numbers.

THE BUSINESS OF BROADCASTING

By William S. Hedges

President, National Association of Broadcasters

REGARDLESS of his theory as to his right to occupy the ether lanes, there is no broadcaster who does not believe that he is performing service in the "public interest, convenience, or necessity," as prescribed by the Radio Act of 1927. If called upon by the Federal Radio Commission to justify his existence as a broadcaster, he will twang all three chords with all his might to show how he, by a peculiar fitness, is able to render valuable service to the public.

When broadcasting first loomed on the horizon of public consciousness, those who entered the field did so without any idea of gaining a direct profit. There were few who deliberately set about to obtain one of the precious channels of radio to "sell time" to others as a business. The most that any of the pioneer broadcasters hoped for was that their broadcasts would gain good will for the benefit of the companies backing them, which ranged from electrical-equipment manufacturers to makers of baking-powder.

In many cases, participation in broadcasting was undertaken merely as a publicity stunt. In other cases, it must be acknowledged in all fairness that there was a purely unselfish purpose of serving the people. This was the spirit prompting such institutions as newspapers to enter the field. To a certain extent this was the idea of the manufacturers of radio equipment, although they had the additional inspiration of developing markets for their products.

The history of radio broadcasting during the relatively short span of its existence following the first successful use of the radiotelephone for general reception purposes in 1921 has been, in brief, the evolution of a business out of a plaything. The early broadcasts were, of course, of interest only to the radio tinkerer or "fan." The programs mattered little; the listener derived his satisfaction and excitement simply from the magic of picking voices or music out of the air.

These happy days in the broadcasting Garden of Eden, when the entire operating budget of an average broadcasting station was perhaps less than $25,000 a year, were destined to pass very quickly. The thing that brought about the change was competition in program quality, and hence in attracting audiences. This competition began to be felt, though rather slightly, as early as the last months of 1923, but it was in 1924 that radio programs as we know them now really began.

The chief cause for this change was the development of chain broadcasting. This feature of radio service, destined to play the principal part in the development of broadcasting as a business, came about originally almost as an accident. The American Telephone & Telegraph Company, which owned and operated station WEAF in New York, was at that time carrying its chief load of ordinary telephone business in the daytime; during the evenings its long line facilities were by no means packed to capacity. It occurred to the telephone company, which was interested also in radio patents and the manufacture of transmitting equipment, that excellent and potentially profitable use might be made of these facilities by distributing over its wires a certain number of the evening programs from WEAF for simultaneous broadcasting by other stations. In order to defray the expense, a plan was evolved whereby the stations would receive this service approximately free, the programs being sponsored so far as possible by advertisers desirous of creating general good will for themselves and their products.

It became apparent almost immediately that the quality of such programs could be made much better than that of any of the local programs being broadcast, because they originated in the nation's great center of entertainment and because an advertiser sending a single program over twenty or thirty stations could afford to spend ten or fifteen times as much as the cost of a local program and still save money. Accordingly, by the autumn of 1925 the chain broadcasting from WEAF had established a wholly new conception of program quality, and with it an entirely new standard of program cost.

Along with the development of chain broadcasting came a complete revision of the idea of radio-station coverage. In the early days, with few stations on the air and little public criticism of quality, a station even with 500 watts power could logically claim to cover an enormous territory. As the number of stations increased, with a consequent growth of interference, and as listeners became more and more exacting in their demands as to quality, the effective range of even the most powerful broadcasting station was gradually cut down. Concerns which had built 5,000 watt stations in the hope of covering the entire continental United States were beginning to discover that their effective range was only within a radius of 100 miles or so. This change was, of course, a tremendous incentive to the further development of chain broadcasting and led to a further concentration of program expense.

By the fall of 1926, program costs had advanced to a point where the majority of the owners of broadcasting stations realized that they, too, must seek outside sponsorship for their local programs if the cost of operation was not to be ruinous. Accordingly, one by one the leading stations swung into the commercial column. Stations which in 1925 had refused to sell a minute of their time for advertising purposes were by the spring of 1927 building up sales organizations and special facilities for the production of commercial or sponsored programs. The gross operating budgets went up rapidly, until in 1929 the gross cost of operating a first-class station ran from $250,000 to $500,000 a year, exclusive of the talent cost for chain commercial programs.

This evolution brought with it certain abuses and many complaints. For better or worse, America had decided to develop radio broadcasting in a manner entirely different from that employed in almost all other countries. Elsewhere broadcasting has been supported by the listeners through taxes imposed on receiving sets, and consequently the programs are largely or wholly free from advertising. In America the listener has paid and is paying nothing for the service, the cost being met by advertisers. Not unnaturally, the advertisers demand their money's worth, though in some instances they appear to have defeated their own purpose by going too far in the matter of direct sales effort and creating a positive ill will among listeners.

On the whole, however, broadcasting appears to have established itself as a definitely valuable advertising medium, and its development in America on the basis of commercial sponsorship of programs seems to be permanent. By the end of 1929 the total amount paid by advertisers for commercial programs, including chain, recorded and local service, was at the rate of many millions of dollars annually, and a considerable number of broadcasting stations were able to report that they were operating at a profit.

The broadcasters today are a complex group, as complex as the American public itself. Stations are now owned by radio manufacturers, newspapers, merchants, churches, colleges, and a variety of other interests too numerous to classify. Most of the stations are now frankly commercial, seeking to earn profits or at least pay their way. The conception the commercial broadcaster holds of his function is that he is the trustee of a channel, held under government license, which he sublets to others whose facilities for bringing audible messages to the public are limited.

The advent of the commercial broadcaster has done much to alter the economic status of all broadcasting stations, with the possible exception of those owned by churches or educational institutions. In the early days it was easy enough to fill up broadcasting time with phonograph records or volunteer talent. The latter was often eager to perform before the microphone for nothing. More than often, such services were worth just that—nothing. Such entertainment did not justify much expense.

The commercial broadcaster, however, having sold time, felt the necessity of showing results in the way of an attracted audience. He spent money for programs, securing good talent by paying for it. Thereby he raised the standard of local broadcasting to approach and sometimes excel that of the chains, subscribing to enough programs of the latter to offer his listeners the high-quality talent that could be procured only at the centers of population which were likewise the centers of entertainment talent.

The path of the broadcaster, however, was not so simple and roseate as this discussion thus far may indicate. Even before being confronted with the necessity of hiring good talent, there was one item of expense that was recurringly encountered. This bill, now one of staggering proportions for the broadcasting business as a whole, was presented by the organized music publishers of the country. They informed station operators that they viewed the broadcasting of their music as a performance for profit and hence a violation of the copyrights they owned. The broadcasters were given the choice between taking a license from the music publishers, whose organization controlled about 90 per cent of the popular music, or else refraining from the use of selections currently rendered in theaters, ballrooms, and other places of amusement. Each unauthorized performance of a copyrighted selection meant a fine, under the copyright law, of $250.

The broadcasters at first protested that they were making no profit from their business; that the broadcasting of such selections tended to popularize musical compositions and thus really helped the publishers by creating wider markets for their product. They fought the copyright-holders on the grounds that their demands were excessive and unreasonable. But the copyright proprietors secured one or two lower court decisions, which were sufficient to convince many of the broadcasters that it would be cheaper to pay for licenses than to continue the litigation. The licenses then amounted to a few hundred dollars for the large stations, but the fee has increased year by year until today the license fees paid by individual stations amount to thousands of dollars.

It might have been possible to build up an independent source of music, but the public had to be considered. Radio listeners wanted to hear the latest song hits, the tunes of current stage shows, and the syncopations to which they danced at their clubs and hotels.

The commercialization of radio brought with it many more problems. Clients of stations became dubious about the effectiveness of radio as an advertising medium. They sought to place announcements in their evening programs which quoted prices. Listeners seemed to resent this. Some advertisers are still unconvinced that the surest way to win over the radio audience is to build good will rather than to attempt to assail its ears with sales talks during the hours of its leisure. Most sponsors of programs, especially evening programs, have found that the mere mention of the sponsor's name and a brief mention of his product constitute the most successful utilization of radio for advertising purposes.

Another problem that faced broadcasters was the matter of phonograph music, sometimes referred to in the press as "canned music." There seems to be no question but that carefully prepared recordings are often superior to unrehearsed programs offered by unskilled artists. Records are particularly valuable sources of broadcasting matter for stations located in regions where talent is scarce.

It remained for the National Association of Broadcasters, which is composed of the owners and operators of a large and representative part of the nation's broadcasting structure, to attempt a solution of the problems relating to the commercial practices of stations. Seeking to regulate their own industry, the broadcasters, at a meeting in Chicago in March, 1929, adopted a code of ethics and a table of standards of commercial practice, texts of which are appended to this chapter.

Commercial problems were not the only ones confronting the broadcasters, however. Not the least of their troubles comes from government regulation. Without such regulation, broadcasting by the very nature of its technical limitations would quickly fall into a state of chaos. Yet regulation has given the individual broadcaster many pains, for it does not permit him the freedom of action other business men have. He has to undergo constant surveillance. His license to use a wave length is issued to him for ninety-day periods only. Yet he blithely must continue to make huge investments in broadcasting equipment and enter into long-time commitments for rent, talent, telephone and telegraph facilities, etc. He does all this with no definite knowledge that he will be in the broadcasting business after the expiration of his present license. He does not know the new wave length to which he may be required to shift momentarily. He does not know whether he will be permitted to retain his present power and consequently his present range of listeners.

He has seen stations ordered off the air by the Washington authorities, never to return. He has seen others shifted, and perhaps himself has been moved, to congested wave lengths, with powers reduced and operating hours limited. All such changes have been for cause, of course, but regardless of the merits of the cases, such a condition does not foster a feeling of security. Nor does it promote stability in the broadcasting industry. Still, perhaps it is well that this is the condition, for a feeling of security might lead to abuse, and stability might foster mediocrity.

Broadcasting is probably the most regulated business in the United States. Even the public utilities must concede this. Nevertheless, it has accomplished two great things in less than a decade of existence. It has solidly established itself in the life of the American people, and it has become an important business with a reasonably sound economic basis.

Code of Ethics

Adopted by the National Association of Broadcasters

1. Recognizing that the radio audience includes persons of all ages and all types of political, social, and religious belief, every broadcaster will endeavor to prevent the broadcasting of any matter which would commonly be regarded as offensive.

2. When the facilities of a broadcaster are used by others than the owner, the broadcaster shall ascertain the financial responsibility and character of such client, that no dishonest, fraudulent, or dangerous person, firm, or organization may gain access to the radio audience.

3. Matter which is barred from the mails as fraudulent, deceptive, or obscene shall not be broadcast.

4. No broadcaster shall permit the broadcasting of advertising statements or claims which he knows or believes to be false, deceptive, or grossly exaggerated.

5. Every broadcaster shall exercise great caution in accepting any advertising matter regarding products or services which may be injurious to health.

6. Every broadcaster shall strictly follow the provision of the radio law of 1927 regarding the clear identification of sponsored or paid-for material.

7. Care shall be taken to prevent the broadcasting of statements derogatory to other stations, as to individuals or to competing producers or services, except where the law specifically provides that the station has no right of censorship.

8. When charges of violation of any articles of the Code of Ethics of the National Association of Broadcasters

are filed in writing with the managing director, the Board of Directors shall investigate such charges and notify the stations of its findings.

Standards of Commercial Practice

Adopted by The National Association of Broadcasters

The Commercial Broadcasting Committee recommends that the following be adopted by the Association as a guide for member stations in formulating their commercial policies and regulating their commercial practices.

I. Program Content and Presentation

A. There is a decided difference between what may be broadcast before and after 6:00 P. M.
Time before 6:00 P. M. is included in the business day and, therefore, may be devoted in part, at least, to broadcasting programs of a business nature, while time after 6:00 P. M. is for recreation and relaxation, and commercial programs should be of the good will type.

B. Commercial announcements, as the term is generally understood, should not be broadcast between 7:00 and 11:00 P. M.

C. A client's business and his product should be mentioned sufficiently to insure him an adequate return on his investment—but never to the extent that it loses listeners to the station.

D. The use of records should be governed by the following:

1. The order of the Commission with reference to identifying "Phonograph Records," and other means of mechanical reproduction, should be completely carried out.
2. Phonograph records (those for sale to the pub-

lic) should not be broadcast between 6:00 and 11:00 P. M. except in the case of pre-release records used in programs sponsored either by the manufacturer or the local distributor.

3. When mechanical reproductions prepared for radio use only, are not for public sale, and are of such quality to recommend their being broadcast, no limitation should be placed on their use, except as individual station policy may determine.

II. Salesmen and Representatives

A. Salesmen on commission or salary should have: 1. Definite responsibility to the station for which they solicit. 2. Some means of identification. Furthermore, contracts should state specifically that they will not be considered as acceptable until signed by an officer of the station; that no agreements, verbal or understood, can be considered as part of the contract. The salesmen's conference with the client should always be confirmed by an officer of the station.

B. The standard commission allowed by all advertising media to recognized agencies should be allowed by broadcasting stations. If selling representatives are maintained by stations in cities where they otherwise have no representation, the station itself should make its own arrangements as to payment for such representation.

C. Blanket time should not be sold to clients—to be resold to them as they see fit.

III. Agencies

A. Agencies have three functions in broadcasting:
1. Credit responsibility.

2. Account service and contract.
3. Program supervision in the interest of the client.

B. Commissions should be allowed only to agencies of recognized standing.

IV. Sales Data—The Best Sales Data Are Result Data

V. Rate Cards

A. There should be no deviation whatsoever from rates quoted on a rate card or cards.

B. Wherever practicable, the standard rate card form recommended by this Association should be used.

VI. Clients

A. Client standards of credit should be maintained similar to those established in other fields of advertising.

B. In deciding what accounts or classes of business are acceptable for broadcast advertising, member stations should be governed by the Code of Ethics adopted by this Association.

AUDIBLE ADVERTISING

By Roy S. Durstine

Vice-President and General Manager
Batten, Barton, Durstine & Osborn, Inc.

A LADY reaches for a caramel and thereby lifts her attention for three seconds from the love story on her knee. A famous soprano is just reaching the climax of a song on the radio. The lady doesn't like high notes. She switches to some dance music and the next morning she tells her husband that there are too many sopranos on the air.

Her husband tells three friends at lunch, and that evening three more homes are sure that there are too many sopranos on the air.

People are funny about broadcasting. They hear it in the intimacy of their own homes. There is no crowd psychology. They form quick judgments and they like to generalize.

The minute a person buys a radio receiving set he naturally becomes a critic. He can tune in and tune out with a twist of the wrist. He is ruthless. That is as it should be because, after all, it is into his intimate family circle that broadcasting comes and there is nobody to tell him what he must like.

Several million people every year are buying radio sets for the first time. Other millions are replacing their old-type sets with new ones. All these people expect to be entertained. Buying a set is buying a seat for the big broadcasting show. Who is going to give it?

In this country that question has been answered like this: The public wants entertainment. The advertiser wants the public's attention and is willing to pay for it. Therefore, let the advertiser provide the entertainment. How does it work?

"Under the present method, the United States is leading every other nation on earth in broadcasting," recently said Federal Radio Commissioner Lafount.

It is an extremely workable arrangement, but because it is new, perhaps, there are some things about it not quite ideal from either the listener's viewpoint or the sponsor's. The listener sometimes becomes restless when the advertiser takes thirty seconds of a thirty-minute program to tell who he is. The advertiser frequently becomes impatient when the public casually accepts a costly program without writing in to say how good it was.

The same advertiser wouldn't expect people to write and tell him how much they liked the painting used to illustrate his magazine advertisement. But radio is a new type of advertising, and sometimes he wants to be reassured about it. Not only does he want to influence people in his behalf, but he wants them to write and tell him *how much they enjoyed being influenced.* And the astonishing part of it is that more than often they actually do!

But still some advertisers, in their anxiety to squeeze out every ounce of value, lose their sense of balance, their sense of taste, and their sense of the ridiculous. They over-advertise. They rub it in. Their number is small, but they make a lot of trouble. One over-reaching program harms a dozen others produced with taste and restraint.

It would be odd if anything as new as broadcasting were ideal from everybody's viewpoint. The important point is that the present arrangement works. Advertisers vie with one another to provide the finest artists available. The listening public is getting a $50,000,000 broadcast show this year—for the price of a receiving set.

The story of how a broadcasting program gets on the air runs somewhat like this:

There is a radio enthusiast among the executives of just about every company. There may be several who have sets and listen frequently, but there is one genuine addict. He knows what you will get at 9:15 on Sunday nights; he can tell you the Happiness Boys' real names, and who makes the musical arrangements for the Revellers. One day he goes into his office and says to his associates, "We ought to use radio." That starts it. And over the next few months or years the discussion goes on.

The company probably asks its advertising agency about broadcasting. Today, fortunately, many advertising agencies have equipped themselves to discuss broadcasting intelligently. The day isn't far off when a working knowledge of broadcasting will be as much a part of every good agency's equipment as its ability to discuss the newspapers of Chicago or the women's magazines or the comparative advantages of color or black and white.

Even now there are agencies playing an increasingly important part in radio advertising—some of them doing the whole job from planning the program to directing it as it is broadcast. These agencies simply engage the mechanical facilities of the broadcasting companies for their clients as they purchase the facilities of a publisher.

One early danger for a company considering broadcasting is that it may be fascinated by the prospect of hearing its name on the air and participating in putting on a show. There is a back-stage glamour about a broadcasting studio. It dazzles people.

The president of the company may turn out to be a season subscriber to symphony concerts, or his wife's ambitions for a musical career may have been ended by marriage. In cases like that, broadcasting ceases to be considered merely as an advertising medium. It becomes an exciting plaything.

It is just as well for such an executive to have an advertising agency at his elbow with enough courage to say:

"Don't use broadcasting by robbing your primary advertising in magazines or newspapers."

For broadcasting supplements the older forms of advertising. It doesn't replace them. It provides a unique background for other types of advertising. It may be said to create a degree of friendliness beyond any other medium. But it does not fill the part required by the kinds of advertising in which direct selling is not only permitted but expected.

When it comes to preparing the program itself, an advertiser has his choice of getting ideas and artists from three sources—the service staffs of the broadcasting companies, the independent concert bureaus, and his advertising agency.

The advertising agency is the only one of the three closely acquainted with all the advertising and selling policies of the manufacturer. It has no special reason to recommend one medium over another. It is not a special pleader for radio or newspapers or magazines. Its business is to look over the whole field of advertising and to base its recommendations on its best judgment, advising the manufacturer whether to use newspapers, or magazines, or billboards, or radio, or street cars, or direct-by-mail, or some combination of two or more of these different kinds of advertising.

Its knowledge of a proper relation between sales volume and the advertising budget prevents it from urging a too great expenditure in any one medium such as radio. The advertising agency which knows its job, and does it, will never try to get an advertiser to take a full hour if a half hour will do the work, or to engage talent which it knows is beyond the means of an advertiser. It has to use ideas, not mere bulk of impression, in planning broadcasting as well as in every other part of its work for an advertiser.

The advertising agency has no list of artists whose services it is trying to sell. It is free to select for a broadcasting program whatever talent seems best suited for the purpose and comes within the advertiser's budget. It can buy from the concert bureaus of the broadcasting companies or from the individual managers. It has made no guaranty to artists for a certain number of appearances within a year. It has no arrangement by which it buys talent at wholesale and sells it at retail.

It has infinitely more at stake with an advertiser than any organization coming in contact with the advertiser at only one point of his advertising. The salesman for a national magazine is paid to sell as much space as he can in his own publication. The salesman for a newspaper is hired to get more lineage. The salesman for a broadcasting company, just as truly, is not only concerned with the sale of that unique commodity—time on the air—but may also be charged with the sale of artists on whose services his company receives a commission.

The advertiser holds none of these salesmen responsible for the outcome of his advertising as he does his advertising agency. It follows that his advertising agency, to maintain the continued relationship which is vital to its reputation and livelihood, is merely serving its own interests when it buys broadcasting facilities and talent with as much economy and care as if it were spending its own money.

Only the advertising agency is in a position to check the results of broadcasting programs for an advertiser. Listeners who write to an advertiser address that advertiser by name, sometimes in care of a broadcasting station, but more often directly to the advertiser's factory. It is a part of the agency's work in connection with radio to keep a record of this fan mail. This record is not merely a count of replies analyzed by localities. It is a careful study of the type of stationery, the sex and apparent age of the writer, a rough classification of good, fair, and poor responses, and a thoughtful reading of the letters for suggestions in building future programs.

No one advertising agency produces a sufficient number of programs to make this an unwieldy task. The greatest number handled by an advertising agency is twelve evening programs and nine short morning broadcasts.

Of course, it is impossible for an advertising agency to start producing broadcasting programs overnight. The technique of planning, rehearsing, and directing them is a study in itself. It is one in which some advertising agencies have been engaged almost as long as broadcasting has existed.

The place to learn to do broadcasting is in the broadcasting studio. The agency or the advertiser wanting to make an intelligent study of it can do no better at first than to call upon the service staff of a broadcasting company for help.

He will find skilled musicians with plenty of imagination in building a musical program of any kind. He will find men and women who are doing a lot of interesting experimenting with dramatic writing and acting. He will find that they possess a good working knowledge of that ability to put oneself in the listener's place and make everything clear and effectively proportioned—that ability which is often somewhat vaguely described as "showmanship."

Few of them, of course, have more than a superficial idea of what advertising is all about. How could they? Most of them have been chosen for their musical or literary background or for experience on the stage. They have no way of knowing that business and the graphic arts have been working together with understanding and success for a great many years. Business and this new art for the ear, with the eyes closed, are getting together very rapidly, too.

The best thing that these service staffs could do for themselves, as well as for broadcasting, would be to educate the greatest possible number of advertising agency executives in the technique of broadcasting. Several agencies, each one concentrating its creative ability on a small number of programs, would produce a better result over a hundred radio programs than a single staff which must, of necessity, spread its ideas thin.

Up to now, for some curious reason, the service staffs do not recognize this fully. Yet a study of advertising history makes it very clear. The advertising agent was originally a salesman of space. The necessity of filling his client's space with pictures and words that would make the advertising pay—that was the necessity which developed the present highly organized advertising agency.

No national magazine today maintains a service staff of artists and writers. The advertising agencies produce the advertisements. Few newspapers and business papers maintain service staffs. When they do, it is only to serve the small or new advertiser. They know that the business of making advertising pay is considerably more than writing words and drawing pictures. They are content to offer facilities for reaching an audience. How that audience is reached and what is said to it—that, they believe, is the agency's job. The true test in broadcasting will come when the novelty has worn off. Then advertisers will use it because it can be made to pay. But there is considerably more in that than words and music.

Already some agencies are well along the road of fitting themselves for this new service. It has been necessary for them to create radio bureaus within their own organizations. A radio program as it exists today in this country puts special emphasis upon music. It follows that men and women with a musical education must be engaged upon this work. It is a fortunate circumstance in some advertising agencies that executives chosen for this work were already well grounded in the fundamentals of advertising and had been engaged in other forms of creative work more directly concerned with the older kinds of advertising. It seems obvious that a person with this sort of training, granted an equal education in music, can produce a more effective broadcasting program for an advertiser than one who is familiar solely with music.

Writers of advertising copy have to receive special training before they can produce even the announcements for a program. Of course, every word that is spoken over the air by an announcer not only is carefully prepared, but is discussed in both the advertising agency and in the organization of the advertiser before it is put in the hands of the announcer.

A specialized training, too, is required for dramatic writing, which, incidentally, is undoubtedly on the increase in radio programs. Many people still maintain that they "do not like talk on the air," but if a dramatic program is skillfully done it attracts to itself a more compact but also a very much more loyal audience than the more conventional type of musical program.

People capable of directing rehearsals must be developed —people who can work with a conductor of an orchestra, with temperamental great artists, with actors and even with the lowly devices which produce the so-called sound effects.

They must know how to recognize a weak spot in a proposed program as it develops in rehearsal. They must have a background which enables them to suggest, sometimes instantly, a substitute number for the orchestra or for a vocal artist. They must be able to tell an actor how to give an effect of foreground, middle ground and background before the microphone. They must know how to create a sound that resembles the closing of a door, the whir of an airplane propeller or the surge of water at the side of a boat, as well as the more conventional windstorms, thunder, revolver shots, trains, and horses' hoofs.

They must be able to time a program down to the second—and then be able to know at any stage of a broadcasting program whether they are running behind or ahead, and how to make a correction and signal it from the monitoring booth without frazzling the nerves of the artists who are broadcasting.

Then there is the business side of an agency's radio bureau. It must know all that it can learn about the coverage of various stations, how they vary at different seasons, what effect daylight saving has on broadcasting, what are the habits of the people in different parts of the country who will receive a network program at different times in the evening. Do people in San Francisco dine earlier than people in Boston? What time is dinner time on the farm? When do women want talks on home economics and beauty?

The bureau must know rates and contract clauses and must be familiar with the astonishing situation that now exists in some stations where local programs are sold for many times the revenue brought to the station by a chain program.

Such a department must be able to propose to an advertiser ways of bringing his program to the attention of the public, by window streamers for the stores of his dealers, by counter cards, by newspaper publicity and advertising on the radio pages. It must be able to work with the agency's general executives in helping them to become familiar with the technique of radio as an advertising medium so that they can explain it to their clients.

Perhaps all this will give some idea of the tremendous task which this new art, this new advertising medium, this new national pastime, has brought with it. And the end is not yet in sight.

One subject on which mighty little progress has been made is the question of coverage. It is all very well for a single station to claim that it reaches every state in the Union, but thoughtful advertising men ask themselves questions like these: When does it? Is its coverage the same on a sultry summer evening as on a frosty clear night in winter? How many people were listening to a certain program last night? How do we know?

Tests are made, of course. Surveys are conducted. Questionnaires are mailed. People will write for souvenirs. Was it enough when five, ten, twenty, or even forty thousand wrote in? Advertisers have had similar experiences with coupons from magazines, and some of them doubt whether it proves very much. Even when the cost per inquiry by radio beats the life out of costs from magazines, does that close the argument?

Two thoughtful advertising managers expressed varying opinions in a recent issue of *Advertising & Selling Fortnightly*. Said one:

"After all is said and done . . . the several broadcasting systems, as well as the individual station-owners, will have to begin to present serious facts as to the 'coverage' they are selling to advertisers. Perhaps the time is now ripe for the radio industry to sit down with representatives of the A. N. A. and of the A. A. A. A. and work out a plan for a national check-up of radio circulation under the supervision of these two organizations and at the expense of the sellers of time on the air."

Said the other:

"Has anybody ever conducted an investigation of great national magazine circulation—to determine how many folks actually see a given ad in a given issue? For instance, in the *Saturday Evening Post* of October 26th, how many folks actually saw the Phillips' Milk of Magnesia ad?

"That is one of the things you would try to find out in a radio investigation. Failure to find it out should not be construed as a slap at radio as an advertising medium. The identical problem has puzzled magazine advertisers for years, and as yet there has been no solution to my knowledge."

Putting it another way, broadcasting contains most of the older problems of advertising as well as some new ones of its own, which is why it is interesting.

It needs time to make itself felt, like any other type of worth-while advertising. It needs study and patient intelligence in planning—and so do the other kinds. It is capricious, elusive, exciting. But its greatest asset is its vitality—the vitality that comes from direct contact with thousands, even millions, of homes with a multiplied intimacy which no other form of communication can equal. That gives the advertiser his great chance and his great responsibility.

If broadcasting is to be a permanent success in this country, it must both please the public and pay the advertiser. That is where the advertising agencies have their opportunity. Long before anyone ever heard of broadcasting, the advertising agencies had learned how to do both.

RADIO AND ENTERTAINMENT

By William S. Paley

President, Columbia Broadcasting System

RADIO once brought many qualms to the legitimate stage, the motion-picture industry, and other forms of entertainment. Actual and potential competition for public attention was feared. Perhaps it is still feared, what with the unbounded prospects that radio holds forth as it broadens its scope as a medium of entertainment.

Radio programs are free to the listener. They reach into his home, his drawing-room, indeed, into his bedroom. The absence of direct cost for radio programs and the intimacy of radio in thus joining the family hearthstone have apparently been the reason for the fact that other entertainment directors have apprehended its growth.

It is my purpose, in this chapter, to discuss the interrelationship that exists and must necessarily continue to exist between radio and the theater, especially in view of the prospect of television.

People have assembled to be entertained and instructed for thousands of years. They will, I believe, continue to gather for these purposes for the generations to come. The theater is as natural an institution as the schoolroom. Moods and desires of peoples are so diverse that all known forms of entertainment, and many perhaps unborn, will be necessary to feed the public's appetite for amusement. Therefore, I regard radio as an integral part of the entertainment industry itself. While its function may be distinct from any other form, it is nevertheless inextricably interwoven with all the others.

When Marconi gave the world "wireless," little did he or an amazed world realize that anything but a potential means of telegraphy without wires was at hand. Certainly no one at that time expected that within a scant score of years radio broadcasting, following along the same principles, would become a vital factor as a vehicle of entertainment and instruction. Even when the transmission of voice was accomplished, few were attracted to broadcasting other than experimenters and amateurs.

It was not until after the war that the experimenters, having gained mature experience in the military communications services, began to crop out as broadcasters. The early notable starts toward broadcasting were made, of course, by men like Dr. Lee DeForest and Dr. Frank Conrad. The Westinghouse Company erected several stations and sought to stimulate the sales of small receiving sets. Soon a small army of radio men began erecting broadcasting stations of their own, first for pleasure, and then for business purposes.

Where to get sufficient talent was a problem from the start. Phonograph records were generously used. The more enterprising sought to attract actual talent before their microphones. Professional entertainers agreed to perform only because they saw publicity possibilities. The better class of entertainers eyed radio askance and scorned appearances before any microphone.

But the idea of a "free show" took with the public. Apace with the improvement in programs grew a healthy manufacturing industry. As programs grew better, radio transmitters and receivers were refined. Radio entered the home as a fixed institution, and the theatrical industry seemed to have reason to apprehend that this competitor might keep people from "going out" of an evening. In fact, they actually felt the effect of radio on box-office receipts at first.

For example, when Dodge Brothers, over a nation-wide network, brought the first big array of stage and screen notables before microphones at different parts of the country to participate in an auspicious program, box-office receipts throughout the country slumped. The slump, however, was short-lived. The novelty soon wore off as more and more such programs and as more and more of the greatest artists and musical aggregations of the theater and concert-hall were attracted by radio.

Brilliant radio programs are everyday offerings now. Artists pause in their stage and their screen efforts to go before microphones. Hardly an evening goes by without some radio attraction to keep people by their firesides. Yet the entertainment industry, basic as it is in the national economy, continues to thrive! The theater even encourages its talent to perform for the radio; indeed, theatrical interests have been the most persistent seekers after wave-length privileges from the government, and some are actively engaged in the broadcasting field.

The explanation is psychological. Man being a social creature, he likes to rub elbows with his fellow men. Emotional response in an audience is infectious. Laughs engender laughs, thrills sweep like electric currents through multitudes. Scenes of dramatic poignancy, on stage or screen or platform, affect a group mind that exists for the moment as one.

The theater, then, for the moment seems safe. But what about television? Is it the sword of Damocles that hangs over the head of the entertainment industry, its slender thread to be cut at the broadcasters' will. Particularly since the introduction of the so called "talkies," demonstrating that the motion-picture industry is also a creature of the laboratory whence radio sprang, has radio broadcasting become the cynosure of industrialists and sociologists. And the talking motion pictures, emerging from the electrical laboratories ahead of television, have served as the basis of much speculation about the future effect of radio on the theater, especially the movies.

Will not the simultaneous reception by radio (or wires) of vision along with sound ultimately shake the theater to its very foundations? Was self-preservation the reason for the corporate affiliation that the Paramount Famous Lasky Corporation effected with the Columbia Broadcasting System in 1929?

In another part of this book, Dr. Herbert E. Ives of the Bell Telephone Laboratories, an eminent worker in the field of television, discusses the technical and some of the social factors involved in television. His deductions convince me more than ever that radio and motion pictures, once considered potential rivals, have become allies. The science that introduced sound into motion pictures gives us reasonable prospect of vision in radio broadcasting. This advent of an element into each field that was formerly peculiar to the other has brought about a mutuality of interests of such far-reaching significance that unlimited new possibilities are dawning in the entertainment world.

Television, we are often told, is "just around the corner." I shall not attempt to predict how far away the corner may be, for the most eminent technical workers in the field balk at definite prediction. But they are all confident that television is coming. It seems as certain as fate.

It is my conviction that, just as the films have utilized the resources of radio science to give the screen a voice, radio broadcasting will eventually borrow eyes from the master minds of the motion-picture laboratory. Whether we will broadcast direct performances from the studios, motion-picture performances from film strips synchronized with sound, or theatrical presentations from the stage, it is still too early to say. Quite possibly all three types will furnish television its subjects, together with great news events, sporting matches, and the like.

What will be the effect of the merging of theatrical and radio interests on the economic structure of the entertainment business?

Does the prospect of television carry a threat against the thousands of theaters throughout the world by promising visual entertainment in the home in addition to the audible entertainment already available?

I have already sought to answer the first of these questions, partially at least, by my references to the gregarious instincts of the people. As for the second, I am one of those who, while thoroughly expecting that the almost inconceivable magic of visual reception will be accomplished within my lifetime, still believe just as profoundly that the theater will survive and flourish.

Questions like these naturally arise when we are faced with the prospect of revolutionary change in any line of endeavor. Yet, pause and consider. Does not science, like nature, always strike a balance? Scientific advancements, suddenly as they sometimes come, seldom destroy the things they presumably replace. Usually new inventions simply make old ones more useful.

Only a few years ago it was felt in many quarters that broadcasting had doomed the phonograph. Instead, radio provided the phonograph with electrical recording and reproducing and with new conceptions of tone qualities and volume. A vast new market was opened, a market that expanded considerably when the radio manufacturers began combining phonographs with radio receiving sets. At least one great merger of radio and phonograph interests has occurred to prove that, far from driving out the phonograph, radio has given it new possibilities.

Just so has radio stimulated the legitimate theater and motion pictures. It has brought on the "talkies," instead of ruining the film industry by keeping the public at home to listen in, as was feared when broadcasting first began. Through an exchange of talent, the attention of a public greater than the theater ever knew before has been focused upon the stage and screen. Through the audible appeal of the greatest artists in the theatrical world, especially the operatic, the potential theater audience has been greatly augmented.

Even when television is perfected on a commercial scale and televised subjects are broadcast for reception directly in millions of homes, the motion-picture theater will continue to thrive as the gathering place of entertainment-seeking multitudes. The history of the theater and the radio would seem to bear me out.

When television comes, whether it be in a few years or a score, it will play a large part in the operation of the very theaters that some may feel it threatens. Our imaginations can run riot when we speculate upon the illimitable possibilities of television in relation to motion-picture theaters.

Consider what can be done in the field of news reels alone! Imagine seeing flashed upon the screen in simultaneous sight and sound a news event of major importance as it is taking place! Visualize world-series baseball games, football games, automobile and horse races, transported the instant they occur on supersized, natural-color stereoscopic screens!

Perfections in the projection of motion pictures will play a large part in making television applicable to theater rather than home presentation. We have not seen the cheap and popular use of filming cameras and projecting machine affect the motion-picture industry perceptibly.

The home can hardly be expected to be transformed into a modern theater having all the perfected devices and appurtenances available to the theater. A glimpse at a few of these devices, some not yet being exploited, suffices to illustrate.

The supersized screen, one that occupies a full stage, is already in use and will be especially adaptable to projecting the musical shows that are becoming regular offerings in the "talkies." Experiments are being conducted with stereoscopic motion pictures, pictures having a third or "depth" dimension. Increasing use of color is being made in current film productions. The combination of these elements with spoken dialogue, music, and natural sounds will set a standard for screen entertainment that audiences will naturally expect and demand when television becomes a commercial practicability. Moreover, some one will have to foot the bill for home television, and it is hard to conceive of an advertising sponsorship of the filmed efforts of Charlie Chaplin, Mary Pickford, and Douglas Fairbanks.

RADIO AND EDUCATION

By Joy Elmer Morgan

Editor, The Journal of the National Education Association

EDUCATIONAL radio calls for pioneers—men and women of daring and vision who are willing to try new things. No petty approach can solve the vast problems which this new marvel creates. Radio is lifting the level of informed intelligence among the masses. Anyone who looks about him can see that this is going on steadily, irrestibly. Not since the invention of movable type by Gutenberg in the middle of the fifteenth century has there been any force so revolutionary in its effect on the human mind. The development of printing made possible our system of common schools, which have been a powerful factor in the rapid development of the American people. Radio promises to make possible even richer schools. It will give to all that common background of information, ideals, and attitudes which binds us together into a vast community of thinking people. It is giving the school a new tool to use in its daily work. No one can estimate the stimulus which will come into unfolding life as radio brings it into instant contact with the great thoughts and deeds of our time.

Anyone who has watched a baby as it learns to creep, to stand, and to walk will see many parallels between that experience and the growth of educational broadcasting. Perhaps educational radio has now reached the standing stage and will learn to walk during the next decade. Already it is face to face with many problems. What will it cost and who shall pay the bills? Shall schools be equipped for radio reception? How shall they be equipped? What subjects shall be taught *via* the air? Who shall teach them? What material is best suited to the various ages of childhood and youth? Shall programs be city-wide, country-wide, regional, or nation-wide? What about international features? What subjects cannot be taught? What educational principles are involved? It is not the purpose of this chapter to discuss in detail these and the innumerable other problems involved in educational radio, but to suggest in a general way the trends and possibilities.

The beginnings of educational radio in America were largely in the colleges and universities and in the city school systems. It was natural for the science departments of colleges to become centers of experimentation and amateur broadcasting. Out of these beginnings grew more ambitious undertakings, until broadcasting came to be a regular activity of leading universities and colleges throughout the country. These broadcasts cover a wide field ranging from such entertainment as jazz music and football games to the serious study of literature, history, science, and art.

The pioneer work in school music was led by Walter Damrosch, world-famous orchestra conductor, who in 1928 broadcast nationally a series of symphony concerts through the network of the National Broadcasting Company. Perhaps this series of concerts more than any other single feature encouraged the schools to install radio equipment. This step was difficult. Schools were inclined to say, Why equip when so little of school value is broadcast? Broadcasters were inclined to say, Why provide programs when so few schools are equipped?

Many schools are now equipped for radio reception. The best school people now believe that such equipment is a legitimate public expenditure, just as are textbooks or blackboards. The costs are no longer prohibitive except for the poorest schools. Experiment is throwing light on the subjects that can best be taught through the ear. Teachers are getting over the strange feeling in the presence of radio.

They are learning to visualize classes through the air, to organize subject-matter for a distant audience, to give talks to teachers and to children through the microphone. School administrators are providing for radio in their plans and in their budgets. The National Education Association uses radio in the interpretation of the schools and has included a broadcasting studio in its new headquarters building in Washington. During the summer of 1929, the Secretary of the Interior, at the request of the Department of Superintendence, appointed a commission to study the educational possibilities of the radio. The stage was thus set for a new era of progress.

The importance of radio in education is suggested when one compares it with the recognized objectives of the schools. The objectives of education as set forth by the National Education Association and as they appear on the membership card which goes to the nearly two million members of the National Congress of Parents and Teachers are: (1) Health and Safety; (2) Worthy Home Membership; (3) Mastery of the Tools, Technics, and Spirit of Learning; (4) Faithful Citizenship; (5) Vocational and Economic Effectiveness; (6) Wise Use of Leisure; and (7) Ethical Character. These objectives are pointing the way toward a much broader idea of education than has hitherto obtained. Under their influence new types of schools are coming into being, and parents and teachers are taking a new attitude toward the child. Radio has many contributions to make to this broader education of the future.

What can radio contribute to health and safety? Health is primarily a set of habits in conformity with the natural laws that govern physical, mental, and emotional well-being. In the main, these habits can be established in home and school, providing the teachers and parents have the necessary information, but most teachers and parents do not yet have this information. The demand for higher standards of fitness has increased so much, and health science has advanced so rapidly, that the best standards are far ahead of the prevailing practice. Then, too, there are many health facts which primarily concern people in middle and later life. They will welcome these facts because the need is immediate and personal. Every device which spreads reliable information helps to lift the level of well-being. Radio, because of its ability to command expert services and to reach out-of-the-way places, has a large contribution to make to health

What can radio contribute to worthy home membership? Radio has already made a large contribution in this direction. It has helped to keep people in their homes and in that way to preserve the integrity of home life. No other agency can take the place of the home as a force for excellence and happiness. In it are the issues of life. In a very real sense it is the soil into which the roots of human life reach for spiritual nourishment and security. Whatever radio can do to strengthen the family circle is clear gain; whatever it can do through widespread instruction, looking toward better home practices in such matters as housing, nutrition, family finance, home relationships, home avocations, contributes directly to a better life.

It is estimated that fewer than 10 per cent of the American people live in homes which could be considered satisfactory when measured by a reasonable standard of human need for light, sun, fresh air, quiet, privacy, play space, and other basic values. May the time not come when a school of home planning and design will be one of our most popular radio features?

What can radio contribute to learning? Radio will universalize learning. It is the most powerful stimulus that has ever come to the human mind. It brings instantly to untold millions the very thinking processes of the best minds. Psychologists have pointed out that an interested audience actually breathes with the speaker. Who can estimate the motivating and inspiring force of some future occasion when the entire race will listen to one of its brilliant scientists as he explains some great truth. A world language is as certain as tomorrow's sun. It will be the language of the best radio programs. The growth of radio will give a new significance to every institution of learning. The school will be the gateway to vast intellectual resources. The library will invite wider exploration into fields that radio has suggested. Increasing numbers of people will catch a vision of what intelligent living really means. Knowledge will be applied in the daily life more and more widely. The quality of thinking among the masses—which is the real measure of civilization—will rise rapidly.

What can radio contribute to citizenship? In the presidential campaign in 1928, tens of millions of people listened to the finest minds discuss the issues of state. Following his visit with President Hoover, Premier MacDonald analyzed in a broadcast speech the great international problem of armament. This practice of bringing living government into the homes and schools will be extended downward into the state and local governments and upward into the problems of world government. There will be a new interest in citizenship on the part of the masses and a new integrity on the part of officers responsible for the management of our public affairs. As human problems multiply, government must adapt itself to the new needs. Radio will help to spread the vision of what L. P. Jacks has aptly called *Constructive citizenship.*

What can radio do for vocational and economic effectiveness? The vocational and economic life of the people is now changing rapidly. Almost overnight inventions come into use which displace thousands of employees. New jobs are opening up. New kinds of training are demanded. Investment problems are no less difficult. These rapid changes cause serious individual and national difficulties unless people are kept well informed. What radio can do is suggested by the vocational guidance program which is a part of the California School of the Air. Each year throughout the school year outstanding men and women of California present the challenge of some thirty different vocations. Each speaker answers five specific questions: (1) What is the place in the life of the community of your profession, business, or industry? (2) What opportunity does it present? (3) What rewards does it offer? (4) What abilities does it demand? (5) What training and education do you recommend for success in this field?

The time may come when we shall know from year to year the number of people occupied in each of the vocations and shall have statistics which show the number of new "hands" needed. Young people will then be able to guide their plans and their training with assurance that they are not preparing for some occupation which is already overcrowded or obsolete. As the art of national advertising develops we may expect the men who produce our great commodities to visualize to the public over the radio in vivid and fascinating terms the processes of their industry, the sources of raw material, the human values in the lives of their workers, their ethical ideals, the opportunities they afford young people seeking careers, their international interests, and the like.

What can radio contribute to the wise use of leisure? Increasing leisure is one of the striking features of the life of today. Machinefacture is rapidly taking the place of man power. The rapid development of electric power and its distribution into the smaller towns and rural communities and the perfection of electric machinery are lightening the burden of toil. The time is now near when the five-day week and the six-hour day will be realities. This increase in free time opens up vast possibilities for education. People are already spending part of this time in listening to radio programs. If they are tired, they will seek release from the serious and heavier things in the lighter radio programs. As the burden of work decreases, they will have a larger margin of energy for study along special lines. Perhaps we shall see a widespread effort to adapt the lighter forms of entertainment to educational ends. Psychologists now point out that the routine and sedentary nature of many occupations has created a demand for movement and free activity. This explains in a measure the so-called dance craze of this period. There are some educators who believe that a nation-wide revival of folk dancing or community dancing of the Virginia-reel type would serve an important need. If such dancing were taught to an entire generation in the school, it might prove a unifying force which would unite our smaller communities, young and old, poor and rich, as no other force has so far been able to do.

What can radio contribute to ethical character? Character is the highest achievement of education and life. It reaches its highest excellence in the riper years. Through experience, through study, through habits of industry and reflection, through long years of right thinking and right doing, there comes into the individual life a unity and a quiet sense of power and happiness which are the highest of human achievements. We believe radio has a contribution to make here both in the school and in the home. It widens the family circle and the school circle to include the ablest teachers, the most earnest preachers, and the noblest statesmen. Exposed to such personalities, may not our young people come to value more highly the qualities of character which their lives reveal?

We may as well face at the start the limitations of radio in education. It would be futile to ignore the light thrown on the problem by philosophy and science. Education is guided growth. It involves self-activity on the part of the learner. Among very young children a large factor of physical activity is needed—larger, perhaps, than most schools now provide. Mutual affection between teacher and pupil is indispensable. As this personal relation is more fully appreciated, the schools will increase the number of teachers and aids to teachers so that there will be fewer pupils for each educational worker. The idea that radio or any other invention will in some mysterious way supplant the teacher or the organized school has not the slightest foundation. The effect of increasing knowledge and of new inventions is to intensify the need for carefully selected, professionally trained teachers.

A vital part of education is the correction of pupils' errors. It is in the day's work, taken for granted by both pupil and teacher. For example, the mispronunciation of a word is not detected by the one who makes the error. He may hear the right form over and over without being conscious of his own error until it is specifically pointed out and he is shown the right way.

The time factor, which many consider a barrier to the use of radio in the schools, is not so great as it might at first seem. It is true that the child's time is valuable and should be so regarded, and that the curriculum is crowded—and the pressure continues to increase. This is true just as much outside the school as within. There are more opportunities than formerly that appeal to people, and like children exposed for the first time to the freedom of the pantry, they have not learned to select and to stay within their capacity. But people both in school and out will learn to select the better values. Much in the school curriculum should have been crowded out long ago. Schools will not begrudge the time required for radio when its offerings make a vital contribution to child growth and development.

While the nation has been slow in getting under way, America offers an unusually fertile field for educational radio. The country is vast in extent, it enjoys a common language, and the aims and methods of work in use in the schools are remarkably uniform throughout the various states and cities. America can afford to spend more money for experiment and the development of progress than any other nation because of its great wealth and of the large number of people involved—nearly thirty million in the schools alone. From its beginning, pioneer spirits in education have foreseen possibilities for radio in the schools. Some of them have made experiments prematurely and have been discouraged. Others have succeeded. College and university stations have developed. The broadcasting companies have shown a lively interest in the growth of educational radio. At the meeting of the Department of Superintendence at Boston in February, 1928, a nation-wide program consisting of addresses and music by school children was sent over a network of the National Broadcasting Company. The mother of Charles Lindbergh was present at this first broadcast under the auspices of the association. At this convention also the problem of radio education was brought before the officers of the association. After thorough discussion the matter was held over for further attention. In May, 1929, the executive committee of the Department of Superintendence passed a resolution asking the government of the United States to call a conference to consider the place of radio in the schools. The Secretary of the Interior called this conference and arranged for a committee under the chairmanship of the United States Commissioner of Education which made a thorough preliminary study as the basis for further development. Three major fields were investigated: (1) the elementary and high school field, (2) the college and university field, (3) the field of informal adult education.

Carrying out instructions given it by the annual convention in 1930, the Department of Superintendence of the National Education Association has appointed a radio commission to present the points of view which should prevail in the development of educational programs. The resolutions adopted by this department point out that radio programs for use in schools must "be free from all advertising, commercial, and propaganda features. They must successfully meet the same impartial tests as textbooks, being wholly in the interest of public welfare and with the approval of responsible school authorities."

There are those who believe that there should be developed under government auspices a nation-wide educational chain operating parallel with the two great commercial systems. Such a chain would unite into one network the stations of colleges, universities, state and city departments of education. It is contended that such a network, by helping to set standards and discover new interests, would contribute to the success of the commercial chains. One of the difficulties in the way of such a plan is the fact that the available wave lengths are already taken. The situation may be changed at any time by the discovery of new channels or new methods of using them. Another possibility lies in wired radio which might use the wires of either the telephone system or the power system.

Colleges and universities have long maintained extension departments to encourage home education. The Massachusetts State Department of Education has maintained what is perhaps the most widely successful enterprise in this field. This state agency has been one of the pioneers in the use of radio. It has included radio courses in the following subjects in which more than five thousand people have enrolled: Household management, appreciation of music, contemporary American literature, short-story writing, French, the making of a music-lover, chief English writers of our day, business psychology, backgrounds of English literature, psychology of understanding people, literary values in new books, journalism, new developments in economics, essentials of drama, appreciation of symphonies, real-estate law, psychology of personal problems.

The extension division of the University of Iowa reports courses consisting of twelve lectures of twenty minutes each, running regularly for periods of twelve weeks, including lesson assignments and textbook work. Each student was expected to prepare six papers and to take an examination. The work was the same as that covered by two-hour correspondence courses. The percentage of completion of these radio courses was greater than it had ever been with regular correspondence courses.

The colleges which have pioneered in this field deserve much credit. They have had the faith to break new ground, to hold on when results were disappointing, and to achieve success as best methods were found. The more progressive forces on the faculties have rallied around the radio department in an effort to develop this new contact with the public. Sometimes the programs have been taken by telephone to commercial stations, and in other cases the college has maintained its own broadcasting apparatus. Music has played a large part in these programs. This has been especially true at the University of Michigan, which has become a great music center due to the influence of Joseph E. Maddy, creator and director of the National High School Orchestra. The development of this orchestra has motivated this branch of music in high schools throughout the country and is of the greatest significance in the evolution of our musical life. The extent of college broadcasting is suggested by the fact that more than fifty colleges and universities have their own broadcasting stations and are offering educational programs, while nearly a hundred colleges and universities are sending talks from near-by commercial stations.

Radio on a state-wide basis is under way. The Ohio School of the Air, which is the pioneer in this field and supported by public taxation, was organized during 1928 and broadcast its first program for the public schools of the state on January 7, 1929. By April of that year the reports received from public schools indicated that more than one hundred thousand pupils in twenty-two states were listening regularly to its programs. The state legislature was keenly interested in the experiment, and before the close of the school year appropriated forty thousand dollars to continue the School of the Air for two years.

The state superintendent of public instruction inaugurated the California School of the Air on October 7, 1929. Among the early features was a series of addresses by leaders in industry and government, giving information on vocations which were open to young people. South Dakota has a state-wide program for high schools and has planned a program to cover all schools. The Young Citizens League—a state-wide organization of young people—has taken the lead in sponsoring radio equipment in the rural schools. The state is now fairly well equipped. Among other states which before 1930 were officially interested in schools of the air are Alabama, Indiana, Kentucky, Louisiana, North Carolina, South Dakota, and West Virginia.

State pride and the desire to provide the best educational opportunities will eventually lead all the states either to provide programs of their own or to share in some way in the programs of neighboring states. Perhaps there will develop several regional systems and eventually a nation-wide system.

Educational radio will do much for one-room rural schools. There are now 160,000 one-teacher schools in the United States which give instruction to more than six million young people. Several million more are in small rural or town schools. During 1928, the Department of Rural Education at Teachers College, Columbia University, began conducting experiments in this field. These experiments point the way toward the use of radio in the improvement of rural education. Program helps were sent out regularly to more than seventy-five one-teacher schools and reports were gathered and analyzed. By such methods as this, problems are brought to solution and the best experience is made available for all schools. In sparsely settled areas where schools are widely scattered, where teachers are frequently young and untrained, country-wide programs may well serve to strengthen school work. Such a program is in operation in Ford Bend County, Texas. All schools are equipped and there is a broadcasting station at the county seat.

Mexico is experimenting with the training of rural teachers in the service. The Department of Public Instruction at Mexico City has a high-powered broadcasting station of its own. The government has installed receiving sets in the rural schools of five Mexican states. Teachers attend lectures in their own schools and receive the necessary instruction by radio from the Department.

England has been a pioneer in the use of radio for educational purposes. The British Broadcasting Corporation has a monopoly in England and has had from the first the cooperation of leading educational thinkers. It has a well-organized educational department and provides broadcasts during both the day and the evening. It distributes printed lectures and program notes. Booklets of information on school broadcasts are sold at a penny each. Literature is distributed through the libraries which supply books for further reading. Research and experiments are going forward. It has been found that classes should be small. It is better to use a distribution system with speakers in classrooms than to assemble the children in larger numbers. This experience corresponds with the results of experimentation in America. The year 1929 showed a marked forward movement in school broadcasting in Britain. It was during this year that the Central Council for School Broadcasting was organized under the chairmanship of the Right Honorable H. A. L. Fisher, distinguished author of the wartime Fisher Education Act and former Minister of Education.

Germany has developed an educational radio program in keeping with the energy and ideals of the new republic. It has a government director of radio education who works with a large committee of educators representing different parts of the country. A weekly magazine describing broadcasts, lectures, and important events is sent to all schools. Experimental classrooms are maintained in Berlin.

The greatest opportunities of educational radio are on the higher levels of the school and among adults. With practice both learners and teachers will become more skilled in their use of the radio. The enriched programs of our lower schools in which there is more freedom, more responsibility, and more activity are now laying, in rich sensory experience, the foundation for a large vocabulary and broadened understanding. Having had some experience in a wide variety of fields, the children will respond to radio discussions which touch their experience. The ability to concentrate and to listen improves with use, just as a muscle improves with use. There will be great gains at this point during the next few years. Five million young people are now in high schools and another million in college, getting the best education ever given to large numbers of people. This rapid upward extension of schooling is already making itself felt in the establishment of libraries and in the circulation of more substantial magazines and books. It will inevitably create a vast body of citizens interested in the more substantial offerings of radio. Many evidences of this new interest in serious things are seen both in America and overseas. The libraries of Newcastle, England, issued in a single session fifteen hundred books recommended for study in radio programs. Leeds has provided a trained and salaried group leader, the study group being regarded as most important.

As experiment and research reveal the most effective educational uses of radio, there will grow up a system of broadcasts to serve the schools throughout the nation. It is too early to tell what pattern that system will take, but it may be worth while to outline possibilities.

Each classroom will be equipped with a loud speaker connected with the office of the principal, or, in the case of rural schools, with the county superintendent. It will be possible for the principal to reach instantly any classroom and for the teacher to reply through a microphone. These local systems will be integrated into state-wide systems, regional systems, and national systems. The amount of time which any particular class will spend listening may be small—perhaps not over fifteen minutes a day—but it will be a most significant part of the day's activity. For the county or city school system, certain specific points which can be better presented by experts over the radio than by individual teachers may be developed. Children may have an opportunity to study political science first-hand by listening to the proceedings of city councils, boards of education, courts, and other civic bodies. Out of this intimate background of living government will develop the study of history which explains the foundations of existing institutions.

The state network will add larger resources which would not otherwise be available in the city or county, and give regular exhibits of the operations of the state government so that each child will feel that he is participating.

No one need think that it will be easy to harness radio for the schools. It is a hard and difficult problem. Some of the first experiments will fail; weak spirits will consult their fears rather than their hopes. Love of the traditional and the easy will be a constant barrier. The development of the radio art itself is a huge task. But, inescapably, this new tool of learning will find its place in the schoolroom and in the home.

INTERNATIONAL BROADCASTING

BY C. W. HORN

General Engineer, National Broadcasting Co.

IT was to be expected that distances covered by radio broadcasting stations would naturally increase as refinements took place in the development of the art. As the engineers pried more secrets from nature and became better acquainted with the fundamental laws governing radio communications, both in transmitting and receiving, the desire to transmit programs to the far corners of the earth began to be realized. There existed a need for such a service, particularly in localities somewhat isolated or removed from direct contact with the great centers in Europe and America. This was the incentive which lay behind the experimental work engaged in by the pioneers, so that today we are embarked upon the task of expanding a useful addition to our already vast broadcasting structure.

Already the people of Europe and America have had the first taste by being enabled to hear reports and descriptions of important events transpiring in a distant land. Extensive experimental work is being carried on with a view to making available to the listeners of all countries the outstanding events and programs as they actually occur, irrespective of where they take place.

This development work is primarily designed to handle not merely the broadcasting of sound, but in reality is directed toward the establishment of reliable links over which not only those programs which affect the ear may be transmitted, but also those which will please the eye. Because the transmission of sound effects is a more simple problem and more highly developed, it naturally follows that these transmissions will inaugurate the service.

At the present moment it is possible to forward programs on broadcasts to some distant point where they are received and retransmitted through the local transmitter, when all conditions are favorable. There are a number of difficulties which must be surmounted before any reliability may be assured or a guaranty of results predicted.

Transmissions over great stretches of territory are accomplished on frequencies or wave lengths different from those by which the average listener receives his broadcast programs. The frequencies used for this purpose are in the order of 6,000 kilocycles and higher. The reason for using these high frequencies is that great distances can be covered with a reasonable amount of power. Another advantage is that static or atmospheric interference is considerably less at these frequencies than at those used for broadcasting. To offset these great advantages, there are a number of difficulties, such as rapid fading and other factors which can and do cause distortion.

The wave is made to reach the distant listener by a very irregular course. The direct radiation along the surface of the earth is quickly absorbed. That portion of the energy radiated from the transmitting station which is directed upward into the heavens is reflected back by what is known as the Kennelly-Heaviside Layer, which is believed to surround our earth's atmosphere. It is in these regions that ionization of the atmosphere takes place, probably caused by the sun, which results in forming a conducting layer and which will reflect, and to some extent refract, the radio wave, thus bringing it back to the surface of the earth. It will be seen, therefore, that the radio energy arrives at the receiving station along a somewhat indirect path.

The reason that these high frequency waves have not been utilized to any great extent heretofore is because of the difficulties experienced in creating them with any reasonable amount of power. With the development of the vacuum tube transmitter, it has become a much easier problem, and great strides have recently been made in this direction. We have today stations utilizing up to 50 kilowatts of power at these high frequencies. This leaves only the problem of making refinements in the art and overcoming the difficulties more or less peculiar to short waves themselves. The chief among these is that of distortion due to the erratic method of propagating the wave around the earth. Slow but definite progress is being made, and those engaged in this work are optimistic as to its eventual solution.

The chief difficulties in connection with the distortion being experienced seem to be the breaking up of the signal by rapid fading and interference between the "side bands." The former is being coped with to some extent by elaborate receiving equipment and the use of large antenna systems. It has been demonstrated that the fading of the signal does not occur simultaneously in different localities. By erecting a number of highly directive antennæ and connecting these different antennæ through specially designed equipment to receiving apparatus, annoyance due to fading has been reduced. The distortion due to interference between waves coming over different paths or because one side band is received out of phase with the other side band is a more difficult problem to handle. One line of development tends to the suppression of one side band entirely. This is easier to do theoretically than practically at the present time.

Certain frequencies give better results during daylight hours than in darkness, and *vice versa*. This makes it necessary to select the proper frequency for the distance to be covered and for the time during which transmissions take place. Over a period of years, a great deal of data has been collected by the experimental stations. These data are helpful in choosing wave lengths most suitable for the time of the day and the time of the year.

A great deal of experimental and research work is still required before definite results can be predicted, but some of the achievements already realized give promise of the early establishment of regular service. Fairly good signals can be received from the English, German, and Holland transmitting stations (these countries have built stations for this purpose) during certain hours of the days, unless some unforeseen atmospheric or magnetic storm intervenes.

Late in 1929 great impetus was given international broadcasting when several successful efforts were made to relay programs picked up on short waves as they came from Europe, notably a description of the Schneider Cup seaplane races taking place in England and a specially arranged Dutch program transmitted from the Philips radio station PHI, near Amsterdam, Holland.

On Christmas Day of 1929, the first two-way exchange of programs on the same day was accomplished. Special Yuletide offerings were sent to Europe in the morning. Then England, Germany, and Holland transmitted programs for reception in America, which were received at the Radio Corporation of America station at Riverhead, Long Island, and relayed to the nation over a network of the National Broadcasting Co. These programs came through with excellent quality and freedom from distortion, and were popularly received on both sides of the Atlantic.

These were simultaneous transmissions on both sides of the ocean. This means that more than one nation shared in the same program.

Then there is the type of program which is flashed across the Atlantic and sent out over the American networks and which is not heard in the country of origin. These are usually reports or resumés of important events. The best examples have been the transmissions early in 1930 from London by the noted journalists, William Hard and Frederick William Wile. These observers attended the Naval Disarmament Conference and transmitted their comments by voice back to America where this direct and first hand information was given to the American radio listeners *via* the networks.

The ceremony during which King George officially opened the Conference and welcomed the delegates was also brought to America. This was the first time the British ruler's voice had ever been heard in this country. By various short wave radio channels, his voice was also transmitted to many other parts of the world; in fact two American short wave stations received this program and repeated it on their own wave lengths, thus acting as a relay to other countries. The short wave system of the British Broadcasting Corporation was used for the relay to America on the one hand, and the long and short waves of the Transatlantic radiotelephone were employed on the other hand.

Various other programs and events have been picked up in America and transmitted to Europe, notably the descriptions of the arrival of the *Graf Zeppelin* on its round-the-world cruise. This was relayed to Germany, where it was broadcast through many German stations. These transmissions, however, were all more or less in the nature of experiments, but they serve to indicate what is in store for us in the immediate future. The high-powered short-wave stations of the General Electric Company and the Westinghouse Electric & Manufacturing Company have frequently succeeded in transmitting programs to such far distant places as Australia and South Africa, and to Commander Byrd's expedition in the Antarctic polar regions. In fact, regular schedules were maintained to provide Commander Byrd and his men with entertainment and news. The explorer, nowadays, even in the most isolated parts of the world, can keep in touch with the inhabited portions or with his base of supplies by means of radio.

Probably future expeditions to the remote parts of the world will have equipment sufficiently powerful to transmit the human voice back to civilization, where it will be connected into the great broadcasting networks, and the public will get first hand and direct information and descriptions from the sturdy men who visit the remote places of the earth.

The great radio engineering organizations already mentioned have for some years been engaged in painstaking and detailed experimental work. There are powerful experimental transmitters at Pittsburgh, Pa., Schenectady, N. Y., and Bound Brook, N. J. From these, signals are sent daily to engineers in many countries in Europe and other continents. Also at the above locations, and at the mammoth stations of the Radio Corporation of America at Riverhead, Long Island, are elaborate receiving stations with many antennæ. Engineers at these points pick up the signals from the foreign stations, which are transferred to land lines terminating at the National Broadcasting Company's main control station in New York City. Signals and programs are carefully monitored and checked and careful records kept as to time, quality, strength, amount of fading, interference from static and their causes, such as the effect of weather, sun spots, etc. These detailed records are gathered from the several stations and coordinated with those received from foreign engineers. They are kept with minute detail, the signals being recorded every few minutes and often continuously over long periods of time.

This work is in reality a world-wide experiment, with observers scattered in many parts of the globe. It is probably the greatest undertaking of its kind. The correlated reports are forwarded to the various groups of scientists, who study the results and make suggestions for further development and new forms of experiment. Only the combined efforts of great engineering institutions could conduct such experiments on such a scale.

This is merely a glimpse at the manner and kind of extensive work that is being carried on, but it shows how such a problem is attacked and the resources, both brain power and material, which are required to create and perfect new services which some day will be accepted as commonplace. Organized research is required for the development of these new wonders of science—it takes the combined efforts of trained minds and the command of unlimited laboratory facilities and resources. No one man or small group can do it.

After the technical difficulties have to some extent been overcome and such international service established, what will be the probable effect and results? Radio broadcasting has for its primary aim the furnishing of entertainment and information to all of the people. We all realize and have heard many times of the great good that the invention of the printing press has conferred upon the people. The nations or races that are the most literate and where the printed word is most widespread are the leaders in civilization. Easy exchange of thought by means of the printed word has accelerated development, not only culturally, but also in engineering and research. The telegraph, cable, and telephone have helped to bind together those nations and races which have taken advantage of the advances made possible by the printed page. In other words, they have supplemented the newspapers, periodicals, and books, and thus have made available to the public throughout the world the news of events and happenings made after the occurrence. To a great extent, these developments have brought about an easy and ready exchange of opinion and thought, so that we have come to understand each other better. To realize the importance of this, think of the handicaps our ancestors lived under a hundred years ago without ready means of communication.

While rapid communication and the printed page have accomplished wonders, I feel that the greatest and most far-reaching step must yet be made. This new duty falls upon radio. If we can provide the means whereby anyone on this globe can in fact participate in events which are of world-wide importance, we shall have removed the last barrier to the perfect understanding among peoples which is so necessary for our peace and development. When we become familiar with the ideals and desires of other peoples, and are acquainted with their customs and tastes, we will be better able to judge their actions and govern our affairs so as to avoid friction and distrust of one another. In plain and simple language, the people themselves will form their opinions and not be dependent upon leaders or spokesmen.

Those races or nations which are behind in material or mental development will speedily catch up to the leaders, because they will be made to realize and become acquainted with the best that exists and will strive to obtain the same benefits for themselves. Such a free and easy interchange of thought and culture will do more than anything accomplished heretofore to break down the disadvantages of many languages. We shall probably witness great changes in the very near future, possibly including the adoption of a few languages instead of many tongues as at present.

The status of short-wave transmission and the international exchange of programs as discussed here are based upon what knowledge we have today. Probably within a year or two after this is written we will be compelled to revise our methods and operation. This is to be expected when we consider the very rapid strides now being made in scientific work. Such changes, however, will open up new avenues of thought and provide us with additional leads along which scientific workers will proceed. For instance, one such new avenue of development is television. While this activity is still in its early infancy, great hopes are held for it. I leave it to the reader's own imagination what effect it will have when it is possible to see as well as hear events which are transpiring in different quarters of the globe.

We are limited today in our quest for knowledge. The mental pictures we are able to form come from what we see locally or hear or read about, and to a great extent also from such services as news-reel motion pictures. Think of the time—and it is not so far off—when we will be able to sit comfortably in a theater, and eventually in our own homes, and see with our own eyes and hear with our own ears great events as they occur in different countries. Our impressions will be the result of first-hand observation, for we will be "actually there."

PART II: COMMUNICATIONS

RADIO IN WORLD COMMUNICATIONS

By Maj.-Gen. James G. Harbord
Chairman of the Board of Directors, Radio Corporation of America

ALMOST from the discovery of electricity, man dreamed of bending it to his service. Yet a steady, reliable source of current was not found until, early in the nineteenth century, the battery was invented.

Faraday discovered that a current could be generated in a wire by sweeping it through a magnetic field. Steinheil of Germany suggested the transmission of intelligence over a single wire, with the earth as the return circuit, as early as 1838. In 1841 Wheatstone and Cooke set up the first working telegraph in England. The public paid it no attention.

Fortunately—for the telegraph—a murder was committed in a London suburb, the terminus of the first 13-mile telegraph line. The murderer escaped by train to London. But a message flowed along the line, and, as he stepped off the train at London, he was apprehended. Instantly the public realized that a practical communication system had been devised.

The American artist, Samuel F. B. Morse, returning on the packet ship "Sully" after a discouraging attempt to sell his paintings abroad, whiled away his time by designing an electrical device based on theories he had learned through a youthful interest in electricity. When the slow voyage was over, he had worked out a complete telegraph that printed dots and dashes on a moving paper-tape.

Time passed. In 1838 a crude model of the telegraph was made, and not long after, Morse, sitting in a room in the Capitol at Washington, ticked out the famous message, "What hath God wrought!" over the telegraph to the receiver in Baltimore.

Experiments in the Hudson River and the English Channel proved that an undersea cable could be laid and utilized. An attempt was made to connect continents by wire. It was a disheartening job. Fishermen caught up the cable; vessels grappled it with their anchors; storms struck the cable-laying ships and broke the cable. Yet, in 1858, more than 700 messages had been successfully sent over the Atlantic cable.

In the meantime, Alexander Graham Bell was endeavoring to apply his knowledge of acoustics to electricity, with the idea of sending the actual sound of the human voice over the wire. By experimenting with the ear of a dead man fastened to the receiving end of his wires, he came upon the idea of a membrane receiver—a disk that quivers under the influence of the near-by electromagnets through which flows the signal current coming over the line, thereby changing electrical variations into sound waves.

At the Centennial Exposition in Philadelphia in 1876, Professor Bell's telephone attracted little attention. It needed an unusual, perhaps cyclonic happening to bring it forcibly to the attention of the judges.

This unusual something arrived in the person of the colorful Emperor of Brazil, who, passing by with his glittering retinue, saw Professor Bell, his old instructor. Bell showed the Emperor his telephone and talked to him from the other end.

The Emperor listened and then ejaculated, "My God! it talks!" That was enough. The telephone became the sensation of the Centennial.

Then continents were spanned by wire lines. Across thousands of miles of wire the human voice could be heard. Yet those who went to sea were still beyond reach of telephones or cable. Of them the world knew nothing from the time they left port until the end of their journey. Vessels in distress were utterly helpless to communicate their plight.

Even the submarine cable was not altogether dependable. It could easily be destroyed by an act of God or the designs of war. Nations without coasts depended upon neighboring states for their transoceanic communication. Something else was needed—something that would ride high above storms, wars, political jealousies, and frontiers.

Meanwhile, let us turn to the laboratory. In 1865 the British mathematician, Clerk Maxwell, had predicted the existence of electro-magnetic waves. In 1887 Professor Heinrich Hertz, a German scientist, demonstrated that electro-magnetic waves were of the same nature as heat and light waves. They could be propagated through space, reflected, deflected, absorbed, and detected. These conclusions made a profound impression upon Guglielmo Marconi, an eighteen-year-old student at the University of Bologna.

This youth argued that if electrical energy could be transmitted without wires, why could not these electromagnetic waves be utilized for wireless communication? He proved that they could.

First it was a few hundred feet, then a few hundred miles, in bewildering progression. The English Channel was spanned early in Marconi's career. Communication was established between ships and land. In 1901 the Atlantic Ocean was spanned, between Cornwall in England and Newfoundland in America. Transoceanic radio was in the making.

For years, wireless telegraphy could not afford to compete with the cable systems and telegraph lines on land. On shipboard, however, it enjoyed a monopoly. Yet again, something startling had to occur before the public became wireless conscious.

That event occurred when the steamships *Republic* and *Florida* collided off Nantucket. Through the night air came the first distress call from a ship at sea—the "C. Q. D." of operator Jack Binns. It was received. More than 1,500 lives were saved. Radio had become a vital factor in safety of life at sea. But radio remained "wireless telegraphy" until another cataclysm gave it incentive to push forward.

Before the World War, Great Britain led in the development of submarine cables. Her economic prosperity depended upon her international trade. That, in turn, necessitated a vast and efficient system of international communications, especially transoceanic. She was particularly fortunate in her plans because she had a monopoly on gutta-percha, the only known material for insulating submarine cable. So in 1914 practically all the world's cable lines converged at London.

Other European nations, hampered in their overseas communications, particularly with far-flung colonies, had turned to radio as a possible and economical solution. France and Germany had ambitious plans for world-wide networks, strongly flavored with military motives. Great Britain, not content with her cable monopoly, conceived of an "All-Red Chain" of world-wide radio networks linking especially the British Empire. All these projects, however, were purely theoretical and fanciful, being planned on a scale fantastic in proportions and far in advance of existing possibilities.

With the outbreak of the war in 1914, Great Britain and the European countries had to abandon their plans. To the United States, however, thrown upon its own resources for the first time, a new impetus was given to research and engineering. The American research laboratory soon became a recognized institution in all industries.

In this period, Dr. E. F. W. Alexanderson of the General Electric Research Laboratory developed the high-frequency alternator. The necessity for a source of high-frequency current as the foundation for economical and positive long-distance radio communication had long been recognized.

During the closing months of the war, the Alexanderson alternator was used in spanning the Atlantic. It played a prominent part in carrying President Wilson's Fourteen Points to the German people. It flashed instructions to our A.E.F. in France. During the Versailles conference, it served as an important link between our peace delegation and the home government.

When the war ended, Great Britain picked up the threads of her "All-Red Chain." Having witnessed the remarkable performance of the Alexanderson alternator in spanning the Atlantic, the British Marconi interests, then operating an American Marconi subsidiary, offered to place some five million dollars' worth of contracts with the General Electric Company in return for exclusive rights to the new alternator.

The British Marconi Company, with its world subsidiaries, was the only logical customer. The General Electric, a manufacturing organization, was justified in seeking an outlet for this invention. It was prepared to accept the British offer.

But President Wilson, then in Paris, foresaw that if Great Britain gained control of the Alexanderson alternator, she would dominate the radio field just as she had virtually monopolized the submarine cables. In this emergency President Wilson sent Admiral W. H. G. Bullard and Commander S. C. Hooper, U.S.N., to General Electric in New York, with the urgent request that the British offer be declined, purely on patriotic grounds. The General Electric complied with that request, but in doing so found itself without an outlet for an invention in which it had made a great investment.

Under Admiral Bullard's able guidance, a plan was evolved. The American Telephone & Telegraph Company, the Western Electric Company, the General Electric Company, the Westinghouse Electric & Manufacturing Company, and the United Fruit Company in 1919 united to form a communication organization known as the Radio Corporation of America.

The property and rights of the British-controlled Marconi Company of America were taken over. Contracts were made with overseas radio organizations for the establishment of radio communications. The necessary financial resources and personnel were mobilized, and the United States launched upon a world-wide communication system.

Today, New York City and San Francisco are focal points of elaborate systems of world-wide radio circuits extending across the Atlantic and the Pacific, as well as to Central and South America.

It is not a selfish network for the sole benefit of America. Many of the smaller nations have found freedom of communication through the R. C. A. World-wide Radio. Poland, for instance, as one of its first official acts as a reborn nation, invited American radio engineers to build a powerful transoceanic radio station at Warsaw, which now maintains direct communication with New York City and other centers.

So radio has donned the drab garb of the every-day worker.

Radio, as used in marine and transoceanic communications, is a constant, efficient, and supremely practical medium of communication. Radio communication is handled over "circuits," which means that direct contact is established between two points. Once the contact is established, the speed of traffic over the circuit is limited only by the terminal facilities. The ethereal medium, unlike the usual submarine cable, has virtually no speed limit. Today, over the latest short-wave circuits, traffic speeds of 200 words and more are often obtained.

Radio also has a flexibility impossible in other forms of communication. Thus, operating equipment may be permanently assigned to important circuits, while minor


S EVENING POST, WEDNESDAY, DECEMBER 4, 1929 11

Cable, Wireless and Other Foreign Dispatches

R 100 PRONOUNCED FAILURE IN BRITAIN

Outlook, on Heel of R 101 Fiasco, Delays Hope of Spanning Empire by Air

$15,000,000 OUTLAY IS SEEN

Evening Post Foreign Service
Copyright, 1929, by N. Y. Evening Post, Inc.

LONDON, Dec. 4.—Following the virtual fiasco of Great Britain's giant airship, the R 101, resulting in decision to deflate and partially reconstruct her, comes the statement published in today's Daily Herald that the eagerly awaited, even bigger R 100 won't stand up against British weather conditions and is completely useless for tropic flight.

If this is true, it means that $2,500,000, which she has cost, were spent in vain, for the establishment of air routes to India and Australia was her chief object.

The launching of the air liner, which was expected to be the largest and the fastest in the world, has been expected for weeks, and has been postponed from day to day because of adverse weather conditions. Now it appears that she so tightly fills the shed that she cannot be launched safely except

Paris, the Real, As Seen Today

Nice the Center of Cosmopolitans From All Nations

By RAYMOND G. CARROLL
Evening Post Foreign Service
Copyright, 1929, by N. Y. Evening Post, Inc.

PARIS, Dec. 4.—Modern Nice, the "solarium of Paris and Europe as well," has certainly far more of the verve of a small metropolis than of a provincial town. It is not Italian, nor is it French. It has an individuality of its own, which it carefully guards, and the best Nicois families pride themselves upon being able to talk their native dialect as fluently as their servants.

Nevertheless, the Nicois are loyal French citizens. Nearly seventy years ago in the "town and county of Nice," out of 30,712 voters, 25,773 voted for annexation to France, against 160 who voted to join Italy. With a population of 200,000, Nice thinks the same today, and Mussolini himself is largely responsible for cementing this sentiment.

We were recently told that Nice is the first station of safety on the "underground route" by which persecuted Italians are flying from the dictator of Italy.

"You are an American writer?" asked an elderly man in perfect English with whom we shared a bench on the widened Promenade des Etats Unis, which forms the lower curve of the Promenade des Anglais.

An Italian Exile

Asked how he came to make such a

who made a will that the name of his hotel must never be changed.

Cosmopolitan Crowds

Nice is inclusive rather than exclusive. All sorts of people flock there, from the red-faced Lord Blottos and the long, lantern-faced female members of the English aristocracy, to the overbearing parvenus of every race and the dingy ex-royalties in reduced circumstances. These people, important at other resorts, are lost in the crowds at Nice.

Now that women of all ages have decided that dancing is beneficial to the health, and that it is a form of exercise no longer the exclusive property of youth and beauty, the gigolo has become a necessary adjunct of every cafe and restaurant on the Riviera. In Nice, he abounds. As a general rule he is efficient, polite, correct and grateful for his tip, and when he has dragged his heavy and ancient lady around the dance floor for a whole evening is well content to retire with his earnings to a blameless petit bourgeois home.

The loreleis are far more active and daring along the Riviera than the gigolos. They invade the best hotels as guests. Women once addicted to gambling in the casinos are lost to reason. They constitute 60 per cent of the players.

Nice is a symphony in blue and white. Its buildings are as white as

was a native of Nice. Carlo Van Loo, painter to the King of Sardinia, was born in Nice, also Giovanni Domenico Cassini, the great astronomer.

Massena, the most famous of Napoleon's Marechals, first saw the light in Nice. His mother, a peasant woman of the nearby village of Levens, was in town on a visit. Disraeli always claimed that Massena was a Hebrew whose real name was Manasseh.

Paganini, the violinist, died in the house which stands at the Rue Saint Reparate and the Rue de la Prefecture. A marble tablet set in the wall says: "His magic notes still vibrate in the soft breeze of Nice."

Frequented by Kings

Queen Victoria spent five successive seasons at Cimiez, which is the elevated and smart section of Nice. Her son, King Edward VII, as Prince of Wales, stayed many times at the old Cercle de la Mediterranee, now the Savoy Hotel. King Leopold II of Belgium, King George of Greece and King Oscar of Sweden all frequented Nice.

Nice today is dominated by the "Big Six"—Donadei, a Senator; Marquet, a hotel magnate; Roditi, a financier; Ducio, an impresario; Sartori, a restaurateur, and Medecin, the Mayor. They hold control of the place almost after the fashion of feudal barons, but their rule is actuated by a common desire to keep Nice popular with visitors.

There are four of the old festivals left, the Presepi, the Noule of the Madeleine, the Lenten processions and the Spring Festina. They are only for

tenated to an altitude of 7,000 feet over Diomede Island, in Bering Straits, the said.

FACSIMILE REPRODUCTION AFTER RADIO TRANSMISSION BY THE RANGER PHOTORADIO SYSTEM.

circuits are allowed to tie up equipment only for a limited time. This makes it possible to establish communication between many points which, under an inflexible system, could not be served economically.

From the huge and costly Alexanderson alternators, our radio technique has gone to the short-wave transmitter. Today, a large part of the traffic is handled by compact, simple, moderate-cost vacuum-tube transmitters.

With short waves, it is also possible to employ the beam system, or directed waves, so that the signals are aimed at the distant receiver with as much precision as pointing a searchlight. This results in greater efficiency and a further reduction of atmospheric interference. The development of the short-wave transmitter has made it possible to establish communication with many of the smaller countries whose traffic would never have justified the heavy investment and maintenance represented in the Alexanderson alternator or in cable facilities.

The many transmitters employed in the R. C. A. world-wide radio system are scattered about with a view to the best operating conditions. But the control of those transmitters is centered in the traffic offices in New York and San Francisco.

Here radiograms are typed on the perforator keyboards, and transformed into perforated patterns in a paper tape. The tape is whirled through an automatic transmitter, and its tiny perforations cause the formation of dots and dashes. The signals flash over direct wires to distant transmitters at Rocky Point on Long Island, at Marion on the south shore of Massachusetts, or at New Brunswick or Tuckerton in New Jersey, in the case of the New York traffic office.

At the New York offices of R. C. A. Communications, Inc., which is America's largest commercial radio communications company operating foreign circuits, direct circuits are maintained with London, Paris, Berlin, Hamburg, Brussels, Amsterdam, Rome, Madrid, Lisbon, Oslo, Gothenberg, and Warsaw, in Europe; Angora and Beyrouth, in Asia Minor; Monrovia, in Africa; Buenos Aires, Santiago (Chile), Rio de Janeiro, Bogota, Paramaribo, Caracas, Maracaibo, Curaçao, San Juan, Havana, San José and Santo Domingo (*via* San Juan), in Latin America; and Melbourne, Australia (*via* Montreal).

On the Pacific side, R. C. A. Communications, Inc., operates circuits between San Francisco and Honolulu, Tokio, Manila, Saigon, Batavia and Suva, with Hong Kong, Shanghai and Bangkok served *via* Manila. There are also circuits between New York and Montreal and New York and San Francisco, and a network of stations linking large cities of the United States for domestic and international service is being projected as this is written. In addition, this company's 1930 expansion plans included direct services with Moscow, Prague, Capetown, and Mukden.

The Tropical Radio Telegraph Company operates a system which links Boston, Miami, and New Orleans with one another and with Nassau in the Bahamas; Preston, Cuba; Santa Marta, Columbia; Almirante, Panama; Cartago, Costa Rica; Tegucigalpa, Honduras, and Managua, Nicaragua. The Mackay Radio and Telegraph Company, radio communications subsidiary of the International Telephone and Telegraph Company, during 1929 inaugurated its first transoceanic radiotelegraph circuits, between San Francisco and Honolulu, and between New York and Lima, Peru. It also has additional radio services in contemplation.

Then there are also individual radio circuits from the United States, such as those between Linden, N. J., and Yacuiba, Bolivia, operated by the Southern Radio Corporation, a subsidiary of the Standard Oil Company; between Akron, Ohio, and Port Marshal, Liberia, operated by Firestone Plantations Company; and the several transatlantic and South American radiotelephone circuits whose American ends are operated by the American Telephone & Telegraph Company.

Early in 1930, Globe Wireless, Ltd., subsidiary of the Dollar Steamship Lines, projected circuits to Hawaii, the Philippines, Guam, and Shanghai.

A glance at some of the important foreign radio communications systems is apropos here. The newly organized British company, Imperial and International Communications, Ltd., which in 1929 consolidated Great Britain's vast cable and radio interests, besides operating directly with various European points and with New York and Montreal in North America, has radio circuits between London and Rio de Janerio, Buenos Aires, Santiago (Chile), Capetown, Cairo, Bombay, Melbourne, and Tokio, in addition to its extensive world-wide cable circuits. This is the largest communications system against which R. C. A. has to contend.

Germany's Transradio Aktien Gesellschaft fuer drahtlosen Ubersee-Verkehr operates from Berlin and Hamburg to New York, Buenos Aires, Rio de Janeiro, Santiago (Chile), Mexico City, Bangkok, Manila, Tokio, and Mukden (China). Radiotelephone service is also provided by this company between Berlin and Buenos Aires.

The Compagnie Radio-France operates from Paris to various European points and to New York, Buneos Aires, Rio de Janeiro, Santiago (Chile), Beyrouth, Saigon, and Tokio. This company also offers radiotelephone service between Paris and Buenos Aires.

Transradio Internacional Compania Radiotelegrafica Argentina, S. A., a South American company operating from Buenos Aires, has circuits with New York, Rio de Janeiro, Santiago (Chile), London, Paris, Berlin, Rome, Madrid, and Manila. The circuits to Berlin and Paris provide both radiotelegraph and radiotelephone services. This Argentine company is jointly owned equally by a consortium of the Radio Corporation of America, Imperial and International Communications, Ltd., Transradio Aktien Gesellschaft fuer drahtlosen Uversee-Verkehr of Germany, and Compagnie Radio-France.

There is also the Companhia Radiotelegraphica Brasileira owned by the same consortium, with radio stations at Rio de Janeiro, Santos, São Paulo, and Pernambuco, which, in addition to intercommunicating, carry on international services with New York, Paris, London, Berlin, Madrid, Lisbon, Rome, Buenos Aires, and Santiago (Chile). In Chile, Transradio Chileana, Cia de Radiotelegrafia Ltda., also owned by the same consortium, communicates from Santiago with Buenos Aires, Rio de Janeiro, New York, Berlin, Paris, and London.

All these South American services have expansion plans.

Added to these, in the northern part of South America, the Venezuelan government communicates by radio from its radio stations at Caracas and at Maracaibo with New York, Bogota, and islands of the West Indies. In Colombia, the Radio Corporation of America and Imperial and International Communications, Ltd., jointly own the Marconi's Wireless Telegraph Company, Ltd., which operates the radio service out of Bogotá to New York, Tegucigalpa, Managua, and New Orleans, in addition to five or six domestic radio circuits with other cities in Colombia.

In the Far East is the Imperial Japanese wireless service operated by the Japan Wireless Telegraph Company, Ltd., which connects Tokio direct with San Francisco, Honolulu, Berlin, Paris, London, Manila, and Batavia, besides operating several other local Far East circuits. Also, in the Philippines, the Radio Corporation of the Philippines, a subsidiary of the Radio Corporation of America, maintains direct radio circuits with San Francisco, Honolulu, Buenos Aires, Shanghai, Hongkong, Bangkok, and Batavia. It also operates a group of local stations for Philippine interisland service.

Radio has evolved from the first crude dots and dashes of slow manual operation to the high-speed automatic operation of today. It has found its voice in the radiotelephone, whose greatest application has been in the unique field of mass entertainment known as broadcasting, although the transoceanic radiotelephone service which links the telephone systems of Europe and the Americas with each other is a development not to be overlooked.

And now radio is finding its pen, so to speak, in the facsimile transmitting system already in every-day use. It is possible to send facsimile handwriting, typewritten messages, greeting cards, fashion sketches, photographs, fingerprints, and other documents across the ocean *via* radio. Important business deals are speeded up by the facsimile transmission of necessary signatures, thus saving five days or more of precious time.

Indeed, with the developments now taking place in facsimile transmission, it seems to be only a matter of time when the dots and dashes of the usual radiogram will be relics of a bygone age, just as the quill pen has been superseded by the more practical if less romantic typewriter. Already the radio communications executives and engineers are looking forward to and planning for the day when record communication will be measured by square inches instead of words, when, instead of brief coded messages, modern business will have its complete letters on the firm's own letterheads flashed through space and delivered by radio instead of by mail—and even to the time when it will be not only possible but practicable to issue newspapers page by page from a central point for simultaneous printing and distribution in any number of far distant cities. Indeed, they even envisage the transmission of communications by facsimile methods not only from one central operating room to another, but from any business man's desk to any other's desk anywhere else, near or far.

MARITIME RADIO

By A. Y. Tuel

Vice-President and General Manager,
Mackay Radio and Telegraph Co.

WITH radio waves today almost as indigenous to ships as the waves of the sea, only a vivid imagination is needed to predict the future of maritime radio communication, which promises amazing developments as soon as public demand catches up with inventive genius and the handiwork of technicians.

About 15,000 ships, according to the latest figures, are equipped with radiotelegraph apparatus, and what was once the lonely isolation of mid-ocean is as full of gossip to be picked up from the air as any old-time country store. Daily newspapers are commonplace on liners, and brokers have established branch offices on the larger passenger boats, which receive the latest ticker information from the New York Stock Exchange all the way from the United States to Europe and back. Pictures have been transmitted to ships at sea, and telephoning from ship to shore and ship to ship promises to become a generally accepted convenience of trans-oceanic travel.

Radio has minimized danger in sea voyaging. Guiding vessels through fog and storms at sea, the radiocompass is man's scientific answer to prayerful pleas of only a few years ago for Divine guidance to the "haven where we would be."

Progress, although swift, has never proceeded with the speed technically possible since the discovery of the electromagnetic wave theory in 1887 and since the historic day in July, 1897, when Marconi maintained communication between shore and ship at a distance of ten miles. Improvement has been consistent, almost breathless. So many innovations are already here, or just around the corner, that it is difficult to single out the high-spot features of radio today and tomorrow, as far as the maritime utilization of radio is concerned.

Participating in the swift improvement have been many men whose names are famous in the radio world. Each man of the brilliant group aiding in the advancement of maritime radio is worthy of a chapter himself. Of necessity, we must turn from personalities to their accomplishments.

Probably the most significant developments have been the increased use of short waves and the installation of continuous wave apparatus, the advances in the use of the radiocompass and the automatic radio alarm apparatus, the growing demand for radiotelephones on passenger ships, the general trend toward less dependence upon the human element and more reliance on machines, and the regulation and control of maritime radio by international convention and national law.

It was only in 1928 that any widespread use of short waves was made for ship communication. With the discovery that frequencies above 3,000 kilocycles, or the so-called short waves, were especially suitable for long distance transmission with the use of unusually low-power apparatus, the attention of experimenters was turned toward adapting those waves for use on board ship. A large number of passenger vessels plying the Atlantic and Pacific are now equipped with short-wave apparatus, and it is being rapidly installed by shipowners everywhere. Short waves made possible the extension of brokerage service to ships at sea. They also made possible the arrangements which have been concluded by radio companies with agencies conducting 'round-the-world cruises for daily contact with the United

States without relay, no matter how far away the ships may be.

Continuous wave transmitters, replacing spark sets, first of the arc and more recently of the vacuum-tube type, have been installed on a great porportion of the transatlantic passenger carriers. The International Radiotelegraph Convention drawn up in Washington in 1927, and ratified by practically all the nations of the world, encouraged the use of this new type of apparatus and makes it compulsory after 1940 to replace the old spark type with it, except for small auxiliary sets.

Continuous waves not only greatly increased the range of the ship's equipment, but, also, through their very narrow or sharp tuning characteristic, greatly reduce the serious problem of interference due to the ever-increasing number of shipboard and other radio installations. In the day of spark transmitters, frequencies between 500 and 1,000 kilocycles were generally used. The adoption of continuous wave apparatus adds other bands from 100 to 166 kilocycles, commonly used for long-distance work, and short waves between 1,500 and 23,000 kilocycles. While 500 kilocycles is the universal calling and distress wave today, many messages are now handled on low frequencies below 166 kilocycles or on high frequencies above 1,500 kilocycles.

Although the theory of directional reception of radio dates back some seventeen years, the importance of the radiocompass or radio direction-finder is only now being fully realized by shipping interests. In fact, the radiocompass was really dramatized successfully for the first time when the S. S. *President Harding* rescued the crew of the *Ignazio Flortio,* and subsequently during the thrilling rescue of the *Florida* by Captain Fried and the crew of the S. S. *America.* The vessels in distress, drifting for days under overcast skies, buffeted by wind and weather, had no means of accurately determining their positions, and directions sent out to listening vessels were as much as 150 miles in error. The radiocompass, however, enabled the rescue ships to set direct short courses, and they arrived alongside in time to take on board the nearly exhausted crews.

In addition to enabling the rescue vessels to steer a straight course to vessels in distress on the high seas, the radiocompass is a further aid to navigation. It utilizes the directive properties of radio waves to guide ships through the danger of fog and thick weather and to fix positions of ships.

Bellini and Tosi in Italy pioneered in researches regarding radio direction-finders prior to 1912. In 1915, Dr. F. A. Kolster, of the United States Bureau of Standards, pointed out the advantages of locating certain radio signalling apparatus at lighthouses, lightships, and other navigational points, especially in time of fog. One year later, Kolster developed the movable coil type of radiocompass, which since has been commercially developed for use on ship and shore stations throughout the world. Sixteen of these compass sets were installed on board United States navy vessels in 1916. During the war the navy set up an extensive chain of shore radiocompass stations, of which today there are more than fifty located along the coasts. The war delayed commercial development of the radiocompass, but since then progress has been rapid.

The radiocompass ashore furnishes positions or bearings to ships in range upon request by locating the true direction from which the ship's radio signals are emanating. In time of peace these stations aid the merchant shipping of the world in fog or thick weather; in time of war they may serve to locate and keep track of enemy ships or fleets along the coasts. Commercial development of the radiocompass has been mainly devoted to apparatus for use on board ship. In this development the United States Lighthouse Service has played a notable part, both in early tests and in the creation of an extensive radiobeacon system.

The average shipboard radiocompass or radio direction-finder is located on the bridge accessible to the navigators. It consists of a movable small frame or loop antenna above the top deck, rotation of which is controlled by a shaft and hand-wheel terminating in the pilot-house underneath. It is electrically connected to a suitable radio receiver. A pointer mechanically connected to and controlled by the shaft indicates the bearing or direction on a compass card. Rotation of the loop antenna by means of the hand-wheel causes variations in strength of the radiobeacon signal in the receiver. At the weakest or zero point of signal intensity, the bearing or angle is read on the pointer and compass card. Those who have used the ordinary broadcast radio receiver with a loop antenna are familiar with variations in signal strength. Although commercial ship installations were first made in this country in 1922, it is now estimated that around 700 American merchant vessels are equipped with radiocompasses or direction-finders.

The radiobeacon system consists of automatic radio transmitters located on principal lightships and at lighthouses on the Atlantic, Gulf, and Pacific coasts and on the Great Lakes. In times of fog or thick weather these beacons send out certain prearranged, simple combinations of dots and dashes at frequencies around 300 kilocycles. It is not necessary to know the radio code to identify these beacons. With his shipboard radiocompass, the navigator can quickly and accurately determine his bearing or position with respect to these beacons, even though he is a hundred miles distant or his vision completely obscured by fog.

Approximately seventy radiobeacons are now in operation along our coasts and on the Great Lakes. While the development of radiobeacon systems has lagged somewhat in most foreign countries, as compared with the United States, the rapid adoption of shipboard compasses as standard equipment is stimulating the erection of radiobeacons in all parts of the world. If radiobeacons are not available, bearings may be taken on any radio transmitting station within range of the compass receiver.

The increase in the application and use of shipboard radio has placed new demands upon apparatus and personnel. As in other arts and industries, it is apparent that the trend is toward less dependence on the human element and more reliance on machines. Apparatus for automatic reception and transmission of messages at high speeds was handled on several transatlantic vessels and shore stations on both sides of the Atlantic as early as 1923, considerable experimental work being carried on in that year. Now the larger liners are using high-speed automatic receiving and transmitting apparatus when conditions permit.

One of the provisions of the Safety of Life at Sea Convention adopted at London in 1929, related to the use of automatic alarm apparatus. This apparatus is actuated by the international radio distress alarm signal sent out by a vessel in range, and will cause a warning bell to ring in the navigator's bridge and in the radio operator's cabin. According to the Convention, it is expected that the use of such an automatic alarm receiver will be of special value on cargo boats, where, under the present regulations, a radio operator is not required to listen in continuously at the radio room. The alarm will serve to call the operator to listen, and, if conditions warrant, will enable him to reply to a distress signal of which he otherwise would not be aware.

International regulations have kept pace fairly well with changing radio conditions. Not only the International Radiotelegraph Conference at Washington in 1927, but the Safety of Life at Sea Conference at London in 1929 encouraged the increased use of radio on board ship. According to the Convention drawn up at the latter conference, all passenger ships and all cargo vessels over 1,600 gross tons, with a few exceptions on limited routes, must be equipped with radio apparatus, and all passenger vessels of more than 5,000 tons must be equipped with the radiocompass. One lifeboat must be equipped with radio apparatus when a vessel carries thirteen or more persons and two when a vessel carries nineteen or more. Another provision increased the number of hours certain vessels are required to maintain radio watches. This Convention was to go into force July 1, 1931, if ratified.

The miscellaneous services furnished by radio to ships at sea are numerous and varied. Correct radio time signals enable the navigator to set his chronometers and clocks accurately. Weather reports and forecasts are furnished for all parts of the world, including hurricane warnings in the Caribbean Sea and typhoon warnings in Oriental waters. The dangerous derelict, ever a menace to shipping, is reported by radio and other vessels warned of its location. In the North Atlantic steamship lanes, international agreement provides for the patrolling of the ice fields by United States Coast Guard vessels, which daily send out radio warnings of drifting icebergs. Latest news of the world is broadcast from shore and received for publication in the small press sheets of the cargo boats or elaborate daily newspapers of the passenger liners. The cargo boat with an ill or injured member of its crew reports conditions and symptoms to the nearest vessel carrying a doctor, or to a shore station, and receives proper instructions and advice for medical treatment. The United States Public Health Service cooperates in this service.

To a great extent, commercial maritime radio has been developed by private companies in the maritime countries. The problem of radio on board ship is international in character as well as varied in its maintenance, engineering and communication aspects. It involves regulation under international conventions and under the laws of the country under which the ship is registered. Apparatus must be specially designed for maritime conditions and operation. Regulations require licensing of stations and their maintenance and operation in conformity with currently accepted engineering practices. The operating personnel must not only be skilled in the handling of radio communications, but they must also be licensed as radio operators by the countries of which they are subject. Records must be kept of messages sent and received through local and foreign stations and a proper accounting and settlement of tolls must be made regularly.

From the inception of marine radio, therefore, it has been the usual practice to leave its development in the hands of commercial radio organizations. It is commonly agreed today that this trust has been well placed.

A great part of the world's shipping is composed of homely but extremely utilitarian cargo boats. Tramping back and forth over the seven seas and on the larger bodies of inland waters, most of these boats are voluntarily equipped today with radio by owners who regard radio as an economic necessity. Aside from its primary safety value, radio keeps owners and agents in touch with the masters. It makes ships and cargo, representing investments of hundreds of thousands and even millions of dollars, a "live" unit of commerce, ever subject to the control of those concerned. In the United States, daily position reports are flashed by ships to the coastal stations, which in turn relay them by land telegraph for publication in newspapers or delivery to agents. Knowledge of the position of a vessel is of great advantage to shipowners. Among other things is enables docking plans to be made, cargo-handling facilities ashore to be prepared, and supplies and repairs to be ordered prior to the arrival of the vessel. In many cases, especially in the case of oil-tankers, a vessel may be sent out from her loading-berth with orders to proceed to a certain port only to have its destination changed in orders sent to the master *via* radio after it is well out on the high seas.

The great ocean liners today are in constant touch with the shore. Through the marvelous properties of radio, these floating communities are becoming more and more identified with the fixed communities on land. Business men remain in ready touch with their offices and affairs, and travelers send greetings easily and economically to their homes and friends. The radio station on board is no longer merely a mysterious and marvelous agglomeration of apparatus to the average traveler.

With today so bright, tomorrow in maritime radio is a subject for those with unbridled vision.

The fact that a wife at home will be able to reach for her boudoir telephone and be connected with her husband in mid-ocean has a human appeal which has given this factor of maritime communication considerable publicity. Yet with all the publicity thus obtained, sufficient demand has not yet been generated to make the widespread installation of the radiotelephone on passenger liners feasible. As a matter of fact, there is nothing particularly new in radiotelephony from ship to ship or ship to shore. As far back as 1907, Dr. Lee DeForest equipped a number of vessels of the United States navy with radiotelephone apparatus. About seven years later, experimental radiotelephone contact between two warships on the high seas resulted in successful communication over a distance of 44 miles.

With the development of the vacuum tube for transmitting purposes, radiotelephone apparatus was improved. During the World War, a large number of naval vessels, including destroyers and transports, were equipped with vacuum-tube radiotelephone transmitters, mainly for ship-to-ship communications. Commercial tests were made in 1922 between the S. S. *America* and a shore station at Deal Beach, N. J. Reliable telephone communication was effected up to a distance of 400 miles. Because public demand still seemed insufficient, tests were discontinued until the summer of 1929, when experiments between the S. S. *Berengaria* and a shore station in France, and between the S. S. *Leviathan* and a United States station, demonstrated clearly that reliable and consistent radiotelephone communication with transatlantic liners was ready for exploitation. Public radiotelephone service to and from the *Leviathan* was inaugurated early in 1930.

RADIOTELEPHONY

By E. H. Colpitts

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A REVIEW of the development and use of radiotelephony as a service-giving agency involves a consideration of certain fundamental requirements which need to be met by any form of facility for public communication. It will be desirable, in considering these requirements, to take notice of some of the characteristic advantages and limitations of radio and to draw some conclusions as to the relationship between radio and wire facilities for telephone communication.

The fundamental requirements of any telephone system may be considered, broadly, as:

1. Availability of ample circuits to meet the traffic demands.
2. Accuracy of reproduction.
3. Reliability.
4. Reasonable cost.

These requirements are applicable regardless of whether transmission is by wire or by radio, and, in general, the one to whom the service is rendered is not so much interested in the means of transmission employed as he is in receiving satisfactorily accurate and reliable service at the lowest possible cost.

The available technical data as to the behavior of radio waves and the performance of radio apparatus enable us to make the following outline of the basic facts now known as to the nature of radio transmission. These characteristics have a direct bearing on the consideration of the usefulness of radio in meeting the telephone requirements outlined above.

1. In the present and prospective state of the radio art, the number of channels available for simultaneous use throughout the entire world is limited. At the present time this number is somewhere around three or four thousand, and the United States can use only a part of this number. In this country alone the number of wire telephone and telegraph channels in simultaneous use is counted in the hundreds of thousands, and the number of circuits which must be available for use is many times this number. It may be appreciated, therefore, that there is little chance of radio being able to play any substantial part in rendering the telephone and telegraph service now carried on by wire.
2. Radio communication is naturally a broadcast form of transmission. This makes it in many respects an ideal means for the transmission of a given message simultaneously to large numbers of individuals in widely scattered locations. Directional methods of transmission and reception involving the use of special antennas may be used to impose some degree of limitation in certain cases where transmission is required between fixed points.
3. All radio communication circuits employ the same transmission medium, so that the separation between the channels which are in simultaneous operation depends entirely upon
   a. geographical separation or directional discrimination between the several points of transmission and reception, and
   b. the proper design of the sending and receiving equipment so as to fix the frequency band employed by each channel.

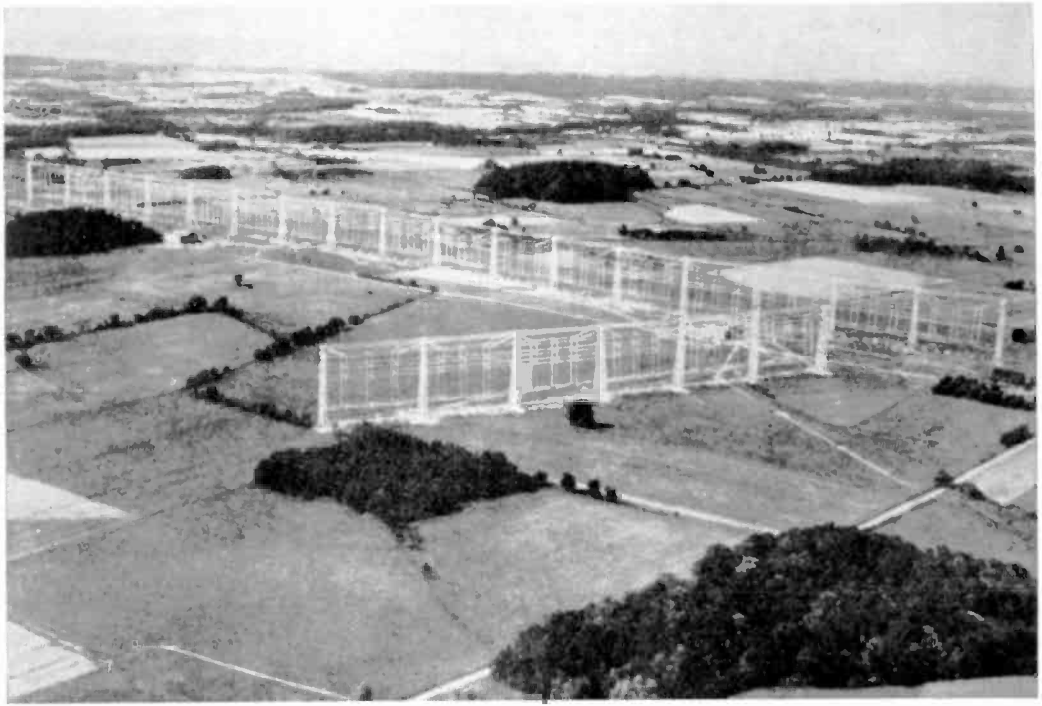
4. So far as we have yet learned, all radio transmission is subject to vagaries in the transmitting medium which are beyond human control. Static and fading at times present difficulties which make a radiotelephone circuit useless for commercial service. These effects are, however, quite different in the low-frequency and in the high-frequency portions of the radio spectrum. This fact and the results of continuing research work give some evidence of the possibility, though not the certainty, that this difficulty may be greatly reduced. This disadvantage is sometimes not so serious a limitation on a radio circuit where traffic requirements are light or where merely intermittent contact is a valuable consideration.
5. Because all radio stations use a common transmission medium, it is necessary to use special means to control the frequency or limit the width of the channel occupied by each station. Full cooperation on the part of all agencies engaged in radio communication activities is necessary in order to reduce to a minimum the possibility of interference between stations.
6. Radio transmission is in general non-secret. Methods have been devised for modifying the transmission so as to make reception difficult by other than the desired stations. Up to the present, however, these devices may react on the quality of transmission and have, therefore, been little used.
7. The fact that the equipment involved exists only at the terminals of the radio circuit has the advantage of making this a valuable means of communicating with mobile objects such as ships and airplanes where the use of connecting wires is impracticable or impossible. This fact offers an advantage, also, in some cases where one or both of the points of communication need to be shifted frequently.

While radio is still a comparatively young art, it has, nevertheless, been in use for a number of purposes during the past 20 or 30 years. From the beginning it has been of especial importance for communication with mobile stations, an example being its use in marine radiotelegraph service. Radio soon found many points of application and, even with the comparatively simple apparatus of its early days, the communication which it made possible to ships and outlying points, over ocean areas, was exceedingly valuable.

Present-day radiotelephony became possible with the advent of the vacuum tube. This device is used as a means for generating radio-frequency waves, for modulating these waves in accordance with the human voice, and for detecting and making these signals audible again at the receiving station. With the vacuum tube and other modern devices, it is possible to make quantitative measurements of the behavior of equipment and of the nature of transmission between the transmitting and receiving location. This makes it possible to develop better equipment and especially to relate the apparatus better to the duty it is intended to fulfill.

Modern civilization, too, has greatly extended the demand for quick communication facilities. Along with the improved performance of radio apparatus and circuits, there have come an increase in the uses for which communication is required and an increase in the accuracy and reliability which are demanded. It is now possible to make a fair estimate of the performance requirements for a proposed communication system and to determine to a considerable degree, as a result of measurements and experience with previously existing circuits, to what extent it will be possible to meet these requirements. In short, it is now possible to "engineer" a radio communication circuit for the duty in hand, though experience and performance records on each new circuit make more certain the engineering work on the succeeding circuits.

Taken as a whole, the present radio communication system of the world consists of a composite of the following three types of service, there being both telegraph and telephone facilities of each of these types:



Airplane View of Short Wave Radio Transmitting Station at Lawrenceville, N. J., Used for Transoceanic Telephone Service.

1. Broadcasting.
2. Communication between fixed points.
3. Communication with ships and with aircraft.

The development of telephone service calls for the use, in each instance, of the kind of facilities most suitable for that particular situation. This requires, therefore, a thorough study of the possibilities and characteristics of both wire and radio communication.

Broadcasting.—The inherent broadcasting characteristic of radio referred to above, is distinctly in its favor as a means for the transmission of programs or information intended for reception by large numbers of people. The recent rapid development of radio broadcasting service as we now have it is proof of the usefulness of radio for this purpose. In this case, also, radio's lack of secrecy is no disadvantage.

As is well known, there have been established extensive chains of radiotelephone broadcasting stations reaching to all parts of the country. Connnections are made from the point where the program originates to these broadcasting stations by wire telephone lines. In this way use is made of the inherent characteristics of radio as a broadcasting medium in each of the areas served by the radio stations, while the wire lines are used to overcome the fading and other irregularities of radio transmission over long distances.

On outstanding occasions broadcasting stations on the North American continent have been provided with programs originating in Europe and transmitted from special relay broadcasting stations or carried over the commercial transatlantic radiotelephone circuit, to which further reference will hereafter be made.

Communication between Fixed Points.—The usefulness of radio for point-to-point communication depends on the balance between a number of its advantages and disadvantages when applied to each situation. First of all, the total number of channels available comes nowhere near meeting the world's communication requirements, so that in the long run only those cases where radio is outstandingly the most suitable means of communication can expect to be served. Previous experience has been that as fast as technical developments make additional channels available, new and insistent demands arise for their use. This limitation on the number of available channels has been one of the most important reasons for the establishment of the Federal Radio Commission in the United States as an agency to determine to which applicants authority to operate radio transmitting stations should be granted, and, subject to the provisions of existing international radio agreements, on what frequencies their operation should be conducted.

In the consideration of the use of radio for communication between fixed points, one of the important aspects is the large cost of the terminal equipment required if satisfactory reliability of transmission is to be secured. With wire transmission, having provided the physical conducting mechanism, one can carry on communication with comparatively small amounts of power, and with relatively simple terminal equipment.

The requirements of telephone circuits as to reliability and freedom from noise are far more severe than those of ordinary telegraph circuits. This is partly because of the more intimate contact which the telephone subscriber has with the physical facilities by which he is served. For radiotelephone service, therefore, the likelihood of fading and interruptions to radio circuits on account of static or other interference must be substantially reduced by the employment of special technical devices and methods, or else the advantages of radio over wire communication in a particular case must be such as to overcome these disadvantages.

It is not surprising, therefore, that the principal use of radio as an element in the telephone service of the country has, up to the present time, been that of extending the service across large ocean areas to other countries.

The earliest long-distance radiotelephone tests were conducted in 1915 when telephone transmission from America was heard both in Europe and in Hawaii. Research and development work during the following 12 years finally resulted in the establishment of the first commercial radiotelephone circuit between New York and London in January, 1927. This research work included, among other things, the development of high-power water-cooled vacuum tubes, the carrying on of transmission studies to secure information regarding the nature of radio transmission between America and Europe, and the adoption and improvement of highly directive receiving antennas which are equal in their effect to the multiplication of power at the transmitting station by about 400 times.

This telephone circuit, initially established between New York and London, has subsequently been extended by connection with the long-distance wire telephone lines in both continents, so that now the network on the American side connects with some 19,000,000 telephones and that on the European side with about 7,000,000, and the over-all system includes over 80 per cent of the world's telephones. The American terminal of this radiotelephone system is operated by the American Telephone & Telegraph Company, and the European terminal is operated by the British General Post Office, which operates the telephone service in England.

Meanwhile, since the opening of this service, the demand has required the addition of three additional circuits. The first circuit employed low frequencies or long waves, while the subsequent three circuits make use of high frequencies or short waves. The nature of radio transmission on long and short waves is such that the natural conditions which have an adverse effect on one type of circuit do not, in general, have that effect on the other.

In spite of the great technical improvements which have been made in the radio circuits since the inauguration of this service, there are periods when transmission conditions are such as to make one or more of them unsatisfactory for commercial use. It is, therefore, planned to supplement these radio circuits for telephony across the Atlantic with a submarine telephone cable.

In addition to the telephone connections between the United States and Europe, the establishment of a radiotelephone circuit between North and South America, the southern terminal being at Buenos Aires, and between North America and lands across the Pacific, along with the other long-distance radiotelephone circuits which are being established between other continents, is apparently but the beginning of an extensive telephone network which bids fair to envelop the world in much the same way as the present system of telegraph cables and radiotelegraph circuits.

In the transatlantic telephone service, the radio paths exist between transmitting and receiving stations at locations which are advantageous for radio transmission and reception. Telephone land line connections are made from the pair of stations on each side of the ocean to a central control point from which suitable connections are made to the regular long distance and local telephone system of the country. In this way the telephone subscribers on both continents are able to talk with one another just as they do over any long distance wire telephone circuit.

Communication with Ships and with Aircraft.—In providing means for communication with ships, aircraft, and other moving points, advantage is taken of one of the outstanding favorable characteristics of radio communication, that no wire connection is required between the points of transmission and reception. Radiotelegraph transmission to and from ships has, since its earliest days, been one of the most important uses of radio. The technical development of means for making radiotelephone connections between ships and the land telephone network was carried out by Bell System engineers about 1920. The work at that time was carried out with wave lengths which are now employed for broadcasting. Later activities have been directed toward the use of comparatively short waves. Some of the larger transoceanic passenger vessels are now being equipped for radiotelephony with these short waves, and suitable shore stations are being established through which connections are made to the land telephone system.

The recent rapid expansion of commercial aviation and the establishment of scheduled air transport lines have called for the provision of adequate means of communication between ground stations and aircraft in flight. Building in part on the foundation laid in work for the military department during the World War, there have been developed radiotelephone transmitting and receiving sets for use in transmitting such information as weather data and landing-field conditions to the pilots and in establishing two-way telephone communication by radio between the pilot and those on the ground.

As has been observed, radio and wire links are in many cases connected to form an integral telephone communication system, each facility serving in the way in which it is best suited and the two being combined to perform the duty required.

The telephone requirements of the world are steadily increasing and there appears to be no doubt that radio circuits will continue to be required to supplement the use of wires. In the further development of communication service, each medium may be expected to be used primarily for those purposes for which its technical and economic characteristics make it best fitted.

RADIO FOR SAFE FLYING

By Fred C. Hingsburg

Chief Engineer, Airways Division, U. S. Department of Commerce

THE field manager at Hadley Airport was standing on the concrete apron in front of the National Air Transport hangar, peering anxiously to the west. The weather was bad for flying the mail over the Alleghanies from Cleveland, the visibility being less than one mile at the airport and the ceiling creeping down to where it was now less than 500 feet. The pilot of the mail plane was reported on the teletype to have taken off from Bellefonte, Pa., at 4:30 A.M., bound for the New York terminal, which is at Hadley Field, N. J. He was now due. The question in the mind of the field manager was, could he make it?

The tops of the mountains along the route were enveloped in clouds, and no ceiling or visibility had been reported at several of the high mountain points in the last hourly weather collection made along the route by teletype from the Department of Commerce intermediate fields and weather-reporting points. Under these conditions, the 2,000,000 candlepower revolving searchlight beacons, which are spaced about 10 miles apart along the route, were completely blotted out, and the pilot must make his way through a rolling sea of blinding vapor, guided only by instruments and radio aids to navigation.

The sound of a familiar propeller and exhaust announced the arrival of the air-mail plane, flying above the clouds directly across the landing-field along the radiobeacon course. Spurred to action, the field manager hurried to the Airways Radio Station and asked to use the microphone. The radiotelephone was placed in operation on the radiobeacon frequency by the radio operator. "This is Field Manager, Hadley, speaking. You crossed directly over the field. Come down, Airport's clear. Visibility is one mile. Ceiling 300 feet and lowering fast. Wind calm."

Five minutes later the mail was being loaded into the Post Office Department truck for delivery, in time to make the opening of the clearing house. This incident, according to Wesley Smith, operations manager of the National Air Transport, represents a typical performance under conditions of bad weather flying, its successful consummation made possible by the use of radio aids to navigation as developed up to this time.

"Radio flying" has already been instrumental in reducing delays and interrupted schedules of the air-mail planes by more than 30 per cent. More gratifying, however, is its contribution to the record of safety in flying the air mail.

As we look over the air-mail plane that has just arrived from Cleveland, we find it to be a mail-cargo plane flown by one man and with the mail stowed in the forward compartment. In addition to the regulation red and green navigation lights and white stern light, the airplane is equipped with bright wing-tip headlights for landing on the boundary-lighted intermediate landing-fields provided along the route at 30 mile spacings, and for landing under conditions of stress of weather. The plane is also equipped with two parachute pyrotechnic flares which may be released and ignited to illuminate a square mile of area to help make safe landings in emergencies. The cockpit is painted jet black for night flying, and the instruments have radium-painted dials conveniently arranged so that the pilot may see them all at a glance.

The airplane has been bonded for radio reception. Strips of copper braid have been installed along the wooden spars and trusses of the wings, and all structural parts have been bonded together with metal braid ties to ground the entire plane to the same electrical potential. This prevents radio disturbances and interference caused by the static charges and discharges resulting from the rubbing of parts while the plane is in flight. All airplanes intended for transport service are now bonded for radio in the course of their manufacture. In addition, the magneto, ignition wires, and spark plugs of the engine are shielded to exclude ignition noises from the radio set. The magnetos are completely housed in metal covers, and a metal braid or tube-covered harness is used for inclosing the ignition and electrical wires. Special shielding is used for the spark plugs, generators, dynamotors and other electrical apparatus, and circuits are provided with the proper inductance and capacitance values to eliminate radio interference.

When the Diesel motor, with its absence of electrical connections, comes to be in general use as the power supply for aircraft, all these precautions against interference will, of course, be unnecessary. Meanwhile, however, the elimination of interference with the radio waves caused by conflicting electrical emanations is an integral factor in the success of flying with the help of radio.

The antenna consists of a stream-lined mast which extends about 6 feet above the fuselage and is mounted behind the pilot. The receiving equipment is suspended in spring or sponge rubber mountings in a fuselage compartment at the foot of the antenna mast. An insulated wire extends through the length of the antenna mast, which reduces "rain and snow static" noises in the receiving set. The receiver is of the tuned radio-frequency amplifier type, utilizing two or three stages of shield grid, tuned radio frequency amplification with a non-regenerative detector and one or two stages of audio-frequency amplification. The overall amplification of the radio receiver is several million. The receiver is tuned by the use of a mechanical remote-control apparatus, the tuning-dial, switch, and volume control, being mounted in the cockpit, where it can be readily manipulated by the pilot. Current is furnished from "A" and "B" batteries for the D. C. type of radio receiver. A dynamotor with filter is used with some sets to furnish the plate current, while the filaments are lighted from a storage battery. The "heater" type of tube is used in the latter type of receiver. The entire weight of the receiving set and power supply is about twenty-five pounds. A simple receiving set of the type described will enable the pilot to take advantage of all of the radio aids established and operated by the Airways Division of the Department of Commerce.

The radio stations for broadcasting weather information to pilots in flight are operated in conjunction with radio range beacons and are located generally about a quarter of a mile from the terminal airports. The greatest advantage of the radio range beacon is its "homing" feature. By means of the radio signals, the pilot can fly directly to the beacon, and from there locate the terminal airport. On the exact quarter hour, the radio range beacon is stopped and identified by a station announcement followed by correct time and the broadcast of current weather information affecting the flight over the airway. The radio aids, in contrast with airway beacon lights, are effective for day as well as night flying. The most valuable information that can be imparted to the pilot in flight is whether or not a safe landing can be made at the terminal field; and, in the event that the terminal is closed in by fog or thick weather, what alternate field should be used. The radiobeacon service and broadcast of weather information is transmitted on channels in the 237-350 kilocycle band. Channels are separated by 6 kilocycles and stations of the same frequency are separated about 800 miles apart.

The United States Weather Bureau gathers weather reports from its primary net twice daily. These reports are gathered by telegraph from five forecasting centers in the United States, and weather maps are compiled from which the aviation weather forecasts are prepared. A secondary net system for airways gathers weather reports every three hours from points 100 or more miles each side of the airways, which are telegraphed to control points located at the principal air terminals. General flying weather forecasts are prepared from the data and weather maps, and the digest of weather is broadcast from the Airways Radio Stations for reception at airports and on airplanes in flight. In addition, spot weather reports are gathered in sequence each hour by means of a printing telegraph or "teletype" circuit from intermediate fields and critical weather points about 75 miles apart along the airways. These form the basis of the sector weather information broadcast to pilots in flight.

The radio range beacon applies directive radio to mark a course about three degrees wide along the lighted airway, enabling the pilot through his hearing to determine whether the airplane is on the true course over the route of the lighted beacons and landing-fields, in the event he fails to see landmarks or beacons on the ground in thick weather. The antenna system of the radio range beacons consists of the equivalent of two directional loop antennas at right angles in the vertical plane and supported on 60-foot poles. At the foot of the center pole, a small wooden building houses the transmitter, goniometer, motor-generator, and signaling devices. The transmitter is a 2-kilowatt power-amplifier type master oscillator, utilizing 500 cycle plate supply. Signals received in the ordinary airplane beacon receiver are of 1,000-cycle note. The signals are transmitted alternately from the loop antennas, sending the latter "A" (dot-dash) on one loop and the letter "N" (dash-dot) on the other, which interlock, marking four courses along lines of equal signal strength. The interlock signal is a prolonged dash, letter "T." The course can be shifted by the goniometer to coincide with the airway to be radio marked. The radio range beacon transmits the "A" and "N" signals in sequence at a rate of 22 signals per minute, which has proved the most effective. In receiving the beacon signal aboard the airplane, the pilot may determine to which side of the course he is deviating by the relative strength of the "A" and "N" signals. Any wavering of the "T" signal indicates deviation from the axis of the airway.

Intersection of the radio range course, or points where abrupt changes in direction or altitude occur, and the principal landing-fields, are marked by radio marker beacons. Signals are transmitted from a low-powered, non-directional radiobeacon on the frequencies of both the adjacent radio range beacons. These have a range of three miles. The marker beacons are automatic in operation and transmit an easily recognizable characteristic signal.

The dissemination of weather information to any one of many established airports, or to the multitude of airplanes which may be equipped with a radio receiver and which fly over the national system of airways, is accomplished by broadcasts from the Airways Radio Stations. The equipment at the radio-communication station consists of a combined telephone and telegraph transmitter, having an output of approximately two kilowatts, for communication with aircraft. The antenna used at the station is strung between two towers 125 feet high and is approximately 375 feet long. In addition, a 500-watt high-frequency telegraph transmitter is used for point-to-point and emergency communication by code. These stations are on the air every 15 minutes. At quarter-hour periods the weather conditions along airways to the north, east, south, and west of the station are broadcast. The sector weather in each direction includes detailed reports from points up to 200 miles distant, together with terminal weather at the remote terminal 300 to 450 miles away. These reports are collected by teletype and keep the pilot advised regarding weather conditions beyond the horizon in all directions. Preparedness and accuracy of weather information to serve any requirement, to any airplane, anywhere, at any time, is the purpose of this system. Captain Frank Hawks, after using this system in his flight establishing a transcontinental record said: "I was never so impressed with the value of radio to aviation as I was yesterday. Passing Columbus and facing the worst of flying territory at night, I felt qualmish until I picked up Cleveland Airways Radio Station and heard in matter-of-fact tones just the information that I needed—broken ground fog over Pennsylvania and broken overcast with a drizzle over New York. I knew then I could make it."

Airports, to obtain a rating from the Department of Commerce, will be obliged to install a radio transmitter for communicating with aircraft. This transmitter will be a low-powered set having an output not to exceed 10 watts and will operate on a frequency of 278 kilocycles. The transmitter will be designed for accurate control of frequency to reduce interference between adjacent airports. It will be operated by the airport manager or officer on watch, communicating with planes, giving the pilots landing instructions, describing the proper runway to use, and giving any precautionary information that may be necessary. Such communications from airports on 278 kilocycles can be received on the simple radio receiving set described heretofore, which will be standard equipment on all aircraft.

Communications from airplanes in flight are required for ultimate safety and will be provided by two-way radiotelephones at airports and at the principal intermediate landing-fields along the airways. A constant watch will be maintained day and night at these intermediate fields on a receiving set tuned to 3,106 kilocycles for reports of position or other emergency communications from airplanes. Position reports from airplanes passing over the principal intermediate fields about 75 miles apart along the airways will be transmitted over the teletype to the terminals. This safety service will be of especial benefit to itinerant flyers and airplane taxi services. The establishment of a national set-up of frequencies for two-way communication between airports, intermediate fields, and airplanes in flight will standardize equipment, reduce costs by mass production, facilitate servicing of radio sets, and make flying safer. In time, airplanes flying interstate and carrying passengers will by regulation be required to be equipped with radio receivers. Airplanes carrying more than four persons will be required to be equipped with a radio transmitter.

The radio aids to navigation for both aëronautics and marine are operated in the same frequency bands. The United States Lighthouse Service operates its system of radiobeacon stations along the coast and inland waters of the United States on six 4-kilocycle bands of channels between 285-315 kilocycles. The marine system of radiobeacons used in connection with radiocompasses aboard ship has been one of the greatest steps forward in bringing about safety at sea. Owing to the importance of the marine radio aids to navigation and the congestion in the frequency bands allocated for radiobeacons, it will not be feasible fully to utilize the marine portions of the radio spectrum for aëronautical aids. The International Radiotelegraph Convention of 1927 set up 333 kilocycles as the calling and distress frequency for aircraft, and this frequency must be guarded and used for safety communications.

Radio transmitters for use on aircraft have been developed by several manufacturers. In general, high frequencies below 6,000 kilocycles are being employed for such communications, working the transmitter either into a fixed antenna or a trailing wire antenna. Equipment is now available which will give an output of 50 watts of power, modulated 100 per cent for voice communications. Electric power for the operation of the transmitter is obtained either through a dynamotor operating from a storage battery aboard the airplane or directly from an engine-driven generator geared to one of the main engines. The weight of a complete transmitter of this type is around seventy-five pounds, and it will provide communication up to about 100 miles. Low-powered aircraft transmitters are also being developed for air mail and sport types of airplanes.

An air transport company flying passenger liners over a regular route on schedule has a responsibility for the safety of lives that cannot be transferred to any communications or life-insurance company. As radio is the only means of communicating with aircraft, the Federal Radio Commission has reserved groups of exclusive frequencies for the interstate trade air routes to be made available for the use of air transport operators. A liberal number of channels scattered throughout the 2,500-6,000 kilocycle spectrum has been reserved, with separate channels for day and night use. The privately owned stations are operated on the basis of "chains," with exclusive frequencies for each route. All air transport companies using the same airway will equip their airplanes and ground stations with radiotelephone transmitters and receivers to operate on the assigned route frequency; and at airports used jointly by the several operators, arrangements are made to operate the ground station jointly. This arrangement is the equivalent of a party wire for each airway. By the use of these radio facilities, any air transport company can maintain constant communication with its ships of the air, its own operations manager standing watch at the airport to safeguard the movements of his planes. A radiotelephone operator's license is all that is necessary for stations with 300-watt input. For stations with greater power a first or second class radio-operator's license is required. A duplicate and stand-by means of communications to aircraft will further safeguard operations under the direct control of the operations manager responsible for the company's interest. A separate high-frequency receiver is placed aboard air liners for this private communications service and may be coupled with the intermediate frequency beacon receiver for radio aids to navigation by having one earphone connected to each receiver, thereby receiving both. By manipulating the volume control, the pilot can concentrate on the communication that is the more important for the moment.

Two-way communication with aircraft is used on the

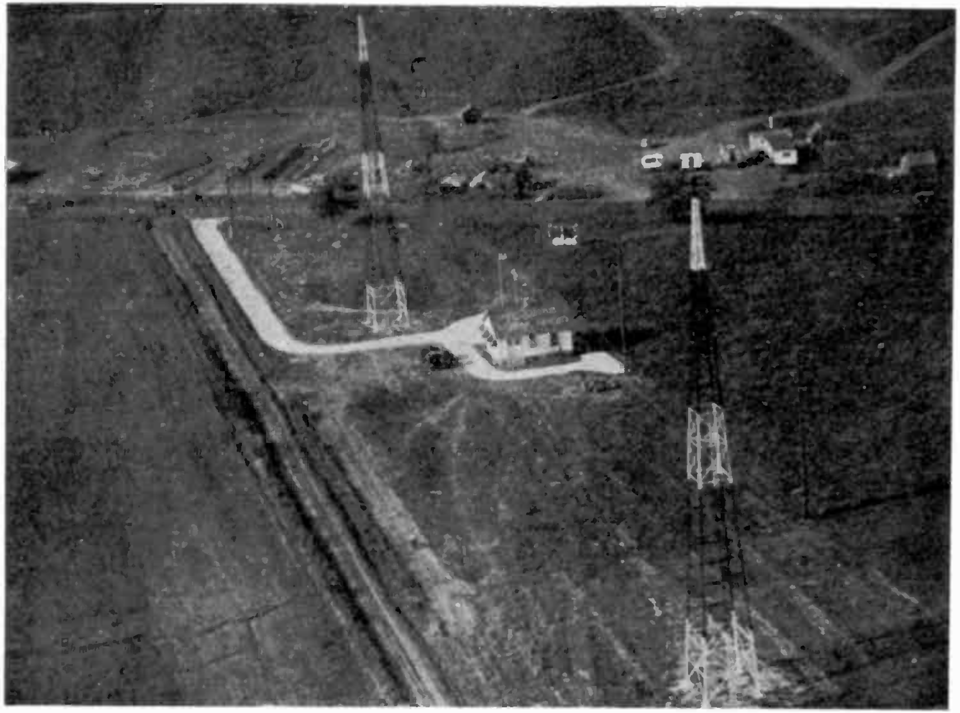
Pan American Airways throughout Latin America, where there are no other air navigation facilities and where flying is cross-country flying and over long watercourses. Constant contact is maintained with the airplane in flight, using high-frequency radio transmitting and receiving apparatus for telegraphic code messages. Radio operators are always carried aboard the airplanes. The ground stations take bearings on the airplanes by radiocompass and plot the courses, advising the pilot regarding positions, drift, weather, and other safety messages. This system has given excellent results and is satisfactory over routes where infrequent flights take place and traffic permits maintaining individual contacts.

In Europe the radio communications and position-reporting system has been on intermediate frequencies, the calling and distress frequency being 333 kilocycles. All passenger liners are equipped with radio transmitters and receivers. If the pilot on the airways wants to know his position or the control station wishes to locate the airplane, the pilot is requested by radio to speak for half a minute. Bearings are taken by radiocompass from three radio stations and communicated by land line to the control station, where the bearings are plotted on a map and position determined. The location of the plane is then communicated to the pilot. The determination of a position requires two minutes. In England, the three radio stations for the channel routes are located at Pulham, Lympne, and Croyden.

The perfection of aëronautical radio facilities plays an important part in conquering weather and making flying safer for transportation. The development of more suitable flying instruments is taking place, and in this field radio and electrical appliances are again predominant. The present altimeter is an application of the aneroid barometer showing the altitudes above sea-level. It is affected by changes in barometric pressure over the route, and requires corrections for differences in temperatures encountered at the various altitudes of flight. The instrument does not show altitude above the ground, and a knowledge of the terrain and the ground elevations is needed to use the instrument with safety.

The broadcast of weather data, including barometric pressures reduced to sea-level and temperatures, together with the altitude of the landing-field, makes it possible to make approximate corrections of the altimeter in flight. The development of radio altimeters has been under way for some time with a view toward perfecting a reliable direct-reading instrument showing accurate heights over all classes of soil and water. Experiments with the radio altimeter have been along the lines of the radio echo principles, induction or capacity, and sonic depth-finding.

"Flying blind"—that is, without seeing the ground for any length of time—using the present turn, bank, and inclino-meter indicators has been a subject of considerable controversy among pilots. In flying the New York-Chicago route, which is equipped with radio aids to navigation, the pilots regularly fly without seeing the ground between intermediate terminals. Much skill is required, especially in rough air, and many pilots have experienced the loss of control on account of erratic movements of the airplane as well as the difficulty of flying without seeing fixed objects on the ground or in the sky by which maneuvers and equilibrium may be controlled. The need for a better flight indicator has led to the development of a gyroscopic artificial horizon which gives the pilot a rational indication for controlling the airplane in level flight. The image of a miniature airplane with respect to a lubber line shows the aspect of the airplane in flight in its relation to the horizon. The corrective movement of the control stick is instinctive. Loss of control under conditions of instrument flying is obviated by this instrument. The gyroscope of the artificial horizon is actuated by a Venturi tube located in the slip stream. This is one of the new instruments used by Lieutenant



Type of Radio Weather and Information Reporting Stations Operated Along the Civil Airways by U. S. Department of Commerce.

"Jimmy" Doolittle in his fog landing experiments at Mitchel Field, L. I. in 1929.

For large air liners, an automatic pilot using the same gyroscopic principle is used. Electrical contacts are made when the airplane deviates from level flight, and the control stick correction is mechanically applied, bringing the airplane back to level flight. The navigation of the airplane, however, is at all times under control of the pilot, and radio direction guides the pilot over the proper course when the ground is not visible. Flying above the clouds and fog with safety is assured some time in the future when confidence can be placed in the reliability of these devices. Superabundance of reserve power in multiple engines is required so that an airplane can proceed to a safe landing in the event one of the motors cuts out.

An automatic pilot was flight tested by Mr. P. R. Bassett, chief engineer of the Sperry Gyroscope Company, in an army transport, with Lieutenant Albert Hegenberger as pilot. The flight was made from Boston to New York on October 17, 1929, which happened to be a cold, windy day with exceedingly rough and bumpy air. The handling of the airplane was turned over to the automatic pilot at 5,000 feet altitude and it worked with the equivalent vigor and strength of 10 pilots to smooth out the influence of each movement while the crew was enjoying the scenery. The airplane passed into a cloud and the one unsolved problem of flying appeared—collection of ice on the struts and wings. The automatic pilot was quickly disengaged and Lieutenant Hegenberger nosed the plane downward. At 3,000 feet the plane had emerged from the cloud and the ice melted. The automatic pilot was again harnessed to the controls and completed the flight to New York.

The application of radio to aviation is comparatively new, but rapid progress is being made in the development of new radio devices. A system of visual indication for radiobeacons has been in the course of development at the

Bureau of Standards for some time, and its application to airways awaits the perfection of commercial apparatus and sufficient flying experience to prove its reliability. The beacon transmits directional signals from two equivalent loops which are modulated to actuate tuned frequency reeds mounted on the instrument board of the airplane. The standard radio receiver is installed on the airplane in the usual manner and the signals are fed to the visual indicator. Each reed is flexed by the modulated continuous signals, and the airplane is on the course when the two reeds are flexed to the same amplitude of vibration. Any deviation from the course changes the strength of the respective signals and is indicated by corresponding changes in the amplitudes of vibration of the reeds. Should the indicator show one reed longer than the other, the pilot alters the course of the airplane until the reeds show the same amplitude. Four courses are marked by the interlock of signals of equal intensities in a manner similar to the operation of the aural radio range beacon heretofore described. The identification of the visual beacon is made by stopping the beacon and making an announcement on the same frequency from the airways radio station, followed by the usual broadcast of weather information. Earphones are required for the reception of voice for weather information and identification of the visual beacon.

A twelve-course visual radiobeacon is under development which may have greater possibilities than radio range beacons now in use, especially at air centers where a number of airways converge. Three sets of reeds for the visual indicator will be required. This development contemplates simultaneous transmission of radiotelephone broadcasts and beacon signals from two stations located 1,200 feet apart so as to avoid local interference. The radiotelephone and radiobeacon transmitters must be designed to have a common frequency-control apparatus and must be in operation simultaneously. The radio receiver aboard the airplane will filter out the low-frequency signals from the earphone circuit and feed them to the visual reed indicators mounted on the instrument board. The identification of the ground station which actuates visual indicators on the instrument board of the airplane is positively determined by simultaneous voice reception through the earphones. Time will tell whether this system can be developed and whether the complications introduced by it will affect reliability. Aids to navigation must be dependable in operation 24 hours a day and 365 days a year.

"Landing blind" has been realized in an experimental way and developments are now being made which will lead to the installation of apparatus at airports to guide airplanes safely to the airport under conditions of thick weather. Such developments may also bring the airplane to the ground. This undoubtedly will prove satisfactory for airmail service where risks are undertaken to advance deliveries of mail, but it appears that for a long time at least safety will demand the landing of air liners at an airport with adequate ceiling and visibility. Radio communications to aircraft will be the means of safeguarding air liners, at least for the present, by directing the pilot to a safe landing-field. An airport radiobeacon of low power will be required to bring airplanes over the landing-field and down to an altitude of less than 100 feet with security and in position to land if the ground is visible from this altitude, or to permit the pilot to "give her the gun" and go around again or leave for a clear airport. Many landings now impossible would be made with safety and the dependability of schedules increased with the development of such a device. An international radio frequency set-up for the airport radio and landing beacon must be made, so that standardized instruments can be used at any airport in the United States as well as in foreign territory. The position control of an airplane involves three-dimensional space and the landings must be made into the wind. A clear approach area to the airport without obstructions would be required, but these conditions might not be met at all airports. A low-powered directional radiobeacon would be required at each airport to mark the course to be flown by the airplane approaching the airport. It also appears that an incline plane must be marked out by directional radio to indicate by instruments the gliding angle to be followed by the airplane to reach the spot at the airport where the airplane is to land. Research work by the Bureau of Standards is steadily progressing to this end.

There are, at this writing, 1,500 airports in the United States, and within a few years the number will be more than doubled. Weather information at airports for the use of pilots is an absolute essential. The transmission of weather maps by radio may become a necessity in the future, so that airports may have adequate and timely weather information. Weather maps are prepared every three hours, based on the secondary net weather obtained at control points, and the transmission of the map upon completion could be used to disseminate weather information quickly and accurately.

There are many airports which are used infrequently at night and do not warrant having an operator in attendance to turn on landing-lights. By use of radio, these lights may be turned on from an airplane in flight by a selective transmitting key placed aboard the airplane for transmitting the proper signal, which in turn will be received at the airport and actuate the relays for controlling the lights. Upon being turned on, the lights will remain in operation sufficiently long to enable the pilot to land. Airport lights may also be turned on by a sound-sensitive relay using a properly pitched siren aboard the airplane.

When large passenger liners are operated over long routes, it may be desirable to trace the course of the airplane to scale on a map of the route. This can be accomplished by control apparatus operated in synchronism with the navigation instruments on the airplane.

As airplanes become larger, it will be desirable to have many communications transmitted to them registered in the form of a written record, and radio teletype is one way in which this may be accomplished. Facsimile messages, weather maps, and pictures can be transmitted by radio to aircraft by the installation of photo-radio apparatus on board. This would permit transmitting maps and photographs of landing fields directly to the pilot. One such system has been used on the Navy's dirigible, *Los Angeles*. Television, when it is perfected, may play an important part in connection with the operation of aircraft.

The use of radio in connection with aviation is in its infancy. Aviation, like maritime shipping, must look to radio for safety communications. Radio today makes possible voice communication to and from the plane and contributes greatly to its control. Tomorrow air-liner passengers may be able to place telephone calls for distant cities, for ships at sea, for foreign lands, and, indeed, for persons aboard other planes. That this can be done has been demonstrated by experiment; time and the physical limitations of radio alone stand in the way of making it a commonplace service.

THE RADIO AMATEUR

By Hiram Percy Maxim

President, The American Radio Relay League
President, The International Amateur Radio Union

THE amateur in radio presents a spectacle the like of which has never before been seen. I cannot think of a parallel to him, and the fact that so little is generally known about him makes it quite worth while to review his record. Aside from its extraordinary human interest, the matter is highly significant. No unusual development in which a large number of persons partake can escape being significant. It invariably portends something important. Amateur radio portends something of great importance in human affairs, and it is one of the hopes of the writer that this review may stimulate some far-seeing mind to estimate what it is.

In 1900, or thereabouts, when Marconi first began showing that signals could be projected across space without the use of wires, I recall that I became much more interested than I could quite account for. It never crossed my mind that others had the same interest. I read everything I could acquire that dealt with the subject, and distinctly recall estimating what it would mean for me to "get into the air" in an amateur sort of a way just to see what it was like.

When Marconi undertook to send the letter "S" across the Atlantic, I was kept out of setting up a listening station at my house only because of an absolute lack of time from my business. It transpired later that several others had the same ambition. Some of them actually got together what they believed was the necessary apparatus and listened.

Amateur radio was born at that time. I repeat that none of these first amateurs had the slightest idea that there were any other amateurs in all the world. Each individual took it for granted that he was alone in his interest.

The reception of Marconi's first "S," to the best of my knowledge, was a complete 100 per cent failure as far as any amateur was concerned. But that mattered nothing. In fact it only added fuel to the intense flame of curiousity. Marconi got his "S" across the Atlantic and it was known that there were signals in the air from an increasing number of land stations. There was nothing for it but to keep at it until they were found.

The public press devoted a lot of space to the new and wonderful achievement of communicating without wires. I have since learned that this material was literally gobbled up by thousands of young men. I know of one young chap in a mid-West city who secured his first information from the contents of an ash barrel. He had found an article on wireless in a copy of the *Scientific American* which had been discarded in the trash receptacle. He read it until it was worn out and undecipherable except to himself. He hungered for more knowledge. He wondered where he might find it. He went to the lady who ran the public library. She had never heard of wireless and treated him with suspicion. He went to the telegraph operator at the railroad station. But nobody knew even as much as he did, and so he was compelled to return to the ash barrels, which he watched carefully thereafter. I mention this to indicate the passionate intensity of purpose that had become stirred by this new idea. It was a very remarkable thing. There is no way to hold down such passionate interest.

It may be thought that lack of money on the part of the amateur would be a difficult obstacle to overcome. Let me say that this amounts to almost nothing. An example is worth citing.

Again in the Middle West, I encountered a young fellow whose parents were very poor. They lived almost in poverty. But this young fellow's "signals" were well known on the air. He reached out long distances, for in his tinkering he had conquered many of those nice details which go to make up a good radio signal. He had a spark transmitter, a continuous wave transmitter, and an unusually good radiophone transmitter for those days. How he acquired all this aroused my interest. I asked him where he got his vacuum tubes. He said he made them himself! He explained that he had located the dump of a wholesale drug house and there he found bits of the kind of glass that can be blown. On the electric light company's dump he had discovered bits of broken tungsten filament from burned-out lamps. With these he had made his tubes. To pump the vacuum he had built himself a mercury pump from the bits of glass tubes from the drug company's dump. The mercury had "stumped" him for a long time. He could not make it. He finally procured some from a friend.

This young man had made his own telephone receivers. In fact he had only made an expenditure in cash for one thing; that was twenty-five cents for a pair of cutting pliers. He could not make those. Again, I maintain, we have a significant example of a really sublime intensity of purpose.

In most cases these experimenters were young men around twenty years of age. There were many that were older. I was forty when I started to master the telegraph code, and there were many near to my age. Their numbers increased very rapidly. We finally came to be conscious of one another's existence by occasionally "hooking up" in the air. I shall never forget the thrill I used to experience when out of the silent ether, late at night, I would hear my call letters and realize that some one away off was calling me! I was about to meet a fellow intelligence in the empty ether! Many thousands of life-long friendships have since come to be made in this manner.

Then it became necessary for wireless communication to be regulated. An international congress was called. This was followed by the wireless law in 1912 in this country. Our government decided not to entirely eliminate amateur radio, but to restrict it so as to avoid amateur interference with commercial and military stations. All amateurs were required to take out operator's and station licenses. In due time a government call-book was issued. Therein were all the ship and shore stations of the commercials and—what was more important to us—there were also the names, addresses, and call letters of all the United States amateurs. Most of us were struck dumb. Instead of finding a mere handful of amateurs around New York City, we saw that there were hundreds of them all over the country. They were located in every state of the Union, in every important city, and in many of the small towns.

An enormous impetus was given amateur radio by this call-book. The possibilities were limitless, it seemed. It was given to me, as a business man, to think in terms of orderly organization. If all these amateurs could be welded together, how much more they could accomplish than by going it alone! The American Radio Relay League thereupon came into being and with it an amateur monthly periodical which we named *QST* because "QST" was the international signal for "Attention, all stations." It was the object of this little periodical to encourage us to foregather once a month, in its pages, and make available to all the experience of each.

Things began to hum forthwith. In the hands of these young human dynamos things naturally happened. The entire country was quickly laid out into trunk lines, and the relay idea put into effect. Messages began going everywhere. It was difficult to jump some of the big open stretches in the far West, but transcontinental relays finally were managed. Message traffic that actually was of no direct commercial importance whatsoever developed rapidly and was taken immensely seriously. Good operating procedure became a religion. A fine standard of conduct, conscientious observance of law, and a high code of ethics were adopted. These young men were easily led to do things right.

And then, at the very height of all our fun, the World War broke out. The Navy Department and the War Department needed thousands of radiotelegraph operators immediately and were faced with the prospect of fashioning them out of butchers, plumbers, farm hands, and salesmen. The amateurs were a better recourse. In a very few weeks more than four thousand of the most skillful and enthusiastic radiotelegraph operators the world possessed were enlisted and in military training.

But amateur radio itself came to a full stop. The thousands of little stations were dismantled and put away as Young America went off to war. It was indeed a stirring spectacle, these thousands of spirited young Americans rushing to their country's assistance with their specialized knowledge and experience.

After the war a curious situation presented itself. There were the original amateurs and there were also the additional men who had received radio training during the war. All of them had been subjected to military discipline and had acquired a wealth of important experience. The ban was lifted from amateur radio in 1919. Young America jumped into the work of reëstablishing its amateur radio league.

Right away a big obstacle confronted them. The last days of the League before the war had drained the treasury dry. To reorganize was going to take a lot of money—and they had no money. Amateur radio men are almost never the sons of wealthy parents. But they were determined to have their League. The money to start the machinery of reorganization was obtained by calling a meeting in New York and throwing into a hat sums ranging from fifty cents to fifty dollars. The much larger sum necessary to guarantee business-like operation for a period of months was obtained by the sale among the amateurs themselves of bonds. Nearly $7,500 was raised in this manner, and the

American Radio Relay League was once more established upon a going basis, with the little magazine *QST* resuming publication. It was a great time!

The law of 1912 gave the amateurs the so called "useless" waves from 200 meters down, considered useless because the commercial stations had found that distance could be bridged only by long waves. The longer the better, was the general opinion. The results of the war-time use of radio had indicated that there probably were possibilities in the short waves if enough skill was maintained in securing ultra-sensitivity of the receiver, ultra-sharpness in the transmitted wave, and ultra-ability in manipulating the former. Furthermore, the international contacts made during the war led to acquaintanceships among the few radio amateurs then in England, France, Belgium, Holland, and some of the other European countries. From this grew the ambition to bridge the Atlantic. The occasional bridging of an equal distance across our American continent led to the belief that there was a chance of getting across.

Tests were arranged by mail with the English and French amateurs, and the most painstaking efforts were made to establish communication. But in spite of the most perfect arrangements the effort could not be called a success.

And then the Americans began to question the resourcefulness of the Europeans. Correspondence flowed back and forth across the ocean by mail, and finally it came to the placing of wagers that even an American amateur with American receiving apparatus could not receive American amateurs in Europe. These wagers were typical of the radio amateur. No conventional money bets were laid. That would have been ordinary. Instead, top-hats and cutaway coats were wagered. The last wager was a pair of "striped pantaloons," to use the words of the Englishman who laid the bet.

The Americans had been very successful in the business management of their League, which by then had acquired a little surplus. It was decided that there was no better way to make use of these funds than to defray the expenses of sending an American amateur with American apparatus to Europe to prove to the Europeans that receiving American amateur signals across the Atlantic with amateur apparatus was possible. And so it came to pass that that splendidly qualified American amateur, Paul Godley, was detailed to undertake the job of showing the Europeans what could be done.

Godley built the most nearly perfect receiving apparatus he could devise, and after much looking around selected Ardrossan, Scotland, as the place to erect his station. He rented a tent and set himself up. Interest was at fever pitch, and the English amateurs in their good-natured way predicted the most awful collapse of American ambitions. When the fateful night arrived for beginning the tests, a raging storm arose in Scotland and Godley was handicapped by the most uncomfortable conditions. The cold was horrible, the rain leaked through the tent, and the conditions were generally about as unfavorable as they could be. But the American signals came through! Godley logged dozens of them. He repeated this on most of the nights that the tests were run, and invited some of the English Doubting Thomases to sit down and hear for themselves.

Arrangements had been made with a commercial transatlantic radio station to run in at a certain time each evening a list of the American amateur stations which had got across. The American amateurs paid regular rates for it, but just the same it was done in a nice little way by the commercials and bespoke the sporting character of the whole enterprise. I listened in on the commercial wave each night at the appointed time. Surely enough, there were the A. R. R. L. prefix and the call letters of the Americans whom Godley had logged the previous night. It was positively thrilling to pick this out of the air and to realize what it all meant. It was later referred to by some of the prominent figures in the scientific world as "the greatest scientific sporting event ever undertaken."

The English amateurs were good sports. Having once been shown that they were really not quite up to the mark, they set to work with a will improving their apparatus. Thus was born international amateur radio. Many of us began asking ourselves if organized international amateur radio was not the next step. If coordinating the efforts of American amateurs had worked such wonders, might it not be that coordinating the efforts of world-wide amateurs would also be a good thing?

I gave this subject serious thought. I saw the enormous possibilities that the vacuum tube as a detector offered us, and the still greater vistas that opened up when vacuum-tube amplification could be fully understood. Furthermore, if the vacuum tube was also to become a transmitting oscillator, then we might count upon even sharper waves and still greater distances. And if it were to turn out to be true that the higher frequencies than 1,500 kilocycles, or the shorter waves than 200 meters, possessed even a fraction of the carrying power that some of the advanced amateurs were claiming for them, then it seemed to me that international amateur radio had a legitimate right to come into being. Certainly signals originating in one country would eventually be heard all over the earth, whether we intended them to or not. International interference would then occur, and this would be no joke.

Expecting to be in Europe in 1924, I suggested some kind of a joint meeting of such amateurs of the various countries as cared to get together. I was startled to find, when I arrived in Paris, that an international dinner had been arranged for us. Prominent scientists and amateurs from some seven countries were present. The idea of organizing internationally was welcomed with open arms. But, rather than rush precipitately into such a serious matter, I suggested that we all wait one year. If, after a year of thinking it over we all still believed it would be a wise move, we could arrange a formal congress of the amateurs of the world and formulate an international amateur radio organization that could operate as the American Radio Relay League operated in America.

In England another meeting was held, less international in character, but nevertheless very much in favor of international organization for mutual help.

The year rolled around, and while it was doing so the most astonishing records were hung up all over the world by amateurs using the short waves. The wave length of 100 meters was the first to be used. Two-way communication of quite good reliability was effected over distances that were almost unbelievable. The greatest enthusiasm for long-distance communication was aroused. Tests across the Atlantic and across the American continent, to South America, South Africa, the Philippines, Australia, New Zealand, and even to Japan and China, came to be arranged, and astounding results were achieved.

The commercial companies became interested. Persons who did not grasp the factor of absolute reliability in all weathers at all seasons, which is incumbent upon a commercial company, asked how it happened that the amateurs with less than $200 worth of equipment were able to bridge distances which required $2,000,000 worth of commercial equipment. Of course the answer was that the amateurs bridged the distance when they felt like it and when the conditions were favorable, whereas the commercial companies had to bridge the distance at all times, regardless of conditions.

Notwithstanding the great distance between the amateur requirements and the commercial and military, the accomplishments of the amateurs on the short waves awakened the commercials to the possibilities. The "useless waves" from 200 meters down came in for a very searching investigation. Matters were at this interesting pass when the international amateur congress in Paris was called.

The congress was convened in the spring of 1925.

Amateurs from twenty-three nations were present. Several days were devoted to discussing the rather complicated situations which existed in the various countries. Some nations prohibited amateur operation entirely. Others permitted amateur transmitting only under the severest restrictions. Still others would not countenance amateurs using the waves that the amateurs in several of the nations were using. Throughout it all the liberality of our United States Government stood out conspicuously, as did the prestige of the American amateur and his organization, the American Radio Relay League. Finally a constitution was drawn up and adopted, and the International Amateur Radio Union came into being. The writer, the president of the American Radio Relay League, was elected president of the International Amateur Radio Union, and Mr. K. B. Warner, secretary of the American amateur organization, was elected secretary of the international organization. World-wide amateur radio thereupon started to become coordinated in a systematic manner, and private citizens in all of the civilized countries of the earth were on the road to being able to communicate with one another by radio directly, without the aid of any governmental or commerical agency. True, not every nation permitted correspondence by radio between its amateurs and the amateurs of other nations. But enough nations of the world did permit it to make it very probable that in the course of time every nation would be induced to do likewise.

The pace was fast and furious from then on. No sooner had we launched the international idea than the United States Navy came forward with an entirely unique offer. The Navy asked for the loan of our communications manager, F. H. Schnell, and offered to give him a free hand to demonstrate what might be done with the short waves over long distances. The Pacific fleet was about to start upon the Australasian Good-will Cruise. There would be a great many ships in close proximity and there would be a splendid opportunity for the amateur to show whether he could carry on direct communication with the American continent from the Antipodes.

Schnell was a Naval Reserve officer, as many of the amateurs are, so all that was necessary was for the A. R. R. L. to give him leave of absence and for him to buy a white uniform. Of course, he also set about revising his amateur apparatus, bringing it up to the last word in sensitivity and selectivity. Improving is one of the things the amateurs can always do more easily than the commercials. The amateur can and does change his station for every improvement that is reported. His station is never permanently rigged. The commercial station, on the other hand, must be built at a great cost and needs a new investment for each radical alteration. It would be utterly impossible for a commercial company to change over all its stations every day or two. This very thing serves to keep up the amateur's interest.

Schnell, who is well known to all amateurs of the earth, let it be known that he wanted cooperation from the amateurs ashore. He was to be permitted to handle his navy traffic through amateur stations if that made for better communication. When Schnell asked for cooperation from his brothers on shore, all the fraternal spirit of the A. R. R. L. was drafted. It would be difficult for the uninitiated to understand what this meant. Some faint notion may be gained when I explain that it meant thousands of listening enthusiasts would sit up all night long, if necessary, and exert the maximum effort to get Schnell's traffic through to Washington. Money cannot hire this sort of thing. It comes only from that thing we call *esprit de corps* and a complete submergence of every selfish motive. Nobody was to get or did get a single cent directly or indirectly for the hours of hard work.

Schnell covered himself with glory. The navy was astonished at the amateur organization and its enthusiasm. Direct communication between the fleet and the American continent was maintained by this amateur with naval as well as amateur stations, even when the fleet was anchored in Australian and New Zealand harbors, a feat that had never before been accomplished by the navy with its standard long-wave transmitters and receivers. There could not have been a more convincing demonstration of organized amateur radio.

Let us consider a few more examples of amateur accomplishment, this time in grave emergencies.

Recall the two Florida hurricanes. The first occurred in the late summer of 1926. It completely wrecked a great part of Miami. At the height of the storm, after every amateur station and every other means of communication had been put out of business, certain amateurs scurried around, found a few dry-cell batteries in a warehouse that had not been totally destroyed, located some storage batteries, salvaged some of the wrecked apparatus from their own stations, and, in the midst of the gale, erected an emergency transmitter and receiver. They were able to contact with another amateur outside of the storm area, and transmitted a message to the Governor of the State. The message reported existing conditions, told what help was needed, and suggested the best means of getting it into the city. From this single hastily-erected station hundreds of messages were sent out during the following days to outside amateurs, who made it their business to see that the messages reached their intended destinations.

Over in Tampa a group of amateurs got together, equipped a motor truck with a portable transmitting and receiving station, drove down into the devastated districts, and sent out all the messages that were offered them.

When the second hurricane struck in September, 1928, again breaking down every means of communication, including amateur stations, the whole story of amateur proficiency was repeated. When it became known that another tropical hurricane was on its way, Forrest Dana, a civil engineer, and Ralph Hollis, a fireman, both amateurs in

West Palm Beach, scurried around at 1:30 A.M. and gathered up the equipment that would be necessary to erect an emergency station in case regular communications facilities went out again. This material was cached where the hurricane could not destroy it. The hurricane came and the devastation it wreaked is only too well known. In the midst of the turmoil, Dana and Hollis set up their emergency station. Before it was completed it was ripped out by the terrific wind and falling buildings. It had to be entirely reerected. Nothing daunted, these young heroes tried again. This time they put up an antenna that held, and in a short time they were in communication with amateurs outside the storm area. From Monday until Thursday they were continuously on the air, taking the call letters of Hollis' station, 4AFC. All the information that the Red Cross and the army got during those terrible days came *via* this emergency amateur station. Could there be a better example of the public value of the special knowledge that amateur radio begets?

Then there was the Vermont flood of November, 1927. Every means of communication was swept away. The authorities in the stricken region went to the amateurs for assistance. They found that the amateurs had already rebuilt their stations and were contacting with the outside world. Red Cross, Army, press, railroads and the general public immediately laid their communication work on the doorstep of these young amateur radio experts, and for several days every bit of communication to and from the stricken area was handled by them.

During the terrible floods at Santa Paula, California, and the Mississippi River floods in 1927, the Red Cross and the Army again received their first communication service from the radio amateurs.

In all, there have been no less than sixteen major emergencies during the past ten years, when for days together the sole means of communication with the outside world has been by amateur radio. In many cases this was handled by hastily erected transmitters and receivers built from scraps of material at hand.

Let me point out that there is nothing in an amateur's license which requires him to do this service. Nor was such service anticipated when the government began licensing amateurs as a class. Emergency service has been developed solely by the amateur himself as one of his services to the public; he serves without hope of compensation—just for the thrill that comes of doing a good job under adverse conditions.

In recent years, the peculiar adaptability of the nation's widely scattered host of amateurs in emergencies has attracted the attention of the United States Army, which is normally charged with the duty of giving emergency assistance when necessary. The result has been the creation of an organized amateur network, operating under Army Signal Corps direction and known as the Army-Amateur Radio System. One of the principal objects of this system is to serve the public in emergencies such as those described; in addition, of course, the army is training many amateurs for possible active service by making them familiar with Signal Corps operating procedure.

As with the Naval Radio Reserve, the amateur has enrolled enthusiastically for this service, and Army-Amateur networks are now functioning in every Army corps area in the United States.

I have mentioned that the emergency service in which the amateur takes so much pride is something of his own making. He is also solely responsible for another great service which has come to be an integral part of amateur radio. It is communication with expeditions.

Back in 1923, Commander Donald MacMillan was preparing for another of his journeys to the far north. He would be gone a year and a half—eighteen months of silence, isolation, and loneliness. So it had been on all his previous trips, and so it had been with every other expedition to remote corners of the earth in history.

In a talk with Commander MacMillan, I put forth the suggestion that amateur radio might furnish the solution of the communications problem for his trip. He was keenly interested. Unfortunately, however, lack of funds would permit no expenditure for a set and an operator to run it.

By this time we were interested, too, even to the extent of gambling a considerable part of the League's surplus on the result. So we made Commander MacMillan a proposition. We offered to aid in getting the apparatus and to pay the expenses of an amateur operator for the duration of the trip if room could be found on the boat. Thus it happened that Don Mix, of Bristol, Connecticut, took an amateur station into regions where neither amateur, commercial, nor government station had ever before ventured. In the United States and Canada hundreds of amateurs overhauled their sets with the enthusiastic resolve that communication was going to be maintained with that expedition at all costs.

It was. The MacMillan party was in almost daily communication with home. The barrier of silence, greatest single obstacle to all previous expeditions, was broken for all time.

MacMillan never again went into the north without radio. Other explorers heard of his success and eagerly sought amateur service for their particular ventures. It was extended to them for the asking. In most cases amateurs went along as operators.

From that lone expedition in 1923, the number depending on amateur radio for all or part of their communication has grown yearly. As this is being written, there are about a dozen expeditions in the field, most of them contacting with amateur stations if not manned by amateur or ex-amateur operators.

The success of the amateur with his short waves naturally stimulated all manner of commercial aspiration. The amateur had shown what was possible with the ordinary short waves and was now even delving into the field of ultra-short waves. In addition to his so-called 200-meter band, he was also regularly using eighty meters, forty meters and twenty meters. He was even "fooling" with ten meters, five meters and three-fourths of a meter. It became necessary in all countries to consider the matter of opening the short waves to commercial companies. This meant ejecting the amateurs from some of the territory that they had done so much to pioneer. In the United States it seemed wrong, after giving the amateur what were thought at first to be the useless waves, to take them away from him after he had shown how to use them. On the other hand, the indubitable fact was that there was a woeful shortage of commercial channels and that something had to be done to avoid actually retarding commercial growth in the radio communication field.

In 1927 the International Radiotelegraph Conference was held in Washington. Fifty-five sovereign nations and twenty-three dominions and colonies participated. All but a half dozen of them were opposed to amateur radio in any form. The English delegates were lukewarm on the subject of amateurs. The French and the Italians were more friendly, but regarded restrictions as necessary. Canada, Australia, New Zealand, and the United States were determined to protect their amateurs.

In view of the apparent international prejudice, amateur radio faced in the fall of 1927 a pretty black prospect. K. B. Warner, secretary of the A. R. R. L., and C. H. Stewart, vice-president, labored valiantly day and night for weeks, endeavoring by every honorable means to make the delegates of the important nations who were against amateurs see their value. We were rewarded with a greater measure of success than any of us believed possible when the conference convened. With the able assistance of the whole United States delegation and the Canadian, Australian and New Zealand delegates, we succeeded in getting the conference to recognize and establish amateur radio as one of the legitimate and accepted forms of radio communication. This fixed a status for amateur radio and placed it where no nation could legislate it out of existence without the approval of all other nations. Warner furthermore succeeded in getting the conference to allocate to the amateurs of all nations bands of frequencies for exclusive use and certain other bands non-exclusively, the latter in this country being unobjectionably shared with certain military services. It was a triumph of that same indomitable spirit that pervades amateur radio. Warner performed one of the greatest deeds in amateur radio history, just as did those amateurs who figured so heroically in public emergencies.

It was true that the bands which were saved were narrower than the American amateurs had enjoyed up to this time; but we gained at least these restricted bands, whereas it appeared certain in the early days of the congress, when the majority seemed opposed to amateur radio, that the amateur might be eliminated entirely.

The restrictions on amateur bands dealt a severe blow to amateur radio in America. For the amateurs of other countries it constituted a tremendous increase in privileges, and was hailed with delight. But in America it at first aroused bitter feelings and caused widespread discouragement. Many believed that it would be difficult to maintain amateur interest thereafter.

Fortunately, this has not proved to be as serious a matter as it was considered immediately after the international conference. We had thought we were done for back in 1912, when amateurs were restricted to 200 meters and below. Time showed we were not. History repeats itself.

Already the amateur has set about finding a way for five amateurs to work where only one was able to work formerly. The American Radio Relay League directors appropriated $5,000 to conduct a research program, in the belief that careful study and investigation would develop apparatus which would enable large numbers of amateurs to operate successfully in the restricted bands. A year was spent in this work, and very encouraging prospects resulted. Refinements in transmitter and receiver have been found which are capable of permitting many more amateur stations to operate in a narrow band than was formerly considered possible.

I am persuaded that amateur radio will continue to flourish in spite of the restrictions that have been found necessary by the authorities. While it is to be regretted that cold water was thrown upon him, with the consequent cooling off of much of his priceless enthusiasm, the radio amateur has never yet been given a problem he could not solve.

RADIO IN MILITARY COMMUNICATIONS

By Maj.-Gen. George S. Gibbs

Chief Signal Officer, U. S. Army

SINCE the year 1860, the United States Army has had a separate arm or branch charged with the specific function of furnishing the communications required for military purposes. This arm, the Signal Corps, has been able to give its undivided attention to the utilization of all available methods of rapid transmission of intelligence or the handling of message matter. Beginning with visual methods and the electric telegraph, and followed by the invention of the telephone and of radio, it has not only adopted and used each new method as it came along, but has made many notable contributions to the progress of the art.

The first operative apparatus for electric wave telegraphy was produced by Marconi in 1896. Early in 1898 a practical radio installation covered a distance of 15 miles, and this distance was extended to 30 miles by the end of the same year. In July and August, 1899, radiotelegraph sets were installed on British cruisers and tried out successfully at maneuvers. By the end of 1901, radiotelegraphy for communication between ships at sea and between ship and shore had been established on a secure industrial basis. Up to the end of 1907, however, the practical limit of radiotelegraphy was for distances of less than 150 miles.

From the very beginning, and throughout the period of this development, the Signal Corps of the Army took a leading part and was alert to the application of this new invention to military uses. As early as 1898, for the period including the Spanish War, the Chief Signal Officer, General A. W. Greely, said in his annual report:

> The policy pursued in the past by the Chief Signal Officer in experimental work along lines of prospective value to the Army has naturally been interrupted by the war. Nevertheless, it has progressed as far as existing conditions have permitted. 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 invention and the conditions of military service shall warrant such progress.

During 1899, experimental wireless communication was installed by the Signal Corps between Fire Island and Fire Island Lightship, a distance of 12 miles, and in April, 1900, wireless stations were installed at Governors Island and at Fort Hamilton, between which points a daily communication schedule was established. This was followed in the same year by similar installations connecting Alcatraz Island and Fort Mason in San Francisco Harbor.

Immediately following the gold rush to Alaska in 1898-99 and the military occupation of that vast territory for the preservation of law and order, the Signal Corps began the construction of a cable and telegraph system to connect up its widely separated communities and to join them with the outside world.

In 1901, before the 1,500 miles of telegraph-pole line was well started, the Chief Signal Officer boldly made a contract for the erection of radiotelegraph stations on the Yukon and at coastal points that would have saved hundreds of miles of construction and two years in time. The stations were built and the apparatus installed, but, unfortunately, the contractor, in the then state of the art, was unable to span the distances and defaulted.

Between St. Michael and Nome, across an arm of the Bering Sea, a submarine cable had been laid, but the receding coastal ice carried it out each season. The Signal Corps decided in 1902 to undertake, itself, the installation of a radiotelegraph channel to cover this distance. Under the direction of Captain Leonard Wildman, Signal Corps, this system, spanning a distance of 110 miles, was placed in successful operation in August, 1903. This was one of the first, if not the first, long-distance radiotelegraph circuits in the world to handle commercial business regularly. Ever since, the inhabitants of Nome and the Seward Peninsula have relied upon this radio circuit as their sole means of rapid communication with the outside world.

Meanwhile, beginning in about 1910, the land lines of the Alaska System have been progressively replaced by radiotelegraph circuits until, in 1928, the last mile of the original 1,500 miles of land line was abandoned.

Remote settlements that could not possibly have been reached by wire lines have been connected into the radio net. More than 100 salmon canneries, tucked away in the bays and inlets of the Alaskan coast, from the southern boundary to Bristol Bay, reach the outside world through contact with the Signal Corps radio net and its connecting cables from Alaska to Seattle.

As this is written, another chapter in the evolution of modern communications is about to unfold in Alaska. The 2,500 miles of submarine cables that furnish the main channel between the United States and Alaska, and which connect the principal coastal communities of Southeastern Alaska, including Juneau, the capital, are about to be supplemented and eventually replaced by radio.

Going back to the adoption and expansion of radio by the Army for communication between fixed stations and between ship and shore stations, we find that by 1912 the Army had in operation 36 fixed stations and 26 ship stations. The fixed stations ranged in power from one to ten kilowatts and were located in the United States, Alaska, and the Philippines. The ship stations were on 14 Army tansports, 3 cable ships, and 9 Coast Artillery tugs.

In this same field of radio operation the Army had in 1929 a total of 211 stations, 109 of them fixed stations located at Army establishments throughout the United States, and in the Philippines, Panama, Hawaii, and Alaska. Thirty-four were fixed stations of the Alaska Communication System and sixty-eight ship stations.

As early as 1906, the Signal Corps had adopted mobile radiotelegraph sets as regular field equipment. Mounted field signal companies, organized as divisional units, were equipped with portable 250-watt spark sets with a range of 25 miles. The mission of these sets was to connect up the divisional or independent cavalry, but they were frequently used to connect the brigades to division headquarters. Two kilowatt, engine-driven sets were built into automobile trucks and used to connect units over longer ranges. These ranges, about 100 to 200 miles in 1908, were increased with the same power to 500 to 800 miles in 1912. The small portable sets were first transported in light spring wagons, but by 1910 were carried entirely on pack animals. The umbrella antenna, the portable sectional mast, and the insulated counterpoise laid on the ground were perfected to a high degree for field use.

In the spring of 1911, a provisional division was assembled at San Antonio, near the Mexican border, under the command of Maj.-Gen. William H. Carter. During the maneuvers and field exercises of this command, the portable radio sets were given a severe service test and were proven to be dependable for all that was expected of them. During this same period these small sets were scattered along the Mexican border in isolated regions and provided the only channels of communication to many patrol and guard units.

The technical development of radio reception in the the years previous to 1907 saw the coherer supplanted successively by the magnetic detector, the electrolytic detector, crystal detector, the thermal and glow-lamp detectors in many forms, and finally the high-vacuum thermionic valve used for reception and amplification, culminating in the three-electrode valve and its amplifying circuit. Each in turn was incorporated in the current equipment of the

Signal Corps. Similarly, the advance from highly damped spark transmission through the quenched spark gap and the use of the electric arc as a means for converting direct current into high-frequency alternating current, to the vacuum tube, was followed and employed.

When the United States entered the World War in 1917, it was at once apparent that the two types of portable radio equipment described were unsuitable for the conditions in the theater of that war from either a tactical or a technical point of view. Spark transmission occasioned too much interference and disclosure. High power was less needed than limited power and range and sharper tuning. This led to the immediate adoption of vacuum-tube transmitters of power enough only to cover the distance required, and of vacuum-tube detectors and amplifiers.

Our Allies, the French, after three years of war experience, had developed types of radio equipment for each class of military demand, incorporating the latest development of the art, and had gone into production on a war basis. It was decided at once to adopt and use French radio equipment until American-built equipment, just getting under way, should not only be designed and built, but be service-tested in the field. French radio equipment was used by us throughout the war.

No support to the American Army could have been more generous than that given by General Ferriè, the Commandant Superieur of the Troupes and Services of Transmission of the French Army. His depot stocks and procurement facilities were placed at our disposal in sufficient quantity to meet our needs, which were truly enormous.

Meanwhile, a Radio Production Division of the Signal Corps in the United States and a Research and Development Laboratory in the A. E. F. embarked on a feverish and far-reaching program of radio development.

Through the effective cooperation of the National Research Council, a notable group of scientific specialists was brouht together, assisted by a staff of skilled artisans.

Among the results that sprang from this activity may be mentioned a radio loop set for local radio communication; improvements in short-wave reception and amplification of far-reaching importance; a complete tank radio set; the development of radiotelephony to a practicable stage for airplane and air-to-ground use, and the development of airplane radio sets.

While the general command and administrative system of communications throughout the war in 1917-18 continued to be the wire system, radio channels were installed to supplement the wire lines, and were often used when wire lines were interrupted by shell fire or other untoward circumstance of combat. Troop units, beginning with army, army corps, and division on down to the battalion were equipped with radio sets and incorporated in command nets. Auxiliary radio nets for special purposes were installed. These included airplane observation and regulation of artillery fire; anti-aircraft artillery observation and fire control; the broadcast of meteorological reports; tactical control of tanks; and the radio intercept and goniometric (compass) service. This latter service was undertaken on a comprehensive scale and was one of the remarkable developments of the war. The work done by it may be classified as follows:

1. The location of enemy radio stations and identification of the units to which they were attached.
2. Interception and decoding of enemy radio messages.
3. Interception of enemy airplane radio signals.
4. Interception of enemy telegraph and ground telegraph messages and telephone conversations.
5. Press radio intercept—enemy, allied, and neutral.
6. Policing of our own communications for matter dangerous to our safety.

For this purpose goniometric receiving sets were placed in suitable locations not far in rear of the front line. From them more identifications were made of enemy units and the locations of their headquarters than by all other methods combined. This was done without losses, whereas the employment of raids to capture prisoners for identification purposes was often very expensive in human life. In several instances enemy radio messages were intercepted containing the details of planned attacks, and were handled in time to make dispositions to frustrate the attack.

After the Armistice and during the American occupation of a sector in German territory, an American radio net connecting Chaumont, Treves, Luxembourg, Spa, and Coblenz handled a very large part of the administrative business incident to that period, and, finally, when military wire communication between Paris and Coblenz was discontinued, the entire volume of traffic was handled over the American radio net between Paris, Antwerp, and Coblenz.

Since the World War the tactical employment of radio has undergone continuous study and improvement. The schematic assignment of radio channels between units and elements in the field has been definitely prescribed in equipment tables, and new sets have been devised for each class of service, employing the latest advances in the art. As might be expected, some entirely new applications of radio have been made. Among these may be mentioned the radiobeacon developed in the Signal Corps Aircraft Radio Laboratories at McCook and Wright fields near Dayton, Ohio. Beacons of this type installed at Crissy Field, California, and in the Hawaiian Islands were placed at the disposal of the participants in the Dole flight and were used by Goebel, the winner, throughout his flight. It is an interesting fact that, of the two planes completing the course, the slower plane following the great circular course marked by the Army radiobeacon was the first to reach the Hawaiian Islands. The Department of Commerce has a number of these Signal Corps radiobeacons built and installed on commercial airways as aids to air navigation. Notable advance has been made in the production of new two-way radiotelegraph and telephone sets for airplanes.

In order to insure that the American Army is kept abreast or ahead of the advancement of the radio art in its equipment, the Signal Corps maintains two radio research and development laboratories—one at Wright Field, Ohio, for the production of types of equipment required by the Air Corps, and one at Fort Monmouth, New Jersey, for the production of types of radio equipment needed by the rest of the Army for all purposes. An important adjunct of the Signal Corps Aircraft Laboratory at Wright Field is its flying laboratory, a three-motored cabin plane which affords ample space for flight tests of experimental layouts of all types of radio and auxiliary equipment needed on airplanes. At the Fort Monmouth radio laboratory there is not only a group of officers and engineers engaged in the production of new and improved types of radio equipment, but also complete shops with skilled mechanics and artisans for the construction and assembly of type models upon which specifications are formulated and contracts for manufacture initiated. The Signal Corps is not in the manufacturing business, but, as an established policy, relies upon the capable firms of the electrical manufacturing industry for its quantity production.

Radio broadcasting did not exist when we entered the World War. In the few years that have intervened, radio broadcast transmitting sets have been installed reaching every quarter of the nation, and with "national hook-ups" able to reach the entire country with a single program or a single voice from any locality. Millions of radio receiving sets have been installed in American homes so that a very large proportion of the population of our country can be reached instantly and *en masse*. It has been said that the institution of broadcasting radio is the first universal system of one-way mass communication developed by man.

The experience of the last war demonstrated that temporary defeat of the armed forces of a nation may be of less serious consequence than the destruction of the nation's morale behind the lines. It is evident, then, that this new agency of mass communication will be a tremendous factor in mass education, in preserving the national morale, in communicating the will of the sovereign power, and in counteracting the deluge of enemy propaganda that may pour in upon us through the air.

Facsimile transmission by radio is already a fact. By its means maps, drawings, photographs, and pages of printed or written matter can be sent over radio channels.

Its further development promises high-speed facsimile transmission that may solve the problem of secrecy for military dispatches, and, by eliminating the processes of coding and decoding, increase the speed and accuracy of communication.

It is reasonable to expect the photoradio transmission from airplanes of scenes and events that transpire on the earth below.

It is still too early to envisage the part that may be played by television, but it is conceivable that a radio television transmitter installed in an aircraft may be able to transmit to a headquarters on the ground a continuous picture of the terrain below, with a living, vivid disclosure of troop dispositions, the effect of gun-fire and other measures of offense, and, in fact, the whole progress of battle, in general and in detail.

With radio equipment now available, it is a certain prediction that we can have adequate channels of communication to a theater of operations anywhere on earth; we can also supplement the wire lines in administrative and tactical areas with radio channels that can handle a workable volume of the most essential traffic. By means of radio we can install circuits between mobile craft on the land, on the sea, and in the air, and between such craft and ground, that will provide adequate communications for the purposes of navigation and of carrying out the special missions assigned such craft.

Even now, the scientific advancement of the production of equipment for radio communication is far ahead of the production of skilled personnel to use it. Our biggest problem is the training of sufficient numbers of men in its use in order that we may have the benefit, to a reasonable degree, of this marvelous aid to humanity.

RADIO IN U. S. NAVAL COMMUNICATIONS

By Captain Stanford C. Hooper, U. S. N.

Director of Naval Communications

FROM the year 1899, when radio was first introduced into the United States as a service utility, until the year 1919, when the United States finally secured its independence as a nation in national and international radio, Navy radio played a most important part in the history of American radio. It was during these twenty years, and under very difficult conditions, that the United States Navy sponsored some of this country's most important national radio interests, as well as those of the Navy itself; fostered the development of radio in the United States; helped to lay the foundation and build up the early framework of our existing national radio structure; and finally brought about the emancipation of American radio.

In 1899, Marconi brought his invention, then only three years old and more of a scientific curiosity than a service utility, from England to the United States to report for the *New York Herald* the international yacht races between the *Shamrock* and the *Columbia.* During his three years of experimentation and demonstration in England, Marconi had succeeded in communicating through space over a maximum distance of thirty-four miles. Following the yacht races, the Navy Department arranged for a demonstration of Marconi's equipment on the U. S. S. *New York* and the U. S. S. *Massachusetts.* Between these vessels signals were exchanged up to distances of thirty-six miles, thus breaking the long-distance record for communicating through space in the infant science of wireless telegraphy.

With this advent there came to mankind for the first time in history a means of rapid communication between ships separated beyond visual distances at sea and between ships at sea and on land. It is not to be wondered, then, that in its early days especially, the realm of radio was confined almost exclusively to the seas where this country's dominant national interest was, and still is, the Navy. Nor is it to be wondered at that the Navy early realized and still realizes that radio, in addition to its enormous value as a humanitarian agency for the safety of life and property at sea, may conceivably represent the deciding factor between victory and defeat in a naval battle or between the success and failure of a naval campaign.

For the foregoing reasons, it was only natural and logical that the Navy should assume a sort of guardianship of our national radio interests, especially during the formative period of our early radio history. As a matter of fact, an interdepartmental board on wireless telegraphy was appointed by President Roosevelt in 1904 to consider the entire question of wireless telegraphy in the service of the national government. This board, known as the "Roosevelt Board," proclaimed that wireless telegraphy was of paramount interest to the government through the Navy Department.

The Navy's radio policy developed gradually along with the developments of the radio art in the United States and throughout the world, but this policy was always dominated by five outstanding motives, namely:

1. To keep the Naval radio system, especially in the fleet, in a more advanced stage of development and efficiency than that of any possible potential opposing fleet for service in the event of war;
2. To insure the maximum protection to life and property at sea;
3. To make the United States self-sustaining as a nation in radio with respect to its industrial, technical, and operational features, so that the radio require-

ments of the Navy, the Army, and our national interests in general could be met by American manufacturers with American labor instead of having to import radio equipment from foreign countries to meet our national needs;

4. To remove the disadvantages of unsatisfactory transoceanic cable services of non-American ownership and operation by the utilization of transoceanic radio services of American ownership and operation;
5. To make the United States as independent in radio as it is in political matters.

Likewise, the Naval radio system has always insured the maximum protection to life and property at sea by the maintenance of daily operation of a chain of shore radio stations along all of our coasts and in our outlying possessions. Throughout the Navy's thirty years of radio history, various commercial radio concerns have established radio stations along ports of our coasts for exchanging radio communications with ships as a business proposition; but, in every case, these companies have found that the business is not profitable except through stations situated near important ports, such as New York and San Francisco. Consequently, commercial radio concerns have maintained radio stations near our important ports, but the long stretches of coast line, where the maintenance and operation of commercial radio stations is unprofitable as a business proposition, would have remained without radio stations had it not been for the Navy's system. The great majority of the Navy's shore radio stations were necessary, of course, to serve the Fleet, but, in many cases, stations which were not essential for naval purposes were kept in operation primarily for the protection of life and property at sea.

Following the initial demonstration of radio in 1899, the Navy, in 1901, sent a commissioned officer and two enlisted men to London, Paris, and Berlin to learn what they could of radio. They returned in 1902 and brought radio transmitters and receivers of English, German, and French design and manufacture back with them. After three months of endeavor, the naval personnel, employing this foreign equipment, finally succeeded in exchanging communications between the Naval Academy at Annapolis and the Navy Yard at Washington, D. C., the intervening air line distance being thirty miles. Later on, in 1902, some of this equipment was installed on the U. S. S. *Prairie* and the U. S. S. *Topeka* for tests in Chesapeake Bay. By 1903, signals were exchanged between these vessels and the Naval Academy station over a distance of 137 miles.

More radio sets were then purchased in Germany and installed on the U. S. S. *Kearsarge*, U. S. S. *Texas*, and the U. S. S. *Olympia* of the Atlantic Fleet. These were employed in connection with war maneuvers held off Maine with such marked success that the Navy proceeded immediately with the work of constructing a chain of radio stations on shore and equipping a large number of vessels of the Fleet with radio. By the year 1907, when the United States Fleet sailed around the world, radio communications were exchanged between the U. S. S. *Connecticut* and the U. S. S. *Missouri* of the Fleet and a naval radio station situated near New York, the intervening distance being 1,280 miles.

During the interval from 1900 to 1915, which may be called the "spark" era in Navy radio, shore radio stations were established along the Atlantic and Pacific coasts, in the Gulf of Mexico, in the West Indies and the Canal Zone, along the coast of Alaska, at Pearl Harbor in the Hawaiian Islands, at Tutuila in American Samoa, at Guam in the Mariana Islands, at Cavite in the Philippine Islands, and within the American Legation Compound at Peking, China.

The spark transmitter was developed in the United States under the sponsorship of the Navy from powers of approximately 100 to 100,000 watts. The ultimate development of the spark transmitter in Navy radio is represented by the Arlington 100-kilowatt, 500-cycle, rotary synchronous gap transmitter.

From 1900 to 1915, radio receiving equipment progressed from the single circuit receiver employing a coherer detector in conjunction with a Morse inker to a coherer employing head telephones, and then progressively to the electrolytic detector, the crystal detector, and finally the three-electrode audion similar to that used in receivers of today.

In 1915, all vessels of the Navy from battleships to tugs were equipped with radio, and these vessels, together with the Navy radio stations, constituted by far the largest radio system in the United States and one of the largest in the world.

In 1912-13, a 30-kilowatt arc transmitter was installed in the Arlington station for comparative tests with the 100-kilowatt spark. Regardless of the difference in power favoring the latter, signals from the former were received at distant ship and shore stations with equal or greater intensity, thereby definitely proving the superiority of the arc over the spark for long-distance communications. These tests were very thorough, and convinced the Navy of the superiority of the continuous wave type transmitter over the damp wave type. The Navy had no misgivings about embarking on a program of changing its system to conform to the continuous wave type. This was a drastic change, however, and the Navy's action profoundly affected the development of the radio art in the United States and throughout the world, because this action marked the definite turning-point of the beginning of the development of the radio art from the damp wave to the continuous wave transmitter.

With the completion of the Navy's chain of low- and medium-power coastal radio stations and the Arlington 100-kilowatt station, Congress appropriated one million and a half dollars in 1912 for the establishment of a chain of high-power stations (100 to 500 kilowatts) at Darien in the Canal Zone; San Diego, California; Pearl Harbor, Hawaiian Islands; and Cavite in the Philippines, with which, and the Arlington station, it was hoped that direct communications could be maintained between the Navy Department and the Canal Zone, between the Navy Department and Cavite *via* the San Diego and Pearl Harbor stations, and through all these stations with our Atlantic, Pacific, and Asiatic Fleets.

After thoroughly investigating the basic principles governing the operation of the two types of transmitters which had then recently been developed—the Federal-Poulsen arc and the continuous wave Telefunken high frequency alternator—it was finally decided to employ the arc, this decision being due principally to the comparative ruggedness of the arc, its simplicity of design, and its ease of maintenance of operation with unskilled personnel.

The high-power stations were completed and placed in service operation just prior to the entrance of the United States into the World War in 1917. A number of less important shore stations were equipped with 30-kilowatt arcs, and virtually all first-class ships were equipped with arcs ranging in power from 5 to 20 kilowatts. Later, a 200-kilowatt arc station was established at El Cayey in Porto Rico, and 100-kilowatt arcs at Mare Island, California, and Guam, Mariana Islands. Almost immediately upon our entrance into the war, a 500-kilowatt arc was begun at Annapolis to supplement the Arlington station and to work with a corresponding station of 1,000 kilowatts power near Bordeaux, France. This action was taken to supplement the transatlantic cables and to insure contact between the United States government and the American Expeditionary Forces in Europe should the cables be cut by enemy submarines.

Like the spark, the arc has now virtually disappeared from naval radio stations, and a third type of transmitter, based on the electron tube, now reigns supreme in the realm of naval radio. The present electron tube, both transmitting and receiving, was born of the incandescent electric lamp and was reared through the medium of the three-electrode audion. The electron tube, a strictly American device, now not only dominates all modern transmitting and receiving equipment in the United States and throughout the world, but it also forms the nucleus of all radio research and development work throughout the world.

The arc transmitter dominated Navy radio from 1912 to 1919, and this interval may be termed the "arc" era. Both the spark and the arc, and their associated equipment, served Navy radio well in their day. The discarding within twenty years of these two dominating types of equipment in a radio system such as the Navy's not only illustrates the extremely forward march in the development of the radio art, but also the difficulties involved in keeping abreast of or in the lead of such developments. With the passing of the spark and the arc and the advent of the electron tube, Navy radio has passed through two complete eras of development and application of radio, and is now in the forefront of the third era actively engaged in sponsoring the development and application of the electron tube.

Upon our entrance into the World War, all radio stations in the United States and its possessions of American and foreign ownership, and those on all ships flying the American flag, with the single exception of those under the jurisdiction of the Army, were turned over to the custody of the Navy by presidential proclamation. The shore stations taken over by the Navy included the German-owned and controlled high-power transatlantic stations at Sayville, Long Island, and Tuckerton, New Jersey, the extensive chain of stations of the American Marconi Company, the stations of the Federal Telegraph Company, the Russian high-power station at Vladivostok, and a number of others. Such of the stations taken over as were needed for war purposes were incorporated in the Navy's already existing extensive chain, the others being closed and held inoperative under the jurisdiction of the Navy.

When the United States Shipping Board assumed control of American shipping and embarked on its immense ship-building program, the Navy undertook the responsibility of equipping all its ships with radio and operating its radio service. Approximately 1,800 ships were eventually equipped with radio, without involving a delay in the sailing of a single ship. Numerous additional low power radio stations were quickly established along our coasts for aid in combating the submarine menace. Numerous yachts and other vessels commandeered for use by the Navy, new destroyers, submarine chasers, and other newly constructed vessels were likewise equipped with radio by the Navy, and battleships and other first-class vessels received additional and improved radio equipment.

During this control of radio by the Navy, the following four outstanding events occurred which finally culminated in the emancipation of American radio:

(1) The German stations in the United States were seized as enemy property; the Sayville station was purchased by the Navy from the Alien Enemy Property Custodian; title to the Tuckerton station, which was at first in dispute between German and French nationalists, was finally adjudged in favor of the French nationalists, who disposed of it to the American Marconi Company.

(2) The Federal Telegraph Company of California had acquired full patent rights to the Federal-Poulsen arc transmitter, not only in the United States, but elsewhere except in Denmark. This arc transmitter dominated Navy radio and was considered to be the most efficient radio transmitter then developed for long-distance communications. The American Marconi Company had negotiated with the Federal Company for the purchase of their chain of radio stations and also for their patent rights to the arc. This matter was brought to the attention of the Navy by the representatives of the Federal Company, who offered to sell to the government on the same terms and in order to

avoid the necessity of paying high rentals and royalties for the use of the arc patents. To protect American national interests in radio, as well as Navy radio itself, the Navy purchased the Federal Company's stations and patents. Incidentally, the Navy later returned these patent rights to the Federal Telegraph Company at Delaware, a subsidiary of the parent Federal Company, to assist that company in its project of establishing high-power stations in China, for which purpose it had obtained a concession from the Chinese government, but the Navy retained a license under these patents for government use.

(3) In accordance with a request of the United State Shipping Board, the Navy purchased for the account of that board the radio installations on American vessels which had been made under a rental agreement with the Marconi Company. These rentals, which, in the opinion of the Navy and the Shipping Board, were excessive, had to be paid by the government during such time as the vessels were under the control of the Shipping Board. The Marconi Company's equipment had been installed on the greater part of the American Merchant Marine. During the negotiations for the purchase of these ship installations, the Marconi Company protested that its extensive chain of coastal radio stations in the United States and its possessions would be valueless through the sale of the rented ship installations to the government, and requested that the Navy purchase all its shore radio stations at the same time, with the exception of the high-power transatlantic and transpacific stations. The purchase, therefore, included these stations, and thereby eliminated from the United States and its possessions all radio stations in which there was any foreign control, excepting the Marconi Company's stations at Tuckerton, N. J., New Brunswick, N. J., Marion, Mass., San Francisco, Cal., and Honolulu, T. H.

(4) Subsequently, after the Armistice was signed, information became available to the Navy that the British Marconi Company was negotiating with the General Electric Company for what in effect constituted the exclusive rights to the Alexanderson high-frequency alternator for international communications. This alternator gave promise of supplementing the arc transmitter and dominating the radio art for long-distance communications in the same way that the arc had supplemented the spark and dominated Navy radio. The General Electric Company had expended a million and a half dollars in development work, and the British Marconi Company had placed an order with the General Electric Company for five million dollars' worth of equipment. If this deal were consummated, it would mean, in the then existing stage of development of the radio art, that the British Marconi Company would become supreme in the field of international radio communications throughout the world, just as the British then were, and had been for many years, in a dominant position with respect to ocean cables. It would also mean a perpetuation of the American Marconi Company's radio system in the United States and in our insular possessions, the British Marconi Company being largely influential in this system, if it did not actually control the American company. Realizing the gravity of this crisis in American radio, and conscious of its own helplessness in the matter, the Navy decided, in 1919, upon the drastic expedient of appealing to the patriotism of the Board of Directors of the General Electric Company, with a view to preventing the consummation of the impending deal with the British Marconi Company. This appeal was heeded, to the credit of the unselfish patriotism of American industry. The ultimate result was the formation of the Radio Corporation of America, a strictly American corporation; the purchase

> by the Radio Corporation of the American Marconi Company's radio stations; the integration of the radio art in the United States by the pooling of radio patents by the industrial concerns controlling the basic patents, namely, the American Telephone & Telegraph Company, the Westinghouse Electric & Manufacturing Company, the Tropical Radio Telegraph Company, and the General Electric Company; and the preservation, to a large extent, of the Monroe Doctrine, in so far as radio was concerned, by the strengthening of the position of the Tropical Radio Telegraph Company in Central America and in securing a favorable position by the Radio Corporation in South American radio.

In 1912, the Navy began experimenting with the Belini-Tosi type of radiocompass—the only type then developed—on the U. S. S. *Wyoming*. From 1912 to 1917 the Navy maintained an active interest in the radiocompass for use on shipboard. In 1916-17 the Navy installed experimental radiobeacons and simultaneous sound radio transmissions at points along our coasts to serve as aids to navigation. The first radiobeacon was established at Point Judith, R. I., in 1916. In 1916 the Navy purchased a license to the Kolster revolving coil-antenna type of radiocompass. By the employment of the audion detector and amplifiers in its associated receiver, this type of radiocompass gave great promise of rendering satisfactory service.

Upon our entrance into the World War, the Navy participated with the Allies in the development and use of the radiocompass for war purposes, but the Navy developed and used the revolving coil-antenna type rather than the Belini-Tosi type. With the signing of the Armistice, the Navy visualized the hazards attendant upon the safe return of more than a million American troops from France within a comparatively brief space of time. Primarily in order to safeguard the troop transports as much as possible, the

Navy hurriedly established radiocompass stations along our coasts, and in the vicinity of the ports at which these transports would arrive. Additional stations were subsequently established to cover all of our coasts as aids to navigation in peace time and to train Navy radio men in the service of tracking enemy vessels in time of possible future wars.

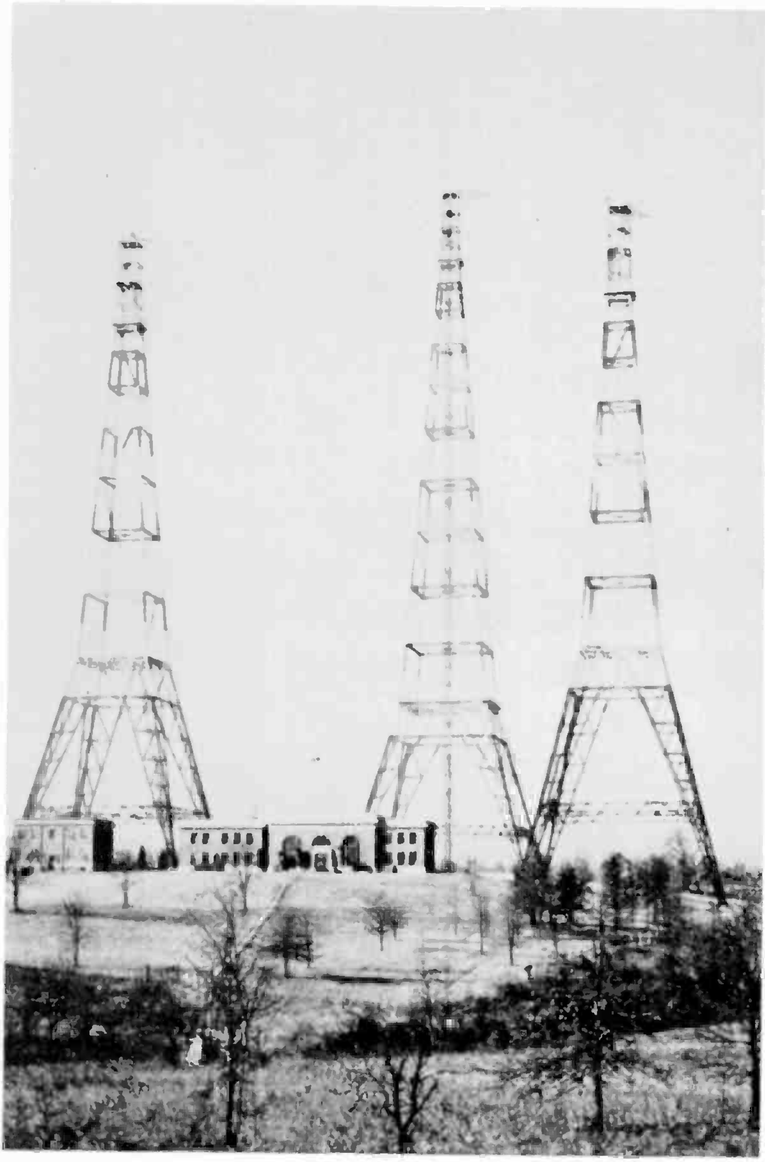
The Navy, in 1912, equipped one of its early-type aircraft with radio, and succeeded in exchanging communications between the plane in flight and the radio station at the United States Naval Academy over a maximum distance of three miles. In 1916 it increased this maximum distance to forty miles, and in 1917 to 150 miles. The Navy through its specifications brought about the development of aircraft transmitters, receivers and direction finders at this time. The first long distance (100 mile) aircraft transmitters resulted from Navy specifications prepared in 1915, some 75 sets being purchased at that time. The first aircraft radio laboratory was established at the Naval Air Station at Pensacola, Florida, in 1916, for the purpose of testing airplane transmitters and developing airplane receivers, interphone systems, and airplane direction finders. This was all pioneer work.

Upon our entrance into the World War, Naval aviation radio proceeded apace, but this presented a virtually new field of endeavor in radio as a service utility, and obstacles exceedingly difficult were encountered. Owing primarily to the time required and the difficulty of training pilots to become radio operators in addition to their aviation training, radiotelephony appeared to be more suitable than radiotelegraphy for aircraft communications during war, and this constituted the primary motive for the development of radiotelephone equipment for aircraft. As a test, several hundred audions were incorporated into an experimental radiotelephone transmitter by the Western Electric Company and installed in the Navy's Arlington station in 1915. During these tests the Secretary of the Navy, sitting at his desk in the Navy Department, actually talked to the commanding officer of the U. S. S. *New Hampshire* off the Virginia Capes, and intelligible words were picked up in Paris and Honolulu. These tests constituted only a sporadic attempt in the direction of radiotelephony as a service utility, and no further constructive efforts were made along these lines until this country entered the war. However, the knowledge gained from these tests proved valuable in connection with the emergency which confronted Navy radio two years later.

Through the Navy's initiative, in cooperation with the Army and Bureau of Standards, meetings were held regularly during and immediately following the war, with the leading commercial development engineers, with a view to perfecting specifications and standards as a guide to the development of vacuum tubes and tube equipment, and much was accomplished as a result. After the war, the manufacturers were unwilling to make further expenditures to develop this type of equipment, and it was necessary for the Navy to spend considerable sums in purchasing vacuum tube transmitters in order to keep the companies interested. The ultimate result was not only satisfactory equipment for the government, but, in addition, the telephone broadcast transmitter, and thus indirectly the broadcast industry of today.

Shortly after our entrance into the World War, the Navy purchased several hundred low-power transmitters suitable for either radiotelegraphy or radiotelephony, and these were installed on submarine chasers and similar craft engaged in combating the submarine menace. This represented the first quality production of radiotelephone transmitters. Transmitters suitable for either radiotelephony or radiotelegraphy were then designed and produced in quantity for aircraft installations.

The Navy began experiments in high frequency or short wave radio in 1921, and, owing to the peculiar nature of these particular experiments, the Naval Research Lab-



Main Towers of U. S. Naval Radio Station, Arlington, Va.

oratory at Bellevue, D. C., enlisted the aid of radiotelegraph amateurs in the United States and throughout the world. High frequency radio electron tube transmitters have been developed for the Navy up to 25 kilowatts power, and all important shore radio stations and units of the Fleet have been equipped with high frequency radio. Primarily, by means of high frequency radio and the Navy's radio system, President-elect Hoover maintained direct contact with Washington throughout his entire trip to and from South America in 1929.

As early as 1904, the Navy inaugurated the practice of broadcasting time signals, primarily for the benefit of ships at sea. Subsequently, weather reports, storm warnings, hydrographic and ice reports were also broadcast for the benefit of the mariner.

Prior to the advent of radio broadcasting, in 1920, the Navy thoroughly explored the possibilities of radiotelephony for Naval use. In fact, the requirements of Navy specifications were largely responsible for the development of equipment which subsequently became the medium of broadcasting. Concerts by the Marine and Navy bands were broadcast regularly through station NKF of the Naval Radio Research Laboratory at Anacostia, D. C., and, through announcements broadcast through this station, the public was invited to send in constructive criticism. These programs, and the experiments and investigations made in connection therewith, continued for more than a year. It was finally decided that radiophone broadcasting was unsuitable for naval purposes, except for the recreation and amusement of its naval personnel. For the tactical and strategical purposes of the Navy, radiotelegraphy rather than any other form of rapid intelligence communications still met the Navy's requirements in 1929, as it did from the beginning of radio in the Navy in 1899.

The United States Naval Communication Reserve, a branch of the Volunteer Naval Reserve, was first started in July, 1925, when the United States Naval Reserve was reorganized by an Act of Congress. At that time the Communication Reserve consisted of a handful of officers and men. Today it is composed of more than sixteen hundred officers and men and is expanding rapidly. This organization appeals strongly to the interest of both commercial and amateur radio operators, engineers, and heads of communication companies. It affords its members an opportunity to learn Navy methods and procedure and fits them for military duty in time of war. Within a short time the Navy will have an auxiliary network of amateur radio stations that can be called upon in case of a local or national emergency.

In 1929 the Naval Communication Shore Service consisted of 118 traffic stations, including 56 radiocompass stations. During the fiscal year 1928-1929, this establishment handled a grand total of 3,586,876 messages of all classes and furnished 268,705 compass bearings to 120,804 ships. In addition, there were 350 Navy ships and 500 aircraft in active commission and fully equipped with radio apparatus.

The use of radio in the Fleet is very important and complicated, and has mostly been developed through the efforts of naval officers. It is confidential, and therefore cannot be described. On shore, the policy is to maintain sufficient radio facilities to meet the requirements of the fleets and of merchant shipping in so far as commercial facilities are not available. During spare time the Navy circuits handle traffic for all United States government agencies in the interest of economy.

PART III: INDUSTRY

ART AND INDUSTRY

By David Sarnoff

President, Radio Corporation of America

IN an age that finds science and industry joined in mutual service, it is inevitable that the distance between the laboratory and the workshop should become imperceptible. The interest in radio no longer rests on the mystery of its origin. The thrill of music and speech coming out of the void, like rabbits from a magacian's hat, no longer moves us to wonder. The more pertinent question now asked with regard to radio is, "Whither bound?"

To give even partial answer to this question, our only course is to pursue the flying coat-tails of progress in order to catch a fleeting vision of what is before us. Not only must we travel fast, but, paradoxically enough, in many directions at the same time. Such are the exceptional demands of an art that spans the oceans with wireless, that unites ship to shore with invisible strands of communication, that makes millions of homes resonant with music and speech broadcast through the air, that has come to create a new art of talking-motion pictures, and that now promises to open an era of sight-transmission by radio.

The success of the radio industry and the growth of a popular broadcasting service cannot obscure the importance of radio as a system of world-wide wireless communication. Until the advent of the new art, communication between great continents depended largely upon thin strands of wire on the bed of the ocean. Great nations situated beyond the seashores of continents remained dependent for their world communications upon the acquiescence or good will of their more fortunate neighbors. The Great War proved, in the case of Germany, that the voice of a nation could be stilled by the deflection of its cable systems, except for the indestructible medium of radio communication. Important as was our own rôle in world relations, the United States was a mere communications tributary to the cable systems of the Old World, until our electrical industry accepted the task of developing an American owned and controlled wireless system. Today the United States occupies an undisputed position of leadership in radio communication, although it is becoming clear that our place will not remain unchallenged.

Radio not only has added enormously to the facilities of international communication directly, but indirectly as well, through the quickening and improvement of the wired systems of communication. High speed telegraphic transmission and transcontinental wire telephony were made possible by the use of instrumentalities developed in the radio art.

The application of wireless to the older systems of communication has resulted also in the epochal feat of spanning the oceans with the human voice. Radio has not only given us the first system of trans-oceanic telephony, but has extended point-to-point telephony to a world-wide range.

At the present time, radio holds forth the promise of an entirely new and revolutionary system of telegraphic service. The progress of facsimile or photographic transmission indicates that the very image of the message, and not its counterpart in code, may be flashed regularly across the oceans. The abolition of the dot-and-dash system of telegraphic transmission would be an achievement of great importance.

The story of radio in ship-to-ship and ship-to-shore communications is graphically repeated every time that a ship in distress sends out a stirring call from the sea.

Radiobeacons, flashing their indentifying signals to ships equipped with radio direction-finders, or radiocompasses, made navigation for them safe in the densest fog.

With the development of aerial navigation, radio has come to bring the same service of communication to airplanes and airships that it has supplied to ships of the sea. No vessel that leaves the shore and no plane that takes off into the air need sever entirely its communication with the ground. No ship equipped with radio is entirely helpless in case of disaster, and no airplane in radio communication with the ground need fly in space blindly.

The growth of the radio industry in the United States is now a matter of industrial history. Responding to the needs of radio service to the home, an industry has arisen in less than a decade that now does a business far in excess of a half billion dollars annually. In this period of time a vast distribution system had to be created. The radio jobber and the radio dealer are new units in our industrial system. For a long time the musical jobber and the musical dealer stood aloof from radio; they were waiting for the time to determine whether a receiving set was electrical equipment or a musical instrument.

When the radio industry outgrew its first customer—the radio amateur—the electrical industry of the United States undertook to create a listening public. It was a unique experiment in industrial development. It was as if the publishing industry were to undertake the task of public education in order to create a class of readers for the printed word; as if musical-instrument makers were to give lessons in music and organize bands throughout the country to establish a market for their products.

Despite the fact that chapter and verse were quoted from economic precedent to show that no industry could survive which was burdened with a service established upon such a basis, the industry grew apace and the listening public with it. In about ten years, more than 50,000,000 people in the United States were radio listeners, and some 12,000,000 homes were equipped with radio receiving sets.

Perhaps we are still largely in the throes of ancient conceptions of the forces that make for or against industrial and commercial growth. Competition is still worshipped as the life of trade, upon one hand, and denounced as an uneconomic force, upon the other. Mass production is still offered as a cure-all for failing markets and ailing sales.

The latest specter raised before industry is the possibility of gigantic competition as between industry and industry. Wheat and meat are to struggle for first place in the human stomach. Coal and oil are to engage in combat for position in the family furnace. Coffee and milk are to race for the public cup. Eloquently as these theories may be stated, the fact remains that in a great and growing market such forces within industry tend automatically to adjust and balance themselves.

The greater danger, it would appear, to industrial growth is industrial self-complacency. The greater menace to the life of any industry is not the competition for a share of the public dollar, but in the supplantive competition which modern science may breed in a laboratory. The greater competition is not as between two products of dissimilar uses or services. It is between industry so stabilized that it can only grow around the waist, and the products of modern scientific research. The ghost of obsolescence can only be dispelled by continuous research and development, and by industrial adaptation.

No better instance of successful adaptation can be cited than the present situation in the phonograph industry. The phonograph of the pre-radio age is thoroughly dead; the modern phonograph industry is both alive and flourishing.

It was not so long ago, however, that the manufacture of phonographs and records had reached such a stage of stabilization that progress toward technical and acoustical perfection had all but ceased. The artist who recorded on the disc, and the cabinet which encased the phonograph, were the stock in trade of public appeal. It was then that radio, rising out of the electrical laboratory, threatened to supplant the phonograph industry. But leading factors in the industry soon began to see the handwriting on the wall. They adopted a policy of adaptation which revolutionized the phonograph industry.

Today the products of both the phonograph and radio industries are often housed in the same cabinet, distributed by the same wholesaler, and sold by the same dealer. In the manufacture of records, in acoustical reproduction, and in various modes of operation, the phonograph of today is really a new musical reproducing instrument, born of the association of an old with a new industry.

Just as the radio industry had to chart new roads of industrial development, so did broadcasting have to find new sources of support for mass communication to the home.

Those who feared the decay of broadcasting through the injection of an industrial message to the listening public need no longer feel disturbed. Those who saw the degradation of music in popular broadcasting are being overwhelmed by the democracy of musical appreciation which radio has developed.

Broadcasting has destroyed the incongruity of shoes and ships and sealing wax, of cabbages and kings. The witticism formerly evoked by the combination of soap and music, shoes and opera, oil and history, has somehow lost its point.

For, after all, the quality of a program rendered by a great artist of the operatic or concert stage is not influenced by whether it is supported by subscribers of the Metropolitan Opera or by a tooth-paste manufacturer seeking good will for his product.

But the profit motive of industry—apparently there's the rub! As an industrial executive I admit a natural prejudice in favor of profitable enterprises, and a disposition to defend the profit motive as against social or intellectual snobbery. For this much is clear: if education and culture are to increase our natural stature, it will be through the democracy of education, not the aristocracy of education, through the democracy of culture, not the aristocracy of culture.

Radio and electrical interests, to increase the opportunities of a new industry, established the first nation-wide broadcasting service in the United States. Today broadcasting serves more than 30,000,000 people with regular programs of music, entertainment and speech.

With the motive of conveying an industrial message, important business interests are now sponsoring concerts rendered by the greatest masters of the operatic stage, by the leading orchestras of the country, by the most eminent soloists of the concert hall.

Not only has industry contributed greatly to the improvement of the broadcasting program, but it has made possible the development and extension of the broadcasting system. In a few years, broadcasting has become a vast educational medium. Certainly the phenomenal interest in the 1928 presidential campaign was due largely to radio broadcasting. The influence of the printed word is great, but the influence of the spoken word was necessary to humanize the political campaign to millions of homes. There, in his armchair at the fireside, sits the American citizen, judging political issues, not only from the record of the parties, but from the personality of the candidates. The catchwords of oratory ring somewhat hollow in such environment; sectional appeal only obscures the message which the candidate desires to deliver to a national audience; the appeal to prejudice has no crowd psychology to give it weight.

Radio has traveled far afield since its establishment as a wireless telegraphic service. It is on the ocean, aboard ship, in the home; it is now entering the theater through the new development of talking motion pictures. Electrical science has finally synchronized sound and motion on the screen. This has been made possible by the vacuum tube, the photo-electric cell and the loud speaker—all of which are developments of the radio art.

Again radio stood before the doors of another great industry, and again its reception was chilly, to say the least. A few years ago, most moving-picture producers stood aloof from these significant developments in our electrical laboratories. Sound, they said, was an intrusion on the "silent drama." Gradually they began to peep into the back yards of the electrical industry; and finally they stampeded toward the magic word "sound."

Nevertheless, there are still those who interpret this development as merely sound added to motion on the screen. What has happened, I believe, is that a new and greater art of picture production has been created, in which neither sound nor motion can go forward without the other's co-operation. Sound has opened an infinitely wider field of dramatic expression for the motion picture. Further experience in the motion-picture art is enabling the electrical industry to imrove greatly the technique of sound recording and sound reproduction for the screen. In the natural development of the new art, it is impossible to separate the moving-picture studio from the sound laboratory.

Beyond our function in the field of international and other telegraphic wireless communications, it is our business to develop sound reproduction through the latest of the arts of electrical communication. Thus the electrical group has established a great nation-wide service of broadcasting in the United States; it has cooperated with the phonograph industry in the creation of new sound-reproducing instruments; it has now come to the motion-picture industry to cooperate in the development of the new art of sound-motion pictures.

In one respect, at least, public expectation with regard to immediate radio development has somewhat outrun the progress of the art. The age of sight through electrical communications is still in the birth throes of development.

The latest child of the electrical arts, as a matter of fact, requires careful nurturing if it is to grow into a great public service. In the present stage of public interest, it would be easy to cry "Television is here," to broadcast light reflections on the basis of catch-who-catch-can, to provide crude receiving equipment for the will-o'-wisps of the air. It would be easy, and it might be profitable, but it would not advance the day when sight is added to sound in an adequate service to the home through the medium of radio communication. In the light of progress thus far made, it is clear as this is written:

1. that television, despite the latest engineering and mechanical developments, is still in an experimental stage;
2. that the broad highway in the ether, necessary for the establishment of a television service, requires continued research into the problem of locating suitable wave lengths;
3. that a service comparable to sound broadcasting must be created to justify visual broadcasting on a scale which would encourage the use of television receivers in the home.

In other words, the greater problem of television is not the problem of making a magic box, through the peep-hole of which one may view diminutive reflections of passing men and events. The fundamental principles of sight transmission and reception are well understood. The greater problems of television are still bound up in the secrets of space.

Modern inventions, adapted to the needs of locomotion, have done much to help man annihilate distance in his physical contacts. With the railway, the motor car, the airship, and the airplane, man hardly needs his feet, except for the purpose of exercise and travel over comparatively short distances. His productivity has been enormously increased by engineering science, and the electric switch, the generator, and the motor are coming to take the place, very largely of the human hand. Electrical communications, instanced by the wire telephone and radio, have extended the range of man's hearing, until he is able to hear the drop of a pin across the distance of a continent.

But consider the eye. With all that science, discovery, and engineering have accomplished in equipping man for the struggle of life, the eye still looks out naked upon the world, aided to a limited extent by pieces of curved, polished glass. A sensitive photographic apparatus, the eye demands that every scene be contracted to its limited field of vision. It tolerates but little interference. Shake a feather before the eye and you blot out the view of a mountain. Project two views simultaneously and you create confusion before the sight. Distort a picture and you destroy its recognizable elements.

Now contrast this with the ear, one of the best-trained organs of the human body. The ear receives sounds from all directions. It is able to recognize and interpret the slightest tonal differences. By an act of concentration we can almost eliminate from consciousness the noise of a roomful of people and conduct a conversation with a single auditor.

Radio broadcasting found a pliable and sympathetic organ of reception in the ear. The ear will stand for a considerable amount of noise interference, both natural and mechanical, with only a moderate loss of musical or tonal values. Thus we have been able to overcome great obstacles to sound transmission by going over or around them. We have found that through high power we may transmit electrical impulses over the discharges of free electricity in the air. Thus the sound of music may be heard over the roar of interference registered in the vacuum tubes. We may vastly amplify the feeble impulses coming from a distant station and with them the natural and mechanical interferences of sound transmission, and still insure the reception of a satisfactory residue of sound or speech.

But in attempting to serve the eye, radio stands squarely before the fundamental problems of electro-magnetic wave propagation through space. Engineering solutions alone will not suffice to lift the bandage that has limited human vision. A sudden blur of interference, barely noticeable in sound broadcasting, may for an instant blot out a distant scene projected by visual transmission. Static, now over-ridden in the broadcasting of sound, may vitiate entirely the broadcasting of sight during periods of severe disturbance. Fading and wave interference may cause fluctuating or multiple images.

Nevertheless, within a few years, I believe we shall be well launched into the dawning age of sight transmission by radio, involving the following developments:

The transmission in rapid succession of a series of still pictures—otherwise, motion pictures—is a logical element in the development of sight transmission. The process, to be sure, involves problems of optical as well as electrical engineering. Nevertheless, transmission from photographic images on motion-picture films may be expected to reach the home.

Certainly the enormous economic advantages of radio motion pictures are great enough to inspire the necessary development. There is a limitless field in the home for motion-picture services, dedicated particularly to the educational and cultural activities of American life. Such services, obviously, are not within the functions of the motion-picture theater, which has a vast entertainment field to cover in the United States. An educational or other event might be broadcast by a single radio operation to a hundred thousand or to one million homes in the country.

The instantaneous projection through space of light images produced directly from the object in the studio or the scene brought to the broadcasting station through remote control involves many further problems. Special types of distribution networks, new forms of stagecraft, and a development of studio equipment and technique are required.

With these must come a new and greater service of broadcasting. A new world of educational and cultural opportunities would be opened to the home. New problems would rain in upon the broadcasting station. New forms of artistry would be encouraged and developed. Variety, and more variety, would be the cry of the day. The ear might be content with the oft-repeated song; the eye would be impatient with the twice-repeated scene. The service will demand, therefore, a constant succession of personalities, a vast array of talent, a great variety of scenes and backgrounds.

The problem of transmitting electrical currents, translatable into light waves that will reflect object and scenes in their natural colors, is a further development which may be reasonably expected, once the fundamental problems of radio television have been solved. When that time comes, as I believe it will, and when three-dimensional projection is added to the art, it will be difficult to differentiate between reality and its electrical counterpart.

In the meantime, it must be remembered with the poets that art is long and time is fleeting. There is no short-cut in the logical unfolding of an art that promises to extend the range of the eye, as it has extended the range of the ear, to the four corners of the earth.

LABORATORY AND FACTORY

By Frederick A. Kolster

Chief Research Engineer, Kolster Radio Corporation

LIKE the automotive and aëronautical industries, radio stands out uniquely among other American industries operating on a mass production basis in that the marketed product is a complex device in which the most modern scientific principles are involved.

The radio equipment one finds today in practically every American home is more than the mere assemblage of a number of mechanical parts compactly arranged and artistically housed. The truly important features are quite invisible to the eye but most impressive to the ear.

It is in connection with the study and development of these invisible features that research and engineering are of paramount importance to the radio industry. It has been appropriately stated by one prominent in the industry that "the radio manufacturer who fails to maintain the best laboratory and research personnel which his resources will permit is going to fade from the radio industry picture."

The real significance of this statement can be appreciated more fully by consideration of the process through which speech and music are transmitted and received by radio, and by realization of the intricate transformations which the radio receiver must properly effect.

Each broadcasting station transmits its programs on a carrier wave of definite frequency within the range assigned for this purpose by the government, namely, between 550 and 1,500 kilocycles. This carrier wave reaches out in all directions, travels at the speed of light and, as its name implies, carries with it all the variations produced by the complex sounds emanating from the instruments in an orchestra or from the voice of a speaker.

The radio set in the home must first be capable of selecting exclusively the desired carrier wave from which it takes an exceedingly small amount of energy. This is then amplified, and from it are taken the complex electrical variations representative of the broadcast program. These electrical variations must now be suitably amplified, then transformed into mechanical variations which are finally imparted to the air to produce sound. Briefly, this, in simple, non-technical language, is what the radio set must accomplish. It will be immediately apparent that the job is clearly one for the scientific laboratory and not fundamentally for the factory.

It is not the purpose, nor is it within the scope, of this chapter to engage in a technical discussion of the scientific principles involved in radio-set design. However, radio has now emerged from the cloud of scientific mystery and has become intimately associated with our everyday life. We depend upon it for entertainment, for musical edification, and for a better knowledge of what is going on in the world. Everyone, therefore, should have an elementary knowledge of the more important principles of radio reception in order to appreciate better what is being accomplished in the scientific laboratories and in order to be able to choose more wisely in the purchase of home radio equipment.

The problems of the research laboratory during the past few years have had to do mainly with the application of known radio principles to a new purpose. Let us take, for example, the important principle of selective tuning. This has been a familiar one to the radio engineer for over twenty-five years, yet the application of station-selecting means to the radio set for the home presents many difficulties because of the severe requirements imposed. The number of frequencies or broadcasting channels in the allocated range from 550 to 1,500 kilocycles is limited. It has, therefore, been necessary, in order to accommodate the large number of broadcasting stations now on the air, to crowd them into the frequency band with minimum separation. It will be apparent, therefore, that in radio-set design, selectivity requirements must be uniquely met. The problem is further complicated by the fact that if a certain degree of selectivity is exceeded, a serious effect upon the quality of musical reproduction results, as evidenced by the complete elimination of high-pitched musical tones. The research laboratory has still much to accomplish before the matter of station-selecting is ideally solved.

Let us now go further into science and consider the little magic lamp known as the vacuum tube. There would be no great radio industry today were it not for the invention of this remarkable device which, among other things, makes it possible to amplify to many times its original strength the feeble radio energy which is picked up by the receiving antenna.

The vacuum tube has been the subject of research and development for at least twenty years, yet, in its application to radio receiving sets, there are a multitude of problems which must have the close attention of the scientific laboratory, for the vacuum tube plays a most important part in the process of radio reception. It is the means by which the feeble carrier wave and the complex superimposed variations are amplified or, let us say, magnified to hundreds of times their original strength.

This electrical magnification takes place in a systematic step-by-step manner. First, the carrier wave is selectively amplified, then it is completely eliminated so that only the superimposed variations remain. Finally, these variations which are the electrical interpretation of music or speech are further amplified until they are of sufficient strength to operate the mechanical device generally known as the loud-speaker.

All of this, of course, is interesting, but the important fact remains that during the various transformations just described the nature of the music or speech originating in the broadcast studio must remain unchanged and undistorted; for just as the poorly-made magnifying glass misinterprets and distorts the object viewed through it, so does the poorly designed amplifier of a radio set misinterpret and distort the electrical counterpart of a musical composition. The result is that what comes from the loud-speaker is either displeasing or not a faithful reproduction of the original program.

Needless to say, the electrical and mechanical design of the loud-speaker plays an important part in the work of the radio laboratory, for it is this device which finally transforms the invisible electrical variations into mechanical vibrations which we recognize through our sense of hearing as musical sound.

The results of research and engineering in the development of electro-mechanical means for the reproduction of music represent today the most outstanding accomplishments of the scientific laboratory. In this new field of science, the radio engineer has found himself confronted with many new electrical, mechanical, and acoustical problems. What has been accomplished to date is best evidenced by the striking contrast between the character of reproduced music as it was in the early days of broadcasting and as it is today. Improvement has been so great, in fact, that the radio set, once merely a fascinating novelty, is now looked upon as a musical instrument. Through improved reproduction and the broadcasting of high-grade programs, radio has resulted in better musical appreciation on the part of the listening audience. This has had a very important effect upon the radio industry which heretofore has been looked upon as involving the manufacture and sale of a purely electrical device or accessory to which, as a matter of secondary importance, a loud-speaker could be attached. The situation is quite different today. The industry is gradually taking on an entirely different aspect, due, first of all, to the fact that research and engineering development have finally reached a point where they can be considered as well abreast with commercial demands. Secondly, the merchandising problem of the industry is fast becoming more than the mere selling of an article. The radio purchaser is rapidly learning that what he must buy is a result and not merely a physical thing embellished with queer and often meaningless names.

If, then, the radio industry is to depend upon the sale of a scientific result for its continued success, is it not reasonable definitely to state that research and engineering must form the foundation from which all other phases of the industry must branch? Certainly, the manufacturer who fails to recognize this will fade from prominence.

We must not overlook the fact, however, that there is necessarily a wide gap between the achievement of a technical result and its practical realization. This is particularly true in the radio industry because of mass production requirements which call for great manufacturing simplicity.

In the practical application of scientific principles, the radio engineer has a most important and difficult task to perform. In the mechanical design of the radio receiver the engineer is immediately faced with two more or less conflicting problems. He must, on the one hand, follow the specifications given him by the scientific laboratory, and on the other hand, he must keep in mind the factory problems involved as well as the matter of manufacturing cost.

It is futile, of course, for the engineer to make his specifications so rigid that they cannot be economically met by modern factory methods. Likewise, is it futile for the factory to undo completely the work of the laboratory through lack of appreciation of the technical result to be accomplished or through the practice of false economies in its effort to reduce manufacturing costs.

The success of the radio industry depends, therefore, upon the close cooperation and the united efforts of the engineering and manufacturing departments. Neither one can stand alone and each must contribute to the success of the other.

On this basis, and with a full appreciation of the importance of scientific research and engineering, the radio industry will continue to flourish.

Looking into the future, it is hard to predict what the radio science will bring forth, but we may be sure that there will be no immediate revolutionary changes in the present-day methods of radio reception. Fundamental radio principles were established long before the advent of broadcasting and it is not to be expected that the scientific laboratory will upset and discard these principles overnight. Without question, many electrical and mechanical improvements will be made from time to time which will result in the gradual perfection of radio reception. It is predicted that perfection will be mainly directed toward the production of better musical results and toward the simplification of the means of obtaining the results.

It has often been stated that the radio industry has now become more stabilized. It would perhaps be more appropriate to say that the scientific laboratory has become stabilized in that it has only recently been able to catch up with the rapidly growing demands of the industry. Scientific development is a much slower process than factory production, and it is a significant fact that the radio industry came so suddenly upon us that we were caught scientifically unprepared.

Up to perhaps a year ago, the technical development of the radio set has been accomplished on the run, so to speak, and for this reason, changes, modifications, and additions came in rapid succession. Battery-operated sets were quickly replaced by sets operated from the alternating-current power lines; the electromagnetically driven horn speaker was replaced by the more efficient electrodynamic reproducer, and other more or less important transformations were made without waiting for their complete development.

Naturally, all of this has had a disturbing effect upon the industry, but this was quite to be expected in view of the industry's unusual and novel character.

Through it all, the public has been patient and tolerant; at first fascinated, then inquisitive, and finally fully appreciative of the real contribution which the radio science has made to modern civilization.

The radio industry is entering a new era in which an entirely different order of things will eventually be realized. Scientific laboratories are rapidly advancing the art; factories are operating on a much more efficient production basis, and radio merchandising has reached a higher plane.

Complete realization of a stabilized and successful radio industry depends primarily upon the full recognition of the importance of research and engineering. The radio business is highly competitive, and in the final analysis it will be a matter of the survival of the fittest. The manufacturer who maintains, supports, and gives full recognition to the scientific laboratory and its personnel will remain prominent in the radio industry.

THE RADIO MARKET

By O. H. Caldwell

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Former Member of the Federal Radio Commission

PRIOR to 1921, radio as a trade and industry comprised only the sale and distribution of a small volume of amateur and ship's radio equipment, running into a few hundred thousand dollars annually. By 1929, sales of radio receiving equipment to the public approached an annual total of three-quarters of a billion dollars. This included nearly four million radio sets, with an aggregate retail value of $500,000,000, besides tubes and other accessories.

Thus, in a few short years radio broadcasting has become not only a major source of entertainment and information for at least 45,000,000 radio listeners in the United States, but it has also reached industrial proportions of the front rank. For between radio manufacturers, radio distributors, and radio broadcasters, the new art now represents a plant investment of nearly a quarter of a billion dollars, with an annual payroll approaching the same amount.

The broadcasting stations alone total $25,000,000 in plant equipment. A modern 50-kilowatt station involves $250,000 to $350,000 in investment. At least 7,500 people are employed in the country's broadcasting operations alone, representing an annual payroll of $15,000,000.

Invested in the manufacture and distribution of radio sets, reproducers, tubes, and accessories, there was at the beginning of 1930 a total of about $210,000,000, according to careful estimates based upon studies of individual manufacturers' figures. These factories and distributing plants employ altogether 100,000 persons, who receive $200,000,000 annually in salaries and wages.

The industry's total annual payroll is thus $215,000,000, or a daily payment of two-thirds of a million dollars.

Radio sales in 1929 totaled about $700,000,000, figured at retail prices. This, added to the $30,000,000 collected by the broadcasting stations and chains, represents nearly three-quarters of a billion dollars taken annually by the radio industry—which is at the rate of two million dollars a day.

Radio broadcasting began in 1920 with occasional transmissions from a small Pittsburgh laboratory at the home of Frank Conrad of the Westinghouse Electric & Manufacturing Company. This station later became KDKA, the first broadcasting station to go into regular operation, although another Westinghouse station, WBZ, at Springfield, Mass., was the first to receive one of the new "broadcasting" licenses from the federal government.

Meanwhile, the Westinghouse Company began the manufacture of receiving sets—its early "Aëriolas"—later combining with the General Electric Company in the building of "Radiolas" for the Radio Corporation of America. An interesting incident of this early history was the attempt by some of the Westinghouse men to interest the Victor Talking Machine Company in the new radio toy, and to get the help of the phonograph people in the manufacture of these sets. According to the story, a curt refusal followed from the phonograph officials, then at the peak of their prosperity. Very bluntly they said they were "not interested." Not many months afterward, however, the great talking-machine factories were standing empty and idle as the result of the competition of the "fool toy." And during 1928 the whole vast talking-machine business was virtually taken over by radio interests to get adequate manufacturing facilities.

Other manufacturers scented the romance of radio and came into the new art. A. Atwater Kent, of Philadelphia, whose important automobile ignition business was already nationally known, rapidly developed his radio sales to a scale requiring many acres of factories. Powell Crosley, Jr., an enterprising young manufacturer of Cincinnati, built up a volume of radio business that astounded his conservative Ohio neighbors. An old-established telephone firm, Stromberg-Carlson, went into the production of quality radio sets.

Other radio concerns entered the ranks, some making outstanding successes, others unfortunate failures. Fortune has never gyrated more rapidly nor more inconsistently than in radio. Well-known names of one year have quickly passed out of the picture the next season, to be replaced in the public fancy by new favorites. It has been a kaleidoscopic industry, but with a few leaders always occupying positions near the top.

In the early boom days of radio, at least three to five thousand manufacturers could be listed. With the stabilization of the business, this number has steadily decreased until now there are only a few hundred. The total of the set-makers will not exceed 60. Concentration of volume in a few hands is equally noticeable. For example, two set-makers (out of the 60) did more than one-third of the 1928 business. Four companies did nearly two-thirds of the total.

An accompanying table traces the growth of radio sales year by year, from 1922 to 1930, the last figures being estimated in the absence of complete returns as this chapter is written. During this period the radio audience has grown as follows, allowing for replacements and obsolete sets:

	Number of Homes with Sets	*Radio Audience*
Jan. 1, 1922	60,000	75,000
1923	1,500,000	3,000,000
1924	3,000,000	10,000,000
1925	4,000,000	15,000,000
1926	5,000,000	20,000,000
1926	6,500,000	25,000,000
1928	7,500,000	35,000,000
1929	9,000,000	40,000,000
1930	11,000,000	45,000,000

Regarding future saturation, these figures should be interpreted in the light of the following comparisons:

Saturation Comparison

Number of homes in U. S.	28,000,000
Number of homes with phonographs	13,000,000
Number of homes with passenger autos	18,000,000
Number of homes with telephones	14,000,000
Number of homes wired for electricity	19,000,000
Number of farms	6,500,000
Number of homes without radio sets	17,000,000
Radio saturation	39%

And though radio has been sold into 11,000,000 homes, to use round figures, it would mean—by any ordinary calculation—that there would remain still unsold about 17,000-000 other homes, since there are roughly 28,000,000 families in the United States.

But let us dig deeper. Let us consider these other figures:

Homes now using electric light	19,000,000	
Number that have radio	7,000,000	
Wired homes still to be sold		12,000,000
Unwired farm homes	6,000,000	
Unwired homes in towns	3,000,000	

Total unwired homes	9,000,000	
Number that have radio	2,000,000	
Unwired homes still to be sold		7,000,000
Grand total of homes without radio		19,000,000

Yet even this is but half the story of our market. In recent years there has been still another revolution in the world of radio. The alternating current receiving set suddenly swept into popularity by raising radio to a new and higher standard of perfection. And it rendered obsolete most of the battery-operated sets in use in the 7,000,000 wired homes that owned radio. According to 1929 sales, it is estimated that only 4,000,000 of these homes have modern A. C. sets.

Therefore, here are the true saturation figures on the radio market as of the end of 1929:

Homes without radio (including wired and unwired)		19,000,000
Wired homes with radio	7,000,000	
A. C. sets in use	4,000,000	
Obsolete battery sets in wired homes		3,000,000
Total homes waiting to be sold or resold modern receivers		22,000,000

In a word, the present practical saturation in the radio market can only be considered as those wired homes that now have the A. C. set—4,000,000—plus the 2,000,000 unwired homes that have battery sets. Thus, out of the 28,000,000 homes in the United States, only 6,000,000 are using satisfactory radio equipment. This means that, despite the fact that the radio industry in 1929 enjoyed its greatest year of sales, the saturation of the market has fallen sharply backward. For there were at the beginning of 1930 close to 22,000,000 homes in America that could be sold or resold modern equipment.

A large market abroad for American radio will eventually be developed. Present exports total about $12,000,000 annually. Canada is our largest customer, but is now setting up her own manufactories behind tariff walls. The South American and Central American republics offer our best future trade in radio, for Europe is already well supplied with radio manufacturers and has generally raised tariffs against imports of our radio goods. The many different voltages and frequencies encountered in electricity supply in England and the Continent also interpose difficulties in the sale of our standard lamp-socket sets. As the electricity supplies of the South American nations become standardized and the radio broadcasting of those countries become coordinated on some international basis, as is now carried out and in effect in Europe, an opportunity for export to the lands lying south will be presented to American radio manufacturers.

Such export business affords a valuable stabilizer of domestic business. It is of especial importance during years of overproduction of receiving sets, such as the American industry experienced in 1928 and especially in 1929. In the latter year, sets manufactured numbered at least 4,500,000—a surplus of 500,000 to 600,000 over total sales to the public. If such surplus could be removed from the American market, without involving the distress selling that usually occurs, a great benefit would be conferred on the domestic trade.

Radio broadcasting developments of the future will undoubtedly take many interesting turns which will greatly increase convenience and satisfaction to the listener.

Several sets are now as much a necessity in the average home as a second automobile for the family's convenience. One radio in the living-room for the use by the whole family, a second in the children's room, a third for the master's bedroom, and a fourth for the kitchen or maid's room, comprise a minimum equipment for the modern-size establishment.

Outlets wired into each room, so that loud speakers may be plugged in at will, afford another convenience which the well-designed house should afford. Hospitals, hotels, prisons, and other large buildings are now being equipped with such so called centralized systems.

Clock switches on each radio set, so that the set will be automatically turned off at a predetermined time, add greatly to the convenience of the listener. With such a device, the listener may drop off to sleep to the strains of music, knowing that the set will shortly afterward switch itself off. The same clock switch may also be arranged to perform an agreeable "wake-up" or reveille service in the morning. It can switch on the setting-up exercise music after routing the sleeper out of bed, and it can turn off the radio after he has left the house.

Outside of radio itself, there are a host of applications to which the amplifying device we know as a radio receiving set can be adopted. These include picture reception, television, "wired radios," talking movies, film-operated phonographs, detective mechanisms, signal operation, machine and elevator control, metering, etc. Developments in these diversified and industrial fields are growing rapidly, and it appears likely that within a few years applications in these various directions will be far more significant, measured in numbers or value, than all of the radio uses combined.

TOTAL RADIO SALES, 1922–1929

Courtesy, *Radio Retailing*

(At retail, in numbers and dollars, during the year)

		1922	1923	1924	1925	1926	1927	1928	1929
Radio sets, factory-built	No.	100,000	250,000	1,500,000	2,000,000	1,750,000	1,350,000	3,200,000	3,900,000
	$	5,000,000	15,000,000	100,000,000	165,000,000	200,000,000	168,750,000	350,000,000	487,500,000
Radio-phonograph Combinations	No.	....	....	....	....	....	....	81,000	218,000
	$	....	....	....	....	....	....	38,000,000	62,348,000
Reproducers (excluding those in consoles and combinations)	No.	25,000	500,000	1,500,000	2,000,000	2,000,000	1,400,000	2,460,000	800,000
	$	750,000	12,000,000	30,000,000	32,000,000	30,000,000	28,000,000	66,400,000	16,000,000
Tubes	No.	1,000,000	4,500,000	12,000,000	20,000,000	30,000,000	41,200,000	50,200,000	71,000,000
	$	6,000,000	17,000,000	36,000,000	48,000,000	58,000,000	67,300,000	110,250,000	177,500,000
A-B-C (dry) batteries	$	4,500,000	6,000,000	55,000,000	66,000,000	80,000,000	68,000,000	50,400,000	30,530,000
A-B power units, storage batteries and chargers	$	....	7,000,000	25,400,000	30,000,000	55,000,000	34,000,000	17,500,000	14,350,000
Other accessories (1928 does not include furniture)	$	3,750,000	4,000,000	11,600,000	24,000,000	33,000,000	38,550,000	8,000,000	9,600,000
Parts (does not include sales to manufacturers)	$	40,000,000	75,000,000	100,000,000	65,000,000	50,000,000	21,000,000	12,000,000	7,500,000
Totals									
Sets	$	5,000,000	15,000,000	100,000,000	165,000,000	200,000,000	168,750,000	306,000,000	549,848,000
Parts	$	40,000,000	75,000,000	100,000,000	65,000,000	50,000,000	21,000,000	12,000,000	7,500,000
Accessories	$	15,000,000	46,000,000	158,000,000	200,000,000	256,000,000	235,850,000	332,550,000	247,980,000
Total sale for year		$60,000,000	$136,000,000	$358,000,000	$430,000,000	$506,000,000	$425,600,000	$694,550,000	$805,328,000

RADIO PRODUCTION

By William C. Grunow

Vice-President, The Grigsby-Grunow Company

DURING a decade, marked by amazingly swift development, the radio industry has grown into one of the industrial giants of the United States. Radio factories are to be found in many American cities. Their products are now in millions of American homes.

The swift march of the industry has brought with it countless manufacturing and merchandising problems. Often we can look into the history of other industries for guidance, but in many cases radio, lacking precedents, must blaze its own trail.

Even before the advent of the alternating current tube, there was a cry for standardization. But radio refused to be standardized. There was much to be accomplished before radio could enjoy general acceptance in American homes. Batteries, for example, were not wholly acceptable. They were regarded with suspicion by many American housewives, who tolerated them in homes where they were admitted only to preserve domestic harmony or because radio was inescapably a remarkable thing.

The first step in socializing radio was the elimination of batteries. This was accomplished to a great extent by the introduction of power packs, which converted and transformed ordinary line currents and voltages so that they were usable by the ordinary radio tubes.

The engineering staffs of the then rapidly growing industry, however, did not sit idly by in the contented belief that the problem had been solved. Instead, they sought a way to utilize the regular power supplies of the homes more directly and more efficiently. The alternating-current tube was the answer. Its production only a few years ago resulted in a veritable revolution in the industry. Circuits had to be redesigned. Production methods had to be changed. The product itself had to be altered to meet the constantly growing demand for a complete radio set in a single unit.

Meanwhile, loud speakers had been undergoing a decided change. They began first as a horn, which amplified the sounds produced in a vibrating diaphragm by means of its air column. The cone speaker was next introduced and it was a material improvement over the original speaker. Some covered the range of musical notes fairly well; some did not, and only a few were capable of bringing out the low notes. The hunger for the low notes was finally satisfied with the introduction of the dynamic speaker.

All of these changes drove home to the manufacturer the necessity of maintaining his factory on a flexible basis, so that he could readily adapt his plant to new conditions.

This is no easy problem. For example, when the Grigsby-Grunow plant in Chicago is turning out 5,000 of its *Majestic* sets per day, a vast amount of raw material must be received daily and converted into completed receivers, which are at once placed in box cars and shipped out, since our company does not warehouse its stock but rather keeps it moving steadily along the merchandising lines toward the consumer. An idea of the amount of material may be gained by mentioning the requirements for such a production.

A total of 125 tons of steel is used—and the sheet steel for the chassis and metal parts and silicon steel for transformer laminations must be cut and pressed. Ten carloads of lumber are needed for the 5,000 consoles and packing cases. Fifty drums of paint and varnish are required to finish the sets. The fixed condensers that go into each receiver need 5,000 pounds of paper, which must be of uniform thickness and free of pinholes and metallic substances. The total amount of wax needed for condensers and tranformers weighs 36,000 pounds. The glass for tubes that such a production requires is one carload. The brass required weighs 8,000 pounds and the aluminum weighs 10,000 pounds. The wire used in the various coils of the receivers would stretch out 34,250 miles.

When all this material has been assembled into completed sets, thirty-two cars, each carrying about 160 crated receivers, leave the factory headed for the jobbers and distributors throughout the country.

In the making of each set, a total of 990 operations and 948 inspections are required. Ten thousand employees, most of whom are on a piece-work basis, participate in this gigantic task of converting all of that material into completed radio receivers. In other words, one set is produced for every two employees.

A high degree of efficiency has been established by most of the leading manufacturers of radio receivers in the process of production. Labor-saving devices of every kind have been employed. Conveyor belt systems are used in some plants; endless belt systems are used in others, while some prefer the use of dollies for moving the chassis along the production line as well as after the chassis has been assembled in the console. Every effort has been made to avoid lost motion and lost time. Each worker has a specified task and a specified length of time in which to complete that task. It is only in that way that production schedules can be maintained, and quality merchandise produced at a cost within the reach of the average man's pocketbook.

There are two classes of radio manufacturers—those who buy their parts from other manufacturers and assemble them in accordance with the ideas of their own engineering departments, and those who manufacture practically all of the parts needed to make a complete set. It is the latter class of manufacturer who has followed the example of

Henry Ford, for they have found it a means of reducing production costs and hence a means of reducing the price of the finished product to place it within reach of a greater proportion of the American public.

In the radio industry there is an increasing tendency toward the production of both the furniture that houses the sets and the tubes that are to be used in the sets. In the fall of 1928, when a shortage of radio tubes interfered with many a radio sale, many manufacturers learned their lesson in this regard.

The manufacturer of radio tubes has created problems that are different from those encountered in producing receivers. When inspections show that a receiver is not functioning as it should, the seat of the trouble is located and the correction is made, but when a tube doesn't function it must be scrapped. Considerable skill is required to produce satisfactory tubes, so the labor turnover is kept at a minimum.

One of the invisible items that goes into the cost of the radio receivers is the royalty collected by the Radio Corporation of America from nearly every one of the manufacturers of completed sets. The fee is charged for the privilege of manufacturing under the radio patents of the General Electric Company, the Westinghouse Electric & Manufacturing Company, the American Telephone & Telegraph Company, and others, all of which have been pooled under the Radio Corporation. The fee paid is seven and one-half per cent of the total sales of the manufacturer.

The patent situation has always been a difficult one for the radio manufacturer and would be materially improved if there was a more general pooling of patents, inasmuch as there are a number of smaller organizations which are now issuing licenses to cover the use of the patents each of them controls.

The majority of radio manufacturers sell their products through jobbers, who in turn supply the dealers with radio merchandise. Others maintain their own distributors. So far as retailing of radio is concerned, an exact parallel between the automotive and the radio field is impossible, since radio is regarded variously as an article of furniture, a musical instrument, and an electrical device. Hence it may be retailed through a furniture or department store, a music store or an electric shop. Nevertheless, radio manufacturers are constantly striving for more efficient and more economical ways of getting their products to the consumer, and some marked changes in methods of distribution may be expected in the not distant future.

Great as the radio industry has become in less than ten years, I forsee an even greater future. The radio audience today contains almost half of the population of the United States. That leaves a great market. There are millions of obsolete models of radio sets still in use. Some day they will be replaced with modern equipment that is capable of doing justice to the quality of the broadcasts, which have shown a steady improvement that matches the progress of the radio industry in improving its products.

I hope the day never will come when we can say, "At last we have the perfect radio set," for I firmly believe that human ingenuity will find ways and means of making constant improvement, just as I believe that our standards of perfection advance with new knowledge. The advances of radio science will create a tremendous business in the replacement of sets, for the American public is satisfied only with the best of everything.

PART IV: REGULATION

RADIO AND THE LAW

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IN the regulation of radio, legislators are confronted, in larger measure than in any other branch of jurisprudence, with the necessity of making their enactments conform to the laws of an invisible world. If the romantic wonderland of radio waves had been completely explored and charted, the task would be immeasurably simplified, although there would still be difficulty enough in translating its abstruse code of laws into rules of human conduct. As everyone knows, however, science is far from having reached such a point, and, curiously, while man's knowledge of some of the external manifestations of electricity is fairly satisfactory, on the more fundamental matters (such as the nature of electricity itself) he is almost as mystified as was his ancestor in the days of Ben Franklin.

The ether, the medium in which radio waves are pictured as traveling, is nothing but an hypothesis which scientists have found convenient to serve as the background for discoveries they have made. Its character is unknown and its very existence is challenged by a respectable body of expert opinion. The conception may at any time be abandoned without a successor to replace it. If it does exist, it must, like Wordsworth's conception of Nature, "roll through all things," for radio waves find their way alike with ease across a vacuum and through many solids of the greatest apparent impenetrability. It seemingly knows no boundaries, either vertical or horizontal, cannot be confined within international boundary lines or subdivided into lots, and extends from the center of the earth to the outer limits of the universe.

Ownership of this greatest of intangibles, the ether, is not a practical legal problem and, except in limited academic circles, has not even proved a topic for serious discussion. The law of property cannot rest upon so fragile a basis. Only a few years ago Congress had a narrow escape from enacting into law a declaration that the ether is the "inalienable possession" of the people of the United States. The intent of the provision (which was to prevent the acquisition of vested rights in radio communication) was laudable, but its phraseology would have made us the laughing stock of radio engineers the world over. Again, no one has dared assert before a court or seriously in Congress that the time-honored rule of real-estate law—that a man who owns a portion of the surface of the earth owns everything below it to the center of the earth and everything above it to the heavens—has any application to the ether so as to constitute the person who transmits radio waves across the owner's property and into his home a trespasser. The same rule of real estate is, however, a very real factor in the development of aëronautical law.

All that can be intelligently discussed, or made the subject of treaties, laws, and regulations, is fundamentally the question as to the *use* of the ether. By "use" is meant simply the operation of transmitting stations and of receiving sets. The former disseminate the electrical disturbances which we call radio waves, and the latter detect these disturbances and translate them into intelligible communications. Since the total facilities for radio communication are limited, the problems of dividing up these facilities among the nations of the world and of parceling out each nation's share to its subjects are very real.

The total number of persons who can simultaneously engage in radio communication at any one time, whether from the point of view of the United States alone, or from that of the continent of North America, or from that of the entire world, is definitely and rigorously limited by the laws of radiophysics. In this fact lies an inexorable truth, recognition of which is being forced upon mankind at a comparatively late date by bitter experience and by the threat of future disaster unless its demands are given appropriate expression in law.

If radio stations in excessive numbers are permitted to propel waves into the ether, then the resulting interference will decrease the usefulness of this new medium of communication and, if great enough, will make it useless to everyone. No other kind of business presents this peculiar dilemma. There may be valid economic reasons against the laying of additional railway lines between two given points, or against the establishment of a second telephone company in a given community, but there are no insuperable physical obstacles in either case. The fact that there are such obstacles in the business of radio communication means that, instead of the comparatively slight amount of regulation that would otherwise be necessary, nations must bind themselves by treaty to obligations which they would not accept with reference to any other activities of their subjects, and that the radio administration within a nation must have a life-and-death power over the radio conduct of its subjects such as it neither has nor desires over their conduct in other matters.

It is beyond the proper scope of this chapter to discuss *why* the total of radio facilities is limited or to explain just what those limits are. It is sufficient for our present discussion to know that the total is limited and that the demand for participation in it, both by nations as against each other, and by individuals within each nation, far exceeds the supply.

The reader is familiar with the fact that by manipulating the dial of the ordinary receiving set he can tune in on a number of different "channels." Engineers distinguish these channels from each other by their "frequency" or "wave length." The range of radio waves on which broadcasting is permitted in the United States consists of ninety-six adjacent channels and is commonly referred to as the "broadcast band." This extends from the frequency of 550 kilocycles (corresponding to the wave length of 545 meters) to the frequency of 1,500 kilocycles (corresponding to the wave length of 200 meters). The ordinary receiving set is constructed so as to cover the broadcast band of channels and no more. There are, however, radio waves which may be thought of as respectively below and above the broadcast band, as covered by the dial of such a receiving set. The range of frequencies higher than 1,500 kilocycles is usually referred to as the high frequency or short wave band, while the range of frequencies below the 550-kilocycle limit is known as the low frequency or long wave band. Special receiving sets are necessary for these two outer bands.

Under an ideal international situation, the nations of the world would, by international treaty, have classified all the radio waves into (1) those the use of which might be duplicated in all countries by certain kinds of stations in simultaneous operation, (2) those the use of which might be so duplicated only on different continents, (3) and those the use of which might not be duplicated anywhere in the world and which would be employed by only one station at a time. Radio waves of different wave lengths differ greatly in their affective distance range, from the point of view both of service and of interference. The uses to which radio waves are put also differ greatly in that some stations (such as those engaged in maritime or aircraft mobile services) are not engaged in continuous operation and may be duplicated on the same channel, where this would not be possible in the case of stations engaged in broadcasting or public point-to-point communication. The nations composing each continent would have agreed as to their respective shares of the class of waves having a continental interference range, and the nations of the world would have agreed on their respective shares of the class of waves having a world-wide interference range.

As a result of considerations too complicated to be discussed in this article, the problem is not quite so simple as might appear from the foregoing. To some extent it runs counter to that troublesome international conception known as "sovereignty," with its theoretical implication that all nations, large or small, have equal rights. To some extent it involves an agreement between nations as to what portions of the various bands shall be used for this or that kind of service or by this or that kind of apparatus. A very knotty element in the problem is the determination of the proper manner of keeping the door open to the advances of science so that, at the same time that the present rights of the several nations are settled, the continued enjoyment of its rights by any one nation shall be conditional on its keeping abreast with improvements in apparatus and in methods of operation. Since from year to year such improvements will increase the total of available radio facilities (*e.g.*, they may at any time make possible operation on three or more channels in the high frequency band where two are now used), the unwillingness or inability of a backward nation to adopt modern methods should not be permitted to retard the world's full use of all that radio has to offer. Again, scientific developments may make changes in the use to which any particular portion of a band can best be put, and there must, therefore, be a certain amount of elasticity in the international radio agreements. Yet, while such considerations increase the practical difficulties of reaching the ideal agreement, they do not alter its ultimate desirability. For the present, however, the radio art is making such rapid progress as to make it improbable that the nations of the world can be brought into agreement except on rather general principles.

What has actually happened in the field of international radio relations? Radio, the practical use of which was demonstrated by Marconi in 1896, the commercial exploitation of which began with the organization of the British Marconi Company in 1897, and the extensive employment of which for ship communication was in full development by the beginning of the twentieth century, had to await the Washington Convention of 1927 before its most important international problem was forced upon the world's attention, only to be partly evaded because of its difficulty and to escape complete solution.

Before the Washington Convention of 1927 there had been two international treaties. One was negotiated at Berlin in 1906 and another was negotiated at London in 1912. Both were largely confined to regulatory measures aimed at inefficient or antiquated apparatus and at refusals of stations to communicate with each other because of operation or manufacture by different companies. The misfortune which was threatening in 1927, and which now is close to becoming an accomplished fact, arises from the failure of nations to agree among themselves as to the allocation of certain channels in the high frequency band, the interference range on which is world-wide, even when used by stations of comparatively low power, and which can, in general, be used by only one station at a time. The nations of the world have recently been engaged in a frantic race to register their stations on as many of these channels as possible at an International Bureau at Berne, Switzerland, on the theory that such registry will give rise to preferred rights in the use of each channel specified. Many, many more stations have been registered than can possibly be accommodated on these channels under modern engineering practice, and if they are ever permitted to go into simultaneous operation, radio communication of the type for which these channels are best suited (transoceanic or long-distance communication with maximum reliable ranges as high as 8,000 miles) will become difficult if not impossible. Earnest efforts are being made by international organizations of technical experts to ward off the calamity. An important meeting of technical radio men of the leading radio-using nations of the world took place at The Hague during the fall of 1929.

The Washington Convention of 1927 did, however, achieve important results, probably the best that could have been expected at so late a date. The whole range of radio waves was subdivided into small bands and the contracting governments (including practically all the nations of the world except Russia) agreed as to what kinds of radio service should be permitted in each band (although, in cases where no international interference was caused, they were left free to carry on or permit other kinds of service). Recognition was given, in substance, to the right of the nations composing any one continent to determine among themselves their respective shares of radio waves, the use of which can be duplicated from continent to continent but not within any one continent. Important obligations were undertaken looking to the discarding of obsolete apparatus, to the diminishing of interference, and to the consequent increase in the total of facilities, and great progress was made in many matters on which uniform international practices are necessary or desirable.

Acting under the power reserved to them by the treaty, the nations of North America, as the result of negotiations carried on by the United States, Canada, and Cuba, but not participated in by Mexico, arrived in the early months of 1929 at an agreement as to the use of the channels in the high frequency band which have a continental interference range. Little or no controversy should arise and certainly no chaos should take place on these channels during the three-year period covered by the understanding. On the other hand, the nations of this continent have no binding international agreement on the use of the channels in the broadcast band. The United States and Canada have a "gentlemen's agreement" which, while at present observed in practice by both nations, has once been badly disregarded by the United States. It is constantly open to violation by either country or to disruption by action on the part of Mexico or Cuba, neither of which nations was specifically taken into account in reaching the understanding.

We have given first consideration to international radio law problems because, unless and until they are solved, our internal radio law problems cannot be given a permanent solution. A treaty to which the United States is a party becomes a part of our law just as much as an Act of Congress. Theoretically, this country's share of the total radio facilities, and all restrictions on the use to which it may put that share, ought to be known before it can safely parcel out facilities to individual citizens under licenses. Fortunately, over the greater portion of the radio spectrum, and particularly over those portions (the low frequency and the broadcast bands) where the greatest development has taken place, the waves for the most part have only a continental interference range. Since we have been able to keep peace with our neighbors on this continent, our government has been able to proceed with the issuance of licenses without too great concern for the unsettled state of important international problems. The exceptions to this have not yet caused a great amount of trouble.

In the remainder of this chapter, we shall forget international complications almost entirely and, assuming that the United States has a definite quota of radio facilities to dispose of among its citizens, shall consider the legal difficulties that arise.

A word should first be said as to the requirements that would be met by an ideal law regulating radio communication within the United States. In the first place, the ideal law must repose the power of radio regulation in one central governmental authority, which for convenience we may call the licensing authority. The licensing authority must first have power and discretion to determine how much of the total radio facilities available to the United States shall be given to each of the various kinds of radio service. The respective needs of ships, aircraft, broadcasting, television, amateurs, experimenters, point-to-point wireless telegraphy and telephony (both transoceanic and domestic) and many others, including a number of subvarieties under each heading, must be balanced against each other. There must be a due regard and suitable reservations for the demands which the future may make. The licensing authority must also have power under reasonable restrictions to change the arrangement which it adopts one year so as to fit in new kinds of radio service which may develop next year, to eliminate those that are not proving worth while, and to shift, increase, or contract others. Such matters cannot safely be prescribed by statute, both because of the length of time which it takes to enact laws and because of the fact that they involve highly technical problems and complicated issues of fact which are unsuited for decision by a legislative body. Some federal authority must also have power to determine how much of the total facilities shall be reserved for use by government stations, such as those of the Army and Navy.

Once having determined the share of each kind of service in the total, the licensing authority must have power to determine what individuals shall be licensed to carry on each kind of service within the band or bands of waves set aside for that purpose. Since in most of the bands the applicants will far outnumber the available facilities, the licensing authority must have a far-reaching power to reject applications for licenses. If by any chance an excessive number of licenses are issued, it must have power to eliminate some of the licensees. It must be able to require applicants to fulfill the most rigid requirements as to technical and financial ability to make use of the privileges granted by the license in the best interest of the public.

In addition to the foregoing, the licensing authority must have a large measure of control over the conduct of licensees. They should be required to keep abreast of the progress of science so that they will not be using an undue share of the total facilities, and they should be required to maintain a service which is in the best interests of the public. If they fail to meet such requirements, the licensing authority should have power to discipline them, and even to eliminate them, by revocation of license or by refusing to renew their licenses. Regulations of this character cannot be set forth in a statute, for obvious reasons.

To what extent have the radio laws of the United States met the requirements of an ideal law? The best and most instructive illustration of our experience is what has happened in the broadcast band, where, under existing practice, the total channels number 96. Six of these are reserved for exclusive use by Canadian stations and eleven more are "shared" by American and Canadian stations, under the "gentlemen's agreement" between the two countries. On the 90 channels available to the United States, there were, by 1930, a horde of about 600 broadcasting stations; at one time the number was as high as 732. Without going into the complicated engineering facts, it is sufficient to say that, even with extensive improvements brought about by the Federal Radio Commission in the fall of 1928, the present number is far in excess of the number that should be allowed to operate on these channels. Reputable engineering opinion everywhere is agreed on this.

What was the cause of this calamity? The blame must be laid on the inadequacy of the statute which was in force when broadcasting first came into existence in the fall of 1920, and on the failure of Congress to remedy the defects of the law until February 23, 1927, when it was too late. The law was enacted in 1912 at a time when wireless telegraphy was the only known practical application of radio. It failed to meet any of the requirements which should be met by the ideal law. The licensing authority, which under its provisions was the Secretary of Commerce, was not given power to determine how much of the total facilities should be given to each type of service or to determine what persons should or should not be licensed. He was given no power to make regulations and no discretion enabling him to keep abreast of scientific development. The failure of the law to empower him to reject applications was clearly pointed out in an opinion by Attorney-General Wickersham as early as the fall of 1912, immediately after its enactment. According to the Attorney-General's opinion, the Secretary of Commerce had to issue every license applied for by a citizen of the United States. A decision to the same effect was made by a lower court in the District of Columbia in 1921 and affirmed by the Court of Appeals in the District in 1923. The last-mentioned decision, however, held that while the Secretary of Commerce had no discretion to reject an application, he did have discretion in selecting the wave length on which the application should operate. It is unnecessary to determine whether or not this interpretation of the law was correct; it was known to be uncertain at best.

Broadcasting stations increased in number until there were 578 in November, 1925. Herbert Hoover, then Secretary of Commerce, appealed to Congress for the enactment of suitable legislation. From 1923 to 1926, three new radio statutes passed one House of Congress only to die an ignominious death in the other. In the meantime, the Secretary of Commerce was trying desperately to preserve a fair measure of respect for engineering principles in the broadcast band and at the same time to grant all applications, as he perforce had to under the law.

The finishing touches on the impending tragedy occurred in the spring and summer of 1926. A Chicago broadcasting station, WJAZ, not satisfied with the very limited assignment which it had received, "jumped" to a Canadian exclusive channel and began operating full time. Legal proceedings brought against the station by the government resulted in a victory for the station and in a decision which was generally interpreted as meaning that the Secretary of Commerce had no power to stipulate the wave length, power, or hours of operation of a broadcasting station. This was followed by an opinion by Acting Attorney-General Donovan on July 8, 1926, in which all doubt on the subject was removed and in which he held not only that the Secretary of Commerce had no power to assign wave lengths, or to restrict the power or the hours of operation of a station, but also that he did not even have power to restrict the length of its license. As a result, a flood of new broadcasting stations, nearly 200 in number, crowded their way into the already overcrowded ether within a period of a little over seven months. Existing stations "jumped" to more desirable wave lengths, including all the channels which had been reserved for exclusive Canadian use, and increased their power at will. In an effort to protect itself against the interference thus caused, one station started a lawsuit in which it claimed a property right as against an interfering station and was upheld in this claim by a lower court in Chicago.

Finally, after the calamity had occurred and after an appeal by President Coolidge in his Annual Message, Congress enacted a new law, the Radio Act of 1927. The Act was a compromise between two bills then pending in Congress which were hastily amalgamated. It set up a new licensing authority, the Federal Radio Commission, which was to exercise its powers for one year. After that the Secretary of Commerce was again to become the licensing authority with the Commission remaining as a sort of appellate tribunal to review his decisions. There are several defects in the law, some important and some not, but in its fundamental principles the law is sound and meets the requirements which we have pointed out as essential. Under it the licensing authority does have power to determine how much of the radio spectrum shall be given to each kind of service and to change its arrangement from time to time; it has power to reject applications and to refuse to renew licenses and, therefore, may both keep the number of stations within proper limits and eliminate any excess; it has broad power to make regulations and to keep abreast of scientific progress. Except in minor particulars, Congress did not attempt to encroach on the proper field of the licensing authority by making permanent statutory regulations. All actions of the licensing authority are required by the law to meet the test of "public interest, convenience, or necessity." While this phrase may seem broad and vague, any more specific test would have been dangerous.

Since its enactment the law has been thrice amended, once in March, 1928, again in March, 1929, and lastly, as this is written, in December, 1929. The Federal Radio Commission was continued for one year as the licensing authority by the first two of these amendments, and, under the last, is to remain the licensing authority until otherwise provided by law. The first two amendments were the cause of a great deal of uncertainty and difficulty because of the fact that they cut short the appointments of the Commissioners from year to year and placed unreasonable restrictions on the maximum length of a license period, which is three months in the case of broadcasting stations. As this is written, bills are before both houses of Congress to create a Commission on Communications, which would supersede the Federal Radio Commission and also take over the regulation of all kinds of electrical communications, including telegraph, telephone, and cables as well as radio.

The 1928 amendment contained a section in which for the first time Congress invaded the field which ought to be left to the discretion of the licensing authority. This section, which is known as the Davis Amendment, has created a world of controversy. It commanded the Commission to divide all broadcasting facilities (including licenses, wave lengths, power and hours of operation) equally among the five zones into which the country is divided and equitably among the states within each zone in proportion to population. No more difficult administrative task has ever been imposed upon a government tribunal. As a matter of fact, the Davis Amendment rests on certain fallacies from an engineering point of view, is wasteful and uneconomic, and is really to the detriment of those parts of the country which it was primarily designed to benefit.

For reasons which need not be discussed in this chapter, the Commission did not do much toward the reduction of the excessive number of broadcasting stations during its first year. In its second year, however, it entered upon strenuous measures to improve the situation and, among other things, eliminated a few stations by refusing to renew their licenses. It also radically reduced the privileges of many others by giving them less power or by forcing them to divide time with other stations. As a result of these measures, several lawsuits were instituted in which it was urged that the Radio Act of 1927 is unconstitutional. These lawsuits were very important because they directly involved the question as to whether the Constitution permits Congress to give a licensing authority the drastic power over radio stations which is required if the laws of radio-physics are to be obeyed. Two stations which have been using power of 500 watts were reduced by the Commission to 100 watts at the end of August, 1928, and they promptly brought suit to restrain the United States Attorney at Chicago from enforcing the Radio Act of 1927 against them in case they should ignore the reduction in power. Another Chicago station which had been using 5,000 watts was eliminated entirely by the Commission's refusal to renew its license; it threatened to go on the air without a license and the government brought suit to restrain it from doing so. In all three cases the stations claimed a property right in the use of the ether which they asserted was either greatly damaged or completely taken away from them by the Commission's actions; that the law is unconstitutional because, in contravention of the Fifth Amendment, it does not force the government to pay compensation to the owners of such property before depriving them of it. Other important contentions were also made, such as that broadcasting is not interstate commerce and that the phase "public interest, convenience, or necessity" is too vague to be valid. The government has so far been victorious in all three cases, two of which are pending before the Supreme Court of the United States as this is written.

The statute provides for an appeal from decisions of the Commission to the Court of Appeals of the District of Columbia and, beginning with September, 1928, an increasing number of appeals have been taken by rejected applicants or by licensees of broadcasting stations who were dissatisfied with the privileges assigned to them by the Commission. Several of these cases have been decided and undoubtedly more appeals will be taken and further decisions made from time to time. The first appeal had to do with station WGY, operated by the General Electric Company at Schenectady, New York, the hours of operation of which station had been reduced by the Commission. It resulted in a victory for WGY (which was restored to full-time operation) but the Court of Appeals rejected the station's claim of a property right. On later appeals, similar claims by other stations have also been rejected.

Since there are more broadcasting stations than there are facilities for them, there must be some standards which will serve as a measure for comparison between their respective and conflicting claims. Nearly all of them want more power or better wave lengths or more time. But as there are only 90 channels to accommodate them, the great majority of them must take less than they want. The gradual evolution of legal standards by which to judge broadcasting stations is proving a most interesting field of law.

Dissatisfied stations have frequently been known to stir up the listening public, sometimes without explaining just what the difficulty is, with the result that a deluge of mail is poured into Washington. This is not so true now as it was in the earlier stages of regulation. Some of the mail goes to Senators and Congressmen, some to the President, but the Commission gets the bulk of it in the form of registered mail, air mail, special-delivery letters, and telegrams as well as ordinary letters. All the local authorities and notables living in the vicinity of the complaining station—the mayor, the aldermen, the judges, the presidents of all the clubs, the hospitals and many others—can be counted on to send in affidavits or other statements in commendation of the station. In a hearing which took place in February, 1929, involving a controversy between an Oklahoma and a Louisiana station for certain preferred privileges, the Louisiana station introduced into evidence nearly 170,000 affidavits which arrived in packing-boxes. In the fall of 1928, one station, which had suffered a cut in time, sent in 400,000 letters from its listening public. Many stations have conducted popularity polls in both city and countryside in an endeavor to show what stations are favored by the listeners; these polls have consisted in some cases of over 100,000 votes, and elaborate analyses of the votes are forwarded to the Commission. The only guide which the law gives to the Commission in passing on disputes between broadcasting stations for preferred assignments is the broad one of "public interest, convenience, or necessity," together with the geographical equalization required by the Davis Amendment.

The Commission has had to pass on the significance which it should attach under this standard to particular advertising practices, such as excessive direct advertising, fraudulent advertising, advertising of patent medicines, advertising of securities in violation of state laws, announcements such as were made in advertising Lucky Strike Cigarettes, and the like. It has had to give its opinion on the undesirability of the broadcasting of private disputes, on the excessive use of ordinary commercial phonograph records, on the use of obscene or indecent language, on deviation from channels, on irregularity of schedule, and on many other matters. It has had to pass on the weight to be given to the fact that one station is older than another, on whether an assignment of license and a sale of the station interrupts such a claim of priority, on whether a station giving a service of general interest is to be preferred to a station which acts as the mouthpiece for a particular school of political, religious, or economic thought, and on whether broadcasting stations are to be thought of as common carriers under an obligation to serve everyone who wants to speak to the public, or whether the broadcaster can, like the newspaper publisher, determine what shall constitute the make-up of his program. As decisions are rendered and find their way into the printed reports, the rights and duties of broadcasting stations, and the tests which they must meet in order to continue to enjoy privileges from the government, will be defined with increasing clarity.

If the ordinary receiving set used for picking up broadcast programs covered the entire span of radio waves, including both the low-frequency band and the high-frequency band, the listener by turning his dial above or below its present limits would encounter a world of activities in radio communication, the existence of which he hardly suspects. Public attention has for the most part been centered on broadcasting because it is one of radio's more spectacular achievements. The other kinds of communication, however, include some that are tremendously important, just as interesting, and with just as many perplexing legal enigmas. By turning the dial into the low frequency band, the listener will hear the familiar dots and dashes of the telegraphic code used by ships in communication with each other and with the shore, by aircraft, by government stations, by stations engaged in transoceanic communication. He may also hear the wireless telephone service which spans the Atlantic. By turning the dial in the direction of the high frequency band, he will again hear ship stations, aircraft stations, government stations, and stations engaged in wireless telegraphy both with foreign countries and within the United States. He will also hear amateurs and experimenters, and even broadcast programs being sent on high frequencies from broadcasting stations in the United States to remote foreign points. If he is properly equipped, he will get the still and moving pictures being sent out by stations experimenting in television. He might hear stations used by oil companies prospecting for oil in the Southwest, by power companies for emergency purposes to protect communication along their lines, by state departments of agriculture for sending out bulletins for farmers, by railroad freight trains communicating from engine to caboose, or by police and fire departments of certain of the larger cities for the apprehension of criminals or the giving of fire alarms. One company alone has established wireless communication between this country and about forty foreign countries. Another is setting up a wireless network among 110 cities of the United States in competition with the telegraph companies. Press interests are establishing a service by which they expect to meet the peculiar communication needs of the newspapers and press associations of the United States.

The legal problems affecting non-broadcasting stations have arisen mostly in the high frequency band. Historically, the low frequency band was the first to be put to practical use and the accidents of history, together with the agreement reached in the Washington Convention of 1927, have pretty well stabilized conditions in that band. Until within the last two or three years, however, the high frequency band was *terra incognita* to all but amateurs and experimenters. It had been thought that the high frequencies, with their peculiar vagaries and erratic performances, would not prove commercially useful. When, however, amateurs and experimenters discovered that these waves were not only useful, but perhaps more useful than any other part of the spectrum because of the fact that long-distance communication up to 7,000 or 8,000 miles was possible with comparatively low power on a large proportion of them, and as apparatus was developed capable of utilizing these waves, there was a deluge of applications comparable to the rush for California gold-fields.

The Federal Radio Commission has had need for all the wide discretion reposed in it by the Radio Act of 1927. It has had to decide (within the limits permitted by international treaty and by our agreement with Canada) what portions of the high frequency band should be allocated to the various types of service, the principal kinds of which have already been mentioned. After making the allocation of services, it has had to choose from among a number of applicants greatly in excess of the available facilities, reject some entirely, and give others much less than they applied for. It has had in some cases to eliminate entirely stations which were established prior to the Radio Act of 1927 and which were first given licenses by the Secretary of Commerce at a time when the high frequencies were thought to be practically useless and virtually inexhaustible in number. By June, 1929, the Commission had disposed of substantially all the available facilities in the high frequency band and, in fact, had assigned what foreign nations charge to be an excessive share of facilities on channels suitable for trans-oceanic communication. At the same time it has attempted to make due allowance for the future increased needs of ships and aircraft.

In the granting or refusing of licenses in the high frequency band, the only standard provided for the Commission's guidance by the statute is again that of "public interest, convenience, or necessity." The application of this standard has raised, and will continue to raise, a variety of difficult legal questions. It is fairly obvious that government stations, particularly those of the Army and Navy, must be provided for, and this function has been left to the President of the United States. The Commission may dispose only of what is left. There is general agreement that ships and aircraft must come first in the scale of preference among the various kinds of services, for there are no other means of communication available to meet their needs.

It is recognized also that provision must be made for amateurs and experimenters (including television and relay broadcasting) for the sake of future advances in the art.

The requirements which must be fulfilled by other services are not so easy to determine. It seems to be generally conceded that transoceanic wireless communication should be provided for, although there is some difference of opinion as to the reasons. Some emphasize its importance as a competitor of cables; others emphasize the fact that wireless can perform services which the cables cannot, such as direct communication with inland foreign nations too small to justify linking them to the cables. Wireless also has an obvious emergency value in the event of cable breaks. Moreover, it is a healthy competitor for cable. On the other hand, the better opinion seems to demand that no person be given a license to use a channel in transoceanic communication unless he be subject to a public service obligation to serve the entire public, or a substantial class of the public, on equal terms. The Commission has adopted this viewpoint, although it has had to compromise slightly with it in continuing two or three stations which have existed since prior to 1927. Even these, however, have been subjected to a public-utility obligation. On the other hand, the Commission has in general rejected applications proposing purely private use of channels; for example, it rejected the application of a concern controlled by stockbrokers for a station to communicate between New York and Paris.

Practically the same policy, with a few exceptions, has been followed by the Commission in granting licenses for point-to-point services in the channels having a continental interference range. On the whole, it has required that the applicants be public service corporations with their facilities open to use by the entire public, or by a substantial portion of it. It has rejected applications by stockbrokers, by chain-store corporations, by packers, by mail-order houses, and by others who desired radio facilities for purely private purposes connected with their respective businesses. It has eliminated several such concerns which had licenses prior to 1927. On the other hand, because of peculiar circumstances, it has permitted Alaskan canneries to continue to communicate between the southern portions of Alaska and the portions which are inaccessible to wire. It has permitted oil companies to use radio in locating oil deposits. It has permitted power companies to use radio for emergency purposes along their power lines.

It is as yet an undecided question whether the Commission will be upheld in its present policy of emphasizing the public service test. Another test which has frequently been raised in the past and is still being urged is that preference should be given only to those types of service and to those applicants whose needs cannot be met by wire or other existing means of communication. The writer believes in the fundamental soundness of this test, which is in no way inconsistent with the imposition of a public-utility obligation on most stations engaged in point-to-point service. Since radio facilities are limited, they should be employed where they will meet the greatest need from a broad public, and not a legalistic, point of view. One of the greatest advantages, perhaps the chief advantage, of radio, is that by one act of transmission, communication may be had with countless receiving stations. This may be regarded as the justification for devoting a large portion of the radio spectrum to broadcasting and other multi-directional services. Who would dare to assert that the bringing of programs of entertainment and education into millions of homes is not fully as important as—if not more so than—the sending of domestic commercial messages by radio, each concerning only two parties, which, if need be, can be sent by telegraph or telephone?

Having discussed the radio problems of international law and of national law, we must give passing mention to the subject of radio regulation by states and by cities, towns, and villages. A necessary corollary to the requirements which must be met by the ideal law regulating radio communication, previously pointed out, is that in any one country there is room for only one licensing authority. Its power and discretion must not be circumscribed by any assertion of control by smaller political units within the country, such as states or municipalities. Otherwise uniformity and general adherence to sound engineering principles become difficult or even impossible. Nevertheless, a surprisingly large amount of radio regulation is to be found in the statutes of states and in municipal ordinances. Some of them have gone so far as to attempt to limit the power, to restrict the hours of operation, and generally to determine the location of radio stations. Some states have attempted to extend their public-utility legislation to include radio stations. The conflict between state and federal control in such legislation is manifest, and lawyers generally will agree that most of these statutes are invalid.

There are, however, state statutes and municipal ordinances which concern radio and which are perfectly legitimate exercises of power over local matters. For example, ordinances which are aimed at electrical interference with radio reception by various electrical appliances, such as electric iceboxes, electric pianos, violet-ray and X-ray machines, vibratory battery chargers, vacuum cleaners, and the like, do not necessarily present any conflict with federal law, although many of these ordinances are phrased so broadly that, if construed literally, they would prohibit the running of any street car in the evening. Another set of ordinances is aimed at the operation of loud speakers in such a way as to constitute a nuisance in the neighborhood. Ordinances of this class are not improper invasions of federal jurisdiction. It is very important, however, that before states and cities rush into hasty legislation on radio, they enter upon a careful preliminary study.

Needless to say, the foregoing is a very incomplete review of radio's legal problems. It has been impossible to do more than touch on the more fundamental questions, without attempting to cover others which are no less interesting or difficult. Radio has brought into the courts and before our legislative bodies new issues on the law of slander, new applications of the law of copyright, of literary property, and of trade-mark registration, new difficulties in the interpretation of the law of patents, and, we regret to note, new methods of defrauding the public and of offending the standards of taste and decency which should be maintained in the home.

Scientific principles, and the practical necessities created by them, have a way of forcing recognition upon courts and legislatures even in the face of serious obstacles created by precedents inherited from an era of more limited knowledge. Sometimes this recognition is achieved promptly, particularly when, as a result of study and of an intelligent presentation of the newly discovered facts to them, judges and lawmakers understand the real problems and can see the inapplicability of old laws and cases which would otherwise present troublesome analogies. At other times this recognition is retarded by exasperating delays caused by unsound statutes and decisions, harmful alike to industry and to the public, and has to be achieved by a devious route hacked out with such weapons as statutory amendments, interpretation, refinements, exceptions and the like, or, in extreme cases, by amendment to the Constitution.

Eventually the slow process of corrosion will remove the obstacle, for, in a combat between the laws of science and the laws of governments, the ultimate victory will always fall to the former. In the regulation of radio communication, however, it is of paramount importance that all such combats be avoided and that legal recognition of the laws of the invisible world, as they are discovered, be prompt and unqualified.

INTERNATIONAL ASPECTS

By Lieut.-Comdr. T. A. M. Craven, U. S. N.

Technical advisor to American delegations at International Conference on Electrical Communications, Washington, 1920; International Radiotelegraph Conference, Washington, 1927; International Technical Consulting Conference on Radio Communications, The Hague, 1929

THE very fact that radio transmission at a particular location is the radiation of energy through space in all directions makes it more than a matter of mere local interest.

First, it may affect, in some way, the life of people in all the cities and rural districts of a state. And further, because of the extreme difficulty in limiting the radiation to comparatively short distances, it is almost bound to become a matter of interest to the people in neighboring states.

Then, if the power used in the transmission is sufficient, the interests of neighboring nations are involved; and if frequencies below 35 kilocycles and above 6,000 kilocycles are used, it is almost certain that the interests of nearly every country in the world will be affected in some manner.

The interest taken by other communities, states, or nations in the transmissions of a single station is twofold. First, they may desire to receive the intelligence which is transmitted from that station or, secondly, they may desire that the very transmission of this intelligence does not interrupt or interfere with the reception of messages from other stations.

In the first instance, radio enters into the political, economic, and educational phases of the daily life of the peoples of all countries as a service of value. It assists in the promotion of commerce and the exchange of news. It provides entertainment and education and aids in increasing the safety of life and navigation on the sea and in the air; and, as a whole, promotes international good will and understanding.

In the second instance, for the reason that the radio communications of one community may "interfere" with those of another, radio can become a source of dispute which may cause both domestic and international misunderstandings.

Since there are practical difficulties in obtaining international cooperation on a comprehensive scale, there are many chances where "interference" could result in numerous diplomatic complaints, especially if the available "space" should become restrictively limited.

"Interference" is at once an irritation and an interruption to service. In the latter case, it may have more or less serious economic reactions because it affects the reliability of a line of communication. The irritating phase of interference may be well appreciated if one could imagine a condition similar to that of being one of an audience at a lecture-hall, the open windows of which permitted the voice of a loud-speaking individual to permeate throughout the lecture chamber and interfere with one's hearing the real lecturer. Or, in more modern parlance, interference exists when the programs of two broadcasting stations are heard simultaneously at the same point on the tuning dial of the receiver. The economic phase can be appreciated if one depended upon the program of one of these interfering stations for his stock-market quotations.

In the case of the lecture-hall, the interference can be eliminated merely by closing the windows. But radio interference is not so easily eliminated. The problem in radio is more akin to that of having the loud-voiced individual within the lecture-hall itself. In order that such interference may be eliminated, this person must either be ejected from the hall and given space to voice his views elsewhere, or the lecture-hall must be subdivided into one or more smaller rooms, permitting several lectures to take place simultaneously.

The problem of elimination of radio interference is comparable to that of dividing the lecture-hall, because no one has the right to eject a radio station belonging to another nation if that nation refuses to move.

In many cases, there is no available space to which a station can be moved. Hence, existing stations must be crowded closer together. In radio parlance, the crowding is accomplished by requiring stations to use frequencies closer in numerical value to one another, and it is equivalent to providing more channels by decreasing the space used by each station.

How to protect existing stations against interference, and at the same time reduce the width of each channel for the purpose of creating additional space, is a most delicate international problem. It involves political, economic, and competitive factors as well as legal and engineering difficulties.

The nations of the world have negotiated treaties on the subject of interference. The first international radio conference was held in Berlin in 1903. This was more in the nature of a preliminary conference and was attended by only nine nations.

At this time, little was known of interference and the treaty dealt more with standardization of communication procedure; that is, it promoted a common understanding or practice among those engaged in handling traffic, then mostly maritime. However, at this conference, it was agreed that steps would be taken to minimize interference.

At the next conference, held in Berlin in 1906, rules of a liberal nature were adopted to prevent "interference and confusion in working." Radio was still confined almost entirely to maritime communications.

FOREIGN AND SHIP SERVICE SECTION OF SWITCHBOARD IN THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY'S LONG DISTANCE OFFICE, NEW YORK CITY.

In 1912, at London, little more had been learned and the Convention contained only the words:

> The working of the radio stations shall be organized as far as possible in such a manner as not to disturb the service of other radio stations.

At the same time, an obligation was imposed on each nation to require that the installation of its ship and coastal radio stations "as far as possible keep pace with scientific and technical progress." These two principles have stood the test of time and appear in every international Convention since that date.

However, since 1912, the use of radio has increased tremendously, and consequently the international problems have become more acute.

During the World War, many stations were erected—new types of service inaugurated, the radiotelephone developed, and new radio aids to marine navigation installed throughout the world. Then came aviation with its absolute need for radio communication. Finally, radio broadcasting swept the entire world into an intense interest and a demand for a new form of entertainment.

The result of all these new developments is to intensify further the problem of interference prevention and to increase the difficulties in securing international agreement. The reason for this difficulty is economic. Certain non-maritime nations are prone to give weight to broadcasting at the expense of communications at sea. Those who have not developed commercial aviation are unable to appreciate the importance of radio to this service and, naturally, give more weight to other types of service. There are nations which do not border on the sea and hence have to depend on other nations for their overseas communications, except in so far as radio provides them with the means for such international long-distance communication.

Until recent years, the cost of long-distance radio stations was prohibitive to smaller nations; but since the advent of high frequency or short wave radio, giving the possibility of extremely long-distance communications with a comparatively small investment, almost all nations, large and small, have entered a race to obtain radio communications enabling them to be independent of other nations for the relaying of their messages. This gives each nation a greater sense of political and economic freedom which, in various attempts at international radio cooperation, is jealously guarded.

In spite of these difficulties, each nation realizes that when a condition of interference exists, there will be no reliability of communications. Hence, there have been various attempts since the World War to arrive at a satisfactory solution of the problem.

As early as 1919, at Paris, the allied and associated powers recommended to their respective governments that there be a distribution of the ether among various types of service such as ships, aircraft, point to point, etc. These recommendations, as the result of the influence of the World War, gave undue weight to military communications. Nevertheless, they did present an excellent principle in the matter of interference prevention.

This principle received further recognition at a gathering of representatives of the allied and associated powers at Washington in 1920. Also at this conference there was an attempt to apportion "space in the ether" to various nations. This attempt failed dismally because no agreement could be reached which, in effect, would limit in any way the sovereign rights of individual nations; nor could any formula be devised which, in giving consideration to political and economic factors, would at the same time represent both an equitable or practical distribution of such an important natural communication resource as the "ether."

In 1927 the International Radiotelegraph Conference was called in Washington. The principle of distributing the ether to various types of service was adopted by the various nations of the entire world; and, after a protracted discussion in which national interests and ambitions were strongly advanced, the various countries were able to effect a compromise which will have great influence in simplifying the problem of interference reduction and permit the unhampered development of the technique. For each type of service, the considerations need not any longer be complicated with factors having no direct bearing on the particular problems to be solved.

While this simplifies the problems relating to interference in general, it apparently limits the number of stations that can be established for a particular service. Many fail to understand the necessity for this limitation; yet if such measures were not adopted, there would be ever present the extreme danger of rendering unreliable all existing types of radio communication. And because there are so many nations which are interested only in one or two types of communication at the expense of other types, there might be an immediate conflict based on economic and political ambition rather than on the general betterment of radio for all classes of service on an equitable basis.

At the present time, the situation in the parts of the ether spectrum reserved for point-to-point services is particularly acute. As has been mentioned before, the advent of the so-called "high frequencies," making possible reliable long-distance communications with but comparatively small power, has made radio a more commercially practical method of radio communication and has attracted the attention of the governments and business interests of the entire world.

In November, 1929, it was estimated that there were more than 1,500 stations in existence or under construction throughout the world for the purpose of long-distance point-to-point communications.

As an example of the importance of this subject to the nations of the world, England, France, Belgium, and Holland depend, to a large extent, upon this type of communication for "linking together the Empire." The United States uses it for maintaining its strategic and commercial communications with the Canal Zone, Alaska, its possessions in the West Indies and the far reaches of the Pacific Ocean.

Every nation, particularly the smaller nations, desires this means for communicating to countries with which it engages in trade. The lines of radio communication between the United States and South America, the United States and the Far East, and with the various countries of Europe, are an important factor in our economic welfare.

The interest of business agencies in the larger countries of the world has been awakened to the commercial possibilities and practicalities of "high frequency radio," and they have been a noticeable influence in the competition to secure "space in the ether."

This competition, involved as it is with the political and economic background, has presented a serious and difficult problem to the radio administrations of the various countries of the world, for the reason that, at the present stage of technical progress, there is not sufficient "space in the ether" for all of these stations to operate without interference.

Judging from the performance of the majority of stations in existence in 1929, there were available in that portion of the ether reserved for this type of service only about 375 non-interfering long-distance high frequency telegraph channels. With the best equipment in use by the better class of stations in operation at that time, there were approximately 765 radiotelegraph channels, about half as many as there were stations under construction. With the best apparatus considered practicable to construction today, there would be about 2,000 channels.

The idealists predict that in the future it will be possible to develop equipment which will permit the use of 10,000 long-distance channels without interference.

In any case, there will a struggle between nationalistic demands, on the one hand, and the limitation of facilities in the ether on the other. The demand is far in excess of the supply at the present, and there seems no hope of securing an agreement to decrease the demand so as to be more in accord with the supply because this involves a curtailment of sovereign rights of nations and a restriction to trade—obviously a dangerous subject even to discuss.

Therefore, the only practical factor left for negotiation is the reduction of the limitations or, in other words, an increase of the supply. This is largely an engineering problem, but it is involved with practical economics requiring close and foresighted cooperation on the part of all nations.

The principal phase of the engineering problem is the practical application of measurements of a very high degree of accuracy. This is very difficult of accomplishment and requires technical genius of a very high order. If the demand for channels is very great, we may witness a contest of skill between the engineers and scientists of many nations, the results of which are certain to be beneficial in many ways to the people of the world.

Naturally, there will be a retardation factor preventing the general adoption of radical advances in technical development. This retardation is in the form of capital invested in the equipment of a station in operation. No business organization can withstand the constant expense of radical changes in design of equipment. On the other hand, no one can logically expect to maintain reliability of communications if one persists in using comparatively antiquated apparatus. Nor under such circumstances may one expect to continue to be accorded the privilege of occupying a comparatively inordinate portion of the ether space.

Just what balance will be maintained between the safeguarding of invested capital and the necessity for making expenditures to permit another agency, perhaps a competitor, to establish a new radio station, is another problem of international politics and economics which may loom large on the horizon if the national interests of any particular country are sufficiently important to warrant exchanges of "diplomatic notes."

It is reasonable to expect, however, that the various nations will take a common-sense view of the solution of the pressing problem now before them, and will at least engage in a cooperative movement to maintain the reliability of radio communications for all concerned by adopting logical and reasonable measures to improve the technical equipment of their stations.

They have already begun such a cooperation at a meeting of the world's leading radio technicists at The Hague in September, 1929. At this meeting, the engineering phase of the problem was recognized as difficult; nevertheless, recommendations were made with the various governments to adopt high technical standards as a method of reducing interference and increasing the number of channels.

If these recommendations are adopted by every nation, disputes will be rare and progress in the radio art will be rapid. On the other hand, if all nations do not adopt these recommendations, there may be not only a decrease in the efficiency of long-distance radio communications of every nation, but also consequent irritations leading to general disputes and misunderstandings which may require international adjudication through arbitration.

It is expected that the desire of each nation of the world to maintain the reliability of its own communications will naturally make cooperative improvements the common-sense course of action.

Whatever happens, the interest of every nation is affected, and care must be taken to maintain international good will throughout the difficult solution, so fraught with new applications of international law, of this political, economic, and scientific problem of the modern era. Patient cooperation and understanding on the part of every nation will be required in order that the spectacle of confusion and disorder may be avoided.

RADIO BY THE AMERICAN PLAN

By Clarence C. Dill

United States Senator; Co-author, Radio Act of 1927

THE legislative problems which radio presents in the United States are widely different from and far more difficult than those of other countries. In nearly all other countries, the government either directly or indirectly manages and controls radio stations and levies taxes or fees to provide funds for their operation.

In the United States, Congress has refused to do either. The only government radio stations are those maintained by the Army and Navy for departmental and official use. In the field of broadcasting reception, the government has left radio listeners absolutely free.

Any resident of the country may make his own set or use any kind of a ready-made set. Properly equipped, he can listen not only to radio broadcasting, but to everything else in the ether, from transatlantic telephone conversations to S O S calls and the experiments of amateurs.

Not only that, but the provisions of the radio law set up as the one and only standard for the issuance or refusal of a broadcasting license, the public interest. The public interest is an indefinite term. The radio public consists of the radio listeners. Their interests are forever changing, and just how best to serve them is an ever-changing problem.

During the period from 1921 to 1927 radio broadcasting was handled by the Secretary of Commerce under a kind of gentlemen's agreement between him and those engaged in broadcasting, because the then existing law applied only to wireless telegraphy and was intended to regulate only such use of radio. Radio broadcasting was entirely unused in 1910 and 1912, when radio laws were passed with maritime communication chiefly in mind.

The law of 1927 was entirely new legislation covering radio. There was nothing like it in any other country. Neither American jurisprudence nor the jurisprudence of other countries gave any precedent or basis for it. Congress acted under the general powers of the Constitution for the public welfare and the public good, but claimed jurisdiction primarily under the commerce clause of the Constitution. It is indeed a new species of commerce, but Congress believed it commerce, nevertheless.

It had only the Interstate Commerce law as a precedent, but could not treat radio as it had treated the railroads in a legislative way for a number of reasons. In the first place, radio is an intangible thing that cannot be seen, felt, or heard as such. There is nothing concrete nor physical about it, except the apparatus used for transmission and reception. The conception called the ether is a theory of scientists. The waves of electrical energy which radio engineers claim pass outward with equal force in every direction from center to circumference, carrying sound or light, are not only unrecognizable by the physical senses, but there is no known method or material to stop them. Certain conditions of the earth and air and man-made interferences hinder and sometimes stop these waves, but radio experts have not yet been able to control or even understand fully these phenomena.

In face of these facts, or rather this lack of understanding, Congress found it necessary to pass legislation or permit radio confusion to grow worse and worse because of the lack of authority in any government official to regulate the use of radio apparatus. Still more important was the fact that unless Congress did act, those who had expended large sums of money for broadcasting equipment and radio service would appeal to the courts for protection of this use of their apparatus. They would secure injunctions against the use of other radio apparatus in a manner that would interfere with the programs they were sending.

In fact, one station in Chicago did take such steps, and the court very properly declared that as long as Congress failed to provide a system of radio regulation the court would recognize and protect such rights.

What did this mean? It meant that within a short period of time every frequency, or wave length, in radio would be used under judicial order and those using such frequencies would probably acquire vested rights in such use, so that rights to the use of all radio frequencies in this country would become privately owned.

Radio in all its forms, both its present uses and its unknown possibilities, constitutes a natural resource of incalculable value to the whole people. It will have still greater value for future generations. It is one public domain that should never be parceled out to private ownership for any price. Yet to be valuable either to ourselves or to our posterity, it must be used and developed.

Foreign governments generally seem to have recognized these facts. They have been extremely jealous of the use of radio privileges and the acquisition of radio rights. Government ownership of public utilities, generally by the state in many countries, made government ownership of radio facilities quite natural and easy to establish. In addition to this, the purpose of many governments to keep control of the transmission of information and views on public questions made a high degree of government control necessary.

But, in the United States, private initiative and freedom of radio, both as to broadcasting and as to reception, represented the American way of utilizing this great resource. Not only was it desirable that Congress should encourage this spirit of private initiative and maintain the freedom of development and use of radio, but it was also absolutely necessary that the legislation enacted prevent any person, firm, or corporation from acquiring any vested rights in the use of radio apparatus. This was necessary if this great national resource was to be retained for the people's benefit.

The radio law of 1927 went as far as legal language can go to make it impossible for anybody ever to acquire vested rights in the use of any part of the radio spectrum. The opening section declares the purpose of the Act to be to regulate radio transmissions and communications, and "to maintain the control of the United States" over all radio channels and "to provide for the use of such channels, but not the ownership thereof" under licenses. Then are added these significant words: "And no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license."

In subdivision H of Section 5 is found this language: "No station license shall be granted by the Commission until the applicant therefor shall have signed a waiver of any claim to the use of any particular frequency or wave length or of the ether as against the regulatory power of the United States because of the previous use of the same, whether by license or otherwise."

In subdivision A of Section 11 is a third provision which reads as follows: "The station license shall not vest in the licensee any right to operate the station nor any right in the use of the frequencies or wave length designated in the license beyond the term thereof nor in any other manner than authorized therein."

These quotations, together with the first paragraph of Section 9 of the Radio law of 1927 (which reads as follows: "The licensing authority, if public convenience, interest or necessity will be served thereby, subject to the limitations of this Act, shall grant to any applicant therefor a station license provided for by this Act") have been termed the American people's "Magna Charta of the air."

Congress has attempted by this legislation to safeguard forever to the people the complete ownership and control of the rights to use radio apparatus in the United States.

The United States Supreme Court must decide whether or not the Constitution empowers Congress to accomplish that end. The lower courts have sustained the legislation. They have negatived all claims of property rights or vested rights in the use of radio apparatus. The Supreme Court has had these questions placed before it as this is written.

Radio is so deeply imbued with the public interest that it is unthinkable that any private rights should ever separate it from that interest. Nobody should be permitted to possess permanently any superior or preferred right in the use of radio as against others who are willing and able to furnish better or more desirable radio service. The unknown possibilities of radio yet to be developed serve to emphasize this truth more than any language can.

Owing to the fact that there is a limited number of frequencies or wave lengths available for use, Congress must prevent private ownership in rights to use radio apparatus in order to insure freedom of development in the art. Every year, almost every month, somebody discovers or invents a new use for radio waves. With regulation unhampered by private rights, the federal licensing authority can act in the public interest in accordance with new conditions. If it were confronted with private property rights in the use of frequencies or wave lengths, it would be compelled to secure the consent of the owners of these rights or provide compensation for new uses of frequencies privately owned. That would mean stagnation and strangulation in the development of the art.

Next in importance to preventing private ownership of radio facilities is the prevention of the monopolization of the use of radio by those who secure licenses from time to time. A monopoly of property is one thing. A monopoly of the one-way mass communication method of forming public opinion, of presenting views and ideas on every kind of subject, of creating and developing musical tendencies in people, is another and entirely different thing.

Congress would find it extremely difficult, if not impossible, to legislate on all the situations and conditions that develop from time to time. For this reason, the radio law granted the Federal Radio Commission, which it established, extremely broad powers. The law gives it special authority to deal with chain programs and forbids the granting of licenses to those found guilty of violating certain statutes against monopoly and unfair trade practices. Although the Commission has used its powers in a conservative and restrained manner, experience demonstrates that these powers and restrictions should be enlarged rather than diminished.

As stated in the beginning of this article, all of the legislative problems of preventing private ownership of radio, and most of those relating to monopolistic or one-sided use of the radio, could be avoided by government operation and control of programs by providing for their expense by a government tax. But that is not the American way. Private initiative, private capital, and, most of all, American business methods of popularizing and developing radio, have placed radio in this country far ahead of that of any other country in the world. In every part of this country and among every kind and class of our people, radio is growing more and more popular and therefore more and more valuable as a method of supplying information and entertainment. In no other part of the world does radio hold such a big place in the lives of the people as a whole as here in the United States.

The only thing that will destroy this popularity, this service to all, this freedom both of broadcasting and of reception, will be the abuse of the privileges now permitted by law. If those now engaged in the use of radio disregard public interest and abuse the freedom they now enjoy, the American people will demand that Congress abolish all private control and all private rights in the use of radio and provide for government operation of every kind of radio apparatus.

Let it be said, also, that to no subject that can come before Congress will the members of both House and Senate be more responsive than to the subject of radio. They know that radio reaches everybody, everywhere, instantaneously and simultaneously, and that on such a subject public sentiment will be irresistible.

A forward-looking spirit on the part of most of those engaged in the industry in this country, and a liberal policy by Congress, have brought radio to its present place. Since Marconi's feat of spanning the Atlantic with radio waves, most of the great radio inventions, and by far the greatest radio developments, have been produced by American inventors and American business men. Radio as we know it today is truly an American art developed and used in the American way. We should keep it so.

A COMMISSION ON COMMUNICATIONS

By James Couzens

United States Senator; Chairman, Senate Committee on Interstate Commerce

PUBLIC opinion in any republic worthy of the name always will direct and determine for good or for evil the future of the government.

Public opinion, to be highly effective, must be organized and marshaled. These necessities are well understood by the skilled publicists and propagandists who are interested in various causes. Public opinion must also be articulate, and certainly, in the interest of good government, public opinion should be based on accurate information and a complete statement of facts.

All of this may sound trite, and probably it is trite until we reflect on the development of the radio, its place in industry, its place in government, and its place in the life of the people. The radio has revolutionized conditions surrounding the transmission of information and entertainment and has provided facilities to assist in the development of public opinion which are perhaps more effective than anything that might now be conceived.

At the same time, while the radio art has offered to us tremendous opportunities for the welfare of good government and good citizenship, it has brought to the fore certain problems. Not the least of these is the question of regulation and control of this tremendous power.

We are a young nation, a very young nation relatively. Yet it is interesting to reflect on the changed conditions that have come upon us in a comparatively short time. Only a few generations ago, we were a closely knit people living within the radius of a few hundred miles of Washington. But with only a few hundred miles intervening, the problem of distance was one which was of the utmost concern to our founders. Some of the wisest of our early statesmen were opposing the admission of Western territories to the Union because it was contended that the inability to communicate rapidly would prevent those people from actually becoming a part of the government. Citizens within a very short distance of Washington were dependent upon the courier for information. Today, a word spoken in Washington, thanks to the radio art, may be heard instantly throughout the country, and the citizen living thousands of miles away along the Pacific Coast may be in as close touch with his government as are the residents of the District of Columbia.

It is because of this transition, marvelous almost to the point of being miraculous, that the government must consider the problem of soundly informing public opinion.

The early fathers had the sound conception that safety lay in an informed public, that the best democracy would be derived from a people possessed of the greatest information. They were concerned to protect the right of free speech and a free press and determined to prevent a censorship on individual thought. Just as they were concerned to insure freedom of the press, so must we now be concerned to insure the utmost freedom of speech and communication through the radio.

From this viewpoint alone, there is hardly any need to argue the cause of government regulation of the radio. Few people will question this necessity, and I believe that few do. This avenue of communication must be maintained and conducted for the interests of all of our people. The government must see that this is done. As one witness before a Senate committee declared, it is as impossible to conceive of the facilities of the radio being controlled by a purely private interest and for the welfare of a purely private interest as it would be to think of surrendering the individual power of speech. It is, as President Hoover has said, inconceivable that a free people would permit this means of communication to fall into the hands of a selfish group, or a monopoly, which would use it for the interests of that group or monopoly. And when we try to visualize the power that lies within the radio, it is not difficult to admit the soundness of the contention of another witness, who declared that a monopoly or purely selfish group, given absolute control of the radio, might easily become more powerful than the government itself.

There is another point well and soundly made in behalf of government regulation and control. The government must retain this power to protect the radio and to permit it to live and develop. The very peculiarities of this means of communication permit it to become the instant prey of anyone bent upon its destruction. A small boy with his amateur contrivance may emit such power into the air as to produce a bedlam of noises and prevent the reception of information. What might be done by conflicting interests intent upon destroying communications may be readily understood.

In view of these facts and these conditions, opposition to the government maintaining regulation and control of the radio is disposed of instantly.

The question still remains, however, as to the best method to be adopted by the government for the regulation of this utility. No sane person has any desire to hamper or obstruct the development and use of the radio. It has become so much a part of our daily life that the public would not permit destructive tactics. The contending viewpoints presented by the various parties interested undoubtedly arise as a result of the same causes that produce differences of opinion in practically every question of government. The issues of government control and regulation should be presented and debated with these thoughts in mind.

Regulation of radio early became a function of the Department of Commerce because it was the only means of ship communications. As the use of the radio developed, the entire administration remained in the Department until the Congress created the Federal Radio Commission early in 1927. But even with that creation, there has remained the contention of many sincere students that the administration of radio would be more efficient if left in the Department of Commerce.

There is legitimate contention against the creation of new boards, bureaus, and commissions in Washington. I have been one of those who have so contended, and I am still one of those who oppose the development of bureacracy in government. However, criticism should depend upon the particular question at issue. In this case, I do not think there can be sound criticism of the commission form of control. I have favored the creation of a Commission on Communications. This does not involve the creation of a new commission, but rather merely calls for the substitution of one commission for another commission.

In any plan which would place the administration of radio in the Department of Commerce or any other department, there is the certainty of one-man rule. The Secretary of Commerce may become the voice of this power, but everyone knows the Secretary must delegate his authority to subordinates. Regardless of what title that subordinate might have, we would have a departmental subordinate dealing with this utility, a subordinate who would hold in his hands, largely, the destiny of an immense power.

In dealing with the radio, the government must dispose of franchises of tremendous value. Just how valuable they are from the viewpoint of profit or gain, it is impossible to say at this time, but that they are of great value is shown by the bitter fights that have already developed over them. Incidentally, some measure of their value can be found in the willingness of corporations to pay millions of dollars for these rights. Because of this, there should be determined opposition to turning this authority and power to dispose of them over to one individual. Human nature is not infallible and it is not above temptation, duress, coercion, and error.

The argument made invariably for departmental control is that commissions move slowly, that they encourage debate and delay in the meeting of minds. Individual control, it is contended, permits prompt action and places the responsibility on the one individual. But efficiency does not mean only speed or rapidity of action. We have made that declaration in the manner in which we have organized this government. We have provided for a system of checks and balances, for deliberation and debate. Despite irritations which arise, most of us will admit that our form of government is sound at least, and that it has carried us through many hazardous experiences.

Undoubtedly, much of the opposition to a commission to regulate radio developed as a result of experiences with the Federal Radio Commission. However, in any criticism of the Radio Commission, fairness should have dictated that consideration should have been given to the immense and difficult task placed upon the members of that Commission. Here we had a new art. The Commission had to chart its course and feel its way with the realization that perhaps tomorrow another discovery would lift the veil and present new opportunities and new problems. At the same time, the Commission was operating with the knowledge that its authority was of a temporary nature, that it was existing from year to year only, that it must organize a staff of experts and of clerks with the understanding that the tenures of office were not fixed and jobs might end with the passing year. In view of these difficulties, it seems hardly fair to discuss the Commission form of government of the radio from the experiences with the Radio Commission.

In the establishment of a Commission on Communications we have a proposal for a definite tenure of office and a permanent body. We have the hope that gradually this Commission will develop until it will gain the confidence and respect which is had by the Interstate Commerce Commission.

Everyone admits that communications by wire and by wireless are intimately related. In fact, up to the present time, the developments in one art have been so related to those in the other that the efficiency of the one has relied to a great degree upon the efficiency and the utility of the other. Students of the radio art are largely agreed that in all probability these conditions will continue, and that the relationships may become more intimate instead of less. Why, then, establish a distinct Radio Commission with the certainty that another government organization is administering its twin utility, that decisions in one field and by one commission probably will have to be harmonized with decisions by another commission, and with the thought that at some future time we shall build another "ell" to our radio house by transferring the authority to regulate wire communications? Why not, then, do a complete job? The answer from some students is that the regulation of radio will suffer, that the task will be so great, because of the additional duties relative to regulating wire communications, that the whole administration will bog down.

Regulation of wire communications has been a duty of the Interstate Commerce Commission. But communications have been an unwanted stepchild of this Commission, and the future offers no reason to believe that more time and more opportunity will be had by its members to administer these duties.

The Interstate Commerce Commission has had its hands full with the regulation of railroads, so full, in fact, that the original plan for the Commission has been changed largely. Originally, it was created with the thought that it would function as a Commission. It was to initiate action, to administer the law. New tasks and the growth of old tasks have changed the picture, however, and the Interstate Commerce Commission has been forced into the position where it is to a great degree a court to which cases are brought. All of this work has been related to transportation; we may say all of it because very few cases involving wire communications have been considered, and where the matter has been purely interstate in character, there has been little in the way of regulation.

In view of this condition, what loss would result for the administration of wire communications if authority over the telegraph and telephone were to be transferred from the Interstate Commerce Commission to a Commission on Communications? We would lose nothing, but we would gain an opportunity for the Commission on Communications to build for the future.

As to details of legislation and details of administration, they must be left for further consideration. Once we are agreed upon the establishment of a permanent Commission on Communications, we shall find some way of resolving differences over the details and reaching a decision. And once the Commission is established, methods will be found whereby the Commission may transfer to subordinate executives much of the routine work. Gradually we shall build another organization like the Interstate Commerce Commission, which itself is the result of slow and gradual growth.

PART V: SOME SCIENTIFIC AND OTHER CONSIDERATIONS

HOW RADIO WORKS

By John V. L. Hogan

Past President, Institute of Radio Engineers
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THE best way to get a clear understanding of how radio works is to consider separately and successively the three fundamental parts of the radio system. Whether we are concerned with the telegraph or the telephone, or even with television, we will find that these three divisions exist and in each case have comparable purposes and structures. In fact, all communication systems have the same basic features; for, to send intelligence from one point to another, we must always provide (1) a transmitter that can start the message going, (2) a conveying medium that can carry it from the origin to the destination, and (3) a receiver that can intercept the message and reproduce it intelligibly. Roughly, these three essentials correspond in their functions to the meanings of the words *"in," "through"* and *"out."*

Let us consider first the radio transmitter. In its simplest modern form this begins with a small vacuum tube, not much more powerful than the tube that drives the loudspeaker in a home radio receiver. This first tube is supplied with electrical energy in a circuit so arranged that it will oscillate, or generate very rapidly changing currents of electricity. These currents vibrate, or alternate in their direction of flow through the circuits, at an exceedingly high rate. The number of times they vibrate in each second is known as their frequency, and may be of the order of millions.

Next in the transmitter we come to a signaling device of some sort. For sending telegraphic messages, it may be simply an ordinary telegraph key. For telephony it will usually consist of a special microphone or telephone transmitter and a few vacuum tubes used to intensify the voice or music currents. In either case the signaling instrument is interposed between the master oscillator or current-generating tube, referred to in the above paragraph, and the later portions of the transmitter. It is arranged to control the strength of the oscillations so that they will properly represent the desired signals.

The high frequency (or radio frequency) currents as controlled by the telegraph key or microphone are then passed to a number of larger vacuum-tube amplifiers, in the circuits of which they are built up from their relatively feeble initial intensity to a value as powerful as may be needed. In a modern station the amplified currents delivered from these final vacuum tubes often represent hundreds of horsepower. Despite their great strength, they are exact copies of the weak oscillations produced by the first small tube or master oscillator, and they swing back and forth in their heavy copper circuits at the same surprising frequencies of millions of vibrations in each second.

Finally, the amplified transmitter-currents are fed into an antenna or aërial wire system, usually supported from tall towers or masts. As the currents surge up and down in these wires, they produce radio waves that flash off into space in all directions. The radio waves are not unlike light waves, though they are, of course, not visible to our eyes. One may, however, imagine the antenna wires of a radio sending station as glowing with energy like a huge electric sign, the radio-illumination (which we cannot actually see) spreading upward and outward over the surface of the earth to great distances.

Broadly speaking, that is all there is to a modern radio transmitter. It will be worth while, however, to consider in a little more detail just how the signals are impressed upon the radio waves. Suppose we have a telegraph message to send. In that case we will arrange our telegraph key between the master oscillator and the power amplifiers, so that when we press down the knob of the key the oscillations will be connected through to the radiating antenna and their energy will be sent out as a stream of radio waves. When we release the key-knob, however, allowing it to spring upward, the circuit from the master oscillator to the antenna will be broken, and, therefore, no waves can go out. Thus, by pressing the key for successive short and long intervals corresponding to the dots and dashes of the Morse code, we can spell out our message, letter by letter and word by word. For every dot a short stream of waves will be radiated from the antenna, and for every dash a longer stream. If we could see the waves, the transmitting towers and aërial wires would appear to flash on and off for the short and long intervals marking the dots and dashes; while the sending key was held down the country-side would be brilliantly alight, and then when the key snapped up and cut off the waves, all would be in darkness.

The transmission of speech or music is not much more complicated. Instead of interrupting the path of the oscillating current from the generating tube to the antenna, and so chopping the radiated waves up into groups representing the telegraph code, the oscillations are allowed to stream through the system continuously. However, their strength is altered by the microphone from instant to instant, so that they will correspond in intensity to the vibrations that make up the sounds to be transmitted. The radio waves sent out from the antenna system always have a strength which is proportional to the power of the currents flowing in the circuits. Consequently, in a radiotelephone transmitter the waves themselves quaver in intensity exactly as do the sounds produced before the microphone at the sending-point or studio. Going back to our illustrative example, in which we imagine that we can see the radio waves, a broadcasting station aërial would appear to be continuously lighted, but its brilliancy of illumination would increase and decrease with the intensity of the sound vibrations being transmitted.

So much for the first part of the radio system. The second division involves the passage of the radio waves through space from the sender to the receiver. Relatively little is known of the exact mechanism involved in this wave-motion, but present-day researches are clearing up many of the problems. It is known, however, that the radio waves travel with very nearly, if not exactly, the speed of light, namely, 186,000 miles per second. This means that a radio signal will go half-way around the earth, a distance of more than 12,000 miles, in about one-fifteenth of one second.

It is also known that radio waves pass through or around most obstacles, and so can travel to such great distances. They are affected in their progress, though not stopped, by some phenomena depending on sunlight; consequently, many radio waves travel better at night and in winter than by day or in summer. They pass more easily over sea water than over land, and some radio waves can only with difficulty penetrate the iron-work of great cities. All radio waves, like light or sound waves, rapidly grow weaker as they travel away from their points of origin. Each radio wave has the same frequency of vibration as has the alternating current that produces it, and this characteristic frequency remains the same however far a radio wave travels.

Furthermore, the length of a radio wave in space can be measured. The wave length is the distance that the wave travels in the time of a single vibration or cycle, and, since the speed of the wave is fixed at a definite value, the wave length is directly related to the frequency of the wave. Knowing a wave's frequency, we can at once find its length. A broadcasting wave of 600-kilocycles (600,000 cycles)-per-second frequency has a length of 500 meters, or about one-third of a mile, as we determine by dividing 600 into 300,000 (the speed of the wave in kilometers per second). Similarly, a 1,000-kilocycle wave has a length of 300 meters, as may be calculated by making a similar simple division.

The matter of frequency (or wave length) is all-important in radio practice, for it is this characteristic of the waves that permits us to tune or select the radiation of one station from the waves sent out by another. Radio waves of a multitude of different frequencies, transmitted from hundreds of different sending stations, are continually flashing through the space about us. If it were not for the fact noted above, that each individual wave keeps its own frequency as it travels away from the sending station, and without regard to how many other waves are passing through the same space at the same time, radio communication could hardly be a practical thing today.

Having in mind this general idea of the second main part of the radio system—the waves carrying signals from the sending-point and spreading out in all directions—let us take up the third part, that is, the radio receiver. It is an interesting scientific fact that whenever a radio wave strikes an electrical conductor, such as a length of wire, it will generate in that conductor a series of rapidly vibrating electric currents. These currents always vibrate with the same frequency as does the arriving radio wave that generates them.

If we purposely arrange a wire so that it will be effectively struck by passing radio waves—for instance, by spreading it out over a reasonable space and fairly high in the air—we have made a receiving antenna or aërial wire system. Such an intercepting-conductor, in some form or other, is the basis of every radio receiver. The next step is to provide a connection through which the wave-currents in the receiving antenna may flow, and this connection usually includes one or more tuning circuits which permit currents of only one general rate of vibration (or frequency) to flow. Such a circuit generally includes a coil of wire, called an inductor, and a variable tuning condenser consisting of two groups of intermeshed metallic plates. By adjusting the tuning condenser, one is able to control the frequency of the current which will best pass through the circuit, and thus to select the waves of certain transmitting stations which are of certain definite frequencies.

In addition to the tuning circuits, most radio receivers contain several vacuum tubes called radio frequency amplifiers, whose function is to intensify the rapidly-vibrating currents generated in the antenna system by the arriving waves. If the waves come from a great distance, or if the receiving aërial wire is relatively small, the wave-currents will inevitably be very feeble. In such cases the radio frequency amplifier tubes are extremely useful, for they magnify very effectively the minute vibrating currents that carry the messages or sound which we desire to receive.

After tuning and magnification comes perhaps the most important operation in the radio receiver, namely, the detection of the signals, or their separation from the wave-currents that have carried them up to that point. This is generally accomplished by means of another vacuum tube, with its appropriate circuits, called a "detector." Its operation is to convert the varying wave-currents, generated in the antenna and led through the tuning and amplifying circuits, into a type of slowly varying current that is directly capable of operating a telephone receiver so as to produce sounds. When only a few people wish to hear the radio signals, ordinary telephones may in fact be connected right to the detector tube of a radio receiver and the dots and dashes of telegraphy or the speech and music of radiotelephony may be heard by listening to these telephones.

Generally, however, the signal-currents produced by the detector tube are in their turn magnified by one or two additional vacuum tubes called audio-frequency amplifiers. Thus strengthened, the currents are applied to a type of overgrown telephone receiver which is capable of reproducing the signal sounds so clearly and intensely as to earn the name "loud speaker." This is generally the final element in the radio communication system. With the aid of the various instrumentalities and natural phenomena that have been outlined in tracing the path of the signals, the loud speaker reproduces at the receiving end a more or less exact copy of the sounds or signals originally created at the point of transmission. Thus the desired object is attained, with a degree of perfection depending very largely upon the care and skill used in the design and adjustment of the many interlinked parts of the system extending from speaker to listener.

It takes some time to consider, however briefly, all of the transformations of energy and all of the instruments that lie between the microphone or telegraph key at one end and the loud speaker at the other. One is apt, therefore, to overlook the fact that because of the astonishing speeds at which electric impulses and radio waves can travel, the whole series of operations takes place almost simultaneously. When you listen by radio to a speaker addressing a large gathering, your radio set brings you his words even before they have reached the most distant members of his immediate audience. A listener standing 600 feet from a brass band will hear any particular note about half a second after that same tone has reached you by radio, even though you may be hundreds of miles away.

The other general effect of radio that one is apt to lose sight of, in considering a system made up of one transmitter and one receiver, is its distributing power. A telephone wire ordinarily connects only two people; it runs from one point to another. On the contrary, radio waves spread out in all directions and by their use one point may literally be "connected" with *all* other points and, at least conceivably, one man can speak at one time to every other person on this earth. The natural or inherent spreading of radio waves is one of the fundamental things that has made possible not only broadcasting, but also dependable communication with ships at sea, with automobiles in great cities and with aircraft over the oceans and land. It permits the interchange of useful signals over great distances, without requiring either the sender or the receiver to be fixed in any definite position. Thus radio is like no other communication system, and has service possibilities that, so far as we know today, can be attained in no other way.

SHORT WAVES

By A. Hoyt Taylor

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SINCE frequency and wave length are in reciprocal relationship, the expression "short wave" is synonymous with the expression "high frequency." Since the length of the wave sent off from an antenna is to some extent dependent upon the medium through which it penetrates, and is therefore not rigidly a fixed quantity, it was decided at the International Radiotelegraph Conference at Washington in 1927 to refer to radio frequency waves and oscillations henceforth, for official purposes at least, in terms of frequency rather than wave length.

When we do speak of wave length, we mean ordinarily the wave length in free space or (what happens to be substantially the same thing) the wave length in non-conducting air. If we were to measure the wave length in hard rubber, glass or various other materials through which the wave is capable of being propagated, we would find it very different.

In further clarification of this matter, it may be stated that, in round numbers, we may think of a frequency of 10 kilocycles as corresponding to a wave length of 30,000 meters, and, reciprocally, we may think of a frequency of 30,000 kilocycles as corresponding to a wave length of 10 meters. At 500 kilocycles the wave length is 600 meters. The wave length corresponding to any frequency may always be obtained by dividing the velocity of the electromagnetic waves in free space by the frequency. This velocity is 300,000,000 meters per second.

Now the frequency at which we consider the wave length to be short—in other words, the region of the high frequencies or short waves—is one which is continuously shifted. Only a few years ago frequencies of 1,500 kilocycles, corresponding to 200 meters, and all higher frequencies were considered, from a radio engineering viewpoint, very high frequencies corresponding to very short waves. It was also erroneously supposed that all such short waves or very high frequencies were useless from the standpoint of effective long-distance communication. Today we find many earnest investigators studying waves which are shorter than one meter in length and therefore corresponding to frequencies higher than 100,000 kilocycles. We also well know that there are other enormously higher oscillations of still shorter wave lengths which exist and which gradually merge into the rays commonly known as light and heat.

The total spread of spectrum of known electromagnetic oscillations is tremendous; and whether or not frequencies are considered high—*i.e.*, waves short—depends very much upon what particular point of the spectrum the engineer or investigator is interested in.

However, a rough subdivision is not only possible, but has come to be more or less tacitly accepted in international negotiation and elsewhere. In this classification, frequencies higher than 1,500 kilocycles, or wave lengths shorter than 200 meters, are known as high frequencies or short waves. We are also already using in common parlance another term, namely, super-frequencies or ultra-short waves—designating waves corresponding to frequencies higher than 23,000 kilocycles, which was the limit of the wave allocations considered at the Washington Conference. In due time it is likely that still further subdivisions of the region may be necessary on account of the rapidly changing character of the waves themselves and the very definite types of applications to which they lend themselves.

It may well be wondered why the amazing ability of the high frequencies to penetrate to immense distances with a ridiculously small amount of power had not been discovered earlier. The answer is that theoretical conceptions of the mechanism of wave propagation were not sufficiently definite, nor was the vital rôle played by the Kennelly-Heaviside Layer quite fully appreciated, until the advent of experimental work in short wave communication which immediately caused a general overhaul of wave propagation theory. The radio amateur played no small part in such experimentation.

Now the existence of the Kennelly-Heaviside Layer has been well known for a good many years. It is a region of partial conductivity at a considerable distance above the surface of the earth. This conductivity is due to free electrons primarily produced by ultra-violet light from the sun, and can only exist in the earth's upper atmosphere. This is true for two reasons: in the first place, very little ultra-violet light penetrates to the lower levels of the earth's atmosphere; in the second place, conditions are not right in the dense molecular population of the lower atmosphere for the production of a large number of free negative particles, namely, electrons.

It may truly be said that in the old days we were looking all the time too close to the ground. The radio waves we were mainly dealing with then always seemed to glide over the ground, standing almost but not quite erect upon the ground and being absorbed by the inevitable induced currents in the ground to a more or less extent depending upon their frequencies.

Elaborate studies were made many years ago on earth absorption, which quite fully explained the behavior of normal daylight wave propagation up to 1,500 kilocycles, and showed that the higher the frequency—that is, the shorter the wave—the worse the absorption became, and therefore the more limited was the range of the higher frequencies.

There was, consequently, little encouragement for the investigator to explore the regions above 1,500 kilocycles.

But these regions were ultimately explored, and astounding results were shown. Instead of the penetration or range of the wave steadily falling off, it began abruptly to rise to enormous values even for transmitters of very little power. Since that time the whole mechanism of radio wave propagation has received much study, and although it is by no means fully understood, it has received a general revision which clarifies not only the peculiar and amazing propagation of the short waves, but has cleared up many phenomena hitherto associated only with long waves. We are at last beginning to appreciate fully the dominant rôle played by the upper atmosphere of the earth in the propagation of all waves, particularly the short waves. Indeed, it is no exaggeration to say that radio communication over distances exceeding more than a few miles would be entirely impossible without the assistance of the Kennelly-Heaviside Layer which exists in the upper regions of the earth's atmosphere.

We know now that, in general, besides our old friend the ground wave, which slipped off the antenna and walked away over the surface of the earth, there exist other rays from the same antenna which rise high into the upper atmosphere and are there refracted or bent back to reach the earth at remote points. We know further a great deal more about the absorptive qualities of the upper atmosphere and are aware that the absorption is enormously less than the absorption which so rapidly sucks the energy out of the ground wave and impedes its progress.

The sky wave which has traveled to the upper atmosphere and down again to reach some remote part is, comparatively speaking, little hampered in its progress, and is therefore able with very little power in the transmitter to reach out to immense distances with sufficient energy for adequate reception. However, since the state of the upper atmosphere varies greatly from day to night and considerably from season to season, to say nothing of material geographical differences, high frequency or short wave phenomena are anything but simple.

If the frequency is made too high, we find that the wave completely penetrates the outer atmosphere and is not valuable for communication with other points on the surface of the earth. Perhaps it will ultimately be used for communication with Mars, but we must admit there appear to be other difficulties more insuperable than possible differences in language and code between this planet and that one. Also, it must be noted that the number of electrons in the upper atmosphere falls off greatly at night, so that it is not as well able to turn waves back toward the earth again. This means a reduction in frequency for night work, since the higher frequencies are more difficult to turn back to earth again than are the lower.

We also encounter the phenomenon known as skip-distance, which, until well understood, was quite a stumbling-block. At the frequency, for example, of 16,000 kilocycles, or wave length of about 18 meters, the ground wave from the antenna progresses outward only a few miles before it is so seriously absorbed as to render reception difficult or impossible. The sky wave in the meantime mounts to the Kennelly-Heaviside Layer, but if it strikes it at anything but a rather oblique angle, it penetrates the layer and leaves the earth's region. That portion of the sky wave which does strike obliquely is immensely valuable for very long distance communication over thousands of miles. However, a simple study of the geometry of the situation will show that the ray drawn from an antenna on the surface of the earth and striking the Kennelly-Heaviside Layer at, say, 100 miles above the earth, at a very oblique angle, must come down again a good many hundreds of miles away from the starting-point and cannot come down any nearer. There is, therefore, a region between the transmitter and the first downcoming sky wave in which the transmitter is not heard except for very feeble echo signals which we will discuss later. Of course, the ground wave does penetrate a very few miles into this region, but not far enough to be of any value for distant communication.

This curious ability of the short wave to skip over certain stations, perhaps 400 or 500 miles away from the transmitter, and yet be very well received at stations 1,000, 1,500 or 2,500 miles away, is called the skip-distance effect. This is, when properly appreciated, no particular obstacle to the use of these frequencies for communications, and indeed may be a distinct advantage under certain circumstances.

In general, we find the lower frequencies in these newer bands, as between 1,500 and 6,000 kilocycles, used for what might be called local or national work, since their daylight ranges are 1,000 miles or less. True, the upper half of this band, between 3,000 and 6,000 kilocycles, oftimes has tremendous night ranges. Nevertheless, because of the still greater suitability of somewhat higher frequencies for very long distance work, we may consider the region from 1,500 to 6,000 kilocycles as local or regional in extent. They were so recognized at the first meeting of the International Technical Consulting Committee on Radio Communications held at The Hague, Holland, in September, 1929.

These frequencies lend themselves to almost any type of radio communication, although there are certain inherent objections which interfere (without entirely preventing their use) with telephony, television, and facsimile work, particularly at night. I refer here to multiple signals and echo signals. Since the effective height of the reflecting layer is more at night than it is in the daytime, the sky wave in general travels farther to reach given points and, furthermore, travels by a good many possible paths which consist of alternate reflections at the surface of the earth and refractions where it bends down again from the Kennelly-Heaviside Layer. Many of the different rays from a transmitter might, by following different paths, therefore simultaneously reach the receiver, but the trouble is that they do not all get there at the same time. This gives us a certain amount of drag, or hang-over, to the signal, which may not be at all noticeable in slow-speed code work, but which becomes troublesome with code work at high speed and highly obnoxious with any system requiring fast modulation, as, for instance, facsimile work, telephony, and television, which require rapidity of modulation, increasing in the order given.

The frequencies from 6,000 to 12,000 kilocycles are admirably adapted for distances up to 2,000 miles—sometimes somewhat more—for daylight work and usually for very great distances indeed at night. It was on such frequencies, for example, that the United States Navy sent its traffic directly to Washington from Melbourne, Australia, during the Australasian cruise of the Fleet in 1925. This distance was 10,000 miles, accomplished with less than 200 watts and without any intermediate stations taking part in the movement of traffic.

From 12,000 to 22,000 kilocycles, we have a region of frequencies corresponding to the wave lengths from 25 to 13 meters, primarily best adapted to long-haul daylight communication and not well adapted at all for work during the dark hours, because the Kennelly-Heaviside Layer is not always dense enough in electrons at night to return such frequencies to earth so that the sky wave may be properly used.

From 22,000 to 35,000 kilocycles, or from 13 meters down to 8½ meters, is a region whose properties are not yet any too well known. Certainly at times very long distance communication can be maintained during the daylight hours with some of these frequencies. It is not yet possible to see just what use will be made of this band, though researches and experiments are constantly in progress.

Between 35,000 and 100,000 kilocycles, or 8½ to 3 meters, there is a region particularly adapted to communication between two stations so located that a straight line can be drawn from one to the other without intersecting any material obstacle or the surface of the earth. In other words, here the ray must travel very much like the ray of a searchlight. If the stations are located at high altitudes, the possible distances of communication are quite considerable. A station in an airplane abroad has communicated on these frequencies with a station located on a mountain top over a distance of approximately 200 miles. Similar results have also been obtained in this country.

One of the most interesting features of the very short waves is the facility with which they lend themselves to directional propagation. It is very easy to build simple beam systems either by the use of specific antenna arrays or by the use of reflectors behind the antenna, or even, possibly, as the Japanese are doing, with directors in front of the antenna. The physical dimensions of such apparatus are proportional to the wave length. Therefore the shorter the wave the cheaper and easier it is to make the necessary arrangements. To put up a suitable beam transmitter for a station in the broadcast band, say on 700 kilocycles, would require a gigantic structure which for successful operation would be much taller than the tallest building in this country and of very great lateral extent. On the other hand, a very concentrated beam of radiation can be obtained at 5 meters with a structure of very moderate dimensions like 150 feet in diameter. It is likely, therefore, that the very near future will see such uses for these upper frequencies developing as can take advantage of our ability to direct the waves.

Communication with airplanes over moderate distances less than 100 miles has already been done both in this country and abroad, using these very high frequencies. With the occupation by various interests of the low, intermediate, and high-frequency channels, the engineers and scientists will be impelled to develop the super-frequency band. Nevertheless, it seems extremely unlikely that any activity of man can fundamentally alter the structure of the Kennelly-Heaviside Layer or control its vagaries. There is, therefore, a limit to what one must expect, and it seems probable that the new uses which will ultimately be developed for the super-frequencies will be applications to such definite and specific problems for which they may be found best fitted. For example, it may well be that they will prove admirable for television work over relatively short distances. There would be no echo signals and very little to bother us in the way of retarded path signals. Except for the limitation of range, they should lend themselves very well to the very wide band of modulation required by television.

Before concluding, it may be of interest to mention the fact that moderate high frequencies from transmitters, if received on ordinary non-directive antenna, are quite capable of interfering with themselves; in other words, it frequently happens that the signal, in reaching a distant point, goes around the world in both directions and sometimes makes two or more trips in one direction. Since it takes 0.14 of a second to travel completely around the world, it must readily be seen that at the receiving point there results a confusion of reception, whether it be by ear or by automatic devices.

These round-the-world signals are of astonishing strength, but fortunately they may usually be avoided by using a directional receiving antenna to eliminate one of the two signals arriving from opposite directions but from the same transmitter. It is an interesting fact, however, that the moderate high frequency transmitter, at least in the bands between 12,000 and 22,000 kilocycles, may be readily tested as to range by observing, at the proper hour of the day and depending on the time of the year, the magnitude of the signals which it is capable of sending completely around the world. If they are not good, strong, readable signals that can be heard readily from a loud speaker, then the transmitter is decidedly not an efficient one. The high-frequency, long-distance "fan" is, therefore, literally looking for new worlds to conquer, because it is a very simple matter indeed to hear signals which have made one or more trips completely around the world.

THE BROADCASTING BAND

By J. H. Dellinger

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THE rise of radio broadcasting introduced wholly new problems, some of them verging on the paradoxical. One broadcasting station renders a certain amount of desired service, but 600 broadcasting stations do not render 600 times as much. And the total service from 6,000 stations would probably be less than that from a single station. In other words, the number of stations cannot be increased indefinitely. This is because of the possible interference of every radio station with the transmissions from every other. Radio broadcasting is thus limited, and the best number of broadcasting stations, to give the greatest total service to the country, is still an unsolved problem.

On the basis of present radio engineering knowledge, it can be said that there are two principal limits to the potentialities of radio. The first and most important of these is that the available number of radio broadcasting channels is definitely limited by interference; the other is the existence of vagaries or irregular actions of the radio waves in their passage between the transmitting station and the receiver. So long as those who would find a way out of radio's difficulties neglect these two limitations, or imagine that they are only temporary and liable to be swept aside at any moment by the progress of invention, their plans will not be fruitful. Beautiful theoretical plans can be and are being devised when it is taken for granted that additional broadcasting channels can readily be created. During a time of considerable newspaper discussion of radio legislation, a news statement declared that the difficulties of radio would be overcome if the government would undertake the creation of 3,000 channels for broadcasting stations, thus giving room for many times the present number. The writer of this newspaper article put his finger precisely on the primary difficulty of the situation. But he was ignorant of the fact that it was the primary difficulty and not subject to cure by legislation or administrative fiat.

The reason that the number of broadcasting channels is definitely limited is interesting, though technical. In the first place, it should be understood that radio is carried on by means of electric currents and waves of very high frequency, ranging from approximately 15 kilocycles to 30,000 kilocycles per second (15 kilocycles means 15,000 cycles or alternations per second). There would seem to be an ample number of separate frequencies for all possible radio stations in this tremendous range, but every station must have its own little band of frequencies in order that it may be received without interference. This band of frequencies is 10 kilocycles wide for each broadcasting station. To use a narrower band would change and distort the music, speech, or other sounds transmitted by the radio wave. All broadcasting is done in that part of the radio spectrum lying between 550 and 1,500 kilocycles. There are in this range 96 bands or channels each 10 kilocycles wide, and therefore only 96 independent channels for broadcasting stations. Of the 96, there are really only 90 available in the United States, as 6 are reserved for exclusive use by Canada.

It has seriously taxed the resourcefulness of the Federal Radio Commission to fit the 600 or more broadcasting stations of the United States to the 90 available channels. To remedy the serious interference which existed at the time it was established in 1927, the Commission had to choose among various alternatives. It decided, first, as a matter of policy, not to reduce radically the total number of stations. It was then necessary to (a) limit the simultaneous operation of an excessive number of stations by making many of them divide time; (b) assign frequencies carefully selected with regard to the geographical separation of stations in order to reduce inter-channel interference (*i.e.*, disturbances of reception of a station on one frequency by other stations on adjacent frequencies); and (c) limit the power of stations so they would not cause interference to other stations on the same frequency. All of this was done in the allocation of broadcasting stations which the Commission put into effect on November 11, 1928, and which is still in effect as this is written.

Proper provision for the differing requirements of the listeners in large rural areas, cities, and intermediate areas made the preparation of this allocation an exceedingly difficult task. It would have been very easy to allocate all existing stations, and many more, if merely local service or the effects a few miles from the station had been considered. As soon as consideration was given to service more than a few miles from a station, serious difficulty arose, since whistling heterodyne interference extends to many times the distance from a station to which actual program service extends. Operation of two or more stations on a channel results in an area of destructive interference very much greater than the area in which program service is provided, unless the stations are of low power and widely spaced geographically. It is only when a station has exclusive use of its channel that program service free from interference can be furnished at great distances. But since there are only 90 channels available for broadcasting in the United States, there could not possibly be more than 90 simultaneously operating stations giving service at great distances.

A reasonable solution of this dilemma was adopted—

the setting aside of 40 of the 90 channels for distant or rural service, each with only one station assignment.[1]

The use of the remaining channels was reserved for service at more moderate distances, with several station assignments on each channel, all with limited power and located systematically at proper distances apart in order to minimize interference.

The channels used for the latter type of station assignments were subdivided into "regional service" and "local" and "limited service" channels. The "regionals" are kept substantially free from heterodyne interference by restricting power to 1,000 watts and keeping the stations on a given channel a maximum distance apart. The "local" and "limited service" channels are those on which heterodyne interference exists in areas far from the stations, but which give satisfactory service in a small local area.

There has been no specific designation of a name for the class of channels intended to give distant or rural service. They have been called variously "rural service," "distant service," "clear," "cleared," "high-power," "heterodyne-free," and "exclusive" channels. Stations on these channels were authorized to use power up to 25 kilowatts, and, experimentally, up to 50 kilowatts.

The principal features of the allocation are indicated in the accompanying table. The available numbers of station assignments have not in all cases been utilized in all the five zones into which the country was divided by the Radio Act of 1927.

[1] The expression "station assignment," or "full-time assignment" indicates full-time operation, twenty-four hours a day, by a station or a group of stations sharing time.

	High-power, 5 kilowatts and up	*Regional, 500-1,000 watts*	*Limited service*		*Local 10-100 watts*	*Total*
			5 kilowatts	*1,000 watts*		
Number of Channels....	40	35	4	5	6	90
Station Assignments per channel	1	2½[1]	2½	5	25	—
Number Station Assignments in U. S.......	40	90	10	25	150	315
Number Station Assignments in each zone [2]...........	8	18	2	5	30	63

[1] Approximate average.

[2] The radio act divides the country into the five zones as follows: First zone—Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Delaware, Maryland, the District of Columbia, Porto Rico, and the Virgin Islands; Second zone—Pennsylvania, Virginia, West Virginia, Ohio, Michigan, and Kentucky; Third zone—North Carolina, South Carolina, Georgia, Florida, Alabama, Tennessee, Mississippi, Arkansas, Louisiana, Texas, and Oklahoma; Fourth zone—Indiana, Illinois, Wisconsin, Minnesota, North Dakota, South Dakota, Iowa, Nebraska, Kansas, and Missouri; Fifth zone—Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California, the Territory of Hawaii, and Alaska.

The allocation is based on night-time conditions, when transmission distances are the greatest. In the daytime, more stations and greater power can be allowed. Besides the classes of stations shown in the table, there are a number of supplementary stations on some channels for daytime operation only. These include a number of "daytime service" stations and "limited time" stations. The latter are allowed to operate during the day and also during certain time (after late evening in the East by Western stations) temporarily not used by the stations entitled to the channel. The "daytime service" stations are allowed to operate only during non-interfering hours. They are required to shut down at sunset. This is taken to be sunset at the daytime service station unless it is the farthest east of the stations on the channel, in which case sunset at the next station west on the same channel. The time of sunset varies from about 4:30 in December to 7:30 in June, local sun time.

The choice of particular frequencies for the several classes of stations is not altogether satisfactory. It was influenced in considerable measure by the frequencies which some stations had prior to 1928. Thus, one reason that the high-power channels were begun at 640 kilocycles rather than at 550 kilocycles was because the public had become accustomed to hearing some of the regional service stations at this end of the spectrum. The placing of several blocks of regional and local service channels in different parts of the dial permitted more stations in certain large cities than would have been possible (because of inter-channel interference) if the channels of each class of station had all been bunched in a single group.

The high-power channels, however, are consolidated into a single block in the spectrum (except for Canadian exclusive and Canadian shared channels and the group of regional channels 880 to 950 kilocycles) so that the listeners on these heterodyne-free channels are as free as possible from inter-channel interference from near-by stations of other classes.

The most striking of the problems involved in the new allocation was the carrying out of the requirement (c), before mentioned, of avoiding interference between stations on the same frequency. Stations assigned to the same frequency have not, up to the present, been able to maintain their frequencies with sufficient accuracy to prevent the existence of a slight difference or beat frequency, producing what is commonly known as heterodyne interference or whistles. Unfortunately, the heterodyne interference reaches out to much greater distances from a station than the program. Consequently, the operation of two or more stations on a channel results in an area of destructive interference far in excess of the area in which program service is provided. For instance, a five-kilowatt station's program can be heard with fair intensity under good conditions at 100 miles, while the heterodyne interference from two such stations is heard at 3,000 miles. Two stations of five kilowatts or more, therefore, cannot be assigned the same frequency in the United States. It is possible, on the average, to put two or more one-kilowatt stations on the same frequency if they are at least 1,800 miles apart, and two or more one-half kilowatt stations if they are at least 1,200 miles apart.

All stations subject to these restrictions have only a small service area, and give little or no service to remote rural areas. Such distant service is given only by stations having exclusive use of the channels to which they are assigned.

The stations on the exclusive channels not only serve very great areas, but deliver a more satisfactory intensity at every point within those areas. Their service is better for all concerned the greater the power they use. This fact is clear when the distinction between the exclusive and the other channels is comprehended. Service on the non-exclusive channels would be utterly ruined if the power limits fixed by the facts of heterodyne interference should be exceeded, and in consequence such stations cannot in general use more than one kilowatt. But on the exclusive channels the service is better the higher the power level. Indeed, such stations will not be serving the public most effectively until the level reaches hundreds of kilowatts.

There is some hope that the limitation of power and hence of service on the non-exclusive channels may be overcome. If the frequencies of stations on the same channel are maintained to a certain very high accuracy, the heterodyne whistle becomes inaudible. The technique of frequency control is fast approaching this goal and success has been attained in isolated instances. The satisfactory service area of such "synchronized" stations is not yet known, but it is believed that it will be substantially greater than when heterodyne interference exists. The significance of this is that the present power limits on the "regional" and "local" stations can be raised, better service given, and wider areas served. Synchronization is therefore looked for as the next great advance in broadcasting.

The 1928 allocation of broadcasting stations was a vast improvement over the conditions it superseded. Over most of the dial of a good radio receiver it made possible tuning in stations without interference. This was almost wholly impossible before the allocation went into effect.

There are several respects, however, in which the broadcasting system of the country is not yet satisfactory. The distribution of stations of the various classes over the country is not satisfactory to many areas, particularly large rural areas in the central portions of the country. The present distribution is based in part on the choice of locations by the individuals who established stations and in part on a 1928 amendment of the radio law which required, in essence, that the stations be distributed in proportion to population.

Another shortcoming of the country's broadcasting system is the extent of time divisions among stations. As already explained, it was only by time divisions that the large number of existing stations could be retained without undue interference. Viewed broadly, this is an economic absurdity. It is as if two or more railroad companies had franchises to operate trains on the same track, each taking turns and having its whole stock and plant absolutely idle when not using the track. This is fruitless duplication of invested capital. It works out that many more broadcasting stations have been allowed to continue in existence than can be justified from an economic standpoint.

It becomes clear that there are rigorous limitations upon broadcasting. There have been urgent proposals and frantic efforts to escape from this straitjacket. A favorite plan is to extend the broadcast range to higher and to lower frequencies. Why not use more of the radio spectrum for broadcasting? This question has been a major issue at every national and international radio conference since 1924. Such conferences have uniformly concluded that extension of the broadcast range of frequencies is impracticable for several reasons. In the first place, all the rest of the radio spectrum is otherwise engaged. The frequencies below those of broadcasting are extensively used and have been long established for ship communication, transoceanic message traffic, aids to ship and aircraft navigation, and government and other uses which are utterly essential and for which radio is the only available instrumentality. The frequencies at the other end of the spectrum, above broadcasting, are also crowded, being required for aircraft, amateur, commercial, television, military, and special uses.

Another powerful reason against placing additional broadcasting stations outside the present broadcast frequencies is that such stations could not be received by the present receiving sets. This would be a hardship on millions of people, who would have to buy new sets or attachments to be added to their present sets.

It is not alone in the part of the radio spectrum devoted to broadcasting that the crowding problem is serious. A radio communication channel is a precious thing, the franchise to use it a valuable asset. The competition for such franchise is as keen, and as fraught with consequences of public interest in the very low and the high frequencies as in broadcasting. Hence it cannot be expected that broadcasting can spread into other frequencies. The very low and very high frequencies are used for transoceanic communication in competition with the cables. Their use vitally affects international commerce, and their importance is so great that there are diplomatic maneuverings over their control and use. It is not at all unthinkable that diplomats of the future will put forth as great efforts to secure or defend radio frequencies for their nations as they now exert to protect territorial and other sovereign rights.

LONG WAVES

By L. W. Austin

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In this discussion, waves of a frequency below 1,500 kilocycles are defined as low frequencies or long waves, as distinguished from those above 550 kilocycles commonly called high frequencies or short waves. The frequencies from 1,500 to 550 kilocycles comprise the band of wave lengths used for broadcasting in America, and are generally known as the intermediate frequencies or waves.

When the layman read in the daily press the complete accounts sent out by Commander Byrd of the doings of his party close to the South Pole, and was told that this excellent communication direct from the Antarctic to New York would be impossible except for the short waves, he may have wondered why long waves are used at all for long-distance communication.

The relative advantages of the long and short waves form a rather complicated subject for consideration. In order to make clear the reasons for choosing different wave lengths for different purposes, it will be necessary to give some explanation of the way in which the waves travel.

It is generally accepted that the wave radiated from an ordinary antenna spreads out in a hemispherical form, extending out in every direction except into the earth. At a height of about 60 or 70 miles, this wave front reaches an ionized conducting region of the atmosphere known as the Kennelly-Heaviside Layer. This stratum is of such a character that the waves, at least the longer ones, do not generally penetrate it to any extent, but are reflected somewhat like light from a rather poor mirror. A portion of this reflected wave reaches the receiving station, while at the same time the lower part of the wave front has been traveling along the ground to the same point. The two waves, in general, arrive in different phase on account of the difference in the length of their paths. This frequently produces fading in the region where their intensities are of the same order of magnitude. The wave which has been reflected is often spoken of as the reflected or downcoming wave, while the wave along the ground is known as the direct or ground wave. Both the ground and reflected waves are subject to absorption along their paths, and, in addition, the downcoming wave has its plane of polarization (direction of oscillation) twisted about in various ways by the earth's magnetic field. The ground wave absorption becomes greater and greater, the shorter the wave. This is true over the whole known range of radio wave lengths, so for what are known as short waves, the ground wave is of negligible importance.

The absorption of the reflected wave in the atmosphere, however, follows a very different law. Here the greatest absorption is found at a frequency of about 1,500 kilocycles, and becomes rapidly less as the frequency is either increased or decreased. From this it follows that, while on the short waves the reflected wave is the only one of importance, on the very long waves both the reflected and ground waves are active for many hundred miles from the transmitter. Beyond this—the distance from America to Europe, for instance—the ground wave, even at great wave lengths, becomes too weak to be of importance, and practically all of the signal is carried by the reflected wave in a series of reflections between the ionized layer and the earth. Up to 50 or 75 miles, however, for very long wave lengths, it is the ground wave which is of chief importance, since here the reflected wave is weak in comparison. The strength of the reflected wave is very much greater at most frequencies at night than in the daytime, due to the fact that the absorption in the atmosphere is usually greatly increased in the daytime by the sun's rays. It is for this reason that, except on the longest wave lengths, reception is so much better at night than in the daytime.

The absorption of the ground wave, on the other hand, is believed to be nearly constant day and night, though, as has already been said, it changes with the wave length. It also differs very much with the character of the ground over which the wave travels. Over salt water it is probably constant for a given wave length all over the world.

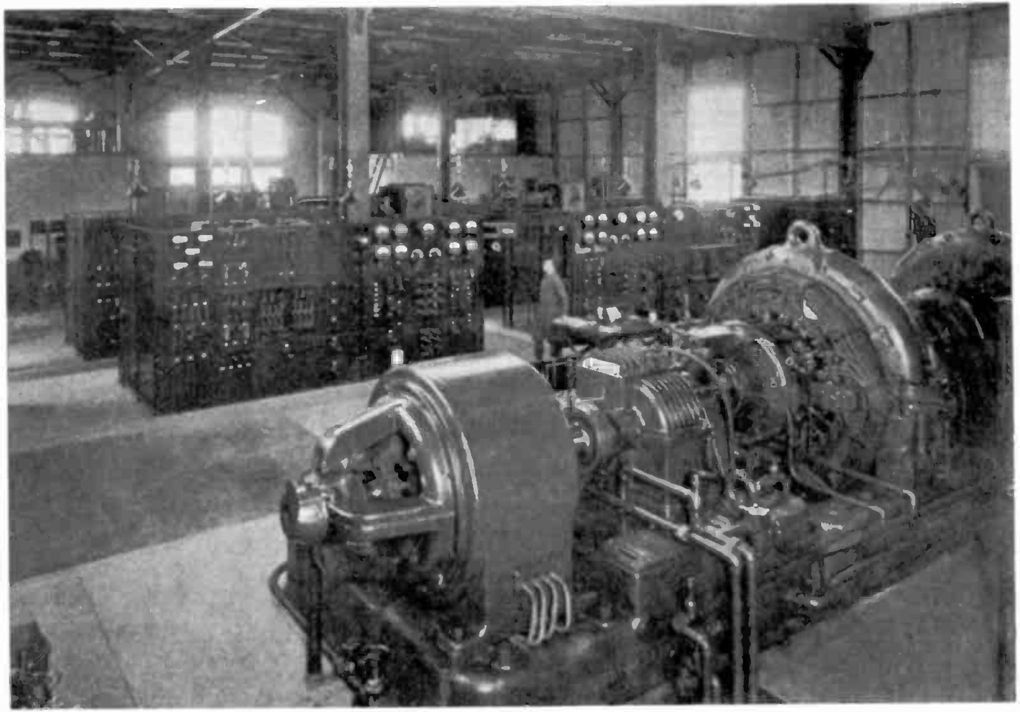
A striking example of the high ground absorption in certain regions and its variation with wave length was observed in some experiments made several years ago by the U. S. Navy between Newport, R. I., and Brant Rock, Mass., a distance of 45 miles. Here it was found that with a frequency of 300 kilocycles the received signal was only 5 to 10 per cent of that which would have been received over salt water. At the same time, signals sent on a frequency of 75 kilocycles gave nearly the same intensity of reception as over water. At this short distance the reception was almost certainly due to the ground wave alone, as reflection could play only a negligible part in the phenomenon. A formula has been derived for the strength of signal over salt water in the daytime, and the observed and calculated values are nearly always in fair agreement. Over land, however, observed values differ greatly from those calculated from this formula, and differ very much among themselves on account of the differences in ground absorption in different regions. For this reason a station which may have practically the same range over land and water at night will have a daylight land range only a small fraction of its range over water.

In general, we can say that the differences in behavior in waves of different lengths are probably due to the differences in the amount of their absorption in the ground and in the air and in the way in which they are reflected or refracted in the upper atmosphere.

There are various reasons for the continued use of the long waves. It must, of course, be admitted that the short waves have many advantages, since their signals are radiated more efficiently from the antenna, are less absorbed in the upper atmosphere, and are less disturbed by static, and since their power plants and supporting masts are relatively small in cost compared with the huge alternators and enormous antenna-supporting towers required by long-wave stations for communicating over the same distances.

Notwithstanding these great drawbacks for the long waves, they have certain points of advantage, some of which are of the greatest weight. The most important quality of any method of communication is its reliability, and in this the long waves have the advantage. All wave lengths are subject to fading—that is, to changes in intensity of signal—and, generally speaking, fading decreases both in intensity and frequency as the wave length is lengthened, so that below 75 or 100 kilocycles it manifests itself merely in comparatively slight changes in intensity from hour to hour or day to day.

Fading is believed to be due to three causes. It is frequently produced, as has been mentioned, by interference between the ground wave and the reflected wave. At the greater distances, where the ground wave is negligible, two reflected waves traveling by different paths may produce the same result. A second cause may be the changes in the absorption of the reflected wave in the upper atmosphere. This may be likened to the changes in light from the sun as masses of cloud drift across the sky. Another type of fading particularly prevalent on the very short waves is probably due to the rotation of the plane of polarization of the electric oscillations in the wave, these at one moment being vertical so as to be received strongly on a



TRANSMITTER ROOM OF ROCKY POINT, LONG ISLAND, TRANSOCEANIC RADIO STATION OF RADIO CORPORATION OF AMERICA, SHOWING THE ALEXANDERSON ALTERNATOR.

vertical antenna, and at the next horizontal so that they are not received at all. A suggested cure for this type of fading would be the use of vertical and horizontal antennas in combination.

Another cause of trouble in short wave transmission appears to be connected with the disturbances in the earth's magnetism, commonly known as magnetic storms. The severity and frequency of these interruptions of communication differ greatly in different portions of the earth, and are more severe when the transmission is at right angles to the magnetic lines of force than when parallel to them. For this reason, north and south communication is generally better than east and west, and in the case of east-west communication the signals are more constant near the equator than in the far north or south. Consequently, while most of the radio traffic of Europe and North America with South America is carried on by means of short waves, a considerable part of the communication between North America and Europe employs waves of less than 30 kilocycles.

T. L. Eckersley, of the Marconi Company, has recently furnished some information in regard to the frequency of this magnetic storm fading which is often so severe that the signals are entirely lost for several hours. He gives the following number of fade-outs between October, 1927, and October, 1928, in the communication between England and various points.

Melbourne, 7; Capetown, 4; Poona (India), 7; Buenos Aires, 4; Rio de Janeiro, 7; Java, 4; Montreal, 49; and New York, 32. It will be noticed how much more severe this form of fading is in the Montreal and New York communications than in the other cases. In comparison with these frequent difficulties in the case of the short waves, waves of 30 kilocycles or less are hardly affected at all by magnetic storms.

Another service, in which moderately long waves are apparently superior to the very short ones, is in direction-finding by means of the radiobeacon or radiocompass. According to the experience of American observers, waves in the neighborhood of 300 kilocycles are found to be freer from the night errors, which produce the chief uncertainty in obtaining correct radio bearings, than waves which are very much longer or shorter. The superiority of this region of wave lengths for direction-finding is questioned by observers in England, where very extensive experiments by the British Radio Research Board indicate that there is very little difference in freedom from night errors in the whole range of frequencies from 15 to 1,000 kilocycles. This difference between the results obtained in England and in the United States may conceivably be due to different radio conditions in the two countries.

One more reason why long waves can probably never be replaced entirely by short waves is the amount of radio business in the world, which will eventually require every channel of communication from the shortest to the very longest wave length which can possibly be used.

The International Radiotelegraph Convention of 1927, adopted in Washington, determined the wave lengths which should be used for different purposes throughout the world. The band from 10 to 100 kilocycles is devoted to communication between fixed land stations. Most of the high-powered transoceanic services employ at present frequencies between 15 and 75 kilocycles, while 75 to 100 kilocycles are used mostly by fixed stations working over more moderate distances. The Bell Telephone System uses a low frequency of about 60 kilocycles for much of its transatlantic telephone service. This frequency is not low enough to give the most satisfactory signal strength at this distance, but was chosen to minimize interference with other services, since interference from telephone stations is particularly troublesome at the lower frequencies. The range from 100 to 150 kilocycles has been allotted to both fixed stations and ships.

Between 150 and 300 kilocycles all types of services are found. Some European broadcasting stations are permitted to work in the neighborhood of 167 kilocycles where a long daylight range is desired. Broadcasting is also permitted between 194 and 286 kilocycles. The air services, too, operate in this band and between about 315 and 350 kilocycles. Radiobeacons use the band 285 to 315 kilocycles, and the radiocompass service operates between 360 and 390 kilocycles. The frequency of 500 kilocycles is the international calling and distress wave.

TELEVISION

By Herbert E. Ives

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TELEVISION, the newest branch of electrical communication, is now just emerging from its crude experimental stage. It has been found possible of attainment. Will it, either soon or after a long period of development, takes its place alongside the telephone and radio broadcasting as a public necessity?

Trustworthy opinion on this question can be formed only after a careful analysis of what television offers to us. It must be evaluated as to appeal, as to quality, as to convenience, as to cost, by comparison with other similar but more established developments. In such an evaluation we must be guided largely by analogies, but we must be careful that the analogies are valid. We must not leap to the conclusion that since the telephone and radio broadcasting of sound grew in a few years from small to enormously large things, the transmission of sight will inevitably develop along similar lines or necessarily occupy a comparable place in our lives. Inherently, as we shall see, television is more complicated and costly than any other form of communication. Its future must accordingly depend, in considerable measure, on its ability to render services which warrant the extra expense.

As here understood, television is the transmission, to a distant point, usually by electrical means, of moving scenes, to be viewed at the distant point practically simultaneously with their original occurrence. The necessity for this strict limitation of meaning becomes evident when we note that with a less carefully circumscribed definition we might have to discuss the viewing of distant scenes by a telescope, the projection of motion pictures from films transported to a distance, or the inspection of telephoned pictures in a newspaper an hour or more after the event. Any one of these methods of seeing distant events is vastly simpler than that combination of selected elements of each that constitutes television, or, as we might more accurately term it, "electro-telescopy."

Essentially the problem of electrical television consists in the transformation of light into electrical signals, the transmission of these signals to a distant point, and the re-creation of light from them. If these three processes can be carried out with adequate speed and accuracy, the transmission of complete moving images may be attained.

Creating electrical signals from light, transmitting these signals and producing light at the receiving end, is a comparatively simple matter if a single light signal is all that is required. In the case of image transmission, however, it is necessary to transmit not one but a vast number of signals, in an excessively short time. Any image or picture may be considered as made up of a very large number of small areas or elements each of different uniform brightness. When a picture is viewed by the eye, the rods and cones of the retina perform this analysis of the image into small elements and the many thousands of fibrils of the optic nerve simultaneously transmit to the brain the impulses set up by light in each of the rods and cones. It would be theoretically possible to build a television system in which a large number of light sensitive cells were simultaneously exposed to an image, and a separate electrical circuit connected with each one carried the electrical signals to a distant point where a bank of lamps was controlled by the signals. Such a multi-channel scheme is not, however, practical, and all successful methods of television have resorted to a process of *scanning*, by means of which the whole of an image is traversed point by point, and the signals corresponding to the various degrees of light and shade are transmitted *in sequence* instead of simultaneously. This is the same device which is used in the electrical transmission of still pictures. But there is a fundamental difference between still picture transmission and television. The still picture may take several minutes to complete, and we must wait that long to see it in its entirety. In television the entire image must be traversed in a small fraction of a second (about 1/20) in order that, through persistence of vision, as in the motion picture, the image when reconstructed may appear complete at all times and so that it may change its character so rapidly that motion of the scanned object may be reproduced without flicker or jerkiness.

Various devices such as vibrating mirrors and rotating discs have been proposed for the rapid scanning of an image for television purposes. The means which thus far has been found most practical is a flat circular disc provided with a spiral of small holes. By the rotation of this disc each hole of the spiral passes in turn across a rectangular opening in front of the disc, as wide as the angular spaces between the holes. Each hole as it goes past traces a line alongside the line made by the previous hole, so that on a complete rotation of the spiral the whole opening has been exposed. The most straightforward way of utilizing such a disc is to project an image of the scene to be transmitted, by means of a lens, upon the opening before the disc, just as the lens of a camera projects its image on the photographic plate. If the disc is rotated at a rate of fifteen to twenty revolutions per second, the image falling through the holes, for instance on a ground-glass screen, appears virtually complete and steady, although it is actually built up of a single sequence of light signals.

The next problem is to take this sequence of light signals and transform it into a sequence of electrical signals which may follow one another over a transmission line as do the dots and dashes of a telegraph message. To produce electrical currents for transmission purposes from the light passing through the scanning disc, use is made of some light-sensitive device. This light-sensitive device must be extremely rapid in its action and should, if possible, give currents of a magnitude acceptable for transmission over a telephone line or some other practical communication channel. In the most successful experiments on television, a photoelectric cell has been used for this purpose. This consists of a glass tube on whose inner wall is a layer of alkali metal, usually potassium. The tube may be evacuated or may be filled with an inert gas, such as argon, at low pressure. Light falling on the sensitive surface causes the emission of electrons, thus producing an electric current which is not only practically instantaneous but is directly proportional to the intensity of the light.

Photoelectric currents suffer from the disadvantage that, as excited by the illumination available from an ordinarily illuminated object, they are excessively minute. It is necessary to step up the photoelectric currents by means of vacuum-tube amplifiers before they can be used at all for transmission purposes. It is, in fact, largely owing to the development of vacuum-tube amplifiers, that it has been possible to bring television to a successful stage. Even, however, with amplification of the order of several thousand million fold the problem of securing sufficient signal energy for transmission over ordinary electrical communication channels is barely met by the use of image-forming lenses of the largest light-gathering power, by employing intense illumination, or by the artifice of sweeping an intense beam of light across the object and receiving the reflected light in a battery of large photoelectric cells (beam scanning). Ordinary indoor illuminations are still quite inadequate for television-scanning purposes.

Assuming that we have produced the television signals, the next problem is that of transmission. This presents considerable difficulty because an exceedingly wide range of frequencies must be sent without distortion. The nature of the problem may be comprehended by considering a typical case. If the image to be transmitted is scanned by a disc apparatus having 50 holes (about the smallest number which can be used with any satisfaction), the analysis of the entire image corresponds to dividing it into 50 times 50, or 2,500 elements. In order to create the illusion of continuity the image must be completely scanned about 20 times a second. This means that, in order to transmit the finest details present, signals corresponding to 2,500 times 20, or 50,000 elements per second, must be transmitted. In terms of alternating-current frequencies, this means approximately 25,000 cycles per second as the upper limit, while for the coarser details everything down to the frequency corresponding to large stationary objects, that is, the number of times per second the entire image is covered, must also be capable of transmission. In the language of transmission engineering this means a *band* of frequencies 25,000 cycles wide. Now speech transmission by the telephone is accomplished by a frequency band of approximately 2,500 cycles, and radio broadcasting stations use signal-bands 5,000 cycles in width (counting one side band only for this comparison). It is, therefore, obvious that a relatively crude image, corresponding in quality to considerably less than a square inch of newspaper halftone (ordinarily 60 to 65 lines to the inch) requires transmission facilities of extraordinary quality. In addition to extreme width of transmission frequency band, there are other unusual requirements. The transmission band must extend to frequencies much below those necessary for speech, and all parts of the transmission band must be in proper phase relation with one another. No escape from these requirements appears possible.

The transmission of television signals may be accomplished either over wire or wireless channels provided they meet the requirements just set. In the case of wire, the system must be reasonably free from interferences such as produce what in voice transmission is called "noise," which in the case of television causes specks or streaks obscuring the image. In the case of wireless there are additional sources of trouble, particularly those associated with fading and multiple reflection in the Kennelly-Heaviside Layer. These latter produce additional images, or "ghosts," whose prominence varies with the distance and time of day, and for which as yet no remedy has been found. A serious commercial limitation at present to high-quality television by radio is the difficulty of obtaining wide frequency bands in the face of the heavy demands for space in the ether by ship, airplane and other communication services.

The simplest method of reconstructing the image from the television signals—the final step—consists in the use of a disc with a spiral of holes at the receiving end similar to that at the sending end. Combined with this is a light source, which will faithfully follow the variations in strength of the incoming signals. The most successful light source for this purpose is a neon glow lamp furnished with a large flat electrode which, when placed behind the disc, fills the whole field of view. As the observer watches the rapidly rotating disc, he sees at any instant a bright point of light which is of the intensity corresponding to the incoming signal. This in turn corresponds to the photoelectric current generated at the sending end—that is, to the brightness of the image on the sending disc. Due to persistence of vision, the observer is conscious only of a completely illuminated field differing in brightness in its different elements. If the receiving disc is rotating at exactly the speed of the sending disc and exactly in phase with it, the image seen at the receiving end is similar to that at the sending end.

Apparatus of the sort just described is suitable for viewing only by two or three people at most, and is inherently very inefficient, in that only a minute fraction of the neon lamp electrode is in sight at any instant, although the whole electrode must be emitting light. Forms of receiving apparatus, both more efficient and of size better suited for viewing by groups of people, have been developed experimentally. One device projects the image of a bright concentrated neon lamp by means of a spiral of lenses carried on a rotating disc. In this way the whole light energy is used all the time, even though it is spread out over the entire area of the image and so reduced enormously in effective brightness. Another device is the use of a long neon tube bent back and forth on itself to form a grid, furnished with a separate electrode for each image element. The current is led to each electrode in turn by a distributor, so that the whole current is utilized all the time, although here again the apparatus is inefficient since the average brightness of the image is only a small fraction of that of any one element actually illuminated— $\frac{1}{2,500}$ for a 2,500-element image. By means of those devices, television images of two to three feet diameter have been exhibited. However, schemes for sustaining the light in each picture element during the whole period between scannings, which would greatly increase the efficiency of the kind of apparatus just described and so permit larger area pictures, have been proposed and appear practical.

One other technical problem must be mentioned before a complete idea of the apparatus necessary for television is before us. In order that the scanning and receiving means which have been described shall faithfully reproduce the scene, it is imperative that the speed of operation of the two ends shall be identical to a high degree of accuracy. Thus with the two 50-hole discs, which have been taken as typical, if a hole at the receiving end is not to shift from its proper position by more than half its diameter—a reasonable restriction—the disc must not move from its proper place during rotation by the distance it travels in about a hundred thousandth parth of a second. Deviations from the proper speed produce wabbling and skewing of the received image. Several different means have thus far been employed to insure the necessary accuracy of synchronization. The most exact calls for two synchronous motors with a large number of poles, operated by relatively-high frequency signals. These high-frequency signals (2,000 cycles per second) may be generated by a vacuum tube oscillator or by light received by an auxiliary photoelectric cell from holes or reflecting spots on the disc. Synchronizing signals so produced require an additional communication channel over and above that required for the image. Some success in avoiding the use of the extra channel has been met by using the image repetition frequency, and by utilizing the space between images or between image-frequency components for transmitting synchronizing pulses. Simpler in some respects is to furnish each end with piezo-electric crystal oscillators which, like super-accurate clocks, run closely enough together to serve. The simplest means of all, where occasional manual corrective is not a serious disadvantage, is to drive low-frequency (60 cycle) synchronous motors at each end from the same source of alternating lighting current. This is, of course, only possible where both ends lie in a region served by a common power supply, which at present means a geographically small area, such as a city.

This rapid survey has covered the essentials of simple television. Before entering into any discussion of the possible future vogue of television, some of the most recent experimental developments, looking toward possible fields of usefulness, may be reviewed. These include two-way television in connection with the telephone, television in color, transmission of talking movie films, the use of film in one-way "delayed" television.

Two-way television as an adjunct to the telephone involves two complete sending and receiving sets so arranged that the parties to the conversation are scanned at the same time that they view the image received from the other end of the communication line. In a demonstration system of this type set up between the offices of the American Telephone & Telegraph Company and the building of the Bell Telephone Laboratories, two special booths are used, each containing a bank of photoelectric cells before which the customer sits. Scanning is by the beam method, the "beam" consisting of a rapidly moving pencil of blue light which is photoelectrically efficient but is sufficiently low in visual luminous value as not to disturb the subscriber's vision of the received image, which he sees below the scanning light. The voice transmission is by means of concealed microphones and loud speakers so that no telephone instrument interferes with the vision of the face. In order to produce a satisfactory image of a face the scanning discs are drilled with 72 holes, which at a rotation speed of 18 per second calls for a frequency band of 40,000 cycles, or about 15 times that required for speech. Separate channels are provided for each direction of transmission, for while speech may go both ways at the same time, visual images cannot be allowed to overlap or interrupt one another. The complete two-way television system to take care of television, synchronization, and speech thus requires over thirty times the transmission facilities of an ordinary two-wire telephone system.

Television in color has been achieved by the use of the three-color principle widely used in color photography. For its attainment color-sensitive photoelectric cells have had to be developed for use at the sending end, and glow lamps capable of providing red, green, and blue lights for use at the receiving end. With these available, the accomplishment of television in color becomes, broadly speaking, a matter of providing three transmission channels, one for each color. By using the beam scanning method it has been found possible to perform the scanning operation with the same disc and light source as is used in monochrome television. Consequently, three-color television does not require three times the apparatus throughout. Very striking results are obtained, but the necessity for 30 times the transmission facilities adequate for a telephone message, to get a 2,500 element picture, appears to limit color television for the present to the category of scientific novelties.

The transmission of images from motion-picture film is a relatively easy task in television, because there is no difficulty in concentrating large quantities of light through the film on to the photoelectric cell. Most of the earlier experimental work in television was in fact done with film. The simultaneous transmission of the sound record from a sound film, or from a synchronized disc, is, of course, an ordinary job of wire or radio communication. Here again the dominant question is that of adequate transmission channels. Experimenters thus far have not found it practical to exceed a sixty-line picture. This, in the oblong "talkie"-frame shape, calls for about 50,000 cycles band width, or 100,000 cycles for both sidebands (the widest band available in 1929 for radio television). With this fineness of structure, a face is well rendered, and two or three half-length figures are shown reasonably well. Where the chief interest is in action, several full-length figures, such as boxers, are satisfactorily handled, but the contents of the regular motion-picture frame would require probably 10 times this amount of detail, calling for a frequency band at present quite unavailable for radio, even were the problems of generation and radiation of such signals within sight of solution.

It is, of course, obvious that the unique gift of television, namely the possibility of viewing an event simultaneously with its occurrence, is lost when transmission is from motion-picture film whose time of development and preparation must intervene. We shall say more later about television as a possible competitor of the home motion-picture projector for films of all sorts irrespective of their timeliness. We may here, however, call attention to the possibilities of film for providing what may be called "delayed television." The essential feature of this would be the use of quick photographic developing methods, so that the total interval between event and showing would still be of no real significance for one-way transmission. The photographic step can be utilized at either sending or receiving end, but its greatest advantage appears to be at the receiving end as a means of producing images of large size suitable for theaters. If the received television image is photographed on to motion-picture film (using an actinic light such as a mercury glow lamp) this film, developed in a minute or less, can be projected while wet to full theater screen size. If now the sound accompanying the scene (announcer, music, footsteps, etc.) is delayed by the same amount, which can be arranged, the showing of distant scenes to large audiences can be accomplished with probably quite as much satisfaction as if the transmission were actually instantaneous. We meet here once more, of course, the problem of providing transmission band width adequate to carry a number of image elements which would be satisfactory for the theater screen. In a theater installation, however, it is not out of the question to consider the use of multiple scanning methods, utilizing several wire transmission lines, whereby the amount of detail could be multiplied many-fold.

With this review, we have before us a sufficient picture of television on which to exercise our imaginations. It should be clear that television requires apparatus largely different from, and inherently more complex than, wire or radio telephone apparatus. Probably we may expect the efforts of the many experimenters in this field substantially to simplify the terminal machinery of television and to bring receiving apparatus within the range of the public that now buys radio receivers. The cost of television, however, is not to be counted solely in terms of terminal apparatus price. Each way we turn in considering applications and improvements, we meet with the characteristic and apparently inescapable demand for wide frequency bands—the equivalent of many ordinary telephone or radio channels. While one good sound transmission line will carry a chorus as well as a solo, the demands of television increase with the number of "performers." Now communication channels, whether wire or radio, have a money value which mounts with the band width occupied, a fact which was often overlooked in the early days of practical "freedom of the air" in radio broadcasting. Television is thus inevitably more expensive than telephony, and this threatens to be a permanent handicap unless some revolutionary development in transmission, let us say the invention of new kinds of electrical conductors, should provide transmission channels at a small fraction of their present price.

Our task in speculating on the future field for television is, then, to estimate how far its relative complexity of apparatus and inherent costliness in transmission facilities will permit it to go toward the goal of those enthusiasts who predict television with every telephone, and television broadcasting by radio on the same scale as the present broadcasting of sound. Let us ask an initial question, What is the value of the addition of sight to sound in communication service and in entertainment? In the case of the telephone it is unquestionable that a very high fraction—perhaps 95 per cent—of all information now sought in telephone calls is carried by sound alone with entire satisfaction. When it is remembered that to take care of the remaining small percentage the transmission facilities will have to be multiplied by thirty, with the cost going up in somewhat the same proportion, it may well be doubted whether television as an adjunct to the telephone can reasonably hope to extend beyond a relatively few appointment stations for those who for sentimental or "personality" reasons place a high value on seeing as well as hearing. Actual service trials may possibly tell a different story, for the psychological factors involved are quite unexplored. In the case of speeches, songs, orchestral music—the bulk of the features now occupying the radio broadcast field—the appearance of the performers plays so minor a part and is so easily imagined that there is probably a real advantage in not having it intrude. We must bear in mind also that television requires a darkened room (decidedly inconvenient at home in the daytime) and calls for all one's attention. It has thus, like many optical entertainments, a distinctly non-social character, fundamentally different, for instance, from music, which can be listened to while other activities continue.

These considerations suggest rather strongly that television is not likely to force itself into the fields most popular now in sound communication. Will it make fields of its own? Several possibilities appear, chiefly in the entertainment realm, in which sight plays a part which sound cannot supply. Foremost among these is the portrayal of athletic contests, such as prize fights and baseball games. We may ultimately see events of this sort received, by radio or wire, in the home, perhaps preceded in time by reception in theaters where the high cost of the apparatus in its early forms will not be such a serious item. Another possibility is the use of television apparatus for broadcasting news reels, which might supplement the news summaries now given by many radio stations. Still another possibility is its use by the motion-picture companies to advertise forthcoming films by pre-views of actors and selected scenes. All of these forms of television entertainment are possible of more or less satisfactory realization in the near future, with the relatively crude images to which the available broadcasting bands limit us. We may confidently expect other suitable subjects for television to be discovered or developed as facilities become available. The ingenuity of advertisers will not long leave neglected any medium possessing new possibilities for conveying information.

Many television philosophers, however, look forward to an art so perfect that there will be no difference between the television image and the picture on the screen of the motion-picture theater. With television developed to this stage, they imagine it as serving not only to send images of events as they occur—the special function of television—but as ultimately displacing the stage and screen theater by bringing their offerings direct to the home. For this latter service television would have as its competitor the home motion-picture projector supplied with rented film. For the competition to favor television, the television receiver would have to bear somewhat the same relation in convenience and cost to the home motion-picture projector that our present radio does to the phonograph. We can only say that the apparatus and the transmission facilities required to achieve this degree of perfection now appear appalling, as to both complexity and cost. It is even possible that adequate transmission channels could be provided only by wire, so that such high-grade television will lie outside the realm of radio.

At the present time, workers in television are divided between two views as to the future. One group believe that the relatively crude television now possible over available radio channels has a sufficient appeal and field of usefulness to warrant its exploitation. The other group hold that television will have no wide or lasting use until it has been developed to yield images of many times the detail yet attained. The verdict must ultimately come from the public, which must decide what value it places on the addition of sight to sound, and whether it is willing to pay a price for that simultaneity of event and viewing which is the essence of television.

THE FUTURE OF RADIO

By Lee DeForest

Vice-President, DeForest Radio Co.; President, Institute of Radio Engineers, 1930

TO one who has been privileged to see his inventions develop from crude experiments to world-wide institutions and industries far beyond the wildest flights of fancy, the rôle of prophet presents problems in unrestrained imagination rather than in conservative deduction. So, in attempting to look ahead in radio developments, I am moved to be as rash as possible in my predictions, fully confident that in so doing I shall make a better guess than the more timid prophets of the past in this field.

To the average man, even a review of today's radio achievements may read like a fairy tale. We are, as it were, too near the mountain to behold its magnitude and beauty. Few of us stop to realize the proportions attained by our broadcasting institution and its resultant radio industry. We now have about 600 broadcasting stations in the United States alone, catering to some 50,000,000 or more listeners-in. Daily, the short-wave broadcasts from this country reach out to Europe, South Africa, Australia, and the Far East, in many instances being rebroadcast so that millions of far-flung people can become acquainted at first hand with American songs, entertainment, education, institutions, public men, and general culture. Short-wave signals from various countries are reaching our shores and, in some instances, are being rebroadcast. We are on the verge of international broadcasting, when the entire world shall become a single audience taking part in a universal forum of enlightenment. No greater contribution has ever been made to world peace.

Then there are the transoceanic radio communications of today, quite overlooked by the average man, even though much of his daily news, business, finances, and international relations may hinge on the intangible threads of communication that spread out from New York and San Francisco to the farthermost corners of the globe. A short-wave radio transmitter, not much larger than the usual steel filing cabinet, maintains constant, positive, high-speed radio communication with a receiving station 5,000 or more miles away. Radiograms in code are hurled through space at fantastic speeds of 200 words per minute and over, with automatic transmitters and receivers. Operators in traffic offices work with transmitters and receivers a hundred or more miles away, while engineers in those remote transmitting and receiving stations go about their work of maintenance with no more thrill than power-house attendants.

Out at sea, ships are always in touch with one another and with land. With the quiet vacuum tube transmitter in place of the crashing spark of former days, a ship now has the choice of several wave lengths for the expeditious handling of traffic. Land stations are arranged for multiplex operation, with several transmitters and receivers, together with a large operating staff, for the simultaneous handling of many ships. The largest ocean greyhound handles two thousand radiograms during a round trip, quite aside from many weather reports, ship's business, press, etc. Nightly, powerful transmitters on land send press reports to ships at sea, so that passengers in midocean may enjoy their morning newspaper. On ocean liners, stock brokerage offices have already been installed, thanks to the long arm of radio which keeps in touch with Wall Street. By means of short-wave apparatus, ships can now maintain communication with land even at distances of several thousand miles during the day. American ships on world cruises maintain contact with stations in the United States throughout their voyages. American steamers in South American waters receive broadcast programs from the larger stations for homesick Yankees. A ship in midocean can, by means of short-wave equipment, maintain simultaneous contact with the Old World and the New.

The airplane, flying through the blackness of the night, even in dense fog, is guided on its way by radiobeacons with as much precision and safety as the motorist following the cement highway by the glare of his headlights. Two-way conversation can be afforded the airman in the clouds with landing fields and even with any telephone subscriber if desired.

Photographs, handwriting, documents, printed matter, fashion sketches are flashed across thousands of miles of land and sea. The fashions at Longchamps or Ascot, seen on Saturday, are duplicated and ready to wear on Fifth Avenue the following Monday morning, reported *via* the photoradiogram sketches. Important business deals are consummated by radio signatures. Colonel Lindbergh lands at Le Bourget field in Paris and a few hours later his fellow Americans have the picture before them in newspapers hot off the press. Still more dramatic, living pictures are being flashed through space and, combined with the living voice of broadcasting, making the final onslaught on the barrier of time and space.

We speak from our desk telephones to almost any phone in Europe *via* radio impulses which meet the wires at the land's ends.

And all these achievements of today, and many more too numerous to mention in a discussion that must deal with tomorrow, are based on a simple device, the audion vacuum tube, an electric lamp somewhat elaborated upon by the addition of a tiny plate, or cylinder, and a bit of coiled wire or grid. Only two decades ago I frantically sought the co-operation of lamp manufacturers in making up a few of these elaborated lamps, so that I might give my wireless-detector idea a practical trial. But the lamp manufacturers of those days were too busy to bother with such fanciful ideas. Today, there are all too many lamp manufacturers and others frantically trying to produce audions, or vacuum tubes, to meet the exacting demands of millions of home radio sets. Two decades ago, in 1910, I essayed the first radio broadcast from the Metropolitan Opera House, with only a handful of radio operators and amateurs for my audience. Today, millions of listeners are receiving not only the finest opera, but also no end of entertainment and enlightenment in a constant variety such as King Solomon himself could not have demanded. Twenty years ago our annual radio trade was little over $1,000,000. Today, I am told, the annual radio trade aggregates well over $600,-000,000.

And all these things have taken place in two decades! Note, too, the comparatively recent inauguration of organized research and engineering development. Indeed, year by year the progress of radio has accelerated as radio men have replaced the cut-and-try methods by highly specialized knowledge of the various subjects. And with the present research and engineering facilities at our disposal, I look forward to still greater pace in molding the future of radio's art and industry.

Even so, there are some things which I do not hope for. So, rather than be accused of being entirely too optimistic and rash in my predictions, I begin my prophecy with a word about the suggested radio transmission of power. Let us note that the transmission of power is a matter of economics, pure and simple. A transmission system is practical only when measured by the yardstick of dollars and cents. Thus, with cheaply produced power, we can better afford transmission losses than with costly power such as we are generating today in our coal-fired power plants. Nevertheless, a transmission system that starts out with thousands of watts and ends in thousandths of a watt is hardly economical! That, precisely, is radio power transmission as we now know it. Although we have explored the radio spectrum up and down the wave lengths, we have had no assurance of economical radio power transmission. Still, who knows? Nikola Tesla, the brilliant electrical worker who has given us our modern alternating current transmission and power system, has predicted radio power transmission. Others have made such predictions. Nothing rational is impossible, if the will to conquer is present.

Television, or seeing at a distance, whether by wire or by radio, is something quite different. While it is true that the present attempts are relatively crude, comprising simple pictures with a modest degree of detail, nevertheless we have ample assurances of better technique and refined methods in the near future. My good friend C. Francis Jenkins, of Washington, D. C., one of the inventors of the motion-picture projector that took movies out of the peephole penny-in-the-slot stage and placed them in the theater, has already made notable progress in television. With the very modest power of his experimental transmitter W3XK at Washington, he entertains some 25,000 lookers-in scattered throughout the States who are compelled to build their own experimental receivers awaiting the advent of commercial models. This is so familiar to me—so much like the pioneer days of broadcasting—that I am sure television must develop along the same broad lines, namely, first, the experimental days, with the experimenters taking part with home-made equipment; then the gradual crystallizing of a practical system, based on knowledge gained in actual work; followed by the mobilization of the essential capital, personnel, and production facilities for the creation of an industry quite as well as the founding of a national institution.

Well, what shall we do with television—the infant of the radio industry? The answer is largely dependent upon how good television technique will be in the future. With the present state of the art, we are limited to simple pictures whose main appeal is based on the thrill of receiving them hundreds and even thousands of miles through space, rather than on the subject-matter transmitted. With the passage of time we must eventually evolve a television system that will have ample detail. Whether this will be achieved through remarkable elaboration of our present methods, or through an entirely new principle, I do not profess to know; but sight broadcasting, like sound broadcasting, must eventually achieve utmost realism.

And when television does achieve the necessary realism, it will find many applications. I look forward to the unfolding of world events on the home television screen, just as they are happening and not several days or weeks later. I expect the living image of the public man to join his voice in the future home radio set. I contemplate playlets within sight and hearing of the home audience.

Nevertheless, I cannot conceive of television eliminating the motion picture. The two serve totally different ends. Television, please note, will be the spontaneous presentation—flashed before the audience for immediate enjoyment or enlightment—born and dead in a fraction of a second. The motion picture, on the other hand, is recorded permanently and made available to any audience at any time and any place. No, I cannot see where television is going to harm the motion-picture industry. Rather, just as the phonograph industry has joined hands with the radio industry to form a remarkable partnership materially benefiting both parties, so must television and the motion picture join hands in the future.

Television, of course, will have an enormous field in the presentation of actual events, particularly sporting events, before many scattered audiences outside the home. I believe it will attain its climax in the presentation of sporting events in theaters and auditoriums and at vast stadiums. The event will be picked up at the scene, and flashed over wire networks, for the wire lines will always present the simplest and best method of supplying maximum detail with the most elaborate equipment. Even today, in its infancy, television leans heavily toward wire transmission because of the abundance of channels available on wires as contrasted with the limited channels in the ether. Radio, on the other hand, will be employed for the true broadcasting of television programs to the unlimited audience in the homes. The time is coming when motion picture theaters will obtain their pictures, like their electric light current, by wires instead of by the express company routes.

By radio, or by radio methods over wires, the entire business of newspaper journalism will be revolutionized. For by a combination of present telephoto and television methods, plus some startlingly ingenious, yet simple, inventions soon to be made in these fields, it will be possible to reproduce facsimile copies of news sheets across the continent, yes, across the oceans, almost before the ink of the original editions be dry.

Instead of boasting of a transmission speed of several hundred words per minute, we shall then speak of reproducing over great distances thousands of typed or written words per second, all set up and ready for transference by well known photographic and electrotyping methods into matrices and forms for the printing press.

Turning to sound broadcasting, with its remarkable achievements of today, it seems hardly possible to envisage further progress; yet I am certain we have done little more than get started toward the ultimate goal. I believe we have perhaps found the lasting basic principles of broadcasting. The audion, or vacuum tube, must always be the foundation, for I cannot conceive of any other method of detecting and amplifying delicate radio and audio energy than the simple vacuum tube, with or without heated cathode. I can foresee many vacuum tubes of entirely new design. The recent introduction of the long-known screen-grid tube, with many times the amplification of the usual three-element tube, yet with an inherent simplicity of construction never before realized, is introducing us to a new era in broadcasting possibilities. There are untold opportunities in vacuum-tube development, not only by way of new tube designs, but also in further refinement of existing types.

I often feel that, although radio reproduction has made remarkable strides in the past few years, there is still ample room for improvement. If we compare the reproduction with the original, whether it be human voice, orchestra, band, or organ, we are immediately aware of the wide discrepancy. Nevertheless, listening to the radio reproduction day after day, we mentally set up false standards for these various kinds of music and become convinced that we have attained the ultimate of perfection in radio reproduction. It is the unemotional sound analyzer of the laboratory that tells us definitely, in quantitative terms, just how far removed our loud-speakers are from the original sounds—and you may be certain there is ample room for improvement.

In the matter of efficiency, as well as in tone quality, our present loud-speakers are notoriously weak. Only a minute fraction of the electrical input is converted into the mechanical energy that sets up the air waves which we call sound. The greatest obstacle in the way of a practical battery set is the inefficiency of the loud-speaker, which now requires too much input for satisfactory battery operation. However, many brilliant minds are now at work on far more efficient loud-speakers. In a recent demonstration I heard a loud-speaker reproducing a full orchestra with natural volume and approximately natural tone, operated by dry-battery-type tubes. I hasten to add, however, that the loud-speaker probably cost several thousand dollars and measured some 20 feet in length—hardly feasible for the average home!

Electric sets are vogue in the cities, but it is a mistake to think that all battery operation is now obsolete. Wonderful battery-type radio sets are bound to appear in the very near future, for the many unwired homes in city and the millions in our country districts. The battery set is by no means obsolete; it has merely halted to catch its technical breath in preparation for a greater forward spurt.

No one can review the rapid progress of transoceanic radio during the past decade, and particularly the last half, or since the short-wave vacuum tube transmitter came to replace the Alexanderson alternator, arc, and spark transmitters, without accepting radio as a positive, economical, and logical means of long-distance communication. Time was when long-distance radio was a standing joke among cable men, whose best patrons were perhaps the luckless radio companies compelled to dispatch accumulated radio messages *via* the competing cables in the face of obdurate atmospheric interference. Today, however, the tables are often turned. Radio circuits not only operate day in and day out, hour after hour, but actually handle messages at a far greater speed than is feasible even with the latest type of improved cable circuit. Short wave transmitters fling messages between New York City and Berlin at 225 words per minute. During certain magnetic storms which have paralyzed the cable circuits, the short wave radio circuits have continued to function, even giving the cables a helping hand now and then.

Radio, particularly the short wave, moderate-power radio circuit, is a competitor of telegraph lines quite as well as cables, but only to a moderate degree. The recent battles for short wave licenses waged by various radio and telegraph interests in the United States serve as ample evidence of confidence in the future of radio links between important centers. It is possible that some day the radio circuits will compete with telegraph lines, but I am more inclined to believe that telegraph lines need fear no such competition. Rather, the transoceanic radio communication companies, heretofore forced to depend on telegraph lines owned by their cable competitors, are operating at a marked disadvantage. It is only natural and just that these should seek short wave links between the terminals of the transoceanic circuits and the many business centers of the nation. Otherwise the radio companies must operate under an enormous and even insurmountable handicap.

Originally, we looked upon the short waves as presenting an enormous and practically unlimited field for future radio communication requirements. But even at this early date the short wave band is becoming quite crowded. Space is at a premium, although there is much room in sight, once a satisfactory technique has been worked out for still shorter wave lengths and for compound or multiple tuning systems. The main consideration at this time is to utilize the existing short wave band to the best possible advantage, and this can be done by such methods as directive transmission and reception, multiplex operation of single radio circuits, and perhaps new methods of wave propagation and reception.

But I believe that the main field of radio is in transoceanic and perhaps transcontinental work, with distances running into the thousands of miles, rather than in intercity communication, in which field the wire lines are entirely satisfactory. Still there is every indication that we are still using blacksmith methods in our radio work, as compared with the precision methods that will come in the future. It must be possible, ultimately, to employ a single short wave channel for several simultaneous functions, such as telegraph, telephone, and facsimile communications. By improved methods of synchronizing two transmitters so that their carrier frequencies may be exactly matched to eliminate interference, and having two distinct audio pitches or frequencies, it should be possible to double the number of short wave transmitters without undue interference. Indeed, the number might be multiplied many fold with proper ingenuity.

While the transatlantic telephone service is in daily use, connecting American telephone subscribers with those in many European countries, I do not look ahead to any extensive use of the radiotelephone in competition with telephone lines. The radiotelephone can serve in spanning vast distances over water, but submarine cable telephony will soon be feasible for distances of three thousand miles, and on account of its greater reliability must inevitably prevail. Yet radio alone can serve in spanning variable distances, such as those between airplane and ground, railway train and stations, etc. As far back as 1914, I essayed radiotelephone service between trains and train dispatcher with fair success. Since then many others have followed in my footsteps, naturally with greater practical results in view of the great advances made in the tools at their disposal. I believe that eventually all ships, railway trains, aircraft, and other vehicles carrying passengers will be provided with radiotelephones so as to establish communication with any telephone subscriber the world over. The principles are firmly established today. It is now chiefly a question of economics.

In the field of aviation, radio is bound to play a leading part. Today we have early indications of this important partnership in the form of the first two-way radiotelephone circuits experimentally established between plane and telephone system, of radiobeacons along our national airways, of radio storm warnings to pilots, of radio direction-finders aboard aircraft. In time, flying will be made comparable in safety with piloting an automobile over our cement highways—thanks largely to the aid of radio.

And with all I have here mentioned, I still believe the story of radio's future is far from complete. There are so many fields to which radio technique can be applied—in geology for the locating of mineral deposits; in agriculture for accelerating plant growth and for exterminating insect pests; in industry for the refining of rare metals in vacuum induction furnaces; in diagnosis and medicine because of the peculiar curative properties of certain high frequencies; in surgery because of the proved value of the radio knife, which sears its way through flesh, cauterizing as it goes; in fine measurement work in the laboratory.

Indeed, no man can prophesy the future of radio with any degree of success. Prophecy at best is a wild guess—and that is precisely what I have attempted to do in the foregoing, perhaps much too mildly, despite my avowed intention of being rash in my predictions.

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