THE BOOK OF RADIO

A COMPLETE, SIMPLE EXPLANATION OF RADIO RECEPTION AND TRANSMISSION, INCLUDING THE OUTSTANDING FEATURES OF RADIO SERVICE TO THE PUBLIC BY PRIVATE AND GOVERNMENT AGENCIES

BY

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FOREWORD BY

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TO

RUTH

MY WIFE AND CO-WORKER

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FOREWORD

Radio Communication, peculiarly a science of the people, is recognized popularly through the agency of radio broadcasting. Few realize that there is another new field equally as fascinating. Radio now links the distant airplane with its home station, and in addition to providing a means of voice communication, it also provides the pilot with all the instincts of a homing pigeon, carrying him across the sky through fog and storm to his destination. Imagine the keen thrill of the pilot on hearing the friendly voice of his home radio station as he battles his lonely way through a midnight storm. Picture all our inhabitants of the far places of the earth—the miner on the mountain top, the snowbound rancher, the flood victim, the occupant of the sick bed, the mariner on the high seas, and the pilot in the cloudland—all bound together under the protecting hand of radio. Here lies one of its deep, gripping appeals.

One use which is perhaps novel to most radio enthusiasts was developed during the war. A squadron of airplanes (usually three, six or nine) is equipped with receiving sets using trailing wire antennæ. A so-called voice control airplane is equipped with a radio telephone transmitting set. A squadron of airplanes can thus be maneuvered with the greatest ease in a manner similar to the maneuvering of a squad of soldiers. You can believe that the first time these maneuvers were conducted in Washington a profound impression was made. All the well-known evolutions, such as right or left turn, right or left reverse, loops, spins, dives and changes of formations, could be accomplished with uncanny precision.

I recall one occasion, when I took up an airplane equipped with a receiving set, while the control station (which is almost invariably a radio telephone) was placed on the ground. A distinguished group of people was present, several taking delight in furnishing me with orders for maneuvering. These voices were received with the utmost clarity, and the orders readily accomplished. The whole affair seemed more than miraculous to most of those present, but I am sure that more than one thought there must have been some trickery. There were scattered clouds, and this condition gave someone a happy thought. I received instructions to enter a nearby cloud, one of the large, white, billowy kind that from above seem solid enough to walk upon. I promptly disappeared from the sight of those below. Then I received instructions to spin out and come out of the spin facing the Capitol. This was immediately executed, and the doubters became enthusiastic believers, as they had previously thought I must have been receiving some kind of visual signals.

The Army, Navy and Post Office Departments are all busily engaged in providing all of their airplanes with airplane radio sets, and practically all of these aircraft will utilize radio telephony. The Post Office Department will soon install such sets on all of its transcontinental air mail planes, as a preliminary step to night flying. All the known radio aids to air navigation will also be provided.

What could be more fascinating than to sit by your own fireside and follow the mail across the heavens on a stormy night? The ether of the near future will be full of thrills provided by man's epic conquests of the elements. I do not doubt but that the exploring parties of the future will carry complete radio sets with them as one of the essentials. Then the time will come when the daily incidents of the explorations of the mysterious, unknown places of the earth will reach us through our great broadcasting systems as we sit together with our families.

The high points in the accomplishments of the human race will not wait on cold, dry print to appear after the world has moved on to other things. The farmer, the rancher and the seaman will thrill to a great event, will sorrow with the universal sorrow, which will be a nation-wide, yes even a world-wide echo of the event or loss.

That radio broadcasting is a practical, proven method of dissemination is clearly shown by the pronounced activities of the various government departments and by commercial concerns. As I write this, the Postal operator is broadcasting a crop and market report for the southern states. Two years ago it would have been inconceivable to imagine a system which would have reached such a large number of individuals instantaneously with only one handling.

Radio broadcasting of the future must develop, if it is to be successful, with a very definite policy in mind, and this is that radio, after all, is only a means to an end. Radio broadcasting will lose its appeal when the novelty wears off, unless the widespread popular interest in the mechanism itself is supplanted by carefully edited broadcasting material whose excellence must at least rival other methods of transmitting such material. Of course radio broadcasting stands alone in its ability to reach vast numbers of people simultaneously. A new field of specialists must grow up, who must be experts in determining public demand, and the best methods of meeting that demand. The radio broadcasting programs of the future will be as skillfully edited as one of our great daily newspapers. This means that great resources for obtaining timely news, educational and entertaining material, must be constantly available.

In view of the fact that radio broadcasting is practically alone in its particular field, and as there is such inherent power for good or evil in its influence on popular opinion, the privilege of using it must be jealously safeguarded. Of course, in this field, as in others, public opinion will be the most potent control. Everyone, however, should welcome government supervision in order to provide for the maximum use of the ether for the benefit of the greatest number of listeners. It was for this purpose that Secretary Hoover recently formed the Radio Telephone Conference.

The representative body of men composing this Conference went into the entire broadcasting situation at great length. The subject is so complex and touches general radio communication at so many points that nothing better than a compromise could be reached. The result is probably as equitable in its effects as can be achieved at the present state of the science. In fact, it seems to be a happy solution of the present unbearable condition. It must be borne in mind, however, that the assignment of wavelengths was the basic problem facing the Conference and the general industry, and in view of this radio communication as a whole was divided into various services. All classes fell under four general heads, which are listed in their order of importance, namely: (one) communication with ships at sea; (two) communication with aircraft; (three) communication to isolated sections; and (four) broadcasting. This arrangement, as is apparent, is based on preservation of life, which must be our first consideration. Of these headings, the newest are the second and fourth classes. The second class, referring to aircraft, is certainly the least known, and due to the increasing importance of aeronautics, a word will not be out of place.

To my mind, the combination of aeronautics and radio forms the most fascinating field in the realms of science. These two will be the hand-maidens of future progress; they are both annihilators of time and space of the first order; they will be Ambition's stepping stones to a new world where civilization will be all that the word implies.

Aircraft radio fulfills two important functions. First, it is the only practical method of intercommunication; second, it provides certain indispensable aids to air navigation. The problem of communication can be passed with a brief examination. Airplane radio communication of the future will utilize the radio telephone almost exclusively. Not only does the telephone lend itself to operation by unskilled personnel, thus reducing the all-important weight element, but the transmission speed is far greater than would be possible with hand sending. Speed and accuracy are essential in navigating an airplane. In cases of emergency, when life itself is measured in fractions of a second, words must be reduced to instant action. Due to its flexibility, radio telephony is therefore preferred.

The radio aids to the actual navigation of an airplane are radio direction finding and radio field localizing. Three methods of direction finding are available, although the radio beacon has the most satisfactory results for use in small airplanes, due to its extreme simplicity. In utilizing this method, the pilot simply wears a special radio telephone helmet, designed to exclude motor noise. In use, the device depends upon the fact that if a coil of wire is wound and connected to a radio receiving set, which is very sensitive, the signals from a given transmitting station are loudest when the coil is pointed directly at that station. If such a coil is rigidly mounted on an airplane so that it points in the same direction that the airplane does, it can readily be seen that if the pilot flies the plane so as to keep a maximum signal in his ears, he is bound to fly to the transmitting station. Such a station is installed on the flying field at the point of destination, and is called radio beacon station.

It was found that a radio beacon would bring an airplane to the immediate vicinity of the flying field but would not exactly locate it during periods of poor visibility when the ground could not be seen, due to the fact that there is apparently a blind spot around each regular transmitting station, the size increasing with the wavelength. The pilot would therefore lose his direction just when he needed it most. It was to fill this gap that the radio field localizer was developed. This device is a peculiar kind of radio transmitter which transmits vertically in the form of a cone which rapidly gains diameter with increased altitude. At the height of three thousand feet above the field, such a cone can be made to have a diameter of nearly a mile. The pilot flying through fog or rain enters this zone of sound before the radio beacon station has become ineffective. Radio thus lends a guiding hand to the pilot from the time he leaves the ground with the latest radio information gathered along the entire route to the time he lands his airplane at his destination many miles away. Radio changes what would otherwise be a trackless sea to well defined airways over which the commerce of the future will move with safety and at a speed which will bring San Francisco within daylight distance of New York.

Radio has another important function in aiding the communications of every-day life. Few know that telegraphy and telephony over land wires have taken advantage of this friendly magician. It is indeed magic, for radio now makes it possible to transmit many telegraph and telephone messages simultaneously over one wire. In this case the wire becomes a guide, and the many messages are carried on high frequency waves which move in the space adjacent to the wire without interference. This system is called "wired wireless" or "line radio." It is of peculiar interest that line radio was developed by technicians in government service. This, then, becomes a government contribution to the advancement of science.

Radio even provides a means of communication for submarines. Strange as it may seem, a submarine can maintain constant communication whether submerged or afloat. Though it sounds absurdly impossible, it thus becomes possible to talk to an airplane high in the air from a submerged submarine.

In spite of all these important applications, radio development is only in its infancy. The future holds great promise, especially in the radio transmission of power, through the use of directional transmission, perhaps at very low wavelengths, communication over great distances with low power transmitters, elimination of atmospheric disturbances familiarly called "static" and the development of a tremendous broadcasting system, both governmental and private, covering all sections of the United States.

I shall take this excellent opportunity to speak a word to the amateurs. As I stated previously, the Air Mail Service will begin an extensive night flying schedule in the near future. The Author, in this book, relates one instance where radio saved a large twin-motored air mail plane from destruction while in flight between Cleveland and Chicago, and amateurs in the immediate vicinity were partly responsible for this happy ending to a near disaster. I take this moment to again call attention to their excellent work.

This incident is a key to the future, when the skies will be full of such airplanes, when there will be many opportunities for amateurs to lend the aid of themselves and their stations in such times of emergency. We look upon stations of this kind as a decided asset in our new ventures.

I have called attention to these various phases of the radio science in the hope that it would bring the realization that in reading this book you will absorb a knowledge of the most delightful of all the sciences.

The author, Mr. Charles William Taussig, is one of the pioneer radio amateurs of this country. He continues to be as ardent a radio enthusiast as he was in the beginning; his knowledge of the subject is unquestioned; he lists among his friends many of the prominent men in radio, and consequently the information he presents is authentic and up to the minute. Mr. Taussig is peculiarly fitted to present the subject of popular radio, due, as stated before, to the fact that he is completely in sympathy with the problems and ambitions of radio amateurs and listeners. Having read his book, I feel sure that you will find it highly entertaining and instructive. You will then be in a position to laugh at an inquiry recently received by the radio editor of a local newspaper. A particular listener, who had recently joined the ranks of radio fans, was having trouble receiving his favorite broadcasting station on 360 meters. His inquiry read something like this,—"Dear sir: My receiver has been giving me trouble in getting the broadcasts during the last few days. Do you think my 360 meter wavelength is worn out? If so, please tell me where I can buy a new one, and how much it will cost."

James C. Edgerton
Superintendent of Radio,
Post Office Department

CONTENTS

APPENDICES

LIST OF ILLUSTRATIONS

THE BOOK OF RADIO

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CHAPTER I

LISTENING IN

Introduction to the radiophone and radio telegraph by visiting a station—Listening to a concert via radio—Mme. Rhappold sings—"This is KDKA talking"—Governor Allen of Kansas addresses Pittsburgh Chamber of Commerce and is heard by vast radio audience—Chicago Grand Opera Company heard in "Butterfly" over radio—Transatlantic radio—Listening in on the world—Prize fights to church sermons by radio—Broadcasting the "Star Spangled Banner" on Washington's Birthday—Learn the code—A tragic sea story as heard by radio telegraph—Government coöperation and regulation—Government broadcasting to amateurs—Radio as a hobby.

Probably the best introduction to the radiophone is to spend an hour or so at the instruments "listening in" on the world. The station we are to visit is in the library of a little home near New York. The instruments appear to the novice as merely a couple of small boxes with black handles protruding, several switches, a pair of telephone receivers, and a large horn, similar to that which formerly adorned our phonographs.

We sit down in an easy chair near the apparatus, and our host hands us a pair of telephone receivers which we fit over our ears, in the manner of a switchboard telephone operator. He turns a switch and three little lights glow within the box and a hissing noise sounds in the telephone receivers. This noise is soon quieted by further switch manipulation, and we now hear a musical note sending out dots and dashes of the code. We are informed that this is the wireless station at Babylon, Long Island, sending a message to the steamship "Olympic" which is bound for Southampton.

A few more turns of a switch and we hear the familiar strains of Mendelsohn's "Spring Song" played on a piano. Every note rings out clear and true, as though the pianist were in the next room. We are told that this is part of the evening entertainment from the broadcasting station at Newark, New Jersey, forty miles away.

The piano selection being over, we wait a few moments and a pleasant voice floats in through the telephones advising us that the next number will be a selection by a well-known orchestra. In a moment, the voluminous strains of the "Pilgrims' Chorus" from "Tannhäuser," played by a famous symphony orchestra, reach us. We listen a few moments and then take the telephone receivers from our ears. Another turn of the switch, and the music is coming from the horn attached to the receiving apparatus. We do not need the telephones now, for the music is as loud and clear as though it were a phonograph being played.

The next number is announced as a solo by Mme. Rhappold, the famous opera singer, who renders for us a beautiful song from "La Bohème." After Mme. Rhappold has finished, we put the telephone receivers on again, and start exploring the ether for further entertainment. This is done by turning several switches and dials. As we move the switches about, we get portions of hundreds of different wireless telegraph messages, which we ignore, as they are, at the moment, of no interest to us. Now we hear, faintly, a man's voice. Careful manipulation of the switches and dials gradually brings the voice to us clear and strong. He is saying, "This is KDKA talking; KDKA, the broadcasting station of the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania. We will connect this station with a banquet hall in Pittsburgh, where Governor Allen of Kansas is now speaking." A moment's pause, and then a stentorian voice delivering an address is heard. It is Governor Allen, explaining in person to the members of the Chamber of Commerce of Pittsburgh, the history of his Industrial Court in Kansas. We remove the telephones and again connect the apparatus to the horn. Comfortably seated in this library, we listen to the famous Governor delivering his address at the banquet five hundred miles away! The voice is natural, and we see him in our mind's eye standing at the speakers' table, addressing the hundreds who are seated before him. They must be drinking their after-dinner coffee now, and we unconsciously reach out before us for the little cup that usually accompanies after-dinner speeches. A humorous remark causes us to laugh. What is that we hear!! Surely it cannot be! But, hold! yes, it is! the entire company of diners roaring with laughter at the humor of the Governor's speech. Their laughter coming from the horn mingles with ours in the library. Frequently the Governor is interrupted by applause, which thunders from the little horn.

The Governor's address finished, we again do a little radio exploring. In a moment, we are listening to another broadcasting station. This time it is grand opera. We soon recognize the familiar music of "Madame Butterfly." It is not so loud, however, as the previous stations, and we have to put on the telephone receivers. Through the receivers the opera is distinct and sufficiently loud to be enjoyable. We pick up a newspaper and turn to the radio page to see what station is sending out grand opera. It is Chicago, over one thousand miles away! From the newspaper, we learn that we are listening to the Chicago Opera Company's performance in the Coliseum. For some time we enjoy the opera, and then the spirit of radio adventure stirs us and again we explore with our switches. We hear various other concerts at Detroit, Mich., Schenectady, N. Y., Medford Hillside, Mass., Bedloes Island, N. Y., and Washington, D. C.

After hearing parts of all these concerts, entertainments, after-dinner speeches, etc., our friend, who is proficient in the code, asks us if we would like to have him try to pick up some long distance radio telegraph stations. This sounds interesting, so we tell him to go ahead. Some more varying of switches, and we hear the radio telephones no longer, but are listening to various high-powered telegraph stations. "That station you hear now is Chatham, Mass., sending a message to Stavanger, Norway," says our friend as he manipulates the switches. Another station comes in and we are informed that we are listening to Radio Central on Long Island sending messages to Nauen, Germany.

Now we hear a clear but somewhat faint musical spark. Our host copies the message. It is in French. The signature is FL. We have been listening to the Eiffel Tower in Paris, over three thousand miles away.

During the evening, we listen to and copy interesting messages from Bermuda, Havana, Porto Rico, Jamaica, W. I., Demerara, W. I., Berlin, Prague, Carnarvon (Wales), Stavanger, Rome, San Francisco, San Diego, and finally before going home, we are fortunate enough to pick up the signals from the United States Naval Station at Pearl Harbor near Honolulu, over five thousand miles away.

Such an evening spent with a good receiving set is not unusual for favorable radio weather. Little wonder that this country has been stricken with the "Radio Fever." From Prague to Honolulu, half around the world; from grand opera to jazz; surely we cannot complain of dull evenings.

An outfit that will receive like the one we have just described, costs between one hundred and fifty and two hundred dollars. However, it does not require such an outlay, in order to have a radio receiver. A receiver that can give considerable pleasure can be built for about two dollars. Such an instrument is described in Chapter V. Of course, the more simple the outfit, the less that can be regularly accomplished with it, but if you live within a radius of twenty-five miles from a broadcasting station, you can build an outfit for about ten dollars that will receive very well, and you can buy one for from fifteen to twenty-five dollars.

In addition to the features already mentioned that can be heard over the radiophone, are weather reports, time signals, market reports, crop reports, daily news, bedtime stories for children, government health reports, sporting events, such as football games play by play, baseball games, election returns, boxing matches (the Carpentier-Dempsey fight was reported from the ringside, as it progressed).

On Sunday, there are numerous sermons broadcasted, of all denominations. In Pittsburgh, direct connections are made between the broadcasting station and the church, so that the sermon and services may be heard by all within radio range of the church. Perhaps the most inspiring rendition of our national anthem that the author has ever heard, was on Washington's Birthday 1922, when the entire congregation at the Calvary Episcopal Church, on Shady Ave., Pittsburgh, sang the "Star Spangled Banner," accompanied by the great organ! Traveling as it had over five hundred miles of our land, over mountains and forests, rivers and lakes, to our radio receiver, it seemed to the author a most appropriate tribute to the father of our country.

It is our advice to the prospective radio listener that he learn the code, so that he can understand the telegraph messages, as well as the telephone. There is a fascination in receiving wireless telegraph messages over great distances that only one who has experienced it can really know.

Then there is the appeal of those dramatic and tragic sea stories that too frequently come to those who can understand the messages. We thrill at a newspaper account of an S O S call and a tragedy at sea. To hear such a call, first hand, and the subsequent messages of hope and despair, is to come in contact with a phase of life that the average man under ordinary circumstances can but read about.

Some years ago, the author awoke at about five o'clock one stormy winter morning. The wind was blowing fearfully, and the snow was blinding. Realizing what such a storm meant at sea, he listened in at his wireless to hear what was happening out there. All was quiet at first, but shortly a pilot ship just outside of New York Harbor sent out a general call and reported that a great wave had swept her from stem to stern, and had washed a man overboard. They had searched for him in vain; that was all. At the conclusion of the message, a few boats near by acknowledged receipt, and then all was quiet again. An incident such as this has more human interest when heard first hand over the radio than the best newspaper story or fiction.

Many of the personal messages sent by individuals, which you can intercept in your home, are most interesting. Of course, you are bound to secrecy, by law; and if you are licensed, by oath. Still, it is legal to listen to these messages yourself, and much pleasure and information are often derived.

There was a time when the activities of the amateur and the novice were a source of irritation to the government. Steps were taken to eliminate him, but were unsuccessful. At the outbreak of the war, the government found thousands of amateurs ready for radio service. It would have taken at least a year to train this large number of men to become radio operators, were it not for their experience as amateurs. Among the many groups of people who claim credit for having won the war, the author wishes to include the amateur radio operator.

To-day, the government not only recognizes them, but coöperates with them and helps them wherever and whenever possible.

The amateur is ably represented by the American Radio Relay League, who send representatives to Washington to confer with the authorities, whenever new legislation concerning amateur wireless is contemplated.

In several Naval Districts, the Naval Stations send special messages to the amateurs for the purpose of affording practice in receiving and to keep them in direct touch with the government. In time of need, the government could reach hundreds of thousands of people within an extremely short time, by means of amateur radio.

At nine-thirty every evening, the radio station at the Brooklyn Navy Yard broadcasts a telegraphic message to amateurs. The message is sent slowly, so that even beginners can copy it. Sometimes it is sent in what is known as the Amateur Radio Code. This is a secret code which is supplied to amateurs by the government, and familiarizes them with the handling of secret code messages. In time of war, practically all radio communication is conducted in this manner, and familiarizing the amateurs with its use makes them more efficient in time of need.

There are many pursuits which men and women follow, outside of their regular business or profession. These "hobbies" include the collecting of coins, stamps, books, pictures, autographs, the study of art, music, literature, etc., all of which are decidedly beneficial. Many neurologists are prescribing for their patients "hobbies." "Acquire a hobby and you won't require medicine," a prominent neurologist told a patient recently.

No hobby is more suitable for people in general than radio. The broadcasting stations provide amusement for those who do not care to take up the study of radio seriously, but decidedly more pleasure can be derived from radio by acquiring some knowledge of the theory and practice.

As before stated, it is a great asset to know the code and to thus widen your scope of amusement and usefulness.

Careful reading of the succeeding chapters will assist in mastering the principles of radio and the practical operation of modern apparatus.

CHAPTER II

THEORY OF RADIO

Theory of radio transmission—Simple analogies—The ether—Electricity travels 186,000 miles per second—Ripples in a pond analogy—How does the receiving station pick up the message intended for it?—Why do not other messages interfere?—The tuning fork—What is frequency?—The limit of audibility.

Before going into the details of practical radio telegraphy and telephony, it is well to consider the theory on which radio communication is based. To understand this theory does not require a scientific education. It can be explained in simple analogies that every one can understand and should understand before attempting actually to operate radio instruments.

Many people have the conception that radio transmission and reception have to do with the air; that the air is the medium through which wireless messages pass. They show this belief by such questions as, "Can you receive messages when the wind is blowing in the opposite direction from the transmitting station?" or, "Can you receive messages during a wind storm?" or, "Is it necessary to open a window when receiving a message?" These questions clearly indicate the state of mind of many people regarding radio.

The medium through which radio messages are transmitted is known as ether (not to be confused with the anæsthetic). Ether is an all-pervading substance, odorless, colorless and inconceivably rarified, permeating all space. It is the medium through which radiant heat, light and electricity travel.[1] By mathematical calculations, it has been computed that light, heat and electricity travel at the tremendous speed of 186,000 miles per second! It takes seven minutes for the light of the sun to reach the earth! One hundred years elapse before the light of some stars reaches us! If we were to attempt radio communication with a star which was so distant, we would have to wait two hundred years for a reply to our message, allowing one hundred years each way for the message to travel. One hundred years for these ether waves to reach a star and one tenth of a second to circumscribe the world in temperate latitudes traveling at the same rate of speed; such is the comparison that makes it appear less wonderful for two human beings, separated by a mere 5,000 miles, to be able to talk to each other through the ether.

Having accepted as our hypothesis that light, heat and electricity are transmitted through this medium we call ether, let us consider some of its characteristics. Light passes through glass; therefore, the medium through which it travels must be in glass. Light passes through a vacuum; therefore, ether must be in the vacuum; and so, by many other similar observations, we come to the conclusion that ether is in all substance; in fact, in everything and everywhere. With this in mind, it is not difficult to understand why the wireless messages pass through houses, mountains, forests, etc.

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[1] Einstein, Steinmetz and others have abandoned the ether theory which is incompatible with Einstein's theory of relativity.

If you throw a stone into a pond, ripples radiate in concentric circles from the point at which the stone entered the water. These ripples are miniature waves, traveling through the medium of water. If the ether is agitated by an electric impulse, waves are immediately formed and travel in much the same manner. Should there be a cork in the pond at some distance from where the stone struck the water, the waves would in time reach it and cause it to vibrate. So it is with waves in the ether; they will in a similar manner cause a vibration to be set up in a suitable apparatus at a distance from their source.

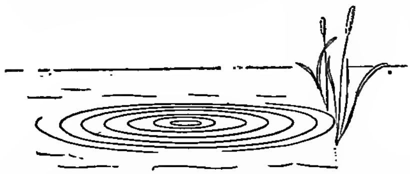

FIG. 1.—If you throw a stone into a pond, ripples radiate in concentric circles from the point at which the stone entered the water. Ether waves are somewhat analogous.

Continuing the same analogy assume that at one side of the pond there was a man who wished to communicate with a friend on the opposite side. He had prearranged a code by which the throwing of one stone into the water would signify a certain message and two stones thrown into the water would mean something different. Perhaps it is dark and the man on the opposite shore cannot see his friend. Soon, however, he hears a rapid succession of ripples lap over the pebbles on the shore. He knows that one stone has been cast into the pond. Now he waits and presently more ripples come and his friend has succeeded in communicating with him, though separated by distance and darkness. In this case, a message has been transmitted by means of water waves. In similar manner, messages are transmitted over great distances through the ether. We do not cast stones into the ether to produce waves, but we do agitate it into waves or ripples in a manner to be outlined as we progress in this book.

After the reader has digested the above analogy, he will probably propound that most perplexing question to the uninitiated: "How does the receiving station pick up the message intended for it, and why do not other messages interfere?"

There are innumerable analogies to show the means by which wireless messages are prevented from interfering with one another, but many of these analogies are more intricate than the wireless phenomenon itself. Probably the simplest analogy is as follows:

Sound is transmitted through the air by means of waves. Every musical note is produced by causing the air to vibrate a certain number of times per second. For instance, the note C is produced by striking a tuning fork that is constructed to vibrate 256 times per second. This produces 256 air waves per second which strike the ear drum and cause the musical sensation known as "middle C." As we travel downward in the musical scale, the number of vibrations per second grows less, the length of the wave produced grows longer, and the note emitted becomes more sonorous. As we ascend the musical scale, the number of vibrations per second becomes greater, the waves become shorter and the pitch of the note becomes higher. The number of vibrations or the number of

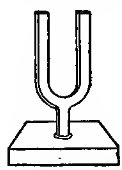

FIG. 2.—The note C is produced by striking a tuning fork that is constructed to vibrate 256 times per second.

oscillations per second is called frequency, a term much used in radio.

A small dog whistle, emitting a shrill sharp note, vibrates at a frequency of about 4,000 per second. The human ear is sensible to frequencies as high as from 10,000 to 15,000 per second, depending on the individual. Frequencies above this cannot be heard. Thus, in radio work, we consider frequencies up to 15,000 [2] as audio frequency and above that as radio frequency.

The average person with acute hearing undoubtedly believes that he can hear everything within proper distance of his ear. He does not realize that his ear is tuned to certain frequencies just as a wireless receiver is tuned to certain frequencies. Neither his ear nor the wireless receiver is capable of receiving impulses from frequencies to which it is not tuned.

In the summer time in the country one hears the shrill notes of millions of insects, yet there are myriads of insects in your vicinity that are emitting vibrations which you cannot hear because they are in excess of 15,000 per second. Undoubtedly insects emitting vibrations above 15,000 are capable themselves of hearing these vibrations.

If the human ear were not tuned to the comparative limited range of frequencies that it is, we should be always experiencing a babel of noises that would make life far less enjoyable.

It is possible for us to make mechanical and electrical instruments that are far more selective to the frequency to which they will respond than the human ear. Let us

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[2] Some authorities place the limit of audio frequency at 20,000 cycles.

take, for example, the tuning fork which we mentioned before, that vibrates 256 times per second and emits the note "middle C." If we have two such tuning forks in the same room, and cause one of them to vibrate, the second tuning fork will receive these vibrations and respond by emitting the same sound, namely, C. You can cause one hundred or more tuning forks of different pitches to vibrate in the same room, but the C fork will only respond to the vibrations produced by another C fork.

Radio frequencies which have been produced thus far, for actual communication, have ranged from about 15,000 waves per second to about 100,000,000 per second. The waves which vibrate at the rate of 15,000 per second are 20,000 meters long and the waves that vibrate 100,000,000 per second are 3 meters long.

Certain Transatlantic radio stations desire to communicate with each other at a frequency of 15,000 per second, that is, with a wave length of 20,000 meters. Therefore, the transmitter is so constructed that it will cause the ether to vibrate at the rate of 15,000 waves per second and the receiver is so constructed that it will respond to this frequency only. Though thousands of messages are traveling through the ether at other frequencies, these stations which are "tuned" to each other can communicate without any interference.

In order to understand how radio apparatus is made, to cause the effects just described, it is necessary to have at least an elementary knowledge of electricity. The next chapter is devoted to this subject.

CHAPTER III

ELECTRICITY

What is electricity?—Two kinds of electricity—Experiments with static electricity—Electricity produced by combing the hair—Dynamic electricity—Analogy of flow of electricity and river—Positive and negative poles—Dry battery—Volts—Amperes—Ohm's law—Resistance—Rheostat—What is a watt?—Magnetism—Magnetic compass—Magnetic laws—Magnetic lines of force — Permanent magnets — Electromagnetism — Induction —Theory of the induction coil—Table of sparking distances—Alternating and direct current generators.

Just what electricity is we do not know, but we do know how to control it and how to make it a useful servant. There are two kinds of electricity, one of which we call into play when we ring the front door bell, namely, dynamic electricity (electricity in motion), and the other kind we meet when we comb our hair on cold days, namely, static electricity (electricity at rest).

Static Electricity.—When we comb our hair on cold dry days, we hear a crackling sound and if it is dark, we sometimes observe sparks. If we take the rubber comb with which we have been combing our hair and bring it near a small piece of cotton or paper, we will note that the comb has the power of attracting those objects to it.

Now, if we take a small bit of cotton and roll it into a ball of perhaps one-quarter inch in diameter and then suspend it on a silk thread, it will be attracted to the comb, but the moment it has touched the comb, it will be repelled from it. This is caused by the ball of cotton becoming charged with the same kind of static electricity as the comb. As long as the cotton ball retains its charge, it will be repulsed by the comb.

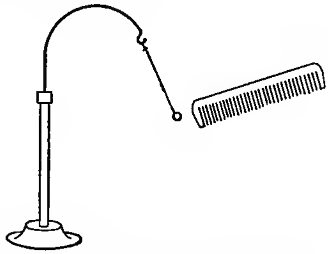


FIG. 3.—Unlike charges of electricity attract each other.

If we take an amber rod and rub it on silk and then bring it in proximity to the cotton ball, the ball will immediately be attracted to the amber rod, for we now have two different kinds of static electricity. The electricity produced by drawing the rubber comb through the hair is negative (—) electricity, and that produced by rubbing amber with silk is positive (+) electricity.

FIG. 4.—Like charges of electricity repulse each other.

It will be noted from the above simple experiment that like charges of electricity (of the same polarity) repulse each other, and unlike charges of electricity attract each other.

Another rule that can be discovered by a similar experiment is that, whenever we produce positive electricity, we also produce negative, and *vice versa.* The production of negative electricity in the comb produced positive electricity in the hair and the production of positive electricity in the amber produced negative electricity in the silk.

The above bodies which we have electrified are non-conductors of electricity and the charge which we gave them was produced on the surface. The same bodies resist the flow of electricity through them and are therefore used as insulating materials. Other insulating materials are glass, air, dry wood, bakelite, shellac, etc.

Static electricity plays an important part in radio and some knowledge of it is necessary, if we are to understand the action of condensers.

Dynamic Electricity.—It is beyond the scope of this work to go into the many details of the production of dynamic electricity; suffice it to say that the common sources of electricity used for radio apparatus come from the generator, the dry battery and the storage battery.

Electricity is said to "flow," and we immediately have a mental picture of a river, which is a fair analogy for the flow of an electric current. In order that a river may flow and produce a current, it is necessary for its source to be higher than its mouth; this produces water pressure and causes the river to flow from the point of high pressure to that of low pressure.

In an electric battery, there are two elements which correspond to the source and mouth of a river. The positive or (+) pole corresponds to the source, and the negative or (—) pole corresponds to the mouth. When a wire is connected between the two terminals, we get a flow of current from the positive pole to the negative, caused by the existing electrical force or pressure between the two terminals or poles. This pressure or "difference in potential" is called "electromotive force," usually written E.M.F., and is measured by a unit called "volt." The amount of current which flows in the wires is measured by a unit called "ampere."

Fig. 5.—An electric battery or dry cell.

Returning to the analogy: if there is a sharp drop in the river, there is considerable water pressure and a large volume of water will flow, providing, however, that the banks of the river are wide apart; otherwise, if we cramp the river between two narrow banks, notwithstanding the high pressure, the resistance of the narrow passage will check the volume of the flow. In like manner, the volume of electric current in a given circuit is dependent upon the pressure and the resistance of the circuit. (When the positive pole of a battery or generator is connected to the negative pole by a wire or other conductor, a circuit is said to have been made.) This resistance is measured by a unit called "ohm." Inasmuch as there are only these three factors, namely, E.M.F., resistance and current in a direct current circuit it has been found that by a simple formula, where two are known quantities, the other can be determined. This formula, shown below, is known as "Ohm's Law."

$$\text{amperes} = \frac{\text{volts}}{\text{ohms}}$$

and, therefore, by transposing

$$\text{ohms} = \frac{\text{volts}}{\text{amperes}}$$

$$\text{volts} = \text{amperes} \times \text{ohms}$$

It can be readily seen from the above formulas that if we wish to control the amount of current that flows in a circuit, we can accomplish this by regulating the resistance. Conductors of electricity have more or less resistance to electrical currents. A copper wire has the least resistance and is consequently used most frequently as a conductor of electricity. A thin wire has more resistance than a heavy wire. German silver wire has a high resistance to electric currents; therefore, by regulating the length of German silver wire through which a current is flowing, we can regulate the amount of current. It is necessary to vary the amount of current flowing in many circuits used in radio. For doing this we use an instrument called a rheostat. This consists usually of a coil of German silver wire with a mechanical means of varying the amount of wire through which the electricity has to pass, in order to complete the circuit. A rheostat used for small currents in radio work is shown in Fig. 6.

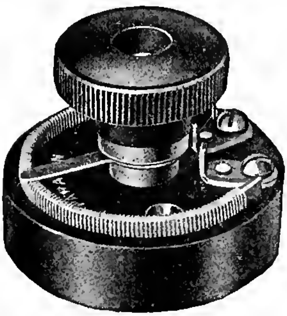


FIG. 6.—For varying the amount of current flowing in a circuit, we use a rheostat.

Resistance, which is really electrical friction, produces heat, just as mechanical friction does. It is therefore necessary, in using a rheostat, to be sure that it is properly constructed so as not to be overheated. Different rheostats are built to carry varying amounts of current.

The rheostat is placed in series with battery or other source of current. Fig. 7 shows a rheostat in series with a small electric lamp and battery for the purpose of regulating the amount of current flowing through the lamp and consequently its brilliancy.

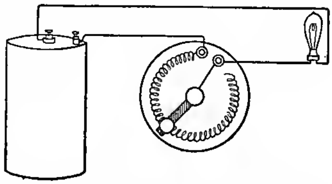


FIG. 7.—A rheostat is placed in series with a small electric lamp and battery for the purpose of regulating the amount of current flowing through the lamp, and consequently its brilliancy.

Besides German silver wire, graphite, carbon, water, mercury, and platinum are sometimes used for their resistance to electric currents.

The amount of power in a direct current circuit is the current times the E.M.F. and is expressed by the unit "watt" (746 watts equals one horse power).

$$\text{Watts} = \text{volts} \times \text{amperes}$$

and by transposing we have

$$\text{Volts} = \frac{\text{watts}}{\text{amperes}}$$

$$\text{Amperes} = \frac{\text{watts}}{\text{volts}}$$

Magnetism.—Magnetism is the power which a magnet has to attract any substance capable of being magnetized.

The earth is in itself a huge magnet, having a north and south pole, and obeying the general laws of magnetism. The magnetic compass needle is attracted by these poles. If we magnetize a steel needle and suspend it by a thin silk thread or hair, we will note that the north pole of the needle is attracted toward the south pole of the earth, and that the south pole of the needle is attracted toward the north pole of the earth. After the needle has come to rest in this position, if we reverse the needle so that the north pole is pointing to the earth's north pole, the needle will immediately reverse itself and point in the original position. This follows the law that like poles repel and unlike poles attract each other. Note the similarity between this law of magnetism and the law of static electricity on page 17.

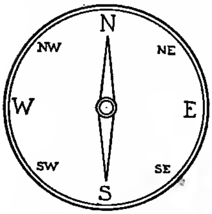


FIG. 8.—The earth is in itself a huge magnet, having a north and south pole, and obeying the general laws of magnetism. The magnetic compass needle is attracted by these poles.

The above law can be demonstrated in another manner. Take two horseshoe magnets and bring their north poles together and you will note that they repel each other. If you bring the opposite poles together, they will attract each other.

A piece of bar steel which is rubbed with a permanent horseshoe magnet will itself become a permanent magnet.

The action of a magnet can be graphically illustrated by a simple experiment. A bar magnet is placed on a table and a piece of white paper is laid on top of it. A quantity of iron filings is sprinkled over the surface of the paper and they will form themselves as in Fig. 10. These lines which appear on the paper are merely the little pieces of iron temporarily magnetized by being in

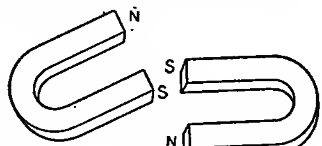


FIG. 9.—Take two horseshoe magnets, and bring their north poles together and you will note they repel each other. If you bring the opposite poles together, they will attract each other.

proximity to the magnet, taking their position along the invisible lines of force which constitute the magnetic field.

These lines of force pass out of the north pole around in a complete circuit to the south pole.

If the reader will make the above experiment for himself, and retain a mental picture of these lines of force, many phenomena of radio will be mastered more readily. As we progress, we will explain in some detail the function of various magnetic fields in radio, and this knowledge will enable the novice to handle his apparatus with intelligence and with decidedly more success than if he were ignorant of these principles.

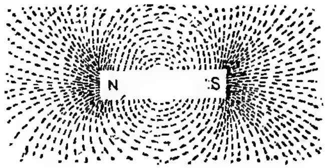


FIG. 10.—A bar magnet is placed on a table and a piece of white paper is laid on top of it. If a quantity of iron filings is sprinkled over the surface of the paper, they will form themselves as shown.

Using the same bar magnet as in the above experiment, place a piece of soft iron near it, but not near enough to be moved by the force of the magnet. If a needle be dropped close to this soft iron, it will be attracted toward it. Now remove the bar magnet and you will note that the soft iron has lost its power of attraction. This phenomenon is caused by "magnetic induction." Any magnetic substance brought into the field of a magnet becomes magnetized, but if it is soft iron or other substance, which cannot be permanently magnetized, it loses its magnetism as soon as the magnetic field is removed.

Electro-Magnetism.—If a current of electricity is passed through a conductor, a magnetic field is formed around the conductor. A simple experiment illustrating this is as follows: Pass a bare copper wire through a piece of white paper and connect the ends to the terminals of a dry battery. Sprinkle some iron filings on the paper as per Fig. 11. Note that the iron filings form themselves in concentric circles about the copper conductor indicating the magnetic field. (In this experiment, keep the battery connected in this manner only a moment, or you will get the wire very hot and destroy the battery as well, due to the short circuit.) These lines of force, which are outlined by the iron filings, have a definite direction, depending upon the direction of the current. If the current is reversed from the direction indicated in Fig. 12, the direction of the lines of force will also be reversed.

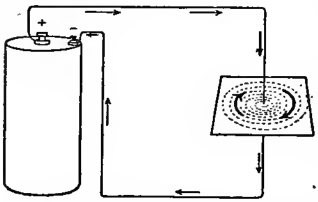


FIG. 11.—The iron filings form themselves in concentric circles about the copper conductor, indicating the magnetic field.

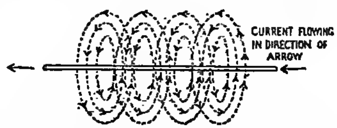


FIG. 12.—Lines of force about a conductor carrying a current of electricity.

If we make a loop in a wire and pass a current through it, the lines of force will take the same direction all around the loop and you will have the lines of force coming in, say, the bottom of the loop and going out the top, as per Fig. 13. The field so produced is similar to the field of a magnet, having, as it does, polarity.

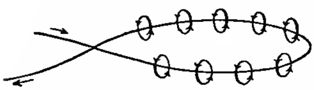


FIG. 13.—Direction of current and lines of force in a loop of wire.

If, instead of one loop, we make a coil of many loops, the lines of force will combine with one another to give an effect similar to that shown in Fig. 14. This coil has the same magnetic powers as a permanent magnet, except that it is entirely dependent upon the current passing through it for its magnetism. The moment the circuit is broken and the current ceases to flow, the magnetism disappears. Such a coil of wires is called a solenoid.

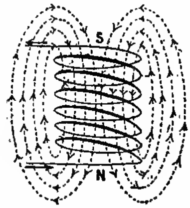


Fig. 14.—A hollow coil of wire through which a current flows is called a solenoid.

If we put a soft iron core into a solenoid as in Fig. 15, the strength of the magnetic field is increased, for iron offers considerably less resistance to a magnetic field than does air. The resistance to a magnetic field is called "reluctance," and is equivalent to electrical "resistance." The strength of an electro-magnetic field is dependent upon the amount of current passing around the coil, the number of turns of wire, and the reluctance. Of these three factors, the first two constitute what is called "magneto-motive force." The unit of this force is the ampere-turn. The ampere-turn will be referred to again in the chapter on telephone receivers.

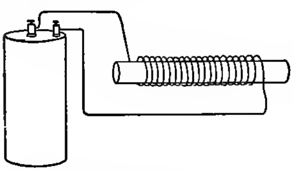


Fig. 15.—If we put a soft iron core into a solenoid, we have an electro-magnet.

By placing a steel core in a solenoid, we magnetize the steel, but unlike soft iron, the steel retains its magnetism, after the current is broken and we have a permanent magnet.

Now, to illustrate further functions of the magnet and electro-magnet, let us attach the two terminals of our solenoid to a galvanometer, which is an instrument for indicating the presence of a current in a circuit. (See. Fig. 16.) If we thrust a permanent magnet into the solenoid, the needle of the galvanometer will move, indicating the presence of a current. What actually occurs is the creation of E.M.F. in the coil, which causes a current, when the circuit is closed through the galvanometer. This current is generated there by what is known as electro-magnetic induction. If we let the magnet rest within the solenoid, the galvanometer indicates no current, but the moment we withdraw the magnet, a current is again indicated, but in the opposite direction from the current that was generated as the magnet was thrust into the coil. If the magnet is rapidly thrust in or out of the coil, a greater amount of current is indicated.

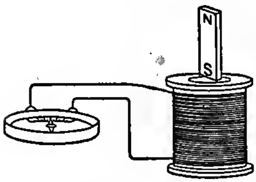


FIG. 16.—If we thrust a permanent magnet into the solenoid, the needle of the galvanometer will move, indicating the presence of an electric current.

It will not be necessary, for the purpose of this book, to go into further experiments to show all the properties of the electro-magnet and the solenoid. The general deduction which we would make after a number of different experiments, similar to the above, is that the amount of current generated in a solenoid depends on the number of turns of wire, and the rapidity with which the lines of force are changed in the coils. This property of generating current by passing lines of force through coiled wire, or coiled wire through lines of force, is of great importance in radio work and we shall have reason to remember this principle as we proceed.

If, instead of thrusting a permanent magnet into a solenoid, we have two solenoids, one of which will fit into the other (as in Fig. 17), and we pass a current through the smaller one and move this coil in and out of the larger one, we will get the same effect in the galvanometer as with the permanent magnet, showing that an electric potential or voltage has been generated in the larger coil. This is called "mutual induction."

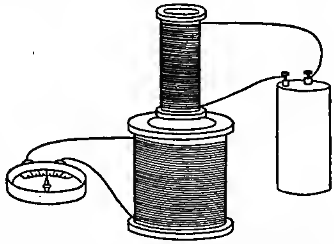


FIG. 17.—If we pass a current through one of two solenoids, fitting inside the other, and move the one through which the current is passing in and out of the other, a current in the stationary solenoid will be indicated.

If, instead of changing the lines of force by moving the coil up and down in the solenoid, we leave the coil stationary, but change the lines of force by making and breaking the circuit by means of a key (as in Fig. 18), we will get similar results. The coil into which we introduce the battery current is called the "primary," and the coil into which the current is introduced is called the "secondary." The combination is called an induction coil.

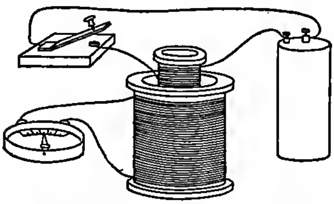


FIG. 18.—If we change the lines of force in one of the coils by making and breaking the circuit with a key the galvanometer will indicate a current in the other coil.

If we place a soft iron core inside the primary coil, we greatly increase the power of the lines of force, and consequently the amount of voltage induced into the secondary coil. If a steel core were used, it would become permanently magnetized, and consequently the change in the lines of force would not be so great on making and breaking the circuit. It is for this reason that a soft iron core is used.

The above principle is employed in certain types of wireless transmitters for producing high voltage currents by means of an induction coil. An induction coil (see Fig. 19) consists of a primary (P), wound on a core of soft iron wires. The primary consists of comparatively few layers of wire (D) which must be sufficiently heavy to carry the amount of current desired to be used.

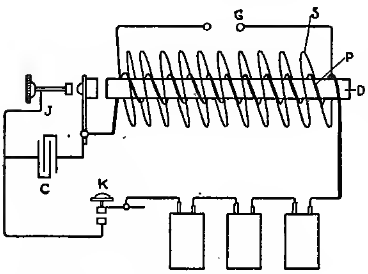


FIG. 19.—Schematic diagram of an induction coil.

The secondary (S) consists of a number of coils of wire wound over the primary. The more turns of wire that are cut by the lines of force, the greater the voltage; the secondary is usually wound with an immense amount of the finest wire it is possible to obtain. In this way a voltage as high as 150,000 volts is frequently produced. Notwithstanding the high voltage produced in the secondary, the amount of current there is very small.

As it is necessary to make and break the current in the primary to induce a current into the secondary, a mechanical current interrupter is used. When the vibrator is in its normal position, it provides a complete circuit for the primary current through the primary coil. When the key (K) is closed, current from the batteries magnetizes the primary coil; the vibrator is drawn by magnetism toward the core, thereby breaking the circuit at (J), as can be readily seen in the illustration. When the circuit is broken, the primary loses its magnetism and the vibrator springs back to its normal position, thereby making a circuit again. This process of making and breaking the circuit is repeated in the usual induction coil about 120 times per second and in some coils as rapidly as 1,000 times per second. Fig. 20 shows an induction coil often used by amateurs for radio transmission.

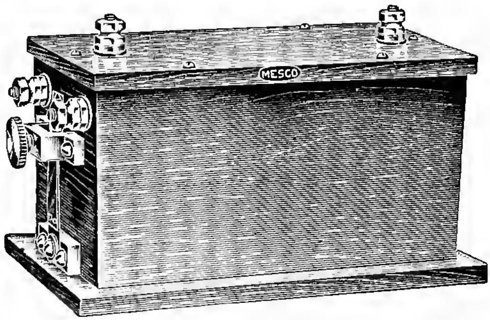


Fig. 20.—Type of induction coil often used by amateurs in radio transmission.

A condenser (C) is shown in the diagram connected across the points of the vibrator where the circuit is made and broken. The purpose of this condenser is to reduce the sparking between the contact points. An explanation of the sparking and its prevention by means of a condenser will be taken up later when we discuss inductance and capacity.

The terminal wires of the secondary are not connected together, but are separated, and the circuit in the secondary coil is completed by the current under the enormous electrical pressure of the high voltage jumping across an air gap (G). The passage of the current through the air is accompanied by a loud crackling noise and is in the form of a very hot flame or feathery spark. The following table will indicate the distance that a spark will jump under the pressure of various voltages.

TABLE OF SPARKING DISTANCES

In Air for Various Voltages Between Needle Points

Volts	*Distance* (inches)	*Volts*	*Distance* (inches)
5,000	.225	60,000	4.65
10,000	.470	70,000	5.85
15,000	.725	80,000	7.10
20,000	1.000	90,000	8.35
25,000	1.300	100,000	9.60
30,000	1.625	110,000	10.75
35,000	2.000	120,000	11.85
40,000	2.450	130,000	12.95
45,000	2.95	140,000	13.95
50,000	3.55	150,000	15.00

An electric battery such as is used in radio telegraphy, in conjunction with receiving apparatus gives a flow of current, the direction of which never varies. This kind of current is called a "direct current." There is another type of current with which we have to deal largely in radio, whose direction of flow is constantly changing. This is called "alternating current." An alternating current is produced in a number of ways.

It was noted (page 26) that when the magnet was thrust into the solenoid, the current generated in the solenoid flowed in one direction, and when the magnet was removed from the solenoid, the current flowed in the opposite direction. Now, if instead of thrusting a magnet, or electro-magnet, in and out of a solenoid, we rotate a coil of wire within a magnetic field (as in Fig. 21), so that the lines of force of the magnetic field pass through the coils of the rotor first in increasing numbers as when, in the last experiment, the magnet was thrust into the coil, and then in decreasing numbers, as when the magnet was removed from the coil, we will have generated in the rotor a current that flows first in one direction and then in another. This current is said to be alternating. The machine that generates it is called a generator or dynamo. The rotor is called an armature, and the magnets are called the field magnets.

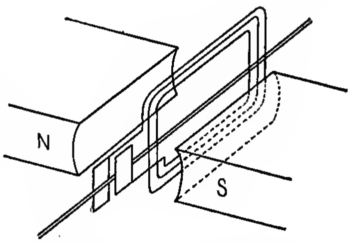


FIG. 21.—If we rotate a coil of wire within a magnetic field, an alternating potential will be set up in the coil. This is the basic principle of the alternating current generator.

If we want to generate current that flows in only one direction (direct current), it is necessary mechanically to reverse the terminals of the armature with each reverse of the current. This is done by a device called a "commutator."

CHAPTER IV

ELECTRICITY AS APPLIED TO RADIO

Graphic illustration of the wave length formula—Apparatus for producing electric waves—Analogy of the swinging door—Oscillations—Inductance and capacitance—Production of electric waves—Open and closed circuits—Harmonics—Theory of radio reception—Telephone receiver—Rectifying oscillations with a mineral detector—A complete receiving circuit—Radio frequency and audio frequency—Wave groups.

We have already, in a brief way, given some analogies of radio transmission and reception, and have taken up the more important principles of electricity, so that if we apply this little knowledge of electricity to the theory of vibrations which we have discussed in Chapter II, we shall be able to understand the principles of radio telegraphy and telephony and to operate the apparatus intelligently.

Science has computed the speed of electric waves at 186,000 miles per second, or 300,000,000 meters per second. Let us assume that we have a wave 300,000,000 meters long. Such a wave would pass between two points 300,000,000 meters apart in one second. The frequency of this wave would then be one cycle per second. A graphic description is shown in Fig. 22.

Now, if the waves were 150,000,000 meters long, then two waves would be required to pass between two points 300,000,000 meters apart, and the frequency of the waves would be two cycles per second. (See Fig. 23.)

If the waves were 75,000,000 meters long, it would require four such waves to pass between two points

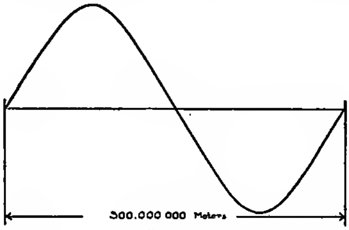


FIG. 22

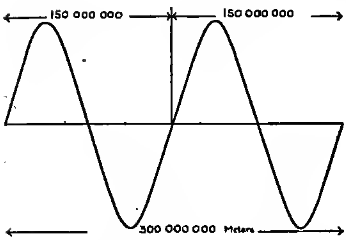


FIG. 23

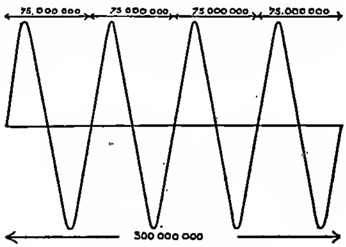


FIG. 24

FIGS. 22, 23, & 24.—Illustrating the relation of wave length to frequency.

300,000,000 meters apart in one second, and the frequency would then be four cycles. (See Fig. 24.)

From the above reasoning, we find the following frequency formula to be true:

$$\lambda = \frac{V}{N}$$

where λ = wave length
V = velocity of electric wave (300,000,000 per second)
N = frequency or number of oscillations per second

transposing, we find that

$$N = \frac{V}{\lambda}$$

Therefore, if we wish to create electrical waves in the ether two hundred meters long we must disturb the ether with electric oscillations having a frequency of 1,500,000 cycles per second.

$$N = \frac{300{,}000{,}000}{200}$$

$$\text{therefore} \quad N = 1{,}500{,}000$$

Now our problem is, if we wish to transmit waves of 200 meters (amateur regulation wave), to produce an alternating current with a frequency of 1,500,000 cycles per second.

We described briefly before, the principle of the alternating current generator. The average alternating current generator that is used for house current has a frequency of 60 cycles. The alternator used for producing musical notes in spark radio transmission usually has a frequency of 500 cycles. The Alexanderson alternator has a frequency of as high as 200,000 cycles per second. Such an alternator is said to produce radio frequencies and is used as a direct source of ether agitation. All frequencies above 15,000 per second are called radio frequencies, and those below 15,000 are called audio frequencies.

The Alexanderson alternator rotates at 20,000 revolutions per minute;[1] therefore, naturally, the adjustments must be very accurate and for many types of work such an alternator would be impracticable. Then again, the highest frequency from this type generator

[1] The large Alexanderson Alternator such as used at Radio Central has a much slower speed.

found practicable is 200,000 per second, and according to the formula just given, would cause a wave of 1,500 meters which is too long for amateur work and, for that matter, for most commercial work on a basis of the present regulations.

The Poulsen arc generator also has limitations and whereas it works efficiently up to 200,000 cycles, above this it is unsuitable.

The vacuum tube used as a generator works efficiently all the way up from the lowest audio frequencies to over 20,000,000 per second. This source of ether agitation will be taken up in some detail in a later chapter.

Ship stations and amateur stations to-day use the spark as the source of power in most instances, and we will therefore take this method of ether agitation first.

We have previously explained the induction coil and will now discuss it as a means for creating high frequency oscillations.

There are two electrical phenomena which we did not take up in the chapter on electricity, but which will be easily understood by those who grasped the fundamentals of Chapter III. These are, namely, capacitance and inductance.

If we apply a force to a swinging door which has a spring attached, and open the door and hold it there, we have stored energy, for when we let the door out of our restraining hands, it will swing back to its normal position and then continue to swing to the other side of its normal position, and then back again to normal, and then to the side on which we originally held it. Were we to place on the bottom of the door, a brush that had been dipped in paint, and then pull a sheet of paper under the door along the line of its normal position for, say, ten seconds, we would have indicated on the paper, a series of oscillations. (See Fig. 25.) These oscillations are in many ways a perfect analogy for the oscillations we get at radio frequency, from an induction coil connected with the proper inductance and capacity. Also, the action of the capacity and inductance are well illustrated.

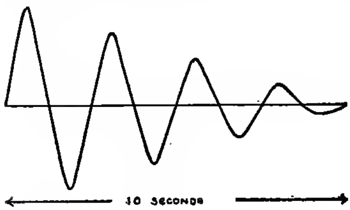


Fig. 25.—Were we to place on the bottom of a swinging door, a brush that had been dipped in paint, and then pull a sheet of paper under the door along the line of its normal position for, say, ten seconds, we would have indicated on the paper a series of oscillations as illustrated.

When we hold the door back, we are storing energy just as we will store electrical energy in the condenser in the circuit indicated in Fig. 26. When the door is released, it can be compared to the discharge of a

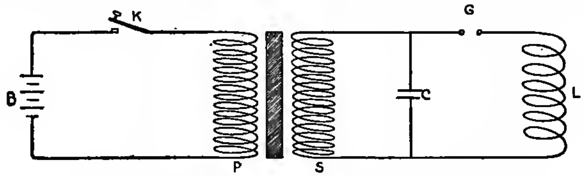


Fig. 26.—Diagram of transformer and oscillating circuit.

condenser, and the inertia, which causes the door to continue to move beyond the normal position to the other side and then to come back and go beyond normal in the opposite direction, can be compared to the inductance which causes the current to flow after the original source of potential has been shut off. The inductance causes the condenser to be charged and recharged successively in opposite directions, each time, however, to a lesser degree, as is indicated by the receding amplitudes of each successive oscillation. (See Fig. 25.) This "dying out" of the oscillations is called "damping," and the waves sent out by such a circuit are called damped waves.

When we press down key K, a current passes through primary P, inducing high voltage current into S. Condenser C consists of a piece of plate glass with a sheet of tin foil on either side. (See Fig. 27.) The high voltage produced in S causes a current to flow to both plates of the condenser, and this charge is deposited thereon. By carefully studying Fig. 26, you will see that there must be a positive charge of electricity on one side of the condenser, and a negative charge on the other side. When the charge on the plates of the condenser becomes great enough, a severe stress is caused and the positive charge seeks to complete the circuit by flowing toward the negative charge. In the analogy of the swinging door, the straining of the spring, when the door is held open, corresponds to the stress in the condenser. Owing to the fact that the glass dielectric is a nonconductor of electricity, the current cannot flow through the condenser, so it seeks to go back through the primary in the opposite direction to which it came. But this it cannot do, for the lines of force that are produced in

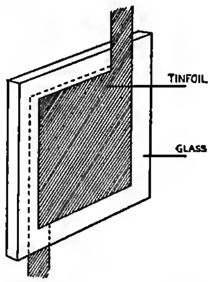


FIG. 27.—A condenser consisting of plate glass with a piece of tin foil on either side.

the secondary field set up a counter E.M.F. and resist the return flow of the current. However, the air between the electrodes in the spark gap G becomes ionized under the high potential. The air thus ionized becomes a conductor of electricity, and the circuit is completed by a spark discharge from the condenser across G and through L.

As the current passes through the inductance L, which consists of a number of turns of wires similar to Fig. 28, lines of force are produced which induce in the coil a counter E.M.F. retarding the flow of current and causing the current to continue to flow after the condenser has lost its original charge, thereby charging it in the opposite direction, but not to as great a charge as before. As soon as the charge produces sufficient stress, it discharges across the spark gap as before, but in the opposite direction. This process is repeated until the resistance of the circuit dissipates the energy, just as the friction of the hinges on the door finally causes it to stop swinging.

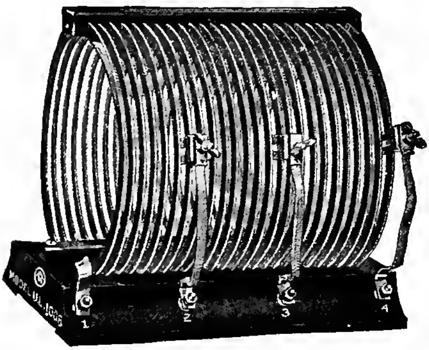


FIG. 28.—Inductance consisting of a number of turns of wire, used in tuning a radio transmitter.

It will be noted that it is the inertia that causes the door to continue to swing after the original tension has been removed, just as it is the inductance that causes the current to flow after the condenser has lost its original charge and is in such a state that it can be recharged in the opposite direction. When the door swings to the other side, it also receives tension, stress, or a "charge" in the opposite direction.

Now, it is well known that when a door swings back and forth it disturbs the air and will cause papers or other light objects, situated some distance from it, to flutter or move. Such a movement by the door produces pressure waves in the air, which are analogous to the pressure or electro-static waves produced in the ether.

The circuit shown in Fig. 26 produces waves in the ether, but inasmuch as it is what is known as a closed circuit, such waves do not travel far. This circuit lacks the ability to radiate.

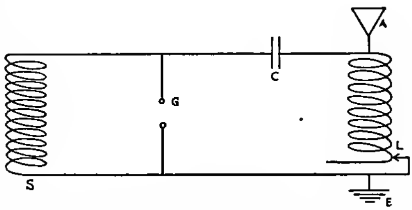


Fig. 29.—An oscillating circuit connected to aerial and ground.

There are two general methods in use for radiating the energy produced in circuits similar to Fig. 26. One method is shown in Fig. 29.

Here we have practically the same circuit as in Fig. 26, but we include an aerial A and a ground E connection. The aerial is really one plate of a condenser; the ground, the other; and the air between is the insulating material or the dielectric. Besides having capacity, the aerial also has inductance. (You will recall that on page 24, we found that when a current is passed through a wire, a magnetic field is formed about it.) This system of aerial and ground, acting as both capacitance and inductance, and covering a comparatively great area, acts as a radiator of the oscillations produced therein. The additional capacity and inductance, represented in the circuit by C and L, are to enable a varying of the oscillating value of the aerial, so that we are not dependent on the "natural period" of the aerial for our wave length.

The electric waves are caused to radiate from the aerial by pressing down the key, thereby closing the primary circuit of the induction coil, causing a high voltage to be impressed on the condenser which discharges in the manner explained. This causes an electrical strain or stress between the aerial and the ground. The positive or negative charge, as it may be, in the aerial, seeks to complete the circuit by flowing to the opposite charge in the ground. The action is the same as described on page 36, which took place in the circuit shown in Fig. 26. This strain produces a wave in the ether, which detaches itself from the aerial with each discharge across the spark gap, so that a complete wave is produced for each oscillation. These electro-static waves, as they are called, are detached from the aerial in a manner similar to the illustration. (See Fig. 30.) It is well for the sake of clarity to note the following features of these waves: The wave length is the distance B G and B′ G′. Each

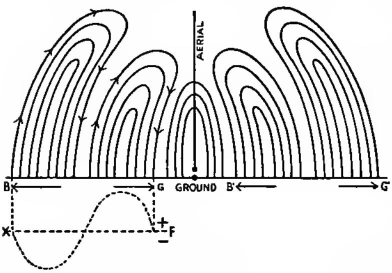


FIG. 30.—The electro-static waves are detached from the aerial in a manner similar to the illustration.

wave corresponds to the oscillation X F which is pictured under the wave. It will be noted also that the change in polarity of each half of the wave corresponds to the change in polarity of each half of the oscillation.

As the waves radiate from the aerial, they increase in area (not in length) and their energy correspondingly becomes diffused, so that the further from the aerial that the waves travel, the less energy they have and the weaker the signals will be in the receiver. It is for this reason that more power is required to transmit over long distances than over short distances.

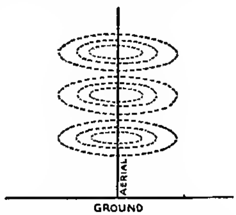


FIG. 31.—With each discharge of the aerial across the spark gap, a current is produced in the aerial, and consequently magnetic lines of force are generated around the aerial.

With each discharge of the aerial across the gap, a current is produced in the aerial and, consequently, magnetic lines of force are generated around the aerial. (See Fig. 31.) These lines of force are also radiated as waves, which are called electro-magnetic waves. The relationship between the electro-static waves and the electro-magnetic waves is rather complex, and we will leave the explanation to strictly scientific books.

In Fig. 29, we show a circuit for producing ether waves which we stated was not in common use to-day. Fig. 32 illustrates a circuit which is more commonly used. This is called a loose coupled circuit. In reality, it is nothing more or less than circuit 26, which is a good oscillator but a poor radiator and an aerial circuit which has no source of oscillation in itself but is a good radiator. Therefore, we cause it to oscillate by means of induction from the closed circuit.

On page 36, we likened an oscillation circuit to a swinging door. We noted that the capacity of an oscillating circuit was analogous to the spring in the door and that the inductance was analogous to the inertia. The inertia of the door is dependent upon its weight. The frequency of the swinging door is dependent on the physical dimensions of the spring and the door. Likewise, the number of swings or the frequency of the oscillating circuit in a given time is dependent upon its electrical dimensions, that is, the amount of capacity and inductance in the circuit. If either the capacity or the inductance, or both, are increased, the frequency of the circuit will be reduced and consequently the wave length will be increased. (See page 33.) If, on the other hand, the capacity and the inductance are reduced, the frequency will be increased and the wave length will be reduced. Increasing or decreasing either capacity or inductance alone has the same effect.

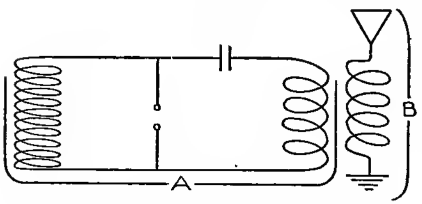


Fig. 32.—Aerial and ground inductively coupled to the oscillating circuit.

If, in Fig. 32, the capacity and inductance of circuit A, which is the same as the closed circuit in Fig. 26, is given a value, so that the circuit will oscillate at 1,500,000 cycles per second (200 meter wave length) and the aerial or open circuit B has the same value of inductance and capacity, then the oscillations set up in circuit A will cause similar oscillations to be set up in circuit B. (Note experiment with tuning fork on page 15.) Circuit B being a good radiator will radiate waves of 200 meters in manner shown in Fig. 30.

It is a well-known fact that, in music, few instruments produce absolutely pure notes; they all have overtones or undertones. These overtones and undertones are feeble vibrations set up, which produce harmonics of the fundamental note. Overtones and undertones add richness to the tone and are desirable up to a certain point. A pipe organ is a good example of overtones and the richness of tone so produced, and the tuning fork, of a pure note and the insipidness of the same.

Similarly in radio transmission, we have waves produced other than those to which our set is tuned. These wave lengths are multiples of the principal wave length. Thus a poorly designed transmitter having a principal wave of, say, 600 meters, will interfere with other stations near by on three hundred meters.

A transmitting station sometimes radiates two wave lengths, one of which is not necessarily a harmonic of the principal wave. This occurs frequently when a circuit similar to Fig 29 is used. By using a loose-coupled circuit, such as Fig 32, this unwanted wave length can usually be eliminated. Using a circuit such as in Fig. 32 the wave radiated will be much sharper than if the circuit in Fig. 29 were used. This prevents undue interference with other stations.

In receiving, also, the sharper tuning can be had with the loose-coupled circuits.

We will now take up the general theory of radio reception. A radio receiver is the counterpart of a transmitter, just described, except that it has means of making audible the vibrations received from the distant transmitter. A receiver has an aerial and a variable inductance and capacity, so that it can be tuned readily to any desired wave length.

When a receiver is tuned to the incoming wave, and oscillations are set up therein, we must find a method to make the oscillations audible. The detector and the telephone receivers do this.

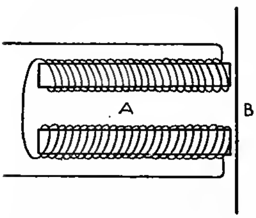


FIG. 33.—Schematic diagram of a telephone receiver showing electromagnets A and diaphragm B.

The telephone receivers consist of a pair of electro-magnets, with a permanently magnetized core of steel (see A in Fig. 33), and a metal diaphragm capable of being magnetized. (See B in Fig. 33.) When a current is passed through the magnets A, the magnetism is increased, and the diaphragm B is drawn toward the magnets, which causes a click to be heard if the ear is close to the moving diaphragm. When the circuit is broken, another click is heard, as the diaphragm returns to its normal position. If we pass an alternating current through the magnets, the oscillations of the current will be reproduced in the diaphragm by a motion back and forth, as the polarity of the current is changed. This motion of the diaphragm which produces sound waves will be heard by the human ear as a musical note. If, for instance, we have an alternating current of 256 cycles passing through the magnets, the tone produced would be middle C. (See page 13.) As long as the frequency of the current is in the range of audibility, that is, below 15,000 per second, we are able to hear it in the telephone, but when it becomes greater than 15,000, the movement of the diaphragm cannot be heard by the human ear.

If we are receiving the oscillations from a 200 meter wave, the surge back and forth at the rate of 1,500,000 per second is far beyond the range of audibility. This high frequency alternating current must be transformed into a direct current so that it will produce an audible signal in the telephone receiver.

Certain minerals have the ability to conduct a current of electricity in only one direction. These minerals are called rectifiers and are used as detectors in radio. There are other rectifiers which are used in radio, which we shall discuss in a later chapter.

Among the rectifying minerals are carborundum, molybdenite, silicon, galena and numerous others. Of these, galena is probably the most sensitive.

In Fig. 34 we have a typical mineral detector receiving circuit, and we shall follow the incoming signal and see how it is made audible.

A transmitting station sends out the letter A by pressing the key for a short interval, and then for a longer interval, closing the circuit for a corresponding length of time and causing, first, a short series of oscillations to be radiated, and then a longer series. These are respectively a dot and a dash. (See Fig. 35.)

Each group of oscillations consists of high frequency alternating current of, say, 1,500,000 per second frequency. The intervals between the groups of oscillations are the interruptions made by the interrupter on the induction coil, if an induction coil be used. These interruptions are at audio frequency and will be heard in the proper receiving station as a musical note. The interval between the dot and dash is made when the circuit in the primary of the transmitter is broken by means of the key. There are, therefore, three types of interruptions in a single letter sent out, namely, radio frequency, audio frequency, and interruptions made by the key to transmit the code.

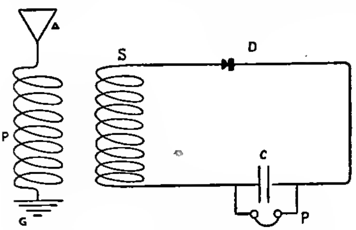


FIG. 34.—A typical mineral detector receiving circuit.

In Fig. 34, A is the aerial, G is the ground, P is the primary inductance, S is the Secondary inductance, C is the condenser, and D is a mineral detector. P is the telephone receiver. Both primary and secondary circuits are tuned to 1,500,000 oscillations per second (200 meter wave length). The incoming wave sets up oscillations in circuit A P G, which in turn sets up similar oscillations in the secondary circuit, charging and discharging condenser C in the same manner that the condenser was charged and discharged in the transmitting

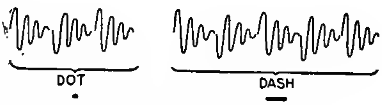


FIG. 35.—A transmitting station sends out the letter A, by pressing the key for a short interval, and then for a longer interval, closing the circuit for a corresponding length of time and causing, first, a short series of oscillations to be radiated and then a longer series. These are respectively a dot and dash.

circuit in Fig. 26. You will recall that the condenser first discharged in one direction and then in another. The condenser C in Fig. 34 discharges in the same manner, but detector D only permits the current to flow through the telephone P in one direction, so that a direct current passes through the telephone magnets, and, consequently, each wave train or group produces an audible vibration. If the wave groups have a frequency of 256 per second, we will hear the musical note C, and if the operator in the transmitting station is breaking up the primary circuit by means of a key, in accordance with some prearranged plan or code, we will hear the C note interrupted in such a manner that, knowing the code, we will understand what the transmitter is telling us.

We now know enough of the theory of the transmission and reception of damped waves to proceed to the study of practical sending and receiving stations. We will discuss the transmission and reception of continuous waves as we progress, as well as the sending and receiving of radio telephone messages.

CHAPTER V

RECEIVING SET FOR TWO DOLLARS

Unlimited power and wave lengths of amateur transmitters in early days of radio—Amateurs interfering with ships—Getting rid of troublesome amateurs by giving them positions on ships—Congress makes laws preventing amateur interference—Observing the Golden Rule by not interfering with your neighbor's receiving —How to build a mineral detector receiving set for two dollars.

The reader should now have a fairly comprehensive view of the principles of radio telegraphy and no doubt will want to apply his knowledge to some purpose. It is the author's intention to minimize, in this book, the subject of the radio transmitters, and to dwell in more detail on radio receivers. The average person who takes up radio, lured by the daily programs of broadcasting stations, will not be particularly interested in transmitting and it is just as well that such is the case, for any amount of experimenting may be done by novices in receiving radio signals, without interfering with other stations, but it takes a fairly experienced experimenter to operate a transmitter and not interfere.

In the earlier days of radio telegraphy, prior to the time that the government took steps to regulate it, any type of transmitter was permissible, and any power that the experimenter could afford to purchase was at his disposal. At that time, there was a wealthy amateur in New York City who played with a ten kilowatt transformer set, tuned very broadly to any wave he desired. It can be well imagined what havoc this made with shipping near the port of New York, there being no laws at the time to prevent him from "hogging" the ether. A few years later, another experimenter, who, by the way, is now prominent in radio circles, spent his evenings "pounding a key" which threw a twelve-inch spark directly across aerial and ground. The aerial had a natural wave length of about 450 meters, and this was all the tuning that was done. When he chose to talk to a friend a block away, ships from Sandy Hook to Cape Hatteras had to stop important commercial work and "stand by" until our friend had asked his neighbor, "How is my spark to-night?" and other important questions.

The only remedy at that time for such interference was for the commercial companies to make flattering offers to these pests and engage them as operators on steamers that traveled far away from New York. Many wireless operators on the West Indian and South American steamers secured their positions for this reason.

The abuse of the ether by amateurs reached such a point, after a time, that there were not enough ships on which to send them away, so the commercial companies sought relief by asking Congress to abolish all amateur radio transmission. Fortunately, however, certain amateurs appeared before the Congressional committee who had the matter in hand, and secured fair and equitable regulations, instead of prohibition. In all fairness to our friend, who played with a ten k.w. transmitter, may it be said that he reformed and was one of the prime movers toward reëstablishing the amateur on an approved basis.

Amateurs who abide by the present regulations will not interfere with commercial or broadcasting stations, but unless they are able to send and receive at commercial speeds (about twenty-five words per minute) they will interfere with their brother amateurs on the same wave length, by taking an unnecessary length of time to carry on their "business." Besides this, it requires some skill and experience to tune a transmitter to the legal wave length and decrement. It is for this reason that the author does not seek to encourage the average person to build or buy a transmitter, until he becomes proficient in the art. The practical reasons for this will become all too evident to the beginner who endeavors to listen to a broadcasting station in a congested radio district. When he becomes particularly exasperated at some one who is "jamming" at the time when he is trying to let his friends hear a fine concert that is being broadcasted, let him remember the Golden Rule, and one more potential interferer will be eliminated.

An Inexpensive Receiving Set.—Those who live within a radius of about twenty-five miles of a powerful broadcasting station can construct for themselves a receiving set for very little money, and without much trouble. A tuning coil, a detector and a pair of telephone receivers, are all that is required, besides, of course, the aerial.

The aerial should be, if possible, a single wire, 100 to

200 feet long and 40 to 50 feet high, and should point toward the broadcasting station, the lead-in being taken

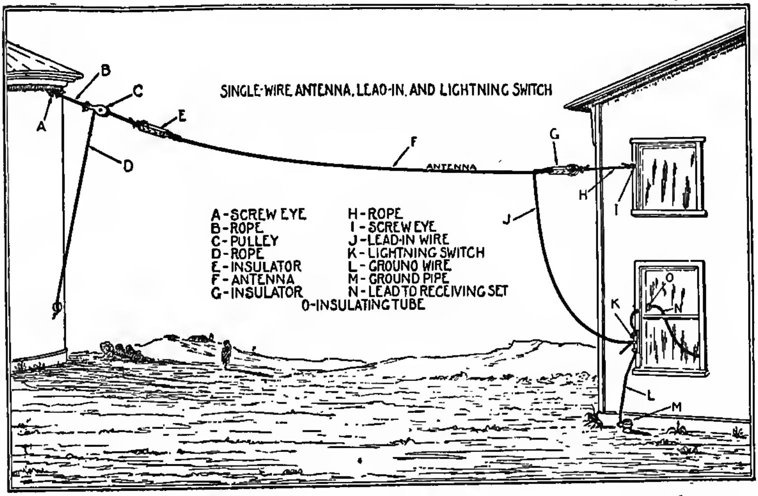


FIG. 36.—The aerial should be, if possible, a single wire, 100 to 200 feet long.

from the end nearest to the station whose messages it is desired to hear the loudest. (See Fig. 36.)

The detector can be made as follows: secure from any electrical supply shop, a clip. (See Fig. 37.) Nail this to a piece of wood. (See Fig. 38.) Attach to the wood a piece of No. 18 copper wire, with a tack, as in the same figure. Wind a piece of No. 30 bare copper or phosphor-bronze wire around the end of the No. 18 copper wire, so that you can make a light contact with it on the crystal of galena that you put in the jaws of the clip.

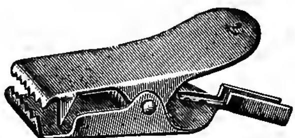


FIG. 37.—Clip for holding mineral in detector stand.

The tuning coil can be made by winding a few turns of No. 18 annunciator wire around a cylindrical cardboard box, such as oatmeal comes in. The number of turns can be determined by trial after the instruments are connected. A good way to do this is to wind five turns around the cylinder and then take a tap, then wind five more turns and then tap three turns and tap and then two turns and tap. When you have found the desired number of turns, the balance may be removed from the coil. (See Fig. 39.)

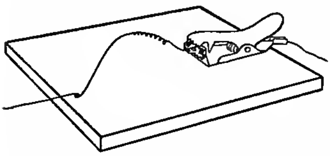


Fig. 38.—Simple, inexpensive mineral detector.

It is difficult to make a telephone receiver, so purchase from an electrical contractor an old receiver, probably from some house telephone. The instruments should be connected up as in Fig. 40. Such an outfit will cost you no more than two dollars, and should receive a broadcasting station very clearly at a distance of five or ten miles, and under favorable circumstances, up to twenty-five miles. Of course, this set cannot be tuned, nor will it be much for appearance; but will serve to introduce an ambitious person to the mysteries and wonders of radio and will encourage him to make or buy a better outfit. The galena crystal can be secured from any wireless shop, and if possible should be tested for

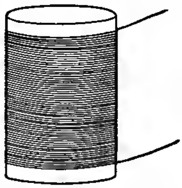


Fig. 39.—Tuning coil without taps, for varying inductance.

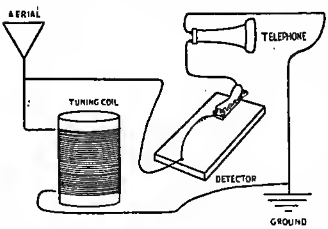


Fig. 40.—Connections for two dollar receiving set with which radiophone can be heard up to about twenty-five miles.

sensitiveness before purchasing, as the above-described apparatus will not afford much opportunity for testing the sensitiveness of the crystal.

Your local newspaper no doubt announces the schedule of the broadcasting station near you and, after having the set connected up, you can test out your crystal during the time you know the near-by station is transmitting. You adjust it by moving the No. 30 wire over the surface of the crystal until you strike a sensitive spot. Note this spot, so that when the detector loses its adjustment, you will be able quickly to readjust it. Any mechanical shock will usually knock the crystal out of adjustment.

The connection indicated in the diagram for the ground wire can be made to a water pipe or steam pipe. Be sure to scrape the connection clean, for, if it is dirty, it may not make an electrical contact.

The cheapest aerial wire is aluminum; No. 14 or No. 18, preferably No. 14, will do. Aluminum oxidizes very readily, so try to make your aerial all in one piece. If, however, this is impossible, tape the connections carefully. Where you use copper wire for the aerial, solder all connections if possible.

Many people who have heard of the wonderful work that can be done on indoor aerials and loops are tempted to try them on sets like the one just described. Know then, beforehand, that it will not work. For indoor aerials and loops, particularly, extremely sensitive sets are required. These will be described later.

The receiver just described can be made more sensitive by using telephone receivers of high resistance, of, say, 2,000 to 3,000 ohms. The author advises the purchase of good telephone receivers, for much better results will be obtained and, no matter what type of instruments you ultimately make or buy, you can use these good telephones. A later chapter (Chapter X) has been devoted to the telephone receiver.

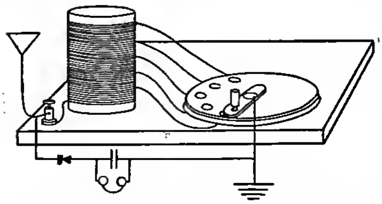


FIG. 41.—Tuning coil with five taps for varying wave length, showing detector, condenser and telephone connections.

If you find it necessary to tune the set just described, the taps indicated in making the tuning coil can be left and each one connected to the points of a five-point switch. The arm of the switch should be connected to the ground. (See Fig. 41.) It will also improve this set to put a fixed condenser across the telephone receivers. (See Figs. 41, 42.)

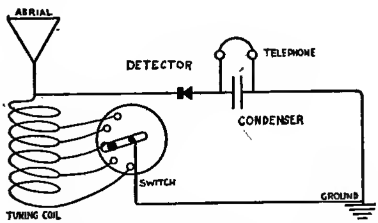


FIG. 42.—Schematic diagram of receiving set shown in Figure 41.

The fixed condenser can be constructed by making four plates, as shown in Fig. 43. The tin foil is made to adhere to the wax paper by pressing with a warm flatiron. They are then put together so that you have first a sheet of wax paper, then a sheet of foil, then wax paper, and so on. The first and third tabs of tin foil should be connected on one side, and the second and fourth connected on the other side. The finished condenser should be wrapped in tape. (See Fig. 44.)

It is not the intention of this book to show how to

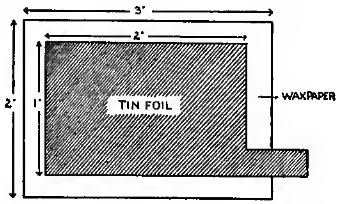


FIG. 43.—One sheet of a fixed condenser showing tin foil and wax paper.

make all the parts of complete receivers. There are a number of books, which those ambitious to make all their own instruments, can secure.[1] The author has found

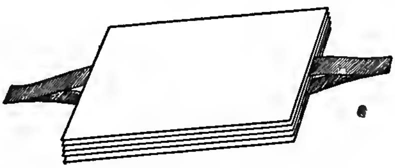


FIG. 44.—Fixed condenser assembled.

that, with the vast amount of "parts" being manufactured to-day, it is unnecessary to make them yourself, for you can purchase these parts almost as cheaply as you can make them, and they are usually a great deal better.

[1] Two home made crystal receiving sets are described in Appendices I and II.

CHAPTER VI

CRYSTAL RECEIVING SETS

Different types of loose coupler—Principle of the loose coupler—Loose coupler receiving hook-up without secondary condenser—With secondary condenser—Methods of hooking up primary condenser—A buzzer test—Types of variable condensers—Types of crystal detectors—Fixed condenser—Simple single circuit variometer receiving hook-up—Types of variometers—Small receiving sets that can be purchased ready for operation.

Probably the most common tuning device used with a crystal detector is the loose coupler. This instrument consists of a primary and a secondary coil, the induc-

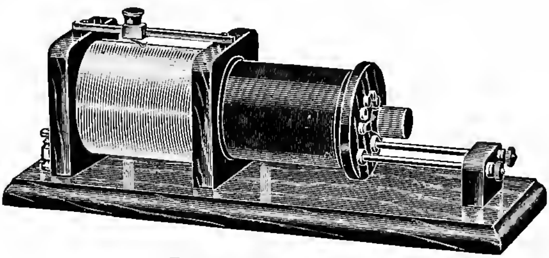


Fig. 45.—Loose coupler.

tance of each being made variable either by means of a sliding contact or a multi-point switch. Fig. 45 shows a loose coupler, in which the primary inductance is varied by means of a sliding contact, and the secondary inductance is varied by means of a multi-point switch, and slides in and out of the primary on two brass rods.

Fig. 46 shows a loose coupler, the primary and secondary of which are varied by means of multi-point switches. The secondary of this coupler also slides in and out on two brass rods.

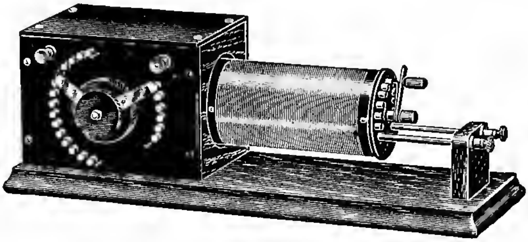


FIG. 46.—Loose coupler, the primary and secondary of which are varied by means of multi-point switches.

Fig. 47 is a loose coupler which varies its coupling by rotating the secondary inside of the primary. The inductance of the primary is varied by means of a 60-point switch, and the secondary is varied by means of a 30-point switch. The handles of both switches are mounted on the front panel.

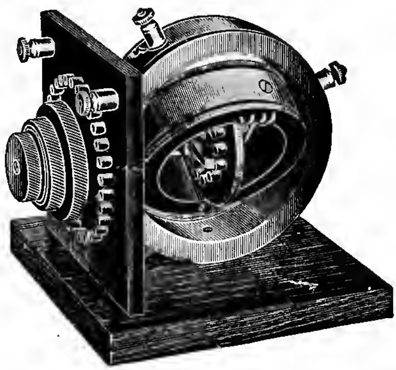


FIG. 47.—Loose coupler, which varies its coupling by rotating the secondary inside of the primary.

The principle of the loose coupler in a receiver is the same as that of the loose-coupled transmitting circuit. By varying the coupling between the primary and secondary more or less, lines of force are cut by the coils and a greater or lesser current is induced from the primary into the secondary. When the coupling is close, the receiver is responsive to much broader waves, and the secondary circuit will respond to the oscillations in the primary, even though they may not be in perfect resonance (tune). When the coupling is close, more stations can be heard at one time. This has an advantage when standing by and waiting for signals that might be calling your station. When the coupling is loose, the secondary does not respond unless it is in absolute resonance with the primary. With a loose coupling, the undesired signals can be tuned out and the desired signals retained, unless the undesired signals are on the same wave length.

In the type of loose coupler represented by Figs. 45 and 46, maximum or close coupling is secured by pushing the secondary into the primary as far as possible, and the minimum or loose coupling is obtained by pulling the secondary out as far as possible. In the type represented by Fig. 47, the maximum coupling is had by turning the movable coil to a position where the two will be concentric. Minimum coupling is had when the coils are at right angles to each other. In types 45 and 46, the wire on the primary and secondary is wound in a single layer around the tubes. In type 46, several layers of wire are wound around the movable and stationary rings.

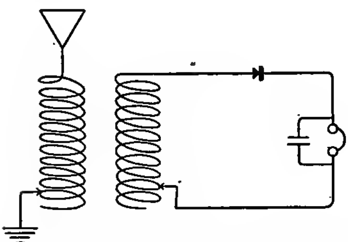


FIG. 48.—Simple crystal detector receiving circuit, utilizing a loose coupler, and with a fixed condenser shunted across the telephone receivers.

In Fig. 48, we show a simple receiving circuit.

For closer tuning of the secondary, Fig. 49 shows the introduction of a variable condenser across the secondary coil of the loose coupler.

It may be well to mention here that from now on we will use in diagrams the standard symbols for various instruments without otherwise designating them. A full list of these symbols as used in this book will be found on page 352.

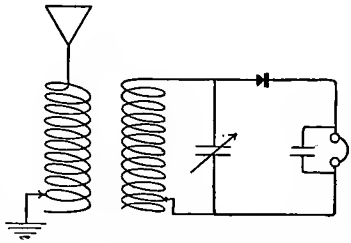


Fig. 49.—Same circuit as Figure 48 with addition of variable condenser across secondary of loose coupler. This gives sharper tuning.

Fig. 50 shows a variable condenser that can either be shunted across the primary or placed in series with the aerial.

Fig. 51 shows what we mean by "shunted." A condenser shunted across an inductance, or across another condenser, increases the wave length of the circuit.

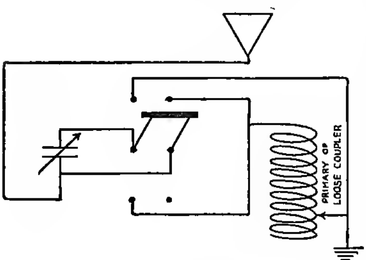


Fig. 50.—Switch connection for changing variable condenser from being in series with aerial and primary of loose coupler to being shunted across primary and vice versa.

Fig. 52 shows a condenser in series with the primary coil and the aerial. This reduces the capacity of the circuit and consequently the wave length.

With the circuit arranged as in Fig. 50, we have the variable condenser in series with the aerial by closing the two-pole switch downward, and we have the condenser shunted across the primary inductance by closing the switch upward. Such a "hook-up" is valuable when only one variable condenser is available for use in the primary circuit.

Buzzer Test.—When operating a mineral detector receiving set, it is well to have a "buzzer test" to keep the detector adjusted. A "buzzer test" is a buzzer which is usually adjusted to produce a high audio frequency note. At each interruption of the buzzer circuit, radio frequency oscillations are produced which set up a minute oscillating current in the receiving apparatus, which will be audible in the telephones if the detector is in adjustment. By closing the buzzer circuit with a small switch instead of a push button, as is customary, both hands will be free to adjust the detector. When the buzzer is heard loudest in the telephones, the detector is adjusted at its maximum sensitiveness. Fig. 53 shows a high frequency buzzer, such as is used for this purpose. Fig. 54 gives the best hook-up for a buzzer test with a loose-coupled receiving set. One of the contacts of the buzzer is connected with the ground.

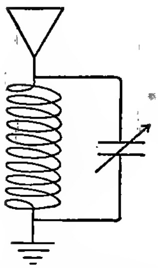


FIG. 51.—Diagram of variable condenser shunted across primary of loose coupler. This increases wave length.

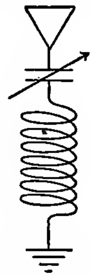


FIG. 52.—Diagram of variable condenser in series with aerial and primary of loose coupler. This decreases wave length, and is necessary when receiving short waves on a long aerial.

Variable Condensers.—The principle of the operation of a buzzer is the same as that for the vibrator of an induction coil as described on page 28.

There are many types of variable condensers that can be used with the receiving hook-up just described.

Those shown in Figs. 55 and 56 are known as variable air condensers, the dielectric being air.

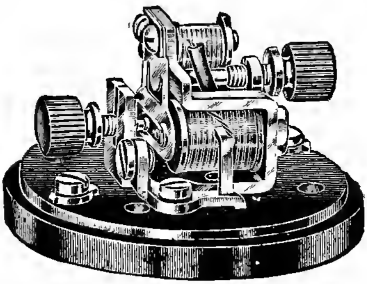


FIG. 53.—High-frequency buzzer, for testing crystal detector. An ordinary house buzzer can be used for this purpose if this special type is not available.

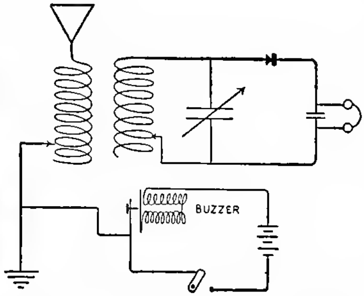


FIG. 54.—How to connect a buzzer test to a receiving set.

The capacity is varied by rotating a set of movable plates within a set of stationary plates. For the receiving sets just described, variable condensers with a

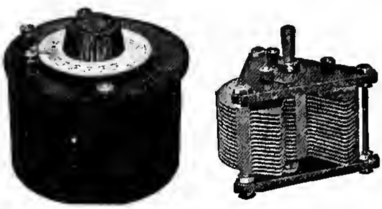


FIG. 55.—Variable air condenser, showing it encased and also without case.

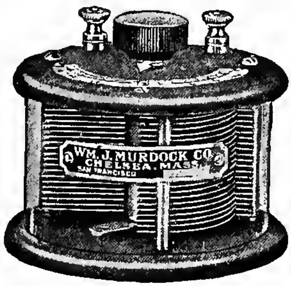


FIG. 56.—Variable air condenser with transparent case so that plates are always visible.

maximum capacity of about .0005 microfarad should be used.

There is some objection to the use of these rotating plate air condensers, as the plates have a tendency to short circuit, excepting in the high-priced condensers of this type, where both the rotating member and the stationary member are each cast in one piece or are made of heavy metal with carefully machined separators. A very good condenser that does not have this objectionable feature is shown in Fig. 57.

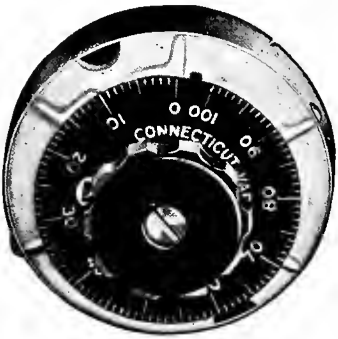


FIG. 57.—Variable mica condenser. The plates of this type cannot become short circuited.

Only two plates are used in this condenser, one being fixed and the other movable. The movable plate does not rotate, but is brought toward or away from the stationary plate by means of a screw and spring. The dielectric in this condenser is mica, which prevents the two plates from short circuiting.

Crystal Detectors.—There are many types of crystal detectors, almost all of which are variations of the simple detector described on page 51. All mineral detectors consist of a holder for the mineral and an adjustable member for making a light and varied contact on the mineral. Whereas there is a wide choice of minerals for detector purposes, either galena or silicon is used almost universally now, as they are recognized as being the most sensitive of minerals.

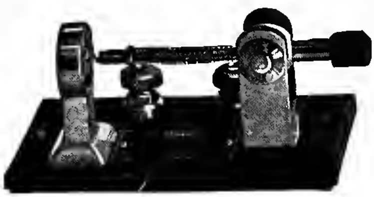


FIG. 58.—Crystal detector stand, with mineral mounted in cup, and held in place with Woods metal.

The author prefers galena as he finds it more sensitive than silicon although not quite as easy to adjust or to keep adjusted. Many detectors are now made with the

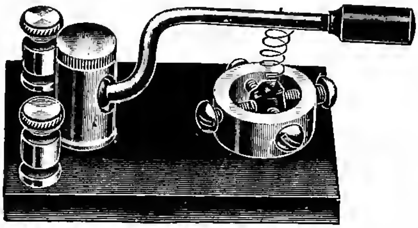


FIG. 59.—Crystal detector stand in which mineral is held in place by means of a cup with four clamping screws.

mineral inclosed in glass. This is a very good idea, as it keeps the mineral free from dust, which is one of the principal reasons for its becoming desensitized.

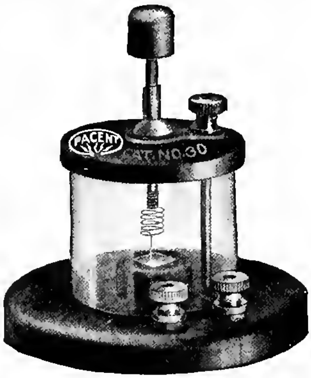


FIG. 60.—Mineral detector enclosed in glass so that surface cannot readily oxidize or otherwise become impaired.

When purchasing a detector, it is well to be sure that the mineral has been tested for sensitiveness, and even if it has, it is wise to purchase additional supplies of minerals. These minerals should be tested out and those that have no sensitive surfaces should be discarded.

The minerals are usually mounted in cups and screwed into place or held there by Woods metal. Woods metal is an alloy with a very low melting point and will not injure the mineral.

Figs. 58, 59 and 60 show three different types of mineral detectors that are recommended.

Fig. 61 is a detector that has novel features, being contained in a vacuum. This is done to prevent dust and oxides from forming on the surface of the mineral and thereby reducing its sensitiveness.

Small fixed condensers to shunt the telephone receivers are purchased very reasonably, and, although

FIG. 61.—Mineral detector in a vacuum, which protects the mineral. Adjustment is made by turning knob.

they are simple to make, as described on page 54, the author recommends that one be purchased. They are very neat and are easier to handle than homemade ones. Fig. 62 shows a general type of fixed condenser for use in circuits described in this chapter.

FIG. 62.—Tubular fixed condenser. Condenser is removable from stand and various capacities can be used.

Any standard make of telephone receivers, wound to about 2,000 ohms, with copper wire, will answer the purpose with the above type apparatus. More details regarding telephone receivers are to be found in Chapter X.

In Chapter XIV, the subject of aerials is discussed and a suitable type to go with the above instruments is shown.

Now let us assume that the reader has decided to construct a receiver, using Fig. 49 as the hook-up. The cost to him will be about as follows: A loose coupler will cost about nine dollars; one variable condenser, four dollars; one fixed condenser, fifty cents; detector, two dollars; telephones, four dollars and fifty cents. The total cost of the receiving set would be about twenty dollars. The aerial and lightning ground connection would cost about five dollars, completing the outfit at twenty-five dollars. There is no upkeep cost to such a set, as it does not require any batteries.

The question now arises, "How far can we receive with such an outfit?" The answer to this question cannot be given although an approximation can sometimes be made. If the reader were to set down accurately the dimensions of his aerial and give full particulars as to his instruments, even then only a rough guess could be made. There are too many uncertain factors that affect reception, to make any prediction as to how far a given set will receive.

The author has received over 3,000 miles with a set similar to the one above described, but this was purely and simply a freak on a cold, crisp winter night when conditions were just right for good reception.

With an aerial of, say, one or two wires (see Fig. 52), 100 to 250 feet long (if over 100 feet, it is best to put a variable condenser in series with the aerial), 30 to 50 feet high and in a place where there are not too many trees or tall steel buildings, which are higher than the aerial, regular reception of wireless telephone broadcasting should be heard within a radius of twenty-five miles, with intermittent results, up to fifty miles. Wireless telegraph stations of medium power should be heard up to five hundred miles distant, and Arlington, Virginia, time, weather and press telegraph reports should be heard, under favorable circumstances, one thousand miles.

Under what we call "freak" conditions, anything is possible in the way of long distance reception.

With the above instruments, continuous wave telegraph stations cannot be heard at all.

Variometer.—One of the most efficient as well as simplest types of crystal detector receivers is made with a variometer, variable condenser, detector and telephone receivers. The hook-up is shown in Fig. 63.

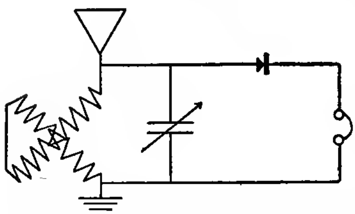


FIG. 63.—Variometer hooked up in a simple mineral detector receiving circuit. For greater selectivity in tuning a variable condenser may be put in series with the aerial and variometer.

A variometer consists of a stationary coil of wire called the "stator" and a movable coil within it called the "rotor." As is indicated in the conventional diagram of a variometer in Fig. 63, the two coils are connected, making a single circuit. By rotating the rotor, so that more or less turns of wire are cut by lines of force, the inductance and coupling are varied. Extremely fine tuning can be done with a variometer in certain circuits. Fig. 64 shows a simple variometer. Fig. 65 shows a variometer that has a special basket winding, which reduces the distributed capacity and thereby increases the efficiency of the instrument. Distributed capacity is the capacity existing in the

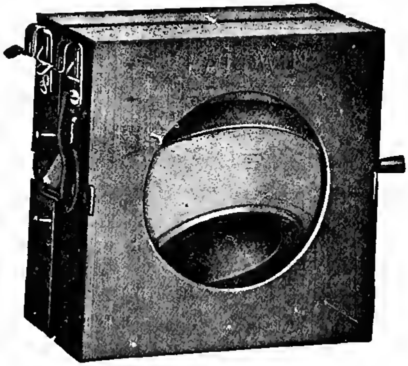


FIG. 64.—Variometer.

winding of a coil. More details of this will be found in Chapter X.

The instruments for a variometer receiving set as in-

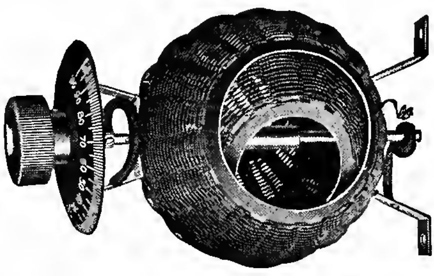


FIG. 65.—Basketball variometer. The specially designed winding reduces the distributed capacity, making the instrument more efficient.

dicated in Fig. 63 can be purchased for somewhat less money than the loose coupler set just described, but it has not the same range of wave lengths, unless additional inductances are added to the primary and secondary circuits.

Fig. 66.—A simple portable receiving set designed by Westinghouse Electric and Manufacturing Company. The whole outfit, including telephone receivers, fits in a box 7 inches by 8½ by 7¼, weighing only 5 pounds.

There are a number of simple compact mineral detector outfits on the market now, ranging in price from fifteen to twenty-five dollars, which can be purchased by those who do not desire to put their own sets together. Of course, better value is obtained by purchasing individual parts and connecting them yourself.

Fig. 66 shows a simple outfit consisting of a variometer, two fixed condensers, detector and telephone receivers. A single indicating arm, operating over a graduated dial, assures quick tuning for the beginner, who has only this one

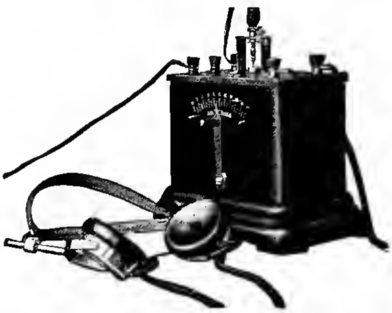


Fig. 67.—Another simple crystal receiving set, manufactured by the Federal Telephone and Telegraph Company.

variation to make. The range of wave length is from 190 to 500 meters. The whole outfit, including telephones, fits in a box 7 inches by 8½ by 7¼, weighing only 5 pounds. Such a receiver is portable. The circuit used in this set is similar to Fig. 63.

Another simple receiving set is shown in Fig. 67. This outfit has two dials for tuning, one for the primary circuit and the other for the secondary. It is very compact and makes a neat appearance.

Fig. 68 illustrates another simple receiving set which is also portable. It consists of a variometer, a fixed condenser, which is automatically cut in or out by turning the dial connected with the rotor of the variometer, a

FIG. 68.—A compact portable crystal receiving set manufactured by American Radio and Research Company.

mineral detector, and a pair of 2,000-ohm telephone receivers; range of wave lengths is from 175 to 675 meters. This set is so constructed that additional inductance can be added to increase the wave length.

These three simple receiving outfits, and others of a similar nature, cost about twenty-five dollars. The range for radiophone reception is about twenty-five miles, more or less, depending on conditions. A somewhat greater range is possible in receiving radio telegraph messages. None of these outfits is suitable for receiving the time signals from Arlington, as they cannot be tuned up to that wave length (2,500 meters).

CHAPTER VII

SPARK TRANSMITTERS

Spark transmitters—Method for tapping house current—Closed core transformers—Leyden jar—Plate condensers—Oil condensers—Dubilier mica condenser—Molded condenser—Theory of spark discharges—Quenched gap—Synchronous rotary gap—Nonsynchronous rotary gap—Open gap—Oscillation transformers—Transmitting key—Simple spark transmitting hook-up with oscillation transformer—Wavemeters—How to tune a transmitter—Hot wire ammeter—Aerial switch—Transmitter and receiver hooked to same aerial by means of aerial switch.

So far, in discussing the transmission of radio telegraph messages, we have given some details of the induction coil as a source of high voltage. In this chapter, where we will describe some practical transmitters of damped waves, we are going to exclude the induction coil, as it is inefficient and incapable of producing large powers.

Most houses that are supplied with power from a central source have a lighting current of 110 volts of alternating current. The usual house circuits are wired to carry a current of not over 10 amperes. In deciding where to install your transmitter, endeavor to choose a place where your power line can be directly connected to the meter, with no house light on the same line. When you use a large amount of current in transmitting, and there are lights on the same line, the drop in voltage causes the lights to flicker.

Fig. 69 represents an alternating current arrangement of circuits that is found in many houses. Here we have tapped the main line for our radio station, putting in a separate fuse block. With such an arrangement no flickering of lights will result. (See Appendix IV.)

We described in Chapter III the production of high-voltage, alternating currents, by means of interrupting

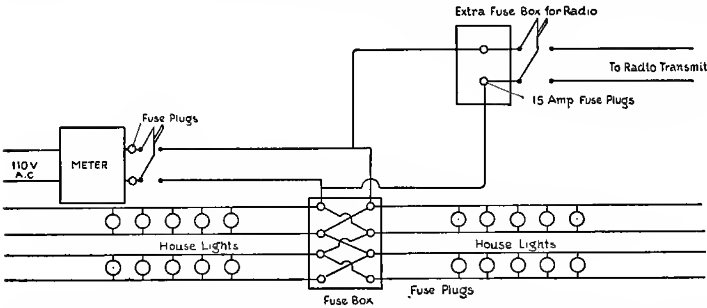


FIG. 69.—Diagram showing how to connect special fuse block to house current for the radio transmitter. Appendix IV tells how to connect a line protector to the house circuit to take care of any high frequency kick-back from the transformer.

the primary current of an induction coil. If, instead of a mechanical interruption of direct current, we use an alternating current in the primary, we secure a similar effect of induction in the secondary, due to the constant changing of polarity of the alternating current and the corresponding changes in the magnetic lines of force cutting the coils of wire of the secondary coil.

Owing to certain characteristics of an alternating current, which an interrupted direct current does not have, the alternating current, high-voltage transformer has a somewhat different design from an induction coil.

There are two general types of transformers. The open-core type, which more closely resembles an induction coil, and the closed-core type. The closed-core transformer is used most frequently for amateur radio spark transmission. Fig. 70 shows a small closed-core transformer. The primary is wound with comparatively few turns of wire of about 14 gauge. The secondary is wound with very many turns of about No. 34 gauge wire. The soft iron core is rectangular in shape, permitting the lines of force to go from the primary coil to the secondary with a minimum of loss.

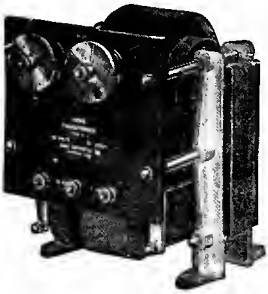


Fig. 70.—Closed core transformer for spark transmitter.

When purchasing a transformer, it is well to state to the supply house the voltage and frequency of the current you intend to employ. This will enable you to secure a transformer that will require no current-regulating devices in the circuit and will simplify the installation considerably. There are types of transformers which have the primary tapped so that you can vary the amount of input power from, say, $\frac{1}{4}$ to 1 kilowatt. (One kilowatt—one thousand watts.)

The condensers required for transmitting are of a much sturdier type than those used for receiving, although the same principles hold good for both. Naturally in a transmitting condenser, the dielectric must be able to resist the higher voltages used, or it will become punctured by sparks jumping through which will cause it to cease functioning.

One of the best condensers for transmitting is the Leyden jar. (See Fig. 71.)

When purchasing a transformer, be sure to ask what capacity condenser is required, as they are designed to operate most efficiently with a certain capacity. By connecting two Leyden jars in parallel, that is, their outside coatings together and their inside coatings together, the capacity is doubled so that, knowing the capacity of a Leyden jar, the proper capacity necessary for the transformer can be built. Should it be necessary to reduce the capacity, it can be cut in half by connecting the jars in series. The same rules hold good for all types of condensers.

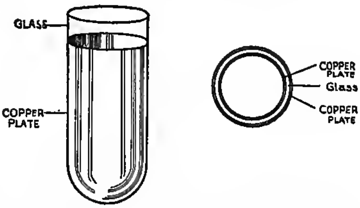


FIG. 71.—Left: Navy Type Leyden Jar for use as condenser in spark transmitter. Right: Sectional view of same.

Another type of condenser is a glass plate coated on both sides with tin foil. Such a condenser is usually mounted in a wooden rack. Any number of plates can be used to build up the proper capacity. A plate condenser is shown in Fig. 72.

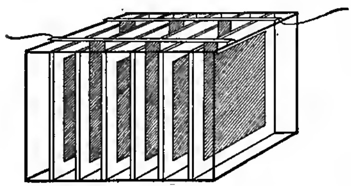


FIG. 72.—Glass plate and rack transmitting condenser.

It will be noted that whenever a plate condenser or Leyden jar is under a heavy electrical charge that blue "brush discharges" are to be seen at the edges of the metallic coating. This represents a certain loss of energy and is caused by the resistance of the air breaking down and becoming a partial conductor. To eliminate these losses which become serious at higher powers, the condensers are sometimes immersed in oil. Compressed air also eliminates this objectionable feature.

The advantage of oil as a dielectric, as before stated, is that there are fewer losses due to brush discharges. When using an oil condenser, stand it in an upright position for twenty-four hours, so that the air bubbles may rise to the surface. Should higher voltages than the condenser can carry be applied to an oil condenser no serious results are had, merely a momentary short circuit, the oil quickly filling up the puncture in the dielectric. This is not the case with glass or mica dielectrics, which are rendered inoperative if punctured. Puncturing is caused by a spark breaking through the dielectric and jumping from plate to plate.

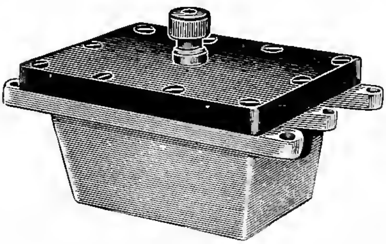


FIG. 73.—Dubilier mica condenser, an efficient transmitting condenser.

In Fig. 73 is illustrated the Dubilier mica condenser.

This condenser is of unique design and is well adapted to amateur transmission. It is composed of several sections, inclosed in an aluminum casing. These units together contain over one thousand sheets of mica and foil. The full voltage across the transformer is consequently minutely subdivided. The voltage that acts across each individual unit is so small that brush discharges are eliminated, thus preventing loss of energy.

A convenient type of condenser is shown in Fig. 74. Each unit can be used singly or a number can be used parallel or in series. The dielectric is a special, molded compound. Its convenient size ($6\frac{3}{8}$ x $6\frac{1}{2}$ x 1 3/16 inches) and the fact that it is solid, makes it desirable wherever apparatus is subject to constant movement or frequent handling. It is particularly adapted for portable equipment, where the more fragile condensers would be difficult to handle.

The subject of spark gap is most important for designing an efficient transmitter. No doubt, before the reader attempts to install a transmitter, he will have done considerable receiving and will know the code. He will also be acquainted with the types of spark signals that are easiest to read. First place will go, no doubt, to the loud, smooth, high-pitched musical note produced by the 500 cycle quenched gap sets. Such an outfit is beyond the means of most amateurs, and consequently is heard mostly from commercial land and ship stations, many of which have adopted this type of transmitter.

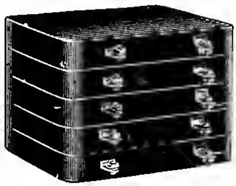


FIG. 74.—Sectional moulded condenser for transmitting circuits.

A quenched gap is a series of very narrow gaps, each gap being formed by two metal plates of fairly large surface. For amateur transmitters, from five to thirty-two gaps are usually required. The separation of the two plates forming the gap is had by means of a gasket made of some insulating material, such as mica or fish-paper. Each gap unit has flanges which cool the plates. The gaps are separated by rings and are held together by a screw clamp. The gaps are from .01 to .04 inch wide.

The purpose of a quenched gap is to prevent the radiation of more than one wave length, thus minimizing interference.

When a spark discharges across a gap, the oscillations set up are similar to those shown in Fig. 25. These oscillations which are produced in the primary circuit are induced into the secondary or aerial circuit from where they are radiated. It will be recalled on page 38, that the electrical stress between the two electrodes of the spark gap caused the resistance of the air between to break down, and the current flowed from one to the other in the form of a spark.

Unless the resistance of the gap is immediately restored after the spark has set up the oscillations in the primary circuit, we have a very complex series of oscillations, for the oscillations in the secondary or aerial circuit are induced back again into the primary circuit and then reradiated from the aerial at a different wave length. This causes useless dissipation of energy, and the second wave will cause considerable interference with other stations than the one to which you are sending.

The quenched gap overcomes this difficulty by "quenching" the spark after a very few oscillations. The gap shown in Fig. 75 has just been described. When the gap is clamped tight, no air can get into each of the narrow chambers, and the spark soon burns up what little air is there. The large sparking surface of the plates prevents any particular point from getting too hot, so that when the amplitude of the oscillations falls to a certain point, the gap has not sufficient conductivity to cause a spark.

Fig. 76 shows the comparative oscillations of an ordinary open gap and a quenched gap.

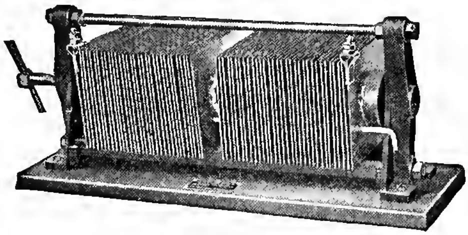


Fig. 75.—Quenched spark gap for transmitting.

Another pleasing, pure, high-frequency spark note that you will hear when listening in is produced by what is known as a synchronous rotary gap. This gap can only be used to advantage with a motor generator set, as the points of the gap must have a mechanical relation to the field poles of the generator. The principle of the synchronous gap is that a spark occurs at the peaks of every cycle, which not only gives an excellent quenching effect, but gives a very clear pure tone because the spark discharge and the surge of the alternating current are in perfect synchronism.

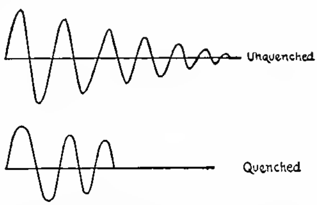


Fig. 76.—Diagram showing the effect of quenching a spark. Quenched oscillations are subject to sharper tuning than unquenched.

After the quenched and synchronous spark, the nonsynchronous rotary spark is easiest to read. This gap is adaptable to amateur stations and many are so equipped. The nonsynchronous rotary spark does not require a high-frequency primary current in the primary of the transformer. There are many types of nonsynchronous

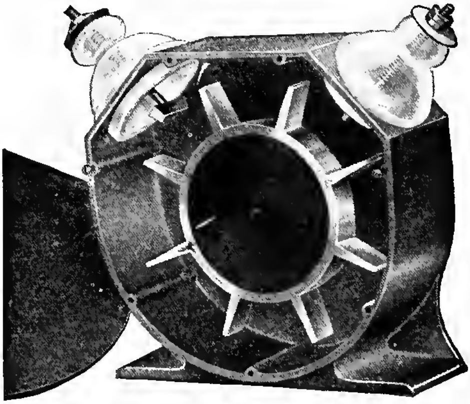


Fig. 77.—A rotary spark gap will give the spark a musical tone as well as slightly quenching it. The illustration shows a rotary gap.

spark gaps. Figs. 77 and 78 illustrate two of the numerous rotary spark gaps of the nonsynchronous type.

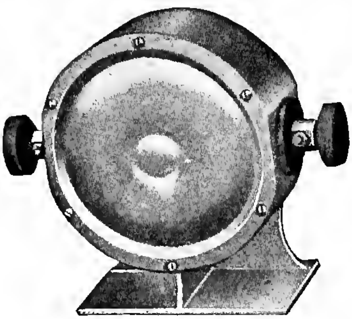


Fig. 78.—By inclosing a rotary gap as in this illustration better quenching is effected and the annoying crash is eliminated.

The ordinary open gap, which is adaptable to the average transformer, is illustrated in Fig. 79. The open gap does not give a musical note, but, when used in a well-designed set, good results are obtainable.

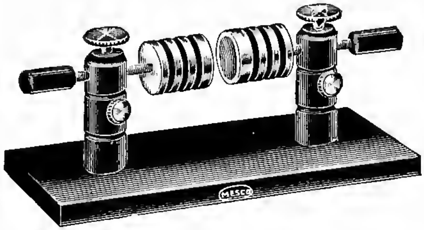


FIG. 79.—The open gap is inexpensive and gives good results on small sets.

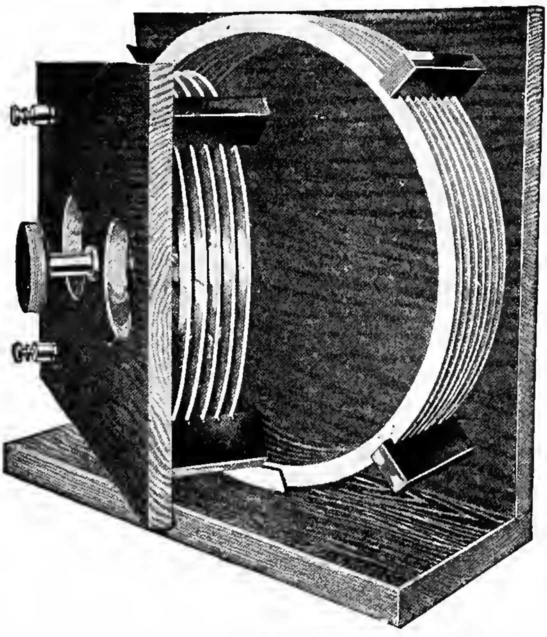


FIG. 80.—Type of oscillation transformer in which the coupling is varied by swinging one of the two coils.

The inductance that is commonly used in spark transmitters is known as an oscillation transformer, and consists of primary and secondary inductances. The inductance of both primary and secondary are variable, and the coupling between the two is adjustable. There are

FIG. 81.—Transmitting tuning coil arranged with plugs for changing wave length.

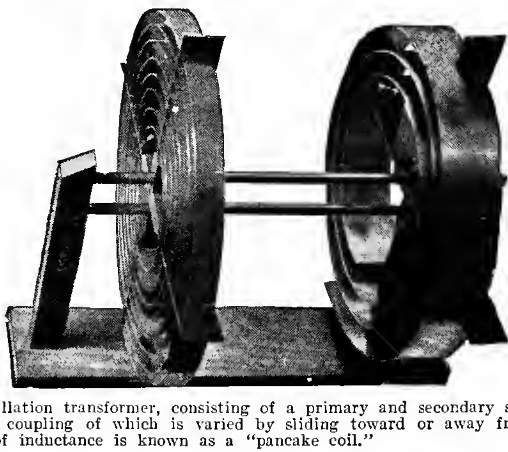


FIG. 82.—Oscillation transformer, consisting of a primary and secondary spiral of copper ribbon, the coupling of which is varied by sliding toward or away from each other. This type of inductance is known as a "pancake coil."

innumerable types of oscillation transformers, and Figs. 80, 81 and 82 illustrate types which are common as well as efficient.

In Fig. 83 we show a transmitting key such as is suitable for breaking the primary circuit in amateur spark transmitters. The contact points are of a composition, which, being a good conductor of heat, cools quickly and

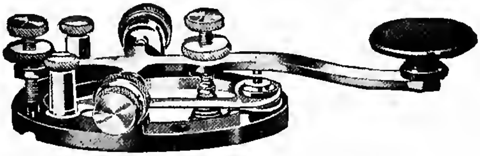


FIG. 83.—Telegraph key for making and breaking the primary circuit of the transformer, thereby causing dots and dashes to be sent out.

consequently shows less spark at the breaking of the circuit. This lessens the burning away of the contacts.

We have briefly described the instruments that are used for transmitting spark signals, and shall now go into some details as to their operation. Fig. 84 shows

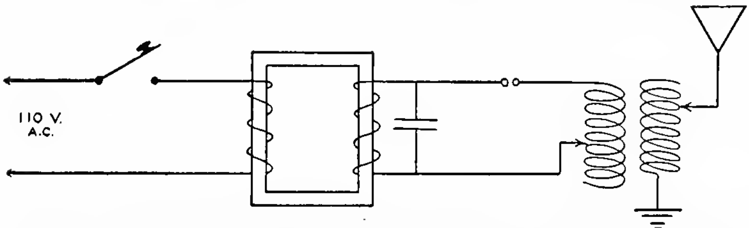


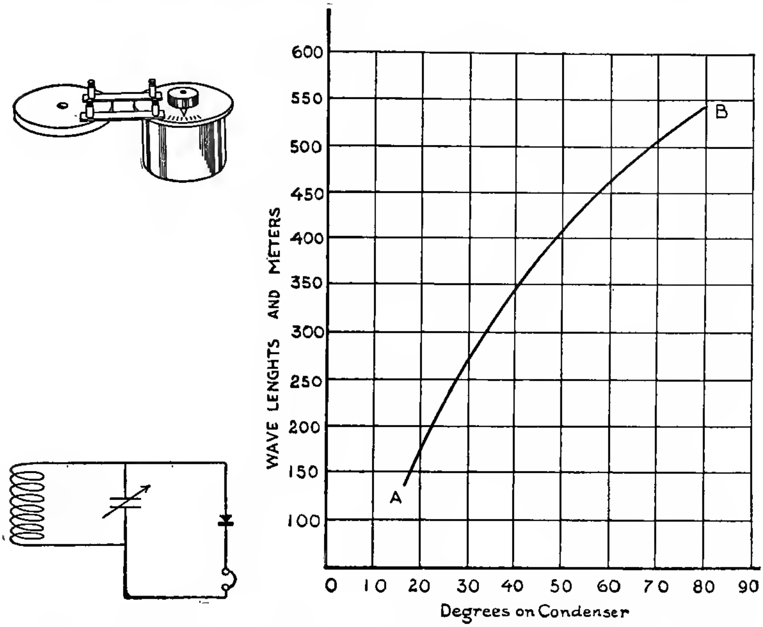
FIG. 84.—A complete transmitting circuit from the key to the aerial ground circuit. Note that a loose-coupled oscillation transformer is used. The oscillation transformers shown in Figures 80 and 82 would serve in this hook-up.

a practical transmitting circuit with an open gap. This hook-up will work well from $\frac{1}{4}$ to 1 kilowatt. For the amateur wave length of 200 meters, the condenser should be .007 mfd. (microfarad). The oscillation transformer can be of any standard make, suitable for transmission on 200 meters.

Having connected the apparatus, as indicated in the diagram, the question of tuning will come up. To tune properly a transmitting set to legal wave length, it is necessary to have a wave meter. This can be bought or, as it is only necessary for use once, if the apparatus is left tuned, it can frequently be borrowed.

A wave meter is really a small closed circuit receiver with a variable condenser which is calibrated at the various wave lengths to which the meter responds. Fig. 85 shows a wave meter that may be purchased from any good radio supply house and Fig. 86 indicates the connections of the wave meter. The inductance, which consists of a coil of wire, is fixed, and the capacity, which is a variable condenser, has the wave lengths indicated on it, or has a dial giving the capacities or merely degrees of rotation which can be translated into wave length by means of an accompanying curve sheet. Such a sheet is shown in Fig. 87.

In tuning a set such as is indicated in Fig. 84, we first tune the primary to the proper wave, namely, 200 meters. This is done by disconnecting the aerial and ground from the secondary coil, and, with the wave meter near the primary of the oscillation transformer, we press the key. It is well to keep the key closed by means of an adjustment or by putting a book on it, so that we can be free to adjust the wave meter. By varying the capacity of the wave-meter condenser, we find a point where the spark is heard at maximum loudness in the telephone receivers. This indicates that the wave meter is in resonance with the primary circuit of the transmitter. Should this point happen to be 30 on the scale, we take our curve sheet and follow the line marked 30 until it intersects the curve A–B. The line at which this intersection takes place has the wave length of the primary circuit marked at the lefthand side of the graph. In this case, it is 350 meters. This wave is too high, so



FIGS. 85, 86, 87.—Simple wave meter, diagram of connections and curve sheet showing wave lengths for various degrees of condenser dial.

we reduce the number of turns of wire in the primary of the oscillation transformer and test the wave again. We repeat this with changes until the wave is indicated at 200 meters.

We now connect the aerial and ground to the secondary of the oscillation transformer and connect a hot wire ammeter in series with the aerial. Fig. 88 shows a hot wire ammeter.

By adjusting the secondary inductance until the hot wire ammeter shows a maximum reading when the key is closed, we secure resonance and have both primary and secondary radiating a 200 meter wave. We now revert again to our wave meter and test the two circuits together. If we find only one calibration on the wave meter where the signals are loudest, and this happens to be the 200 meter wave, we are all right and the set is properly tuned, but should we find not only a reading of 200 meters, but also another wave length at which we get a maximum signal, we are radiating two waves and must vary the coupling until the wave meter shows only one reading and that at 200 meters. It is illegal to transmit

FIG. 88.—Hot-wire ammeter, to be connected in series with aerial, to show the amount of current that is being delivered to it.

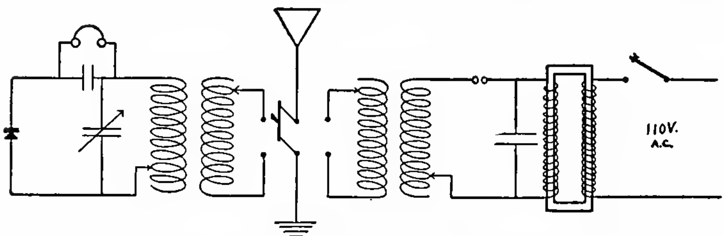


FIG. 89.—Complete transmitter and receiver, connected so that either can be thrown into the aerial-ground circuit by means of an aerial switch.

with a set that is radiating more than one wave length.

Fig. 89 shows the same transmitter that is diagrammed in Fig. 84, hooked up with a receiving set and an aerial switch, so that both sending and receiving can be done with the same aerial.

When transmitting, we close the double-throw, double-pole aerial switch to the right, and connect the aerial and ground to the transmitter, and when we receive, we close the switch to the left, connecting the aerial and ground to the receiving transformer or loose coupler.

Fig. 90 shows an aerial switch. There are many different types of these switches. Some of them do not provide for switching the ground, but leave the ground

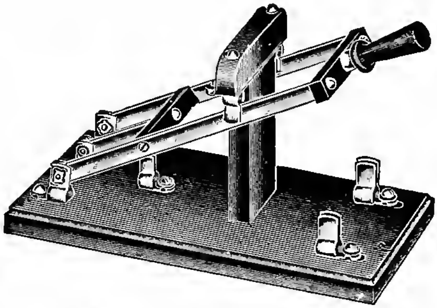


FIG. 90.—Aerial switch similar to one used in diagram Figure 89, excepting the third switch blade, which is used for switching on and off the 110 V. input current when sending and receiving respectively.

connection on both transmitter and receiver at the same time. Others provide for making and breaking the transformer primary circuit when sending and receiving respectively. Still other switches will start the motor on the rotary gap when thrown to the transmitting position. Almost any combination can be had in an aerial switch.

Much more can be written about spark transmitters, but as has been said before, the author does not wish to encourage the beginner to transmit until he is proficient in the art of radio telegraphy, and then it is more than likely that he will choose to transmit with a continuous wave set that will be described in another chapter.

CHAPTER VIII

CONTINUOUS WAVES

Damped oscillations and decrement—Undamped oscillations—Analogy of voice modulation and why C. W. must be used—Methods of producing continuous waves—The arc—Lafayette Station—Alexanderson high-frequency alternator and vacuum tubes—Radiophoning 5,000 miles—Broadcasting stations equipped with vacuum tube transmitters—Modulating continuous waves—Radiophone and telegram simultaneously sent from same station—Continuous waves enables sharp tuning—"Tone tuning"—Greater speed using C. W.

Thus far, in discussing radio transmission, we have been dealing only with damped oscillations, which produce discontinuous waves. Damped oscillations decrease in amplitude with each successive oscillation. This decrease in amplitude is uniform, and the relation of one oscillation to the next succeeding oscillation is called the decrement. The amount of decrement of transmitted oscillations is limited by government regulation. Fig. 35 on page 46 shows a number of groups of damped oscillations.

For radio telephony, it is necessary to produce undamped oscillations, which in turn cause continuous waves. It is easily understood that, if each succeeding amplitude of an oscillation diminishes as in Fig. 35 and the waves are discontinuous, any attempt to modulate or to modify this type of wave by vibrations from the human voice will not produce understandable modulations in the receiver. The change produced by the voice on a varying current, such as is shown in Fig. 35, could not possibly reproduce the voice.

It is, therefore, necessary to create a continuous wave in order that we may transmit the modulations of the human voice by means of it. Undamped oscillations which produce the continuous wave are shown in Fig. 91. This continuous wave, when modulated by the various frequencies of the human voice, produces an effect which can be received as an audible, understandable voice modulation.

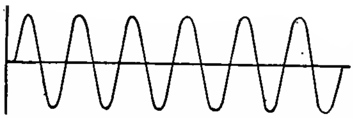


FIG. 91.—Undamped oscillations, for producing continuous waves. Note constant amplitude. Compare with damped oscillations, Figures 25 and 76.

Analogy of Voice Modulation.—Perhaps the following analogy will make this more easily understood. Let us for a moment forget the transmission of voice through the ether, and consider the transmission of voice by means of sound waves through the air. If we are in a room where the air is quiet and there are no disturbing sounds, the voice is easily carried from one end of the room to the other and is understood. Now let us assume that instead of having a quiet room, in which the air is undisturbed, we introduce into the room a very powerful jet of compressed air, which agitates the air in every conceivable direction and causes it to whirl and whistle in uneven and uncontrollable oscillations. A word spoken by the human voice in such a room would be indistinguishable to a person even close by. The modulation of the air in the room by the voice would be so distorted by the uneven and violent agitation of the air, due to the inrushing compressed air, that the voice would not carry and the modulations in the air caused by the voice would be severely distorted.

This latter condition is, in a way, analogous to the damped oscillations, which are not only of varying amplitudes but also are interrupted after each successive spark discharge.

Methods of Producing Continuous Waves.—To produce the desirable continuous waves for voice modulation, and also for the most efficient type of radio telegraphy, known as continuous wave or C. W. transmission, several methods are used.

Duddell of England and Poulsen of Denmark took the ordinary arc light and, by modifying same and introducing capacity and inductance into the circuit, produced continuous waves. The first radio telephone transmission was accomplished by means of continuous waves produced with an arc. To-day, however, the arc is not frequently used for radio telephony, but is used to a very large extent for the transmission of continuous wave telegraphy.

Most of the large warships of the U. S. Navy and the high-powered land naval stations have arc sets. In trans-Atlantic work, the largest arc transmitter is the one at Bordeaux, France, known as the Lafayette Station, which was built by the U. S. Navy for handling overseas war communications, but which was not completed until some time after the armistice had been signed in 1918. Later it was turned over to the French government and now constitutes one of the principal commercial trans-Atlantic stations. This station has an arc transmitter of 1,000 kilowatt capacity, which undoubtedly is the largest individual arc unit in the world.

The two methods of producing continuous waves, which are useful in radio telephony, are the Alexanderson high-frequency alternator, and the vacuum tube.

The Alexanderson high-frequency alternator is not being used at the present time to any great extent in radio telephony, although it is quite possible, where a very large amount of power is required, that this will be one of the principal means of long distance radio telephony.

Soon after the war, when President Wilson crossed the ocean on the *George Washington,* the high-powered trans-Atlantic station at New Brunswick, N. J., which was then being operated by the U. S. Navy, succeeded in modulating the continuous waves produced by the Alexanderson high-frequency alternator, and kept in telephonic communication with the *George Washington* all the way across the Atlantic.

The record, however, for long-distance telephonic transmission goes to the vacuum tube. The Western Electric Company, together with the American Telephone & Telegraph Company, conducted experiments at the Arlington, Va., Government Naval Station in 1915, where, by means of a complicated system of vacuum-tube generation and modulation, they succeeded in talking to the Eiffel Tower in Paris and to the Government Naval Station in Honolulu, the latter over five thousand miles away!

At that time, the use of power vacuum tubes for producing the very large amount of current that was required for this long distance telephony was probably too expensive.

Dr. Alfred N. Goldsmith, in his book, *Radio Telephony,* estimates that it cost $10,000 a day in tube replacements to operate the Arlington station during the tests that were made in 1915. Sixty amperes of current were radiated from the aerial, generated and modulated by over 300 vacuum tubes.

However, for ship-to-shore telephony and for broadcasting, the vacuum tube seems to be by far the most efficient and most easily controlled means of producing continuous waves. All the broadcasting stations in the United States are equipped with vacuum-tube transmitters; also the several trans-Atlantic steamers that are equipped with wireless telephones are utilizing the vacuum tube. Several trans-Atlantic radio telegraph stations are now using vacuum tubes.

Modulating Continuous Waves.—In continuous wave telegraphy, owing to the fact that there are no audio-frequency interruptions, as in spark telegraphy, where each spark occurring at audio-frequency intervals causes an interruption in the wave train and a consequent audible signal in the receiver, it is necessary to change these radio-frequency impulses into audio-frequency impulses, if the signals are to be heard. This is done in several ways. Sometimes, at the transmitter, instead of modulating the continuous waves with the voice, a buzzer is used. The buzzer impresses on the continuous wave its own audio-frequency in the form of a modulation similar to the modulation that was produced by the voice, only, of course, at the constant frequency of the buzzer.

This audio frequency modulation can be received by the ordinary set used for the reception of dampened waves.

However, more commonly, the continuous wave is merely interrupted by a key, or special type of relay, and sends out groups of undamped radio-frequency oscillations. These radio-frequency oscillations cannot be heard by the ordinary damped wave receiver. In order to hear them, it is necessary to break them up in the receiver at audio-frequency intervals. This is accomplished by several means. Perhaps the most common to-day is the internal heterodyne or autodyne of the ordinary regenerative vacuum-tube receiver, such as is used by most people who have a vacuum-tube receiver for the broadcasting station. This method is described in more detail in another chapter.

Another means is by the external heterodyne which is also described in another chapter.

If a crystal detector is used, a tikker or tone-wheel is sometimes employed. This consists of a disc with a number of metallic segments, mounted on a motor which interrupts the incoming continuous waves at an audio frequency most convenient for reception, usually 1,000 interruptions per second. Such a tone-wheel is shown in Fig. 92.

Mr. Elmer E. Bucher devised for this purpose a rotary condenser which by de-tuning the wave length of the receiving circuit 1,000 times per second, succeeds in obtaining similar results. A rotary condenser is shown in Fig. 93.

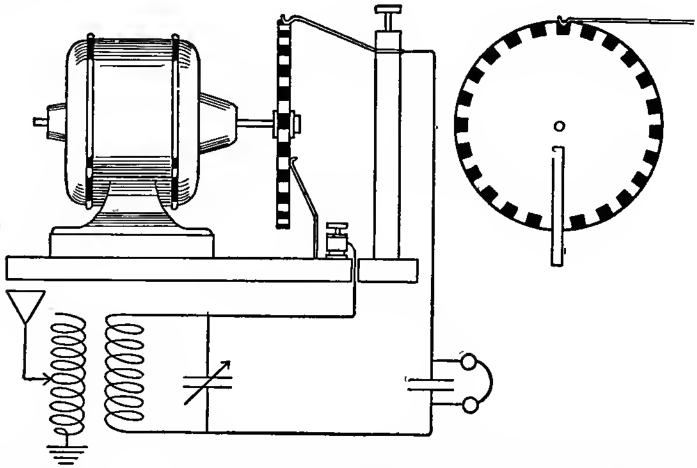


FIG. 92.—Tone wheel, for making high frequency undamped oscillations audible. No detector is necessary when a tone wheel is used in the circuit indicated. The speed of the motor determines the audible frequency of the received signal.

Radiophoning and Telegraphing Simultaneously. —One of the latest developments in radio telegraphy and telephony is the simultaneous transmission of radio telegraph messages and radio telephone messages from the same source at the same time. This system is now installed on the *America* and is successfully being operated. While the radio telegraph operator is busy sending and receiving his telegraph messages, the radio telephone can be working

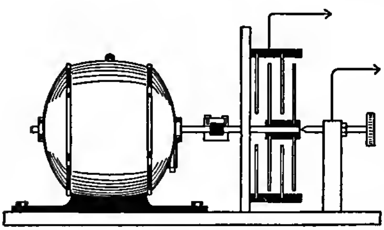


FIG. 93.—Rotary condenser for making undamped high frequency oscillations audible. This is accomplished by tuning and detuning the receiving circuit at an audible frequency.

another station, and so there is no interruption in the usual ship's routine of telegraph messages, while the passengers are talking to their friends ashore.

Advantages of C. W.—The time will probably come when the spark transmitter will be completely eliminated in favor of the continuous wave or C. W. transmitter. In the first place, radio telephony is possible on most continuous wave outfits merely by the introduction of a microphone with the necessary modulator.

Extremely sharp tuning can be done with continuous waves and less interference is had than with a spark. With a spark transmitter the tone of the received signal is dependent entirely upon the tone of the transmitted signal, but, with continuous wave, the tone of the received signal can be changed, by means of the tone-wheel, tikker or heterodyne, to whatever tone is desired, and frequently tuning by means of tone is possible, as well as by means of a change in wave length.

For instance, with two stations coming in on the same wave length, by slightly changing the wave length of the receiver and changing the tone of one of these stations, it can be easily read notwithstanding the unwanted station is still audible.

Lower voltages are used with continuous wave and consequently less electric strain on the insulators is had, and the loss of energy is not so great.

Owing to the different methods for modulating the continuous wave, a much greater speed can be obtained in continuous wave telegraphy than in spark telegraphy. This is of inestimable value for Transatlantic traffic, where transmission and reception is done by machine, and where the amount of traffic that can be handled during each twenty-four hours is a matter of dollars and cents.

CHAPTER IX

VACUUM TUBES[1]

Most important device in modern radio—Not foolproof—Two distinctive types of vacuum tubes—Two-electrode tube—Three-electrode tube—Edison's discovery—Fleming puts Edison's discovery to practical use—Electrons—Rectifying action of two-element tube—De Forest introduces a third element, the grid—Explanation of three-element tube, as detector, as amplifier—Armstrong "feed-back"—Audio- and radio-frequency amplification—Amplifying transformers—Heterodyne and beat reception—Vacuum tube as a generator—Armstrong super-regenerative receiver—Types of receiving tubes.

We now come to the most important device in modern radio, the vacuum tube. Perhaps never before has the general public been obliged to handle so delicate a piece of apparatus in pursuit of its pleasure. It is gratifying to see that the average person takes sufficient interest in radio not to be satisfied in merely operating a receiver, but wants also to know something about the appliance. The vacuum tube is not sufficiently perfected to be foolproof and it is doubtful if it ever will be. Owing to its sensitiveness, a working understanding of principles is necessary if the best results are to be obtained.

There are two distinctive types of vacuum tubes, one, the two-electrode tube, and the other the three-electrode tube. The two-electrode tube functions quite similarly to a crystal detector, its effectiveness being due princi-

[1] Electron tubes.

pally to its rectifying action. The three-electrode or three-element tube has, in addition to a rectifying action, a relaying action by which the feeble impulses from the distant transmitter act upon a local current causing variations in it which are greater than the original impulses and produce an amplification of them.

It was Thomas Edison who discovered that a wire heated to incandescence in a vacuum caused the surrounding air to become a conductor of electricity. Fleming later put this discovery to practical use by devising the two-electrode vacuum tube or "Fleming Valve" as it is called.

Two-Element Vacuum Tube.—Fig. 94 shows a schematic diagram of a two-element tube. F is the incandescent filament or hot cathode, P is the plate or cold anode. A is a milliammeter, FB is the filament battery, and G is an alternator. When the filament is lighted to incandescence and the current from the alternator is passed through the circuit, the milliammeter will show a current flowing in one direction only, showing that the tube has a rectifying or valve action. When the filament is hot, it throws off particles of negative electricity called electrons which flow from the filament to the plate. Electrons are the smallest known units of matter and are a subdivision of the atom which was previously considered to be the ultimate particle of matter. The electron carries the smallest known charge of negative electricity.

The rectifying action of the "valve" can be explained as follows: Whenever the plate becomes charged with positive electricity, the electrons, which are negative, will be attracted toward it, in accordance with the law of static electricity that charges of opposite polarity attract. Now, when, in the course of the cycle of alternating current produced by the alternator G, the plate becomes charged with a negative charge, the electrons cease to flow and no current passes through the circuit. Thus, only current in one direction can flow through the circuit, and the vacuum tube is said to possess unilateral conductivity.

When high-frequency alternating currents pass through the tube, they therefore are rectified. Consequently, the tube can be used as a detector of radio-frequency impulses, in a manner similar to a crystal detector.

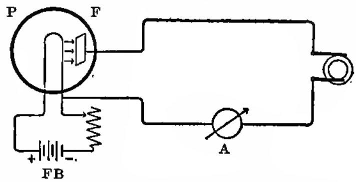


FIG. 94.—Two-element (two-electrode) vacuum tube with alternating current generator and milliammeter in plate-filament circuit to demonstrate unidirectional flow of current. Arrows indicate direction of flow of electrons from filament to plate.

However, the two-element valve is not limited merely to being a rectifier, but it also has an amplifying action.

In Fig. 95, we find, by varying the voltage of battery B, the positive terminal of which is connected to the plate P, and the negative terminal of which is connected to the filament F through milliammeter A, that the current through the plate circuit varies as is indicated by the milliammeter A. It will also be noticed that the current does not vary uniformly with the variation of the voltage. Varying the voltage, say from a potential of ten to thirty volts, may have little effect on the current flowing through A, but varying the current from forty to fifty volts may show a comparatively great increase in current. Each valve differs somewhat in these characteristics, although all follow the same general rules. As we increase the voltage above a certain point, we will again find little change in current until finally we may increase or decrease the voltage without any change in current at all. We then have reached what is called the point of saturation.

The curve that can be plotted from such an experiment is called the characteristic curve of the vacuum tube.

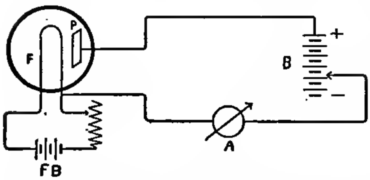


FIG. 95.—Another experiment illustrating that current will flow only in one direction through a vacuum tube. This property known as "rectifying" enables the vacuum tube to be used as a detector in radio receiving circuits and also in alternating current circuits to change alternating current to direct current.

By varying the amount of current in the filament, a similar curve can be plotted. At a certain filament temperature, the largest change in plate current takes place with the smallest change in potential.

By thus knowing the characteristics of any particular tube, a maximum degree of sensitiveness can be obtained. It can readily be understood that if we have a two-element vacuum tube at its maximum degree of sensitiveness, and if we impose on the plate circuit the oscillating current of an incoming radio message, it will be rectified in the plate P (telephone P-1) circuit and will assist the battery B-2, thereby causing a comparatively large change in the current flowing through the telephones. This change of current will produce signals in the telephone receivers. (See Fig. 96.)

Three-Element Vacuum Tube.—Although a certain amount of control can be had over the flow of electrons between the filament and plate, by varying the potential of the plate, Dr. Lee de Forest discovered in 1906 a new means of controlling the flow of electrons by which much greater variations in current could be produced in the telephone receivers, by means of the feeble impulses impressed on the vacuum tube by the received radio oscillations. Dr. de Forest introduced between the filament and the plate at third element, a grid of fine wire. (See Fig. 97.)

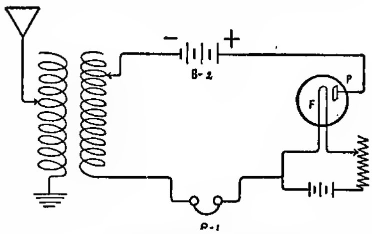


FIG. 96.—Diagram of a receiving circuit using a two-element vacuum tube as a detector.

This third element between the filament and the grid has the power to check or permit the flow of electrons. As before stated, electrons carry charges of negative electricity. If the potential of the grid is negative, in respect to these charges, the electrons will not be permitted to pass through the grid to the plate, for the negatively-charged grid will—in accordance with the law of static electricity, which says like charges repel one another—repel the negatively charged electrons; consequently, no current can pass between the plate and the filament. Now, if the grid is positively charged, in

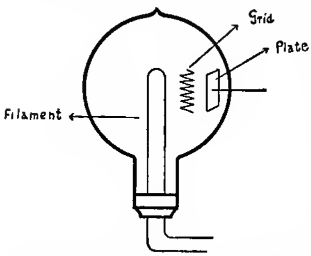


FIG. 97.—Three-electrode vacuum tube also known as a "triode." Three electrode tubes are used as detectors, amplifiers and also as generators of high-frequency oscillations for transmitting continuous waves.

respect to the negatively charged electrons, they will be attracted to the grid, and furthermore, any surplus of electrons will pass through to the positively charged plate, thereby completing the circuit and causing current to flow from the plate to the filament.

Between the two extremes, of electrons, being entirely checked by the grid in their flow toward the plate, and of a large amount of electrons flowing from the filament to the plate, we have varying degrees of these conditions, producing varying current in the plate-filament circuit. The variations in current in the plate-filament circuit, due to the local B battery are much greater than the variations in potential in the controlling grid.

The potential of the grid is established either by a special battery in the grid circuit, sometimes known as the "C" battery, or by means of the "A" battery, that is, the filament battery. The latter is the most common means of giving the initial potential to the grid. High-frequency alternating currents impressed between the filament and grid, are rectified for the same reason and in the same manner that the alternating current was rectified in the two-electrode vacuum tube, as previously described in this chapter.

The rectified current of the incoming oscillations causes a change of potential in the grid. This change of potential in the grid checks or permits the flow of electrons as before described, thus regulating the more powerful current of the B battery, producing changes in the amount of current flowing through the telephone receivers and thereby causing audible signals. In the average vacuum tube used as a detector in a radio receiving set, the feeble incoming oscillating current in the grid-filament circuit controls a current many times greater in the plate-telephone-filament circuit, thereby amplifying the incoming oscillations considerably. This amplification must not be confused with the amplification caused by regeneration, nor with the amplification produced by means of a number of vacuum tubes in cascade, both of which phenomena will be discussed later.

The action just described has to do with audio-frequency oscillations. One half of each cycle of incoming oscillations is impressed as a charge on the surface nearest the grid, of the grid condenser C, in Fig. 98. The accumulated charge during a complete group of oscillations causes a single change of potential in the grid, and consequently a single change of current in the telephone receivers. These changes occur at an audible frequency.

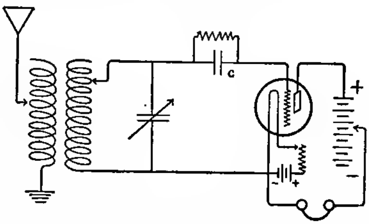


FIG. 98.—Simple vacuum tube receiving circuit, using one tube as a detector, and containing grid-condenser and grid-leak in the grid circuit. It is advisable, although not necessary, to shunt a small fixed condenser between the positive side of the B battery (plate circuit), and the filament side of the telephone receivers.

The complete cycle which, due to the rectifying action of the vacuum tube, does not impress itself upon the grid, is also used and produces in the plate circuit an amplified radio-frequency current at the same time as the amplified audio-frequency current is produced. An explanation of this phenomenon requires the use of a graph, and as we wish to avoid going into such technicalities, we will leave the explanation to more technical books. This radio-frequency component does not produce audible signals in the telephone receivers, and was completely wasted until E. H. Armstrong discovered a method of feeding back the radio-frequency component

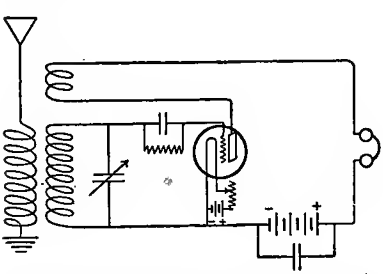


FIG. 99.—Typical Armstrong regenerative or "feed-back" circuit. Note coupling between grid circuit and plate circuit, through the secondary of the vario-coupler. The third coil is called the "tickler coil." This hook-up is suitable for honeycomb coils and three coil vario-couplers.

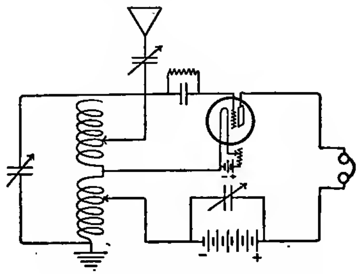


FIG. 101.—Single circuit regenerative hook-up.

into the grid circuit and thereby utilizing this formerly wasted energy to fortify the incoming oscillations. This

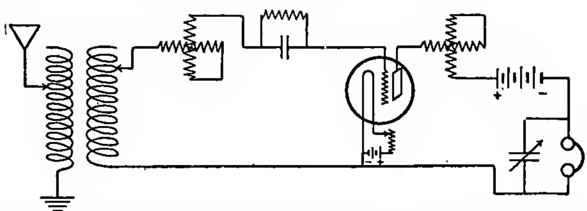


FIG. 100.—Regenerative circuit employing a vario-coupler, a grid variometer and a plate-variometer. This circuit is popular among amateurs. Variations can be made in it by inserting a variable condenser in the primary circuit as in figure 50. A variable condenser can also be inserted across the secondsry of the variometer. The variable condenser across the 'phones is not necessary. The simplest method of connecting the "by-pass" condenser, as this condenser is called, is shown in Figure 109.

is accomplished by coupling the plate circuit in one of a number of ways to the grid circuit. Such hook-ups are shown in Figs. 99, 100, 101.

Audio- and Radio-Frequency Amplification.— The three-electrode vacuum tube can be used to amplify the signals detected by another vacuum tube or by a mineral detector. Such amplifications can be created by using either the radio-frequency component, or the audio-frequency component, or both. Audio-frequency amplification is attained by putting a small transformer in the plate circuit of the detector, in place of the telephone receiver. A step-up transformer is used for this purpose; that is, the secondary of the transformer has a greater number of turns than the primary. The secondary of the transformer is connected to the grid and filament of another vacuum tube in a similar manner to which the detector was connected to the source of incoming oscillations.

The amplifier takes the signals already amplified and regenerated in the detector, stepped up to a higher voltage by means of the coupling transformer, and puts them through a similar process of amplification as did the detector. The result is that we have audible signals, many times louder than with the detector alone. Any number of stages of audio-frequency amplification can be added up to six or seven stages. However, for most practical purposes, two or three stages of audio-frequency amplification is sufficient, except where power-tube amplifiers are used for loud-speaking telephones, such as are described in another chapter.

Audio-frequency amplification is attained after the oscillations have been rectified in the detector. Radio-frequency amplification takes place prior to rectification. Fig. 102 shows a two-stage radio-frequency amplifier detector and a one-stage audio-frequency amplifier. The figure shows a loop antenna connected to the first stage of radio-frequency amplification. The secondary of a vario-coupler should be connected here when using an aerial and ground.

In audio-frequency amplification, the coupling transformers need not be tuned, and usually have an iron core. Radio-frequency coupling transformers either operate on a comparatively narrow band of wave lengths, or must be tuned. Radio-frequency amplifiers can also be coupled with resistance couplings.

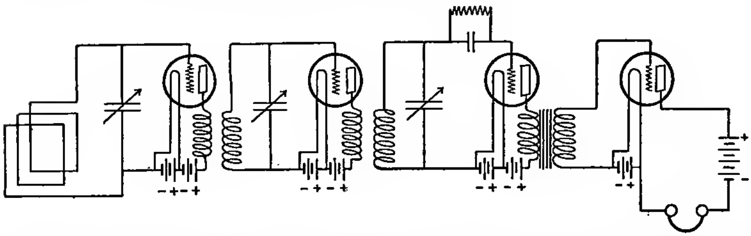


FIG. 102.—Loop antenna with two stages of radio-frequency amplification, detector and one stage of audio frequency amplification. When this circuit is to be used with aerial instead of loop, the secondary of the vario-coupler is connected in place of the loop across the first variable condenser. To simplify the diagram, individual A and B batteries are used for each unit of amplification and the detector. In practice, a single A battery, and a single B battery can be used.

At the present time, comparatively few radio-frequency transformers and other coupling devices are in use by amateurs and novices, owing to the somewhat delicate adjustments that are necessary to secure good results. However, several manufacturers are now producing radio-frequency transformers which require little or no adjustment, but which are limited to specific bands of wave lengths. The radio-frequency transformer shown in Fig. 103 requires no adjustments and can be used for amplifying oscillations whose wave lengths range between 200—500 and 500—5,000 meters.

Another method of radio-frequency amplification is by means of resistance coupling. Such a device can be purchased very easily. Resistance coupling covers a larger range of wave lengths for the same resistance than does any other nonadjustable method of coupling, but the losses are greater in the case of resistance coupled amplifiers than with air core transformers.

FIG. 103.—Radio frequency transformer. The shunt shown at the top of the transformer can be changed so that either a range of from 200 to 500 meters, or from 500 to 5000 meters are available.

Fig. 104 shows a detector, and two stages of audio-frequency amplification.

Heterodyne and Beat Reception.—The vacuum tube has another function than that of rectification and

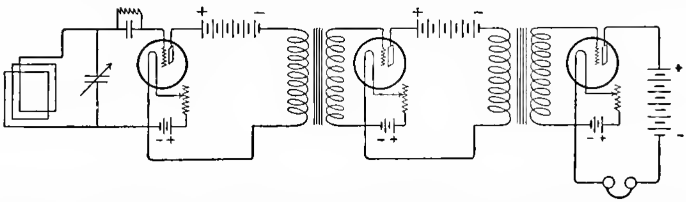


FIG. 104.—Two stage audio frequency amplifier, and detector with loop antenna. By substituting the secondary of a vario-coupler or honeycomb coil for the loop, the circuit can be used with an aerial in the usual manner. For regeneration, insert a tickler coil in the plate circuit of the detector. See Figure 99. Separate A and B batteries are used in this diagram for simplicity. In actual work, the same A battery can be used for all three tubes, and a B battery for the detector, and another B battery for both stages of amplification.

amplification. It was noted in this chapter that by coupling the plate circuit to the grid circuit, we can regenerate the otherwise wasted oscillations, and that same can be used to fortify the incoming oscillations. Under certain conditions these oscillations once set up and fed back to the grid circuit will be continuous, irrespective of any further incoming oscillations, that is, the oscillations in the grid circuit take on additional power in the plate circuit, due to the local B battery, and are then fed back to the grid circuit, where the operation is repeated. By tuning the grid circuit and the plate circuit, that is, by varying the inductance and capacitance of these circuits, any desired frequency can be generated in the tube itself. This phenomenon is used for generating high-frequency currents for continuous wave telegraphy and for radio telephony. We will discuss it a little later. In the receiving tubes, the production of local oscillations has a most interesting use.

In Chapter VIII we showed how it was necessary to make audible the radio-frequency signals received by means of continuous waves. A continuous wave transmitter, sending on a wave length of 15,000 meters sends out signals having a frequency of 20,000 per second, which is above the range of audibility. If we produce in our detector, by means of tuning the plate and grid circuit, self-generated oscillations having a frequency of 19,500 cycles per second, and the incoming oscillations from the distant transmitter have a frequency of 20,000 per second, we have a beat note of the difference between these two frequencies, which is 500 cycles per second, and which is audible as a shrill musical note very easy to read. The phenomenon is called in radio heterodyning.

This principle of beat reception was first applied to radio some years ago by Mr. J. V. L. Hogan. Perhaps the most notable example of this action, outside of radio, is to be found in a large auditorium where an organ is being played. You will notice that when a chord of two notes is played, in addition to the two notes, you hear a slow, steady, beating sound, which is an audible vibration produced by the difference in frequency of the two notes. The frequency of this beat is equal to the difference in frequency of the two notes in the chord. Another noticeable effect of this sort is when an aeroplane with two motors is flying over one's head. In this case, the beat note of the difference in frequency between the two engines is distinctly audible.

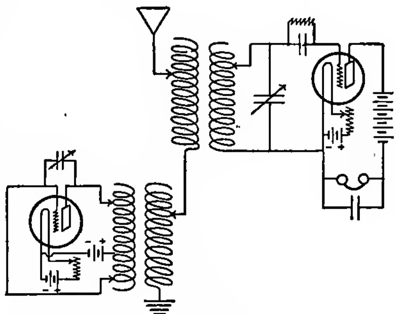


FIG. 105.—Hook-up employing an external heterodyne.

The most efficient way to utilize the heterodyne effect is to have an external heterodyne, that is, a special vacuum tube, disconnected from the detector, or very loosely coupled thereto, whose sole function is to produce oscillations of such a frequency as to cause an audible beat note in the telephone receivers of the receiving set. Such an external heterodyne hook-up is shown in Fig. 105.

Vacuum Tube as a Generator of Oscillations for Transmission.—As before stated, the oscillations generated in a vacuum tube can be used for transmission. The ordinary receiving tube, when made to oscillate, causes electrical waves to be radiated from the antenna. These, however, are very feeble, due to the small amount of energy used in the receiving tube. They are sufficiently powerful, however, to be heard at short distances, and at times create interference, due to the heterodyne action caused between these feeble impulses and the incoming oscillations of a transmitting station using a similar wave length. For transmitting purposes, more powerful tubes are used, but the same principle applies.

A simple transmitting circuit is shown in Fig. 106. By shunting the telephone transmitter T and breaking the circuit with key, telegraphic signals may be sent out. For handling larger currents, a different arrangement of voice control and control with the key must be had. This is shown in another chapter.

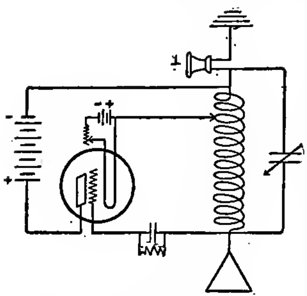


FIG. 106.—Simple transmitting hook-up for radiophone.

Super-regeneration. — Major E. H. Armstrong has invented a system of radio reception, which will more than likely revolutionize the present systems of radio telegraphy and telephony. His new system amplifies signals from 100,000 to 1,000,000 times the audibility of signals in an ordinary regenerative receiver. We will not go into the details of the scientific theory of Major Armstrong's super-regenerative receiving circuits, as he calls them, but will outline the circuit and principle from the standpoint of the novice and amateur.

Those who have made experiments with a regenerative set have undoubtedly noticed that as they make closer the coupling of the tickler coil, the loudness of the signals increases, as the regeneration becomes stronger. Just at the moment when the signal seems to reach a phenomenal loudness, the vacuum tube commences to oscillate, and the signal is lost. This applies both to telegraph signals and to radiophone.

Perhaps, the novice, while adjusting his set, has wished that he could retain the adjustment that he had just prior to the tube breaking into oscillations and losing the signals. Major Armstrong felt the same way about it, and he discovered a method by which he could attain the desired results. His idea was that if momentarily the circuit could be brought into maximum regeneration, without going into the oscillating stage, as can be done on any ordinary regenerative receiving set, why not electrically control the circuits so that this condition of maximum regeneration could be brought about intermittently for such a short duration that the tube would have no chance to go into the oscillating stage. He, therefore, devised a circuit by which the addition of an oscillating electron tube causes the regenerative circuit to go into the maximum regenerative stage at from, say, twelve to twenty thousand times per second. This produces an oscillating current which is subject to a maximum of amplification.

There are quite a number of different types of circuits for securing super-regenerative effect, but the one shown in Fig. 106-A is perhaps the best for the amateur to experiment with.

The coils L1 and L2 are the primary and secondary of an ordinary, short-wave vario-coupler. The secondary L2 is used as the tickler coil. It may be necessary, according to Major Armstrong, to add a few turns to the secondary in order to secure the best results. It will be noted that the loop aerial is connected across the primary of the vario-coupler. This should be tuned to the wave of the signal that it is desired to receive. The loop aerial can be made on a frame three feet square, and wired with twelve turns of No. 18 cotton-covered wire, spacing each turn about one-eighth of an inch from the next.

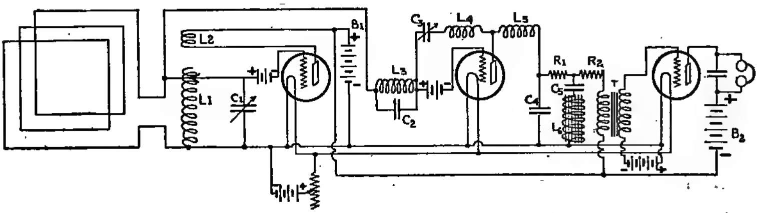


FIG. 106-A.—Armstrong super-regenerative hook-up.

The coil L3 is a honeycomb coil of 1250 turns. The coil L4 is an iron core choke coil with an inductance of 10 millihenrys. The coil L5 is a honeycomb coil of 1500 turns. It might be mentioned here that the first tube is used as a detector, the second tube as the oscillator which causes the detector circuit to reach a maximum degree of regeneration periodically as explained before. The third tube is an ordinary audio-frequency amplifier. The system of coils and resistances between the second and third tubes is known as a filter system. This system filters out any audio-frequency oscillations which may be produced by the oscillating tube. The filter system consists of resistances R1 and R2, each

12,000 ohms, an iron core choke coil, L6, 100 millihenrys inductance, such as is used in regular telephone communication for filtering purposes, and condenser, C5, .001 mfd. T is an audio-frequency transformer, such as has been described in another chapter. The values of the other parts of the circuit are as follows: C1, variable condenser .001 mfd.; C2, fixed condenser .0025 mfd.; C3, variable condenser .001 mfd.; C4, fixed condenser .005 mfd.; B1, B battery 90 volts; B2, B battery 110 volts.

The tubes used are 5 watt transmitting tubes, and although the three tubes can be lighted from the same storage battery, it is necessary to use at least an 8 volt battery, as the filaments of these tubes require 7½ volts.

Separate B batteries are used. It will be noted that the B battery in the telephone circuit is led back to the first battery. This gives additional voltage, making a total of from 160 to 200 volts, which is necessary to put on the complete circuit and the amplifying tube. The battery indicated in the grid circuits of the first two tubes, is known as the C battery. It is for the purpose of putting a negative potential on the grid. This C battery can be eliminated by varying the voltage of the B battery until the best results are obtained.

Notwithstanding the fact that the complete values for the various species of apparatus are given here, and that the circuit is shown, much difficulty will be found at first by the amateur and novice in operating this set. It is extremely sensitive and it will undoubtedly take many days before it will be made to operate satisfactorily.

The author has talked with a number of amateurs who have attempted to build this set. The results obtained were not altogether satisfactory, but when the final adjustments were made and the set operated properly, most astounding results were obtained.

When Major Armstrong demonstrated this apparatus at a meeting of the Radio Club of America at Columbia University, New York, he used a small loop as described, and the signals from the Newark radio station came in louder than music from an ordinary phonograph. Using an ordinary regenerative set with two stages of audio frequency, no signals at all could be heard from the loud speaker, and signals so faint were heard in the telephone receivers that they were not distinguishable.

It is not advisable to use telephone receivers on this set, if 5 watt tubes are used, as the signals are so loud that they cannot properly be reproduced by the telephone receivers, and it is necessary, therefore, to use a loud speaker. With the ordinary hard amplifying tube, telephone receivers can be used, providing the transmitting station is not too close. Under no circumstances, use soft tubes or detector tubes, as these will not operate properly in the super-regenerative circuit.

A loop should always be used in receiving with this type circuit, for oscillations of some little intensity are radiated, and where an aerial is used, interference is apt to be caused with receiving stations in the vicinity.

Types of Receiving Tubes.—For receiving, there are two general types of three-electrode vacuum tubes in use. For the detector, what is known as a soft tube is used. Certain rarified gases are contained in such a tube, which aid in its action as a detector. For amplifying purposes, what is known as a hard tube is generally used. The so-called hard tube has the highest amount of evacuation possible. Whereas the two types of tubes are built for their respective kinds of work, they are interchangeable, although, when operated for other than the purpose for which they were intended, they are usually not as efficient.

An amplifier tube can generally be used as a detector, by increasing the plate voltage. The following table shows different makes of vacuum tubes, and the amount of plate and filament voltage necessary for their proper operation.

MAKES OF VACUUM TUBES

Tube	*Filament Amperes*	*Plate Voltage*	
Radiotron UV 200	1.1	15- 22	detector
Radiotron UV 201	1.0	60-100	amplifier
Moorhead (Electron Relay)	.75 to .85	15- 30	detector
Moorhead (Hard)	.65	60-100	amplifier
Myer RAC 3	0.7	40	detector and amplifier
Western Electric Co. "J"	1.1	20- 40	amplifier
Western Electric Co. "N"	.25	20- 40	amplifier
De Forest VT 21	1.1	40	

CHAPTER X

HOW TO PURCHASE OR ASSEMBLE COMPLETE VACUUM-TUBE RECEIVING SETS

Purchasing a vacuum-tube receiving set—Unscrupulous manufacturers—Short-wave receivers—Long-wave receivers—Combined short- and long-wave receivers—Third group most desirable—Auxiliary coils for increasing wave length—Single-circuit receiver—Double-circuit receiver—Types of hook-up—Nonregenerative circuit—Armstrong regenerative circuit—Types of inductance—Vario-coupler—Variometer—Bank-wound coil—Reducing distributed capacity—Honeycomb coil—Spider-web coil—Purchasing or assembling a vacuum tube detector—Grid-leak—Grid-condenser—Filament-rheostat—Purchasing or assembling an audio-frequency amplifier—Telephone jacks and plugs—The head-set—Resistance—Beware of German-silver wound head-sets—Storage batteries—Lead batteries—Edison battery—Care of battery—The B battery—Eliminating both A and B battery by new device designed by Bureau of Standards—Loud speakers.

The moment we leave the field of crystal receiving sets, and enter into that of vacuum-tube sets, we become, of necessity, more careful buyers. The modern receiving set, utilizing one or more vacuum tubes, is not inexpensive, and care and good judgment should be used when making a purchase. Even the expert is sometimes puzzled when about to purchase a receiving outfit, and the novice is either frightened away by the seeming perplexity of the situation, or is rushed into buying an outfit unsuitable for his needs, by some overzealous salesman. Like every new commodity over which the public has suddenly become enthusiastic, buyers of radio apparatus have, in a large way, become a bonanza to unscrupulous manufacturers and tradesmen. Much worthless apparatus is being sold to the public, and it is not only proving a source of disappointment to the victims, but is hurting popular radio.

Principal Types of Receiving Set.—Let us try to group the various types of radio apparatus, so that, when buying, we can first determine the group to which the prospective apparatus belongs and then ascertain whether or not it will meet our requirements. We will consider for a moment complete radio receivers either with or without the vacuum-tube detector and amplifier.

The first three principal groups are, *short-wave receivers, long-wave receivers,* and *combined short- and long-wave receivers.* Undoubtedly, the greatest number of outfits purchased are short-wave receivers, with a range of wave length from about 150 meters to 500 or 600 meters. The advantage of such a receiver is that it is usually compact, sometimes comparatively inexpensive, and suitable for receiving amateur telegraph and telephone stations and also broadcasting stations, the bulk of which are now sending on 360 meters. Time signals can only be received on outfits with this limited range of wave length, provided a broadcasting station within range relays the signals.

Notwithstanding the present popularity of the short-wave tuner, it is, in the author's estimation, an unwise purchase for general use, because even now much interesting information, as well as some radiophone broadcasting, is to be heard on higher wave lengths than can be received with a short-wave tuner.

The second group consists of the intermediate and high-wave receiving set. The intermediate waves are above 600 meters to 3,000, and from 3,000 up to 20,000 can be considered high waves. Such outfits are of strictly limited use to the novice and are not recommended at all. Under the class of intermediate wave-length receivers would come the so-called "jewelers' outfits," designed principally for receiving time signals. The limitations of this second group are obvious.

The third group is the most desirable, for with it and proper auxiliary apparatus, anything that is sent out in the ether can be heard. With the rapid changes in radio that are taking place to-day, flexibility in the matter of wave length is desirable. The proposed new allotment of wave lengths provides for interesting transmission on practically all wave lengths up to 20,000.

Short-wave tuners, with auxiliary coils for increasing wave lengths, are usually inefficient. Where primary, secondary and tickler circuits are used, the difficulty of getting all three circuits into resonance and properly adjusted is increased when using auxiliary loading coils.

Single-Circuit and Double-Circuit Receivers.—The above three divisions can fall into either of the next two groups, which are single-circuit and double-circuit receivers. The single-circuit receiver is identified by the primary and secondary inductance being contained in one coil. The double circuit is identified by a separate primary and secondary coil, such as are to be found in the loose coupler or vario-coupler. The single circuit receiver is to be found usually in the cheaper sets, and is not as a general rule as selective as the two-circuit receivers. There are exceptions, however, to this, and some single circuit receivers have been capable of sharp tuning. The single-circuit receiver calls for fewer adjustments than the two-circuit receiver, and is, therefore, used on a number of outfits manufactured for the novice, where simplicity is desired.

Types of Hook-Up.—The third of the major considerations is the general type of hook-up to be used, that is, whether the regenerative or nonregenerative circuits are to be employed. The nonregenerative circuit is grossly inferior to the regenerative. Using a vacuum-tube detector of the usual type, we have an amplification of from five to seven times the incoming signal strength in the telephone receiver. Using the Armstrong regenerative circuit, the amplification is about fifty times the incoming signals. This does not take into consideration further amplifications by means of radio- or audio-frequency transformers, and additional tubes in cascade. The Armstrong patents, covering the use of regenerative hook-ups, are controlled by the Westinghouse Electric & Manufacturing Company. Certain other manufacturers are licensed under these patents to manufacture receiving apparatus containing the Armstrong feature. Many manufacturers, not caring to pay the royalties which the Westinghouse Company receives for granting licenses or who are unable to secure a license, produce apparatus without the regenerative feature. Some make extravagant claims for such apparatus, which inevitably fail to materialize.

The license for the use of the regenerative feature for commercial stations is closely held, but, for novice and amateur use, such apparatus is always available. The fact that a young American, who was hardly out of the amateur ranks and had not yet graduated from Columbia University, should have invented a system of radio telegraphy and telephony, without the use of which modern radio work is impossible, stands as an everlasting monument to the ingenuity of American youth.

Fig. 107.—Vacuum tube for a receiving set.

It is advocated that all prospective purchasers of radio receivers using a vacuum tube as a detector should demand that the Armstrong regenerative circuit be employed in the sets which they buy.

When the amateur or novice builds his own set, or purchases parts and connects them, he usually uses the Armstrong circuit. Technically speaking, this is a violation of the patent rights, but, owing to the impossibility of enforcing these rights and due to the liberality which inventors and owners of patents show to the American experimenter and amateur, no objections are ever raised when patented features are made use of for these purposes. In fact, radio magazines are filled with details of how to construct your own outfits, which call for many patented features.

Types of Inductance.—The fourth feature to be considered is the type of inductances that are to be used in the tuners. Generally speaking, there are five types, namely, *vario-couplers, variometers, bank-wound coils, honeycomb coils* and *spiderweb coils.* These five types of inductances can be used separately, or in conjunction with one another, in many different types of hook-ups. The principal features to be borne in mind are as follows:

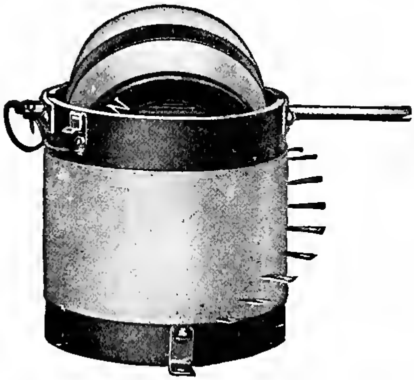


FIG. 108.—Vario-coupler.

The vario-coupler is a coupling device in which either the primary or secondary coil rotates within the other, so that an extreme range of inductance can be had. Fig. 108 shows a vario-coupler in which the primary inductance, consisting of a number of turns of wire on a stationary cylinder, can be varied by means of a switch which taps the coil at intervals. The secondary coil is mounted on a cylinder within the primary, and rotates so that a maximum and minimum coupling can be had between the two circuits.

The vario-coupler is used in a vacuum-tube receiving circuit in a manner similar to that in which the loose coupler is used. It is, however, more efficient. A vario-coupler can be used either in a one-circuit receiver or a two-circuit receiver. When a vario-coupler is used in a one-circuit regenerative receiver, a hook-up similar to Fig. 109 is usually adopted. In this case, the secondary coil acts as the tickler coil, also known as the plate circuit inductance, which feeds back the otherwise wasted oscillations into the grid circuit for regeneration. (See Chapter IX.)

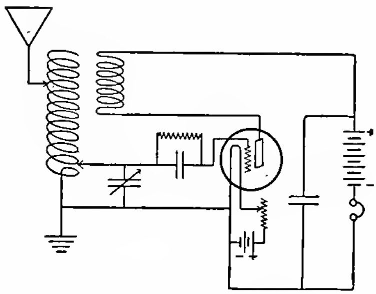


FIG. 109.—Single-circuit regenerative hook-up.

The use of the vario-coupler in a two-circuit receiver may call for a variometer in the plate circuit, which gives the regenerative effect. Such a hook-up is shown in Fig. 100. In some receiving sets, the vario-coupler is constructed with two rotating coils within a secondary coil. (See Fig. 109A.) In this type of tuner, one of the rotating coils is the primary, and the other rotating coil is the tickler. Fig. 99 shows a hook-up for this type of vario-coupler. This combined vario-coupler and tickler coil is a convenient

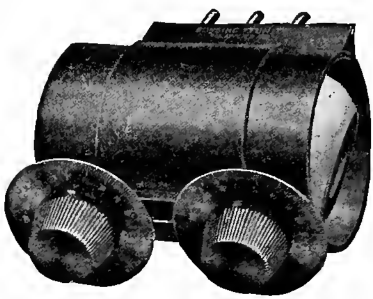


FIG 109-A.—Three coil vario-coupler, which fits into a honeycomb coil mounting, and can be substituted advantageously for the three honeycomb coils for wave lengths from 150 to 600 meters.

piece of apparatus, and more will be said about it a little further on. Fig. 110 shows a three-coil coupler, with

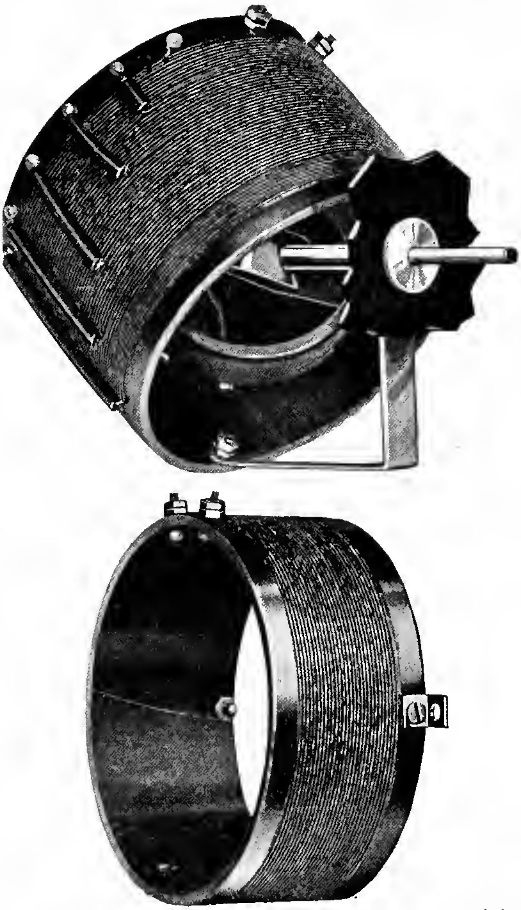


FIG. 110.—Another type of three-coil vario-coupler, which can be used in many different circuits to advantage.

the third coil detached. This is a popular type of vario-coupler and lends itself readily to the hook-up shown in Fig. 99.

Variometers can be used in a regenerative hook-up for short-wave receiving, without any other tuning devices than variable condensers, as shown in Fig. 111. The relative merits of the variometer used with or without condensers is a much-discussed question. Some authorities claim that in short-wave receiving the less capacity introduced in the circuits the better the results obtained. On the other hand, equally well-versed au-

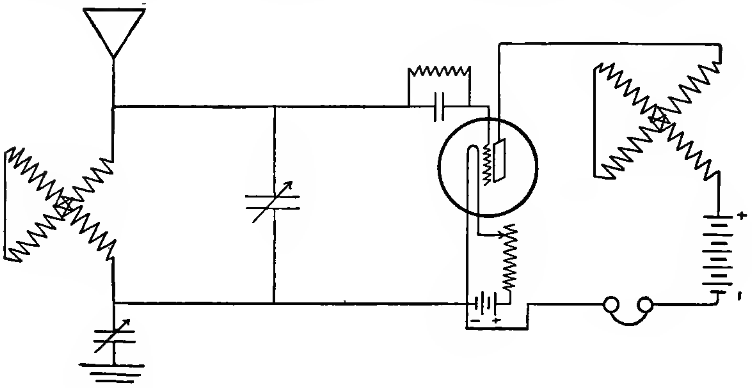


Fig. 111.—Regenerative hook-up using variometers for tuning.

thorities contend that the use of variable capacity in short-wave receiving sets is desirable. According to the author's experience with both types, from a practical standpoint, he is willing to call the controversy a draw. It is, however, generally conceded that the variometer, either in conjunction with condenser, or without, gives the best results for short-wave tuning.

The third type of inductance is *the bank-wound coil.* The bank-wound coil and the honeycomb coil are radical departures from the former methods of manufacturing inductances for radio telegraphy and telephony.

Prior to the war, inductances were usually confined to cylinders, over which a single layer of wire was wound. It was impossible with this type of inductance to build long-wave receiving sets, without coils of enormous dimensions. Coils six or seven feet long, and even longer, were required when tuning to wave lengths of the order of 15,000 to 20,000 meters. Where more than one layer of wire was used in a tuning coil to secure proper inductance, the capacitance which was created in the coil, due to the proximity of conducting wires of different potential, proved to be of such a detrimental nature that multi-layer coils could not be used. The capacitance in a tuning coil is called distributed capacity. It was found that by winding the coils so that the wires carrying a large difference of potential were separated by sufficient space from each other, multi-layer coils could be made.

If a voltmeter be connected between two points of a wire carrying a flow of electricity, a difference of potential will be noted, and the greater the distance between the two points in the wire, the greater will be the difference in potential. It was, therefore, found that by winding the inductance coil in accordance with Fig. 112, a minimum of distributed capacitance could be obtained, and a large amount of inductance could be obtained in a comparatively small coil. It is now possible to purchase portable receiving sets that will receive wave lengths over 20,000 meters.

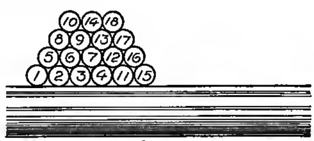


Fig. 112.—One method of placing turns on tube in "bank-winding" a coil. The numbers indicate the relative position of each turn of wire.

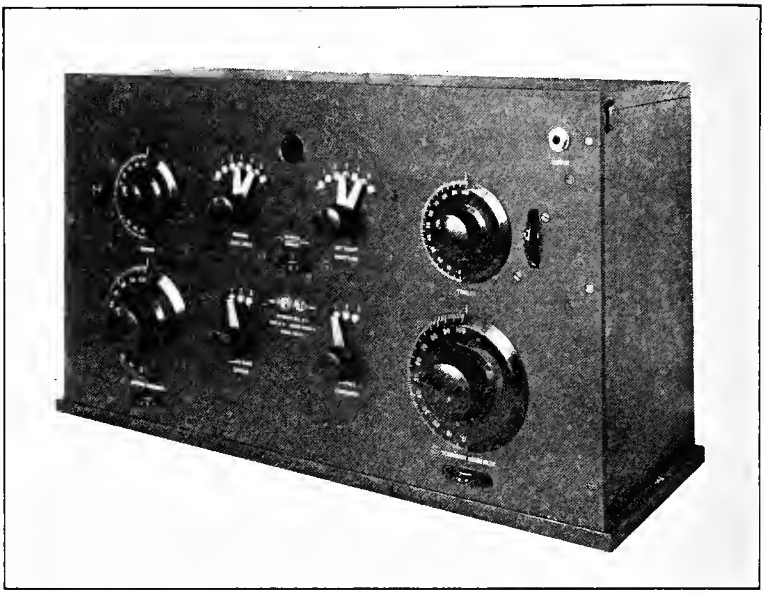


FIG. 113.—Front view of a Grebe receiving set with a range of wave lengths from 500 meters to 24,000 meters.

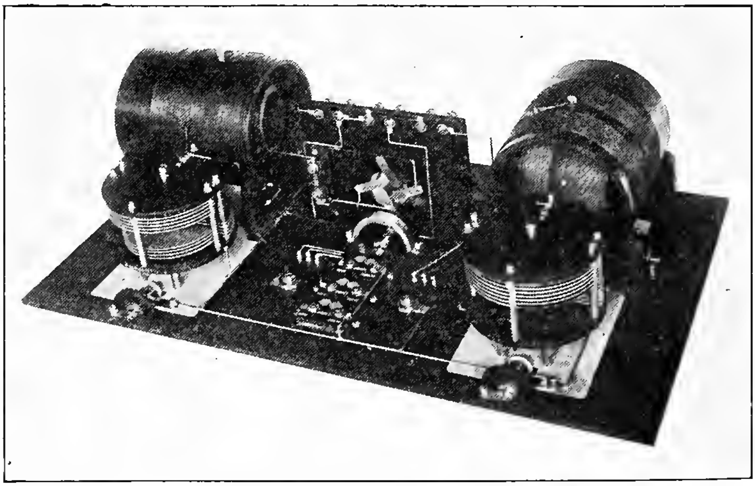


FIG. 114.—Rear view of same set. Note bank-wound coils, and their compactness.

Receiving sets can be purchased, using either a variometer hook-up or a vario-coupler hook-up, or a combination of the two, that provides for the introduction of bank-wound coils, so that, by switching them in, the range of wave lengths can be increased to any desired length. Such receiving sets are most desirable, but usually come very high in price, ranging from $150 to $200 without the detector, amplifier, and other equipment. Figs. 113 and 114 show the inside and outside of a combination short- and long-wave receiving set with range of wave length from 500 meters to 24,000 meters.

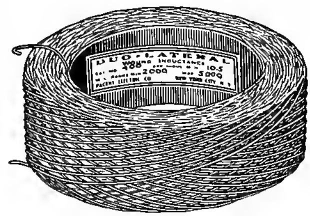


Fig. 115.—Duo-lateral honeycomb coil.

The fourth type of inductance is *the honeycomb coil,* a type of which is known as the "duo-lateral" coil. These coils make use of a principle similar to the bank-wound coil and reduce the distributed capacitance by winding the wire zigzag, effecting the appearance of a honeycomb. Fig. 115 illustrates a duo-lateral coil.

Owing to the simple method of interchanging honeycomb coil inductances, it is the most economical type of apparatus to use, when a combination of long- and short-wave receiving is desired. Each coil is provided with a plug that fits into a receptacle on a honeycomb coil mounting. The various-sized honeycomb coils that can be fitted into the receptacle cannot in themselves be varied, that is, there are no taps to vary the inductance of each coil. However, the receptacle on which the coils are mounted is movable, and the coupling between the coils can be varied.

For accurate tuning with any particular set of coils, condensers or variometers in series, or parallel with the coils can be used. The duo-lateral wound coils are standardized by numbers, and coils of a particular number have a certain range of wave length. The most common and the best hook-up, using honeycomb coils, requires three coils, the primary, secondary and tickler

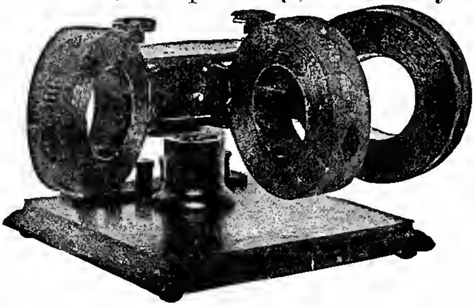


Fig. 116.—Three-coil honeycomb coil mounting that can be used in hook-ups, such as Figure 99.

coils. Fig. 99 shows a hook-up for honeycomb coils, employing the Armstrong circuit. The honeycomb coil mounting shown in Fig. 116 enables the use of this circuit.

By using a switch as shown in Fig. 50, the condenser which is in series with the primary can be connected in parallel at will. If the set is to be mounted on a panel, a better type of switch, designed particularly for this purpose, can be purchased. Such a switch is shown in Fig. 117 and is sometimes called a primary condenser switch.

The table on page 127 gives the list of coils necessary

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connections to the tuner and telephone receivers and batteries are to be made.

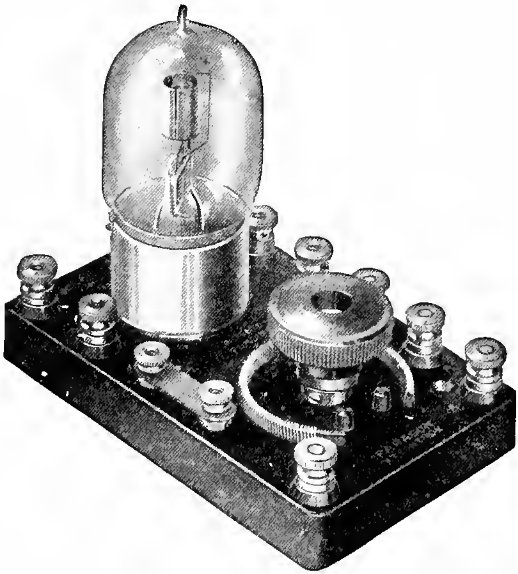


Fig. 117-A.—Paragon detector stand, neat, compact including grid-leak and grid-condenser.

Where the detector is to be assembled, rather than purchased complete, it is necessary to buy one standard receptacle, such as is shown in Fig. 118, a grid-leak, a grid-condenser and a rheostat. The receptacle has four connecting posts; one is marked with the letter P, indicating the plate of the vacuum-tube connection. The one marked G indicates the grid connection, and the two marked F are where the filament connections should be made.

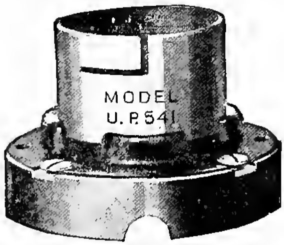


Fig. 118.—Standard four prong vacuum tube receptacle.

For hooking up the detector, you are referred to the schematic diagrams in this book. The grid-leak shown in Fig. 119 is adjustable. Tubes containing various resistances can be put in the grid-leak receptacles at will. The resistances range from .05 megohms to 5 megohms—1 megohm equals 1,000,000 ohms. The grid-condenser can also be had in tubular form to fit a similar mounting to Fig. 119. There are four capacities of condensers fitting this mounting, ranging from .00025 to .0025 mfd. A combination grid-leak and grid-condenser, which is compact and convenient, is popular at the present time.

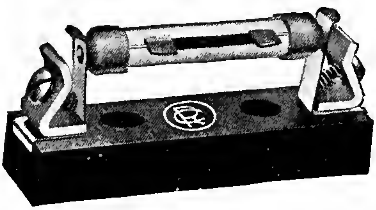


Fig. 119.—Grid-leak and standard.

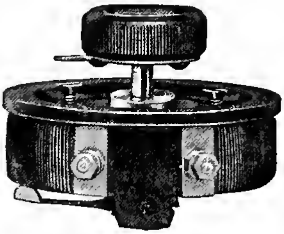


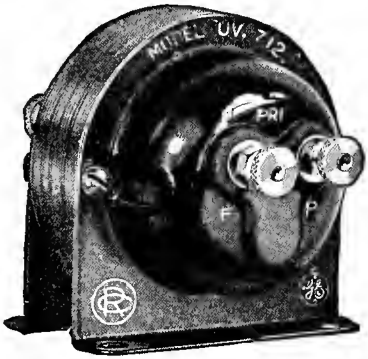
Fig. 120.—Filament rheostat.

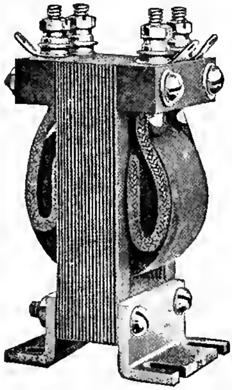
A rheostat suitable for filament regulation in a detector is shown in Fig. 120.

Purchasing or Assembling an Audio-Frequency Amplifier.—In making an audio-frequency, one- or two-stage amplifier, from standard parts, great care must be taken with the connections, otherwise howling or hissing noises, which cannot be eliminated by tuning, are apt to be heard in the telephone receivers. All wires should be as short as possible, well insulated with "spaghetti" tubing, which is a form of insulation that slips over a wire and resembles spaghetti in appearance.

All connections should be soldered and the wires, wherever possible, should run at right angles to each other, to prevent capacity effects or induction.

There are several types of audio-frequency transformers. Two of these are illustrated in Figs. 121 and 122. When two transformers are connected in a two-stage amplifier, they should be, if possible, separated from each other, by five or six inches at least, and when convenient, placed so that their windings are at right





FIGS. 121, 122.—Types of audio-frequency transformers.

angles to each other. This will serve to prevent induction from one transformer to the other, causing howling and other disagreeable noises in the telephone receivers, and otherwise reducing the efficiency of the amplifier.

The audio-frequency transformers have four binding posts, two of which are usually marked P, indicating primary, and the other two marked S, indicating secondary. The primary binding posts should be connected in the plate circuit, and the secondary binding posts should be connected in the grid-filament circuit.

The hook-up for a two-stage audio-frequency amplifier is shown in Fig. 104.

It is recommended, wherever possible, that a detector and two-stage audio-frequency amplifier, mounted on a panel and inclosed in a case, should be purchased. Owing to quantity production, this type of apparatus can be purchased at a comparatively reasonable price, and,

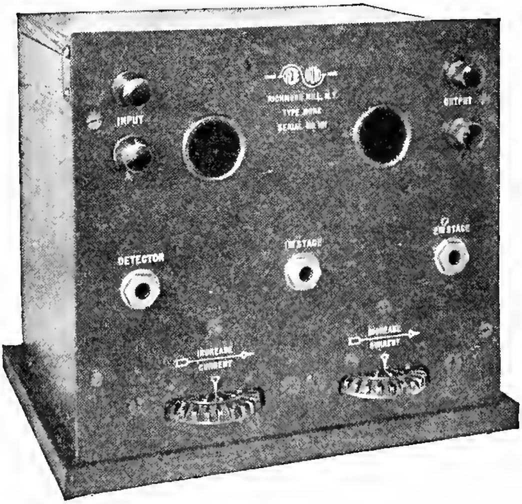


Fig. 123.—Grebe detector and two-stage audio-frequency amplifier.

as they are usually designed by radio engineers, a maximum degree of efficiency can be expected. Figs. 123, 124 and 125 show a type of detector and audio-frequency amplifier combined and also the outside and inside view of a two-stage amplifier without a detector.

There are many similar types of apparatus on the market. Some of them provide for a separate B battery for both the detector and the amplifier. Others utilize one B battery for both. Some provide for three

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turns of very fine copper wire wound around a core of particular size, and, inasmuch as the dimensions of all telephone receivers used in radio are about the same, such designation serves as a fair comparative value. However, there are unscrupulous manufacturers who take advantage of the loose use of resistance rating in head-sets, and, by winding their telephone receivers with a comparatively few turns of high resistant German-silver wire, secure the proper resistance, but do not have the proper number of ampere turns. Such telephone receivers are grossly inferior, and care should be taken to purchase receivers only when it is known that they are wound with copper wire.

An important feature to consider in telephone receivers is the type of diaphragm used. Metallic diaphragms in radio head-sets are usually designed to vibrate best at a certain frequency, and, for telegraphic reception, the receivers designed to respond to vibration of from 500 to 1,000 cycles are the best. For the reception of radiophone, a receiver designed to respond to vibrations of about 250 cycles reproduces the clearest voice modulation.

Another type of telephone receiver has a mica diaphragm. The vibrations are produced in the mica diaphragm by means of an armature, which responds to the changes in strength of the magnetic field around the magnets. This type of telephone receiver is the most sensitive, and, owing to the slight leverage action of the armature, which is attached by a pivot to the mica diaphragm, an amplification of signals takes place. Comparative tests of signal strength with a receiver of this type, compared with the ordinary metallic diaphragm receiver, shows an increase of audibility in signals. Fig. 127 shows a popular type of head-set. In Chapter IV is to be found a schematic diagram of the ordinary type telephone receiver. (See Fig. 33.)

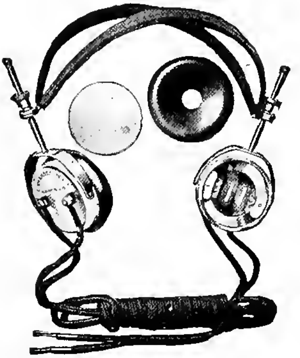

FIG. 127.—Telephone receivers, or, as they are also called, the head-set.

It is frequently desirable to connect more than one pair of receivers to a set, so that a number of people can listen in. The receivers should be connected in series. A convenient way to do this is to employ a multi-jack and plug. Such devices are shown in Figs. 128 and 129.

The telephone receiver is a delicate piece of apparatus, and great care must be taken not to injure it mechanically, by hard knocks or by dropping it on the floor. The steel cores of the electro-magnets are permanently magnetized. This magnetism in time grows weaker, and the 'phones become less sensitive. It is, therefore, wise at infrequent intervals, to have the head-set re-magnetized. This can be done either by sending the receivers to the manufacturers, or, if you

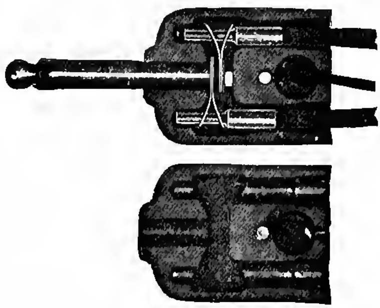

FIG. 128.—Telephone cords connected to Pacent plug.

have 110 volts of direct current available, connect the head-set across the power line for a few moments. There is sufficient resistance in the coils to prevent burning out, and this current passed through the 'phones for about five minutes will renew the permanent magnetism considerably. Care should be taken that the current is passed through the telephones in the right direction, otherwise the magnetism is apt to be destroyed instead of increased, making the 'phones less sensitive.

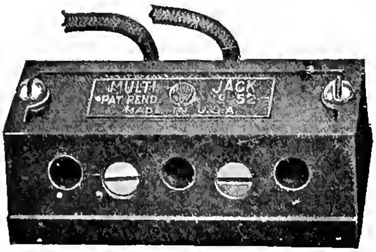

FIG. 129.—Multi-jack, for connecting three pairs of receivers in series.

Many telephone receivers have the cords properly marked, so that the polarity is apparent. When the polarity of the telephones can be ascertained easily, it is advisable to connect the terminal marked "negative" to the negative terminal of the B battery when the 'phones are connected in the receiving circuit; otherwise, if the direct current of the B battery passes through the coils of the telephone receivers in the wrong direction, it gradually demagnetizes the permanent magnet.

Storage Battery—Lead.—There are two principal types of storage batteries that can be used for lighting the filaments of the vacuum-tube detector and amplifiers. One is the lead battery, similar to those commonly used in automobiles, and the other is the Edison nickel-iron battery. The lead battery consists of plates which are cast from lead made in the form of a gridiron, that is, the plates are so constructed that a paste made up of certain lead compounds can be applied in the indentation on the plate. Each cell in the storage battery consists of two plates: the positive and the negative. The positive plate has applied to it a paste made up of pure red lead, combined with diluted sulphuric acid. The paste applied to the negative plate consists of chemically pure litharge. The plates are immersed in a solution of approximately 20% chemically pure sulphuric acid, in distilled water.

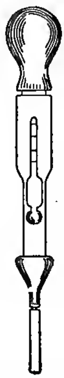

Fig. 130. — Hydrometer for testing electrolyte in storage battery.

The plates thus made, forming a cell, are put through a series of charging and discharging operations, so that the proper chemicals are formed on the respective plates, through the process of electrolysis. The action of charging the cell with electricity turns the litharge on the negative plate into spongy, metallic lead, and the red lead on the positive plate becomes lead peroxide.

In order to determine whether a battery is fully charged, the best method is to use a hydrometer. (See Fig. 130.) The acid solution used in storage batteries for radio purposes should be between 1.125 and 1.220 in specific gravity. As the battery is being discharged, the specific gravity will gradually diminish, owing to the acid taking part in the chemical change on the plate. When the specific gravity has fallen to 1.150, the battery can be considered fully discharged and unless the battery is immediately recharged, deterioration of the plates take place.

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10 amperes, would be eight hours. If a smaller current is used, a proportionately greater length of time must be taken. There are two methods for determining when the battery is fully charged. One is to use the hydrometer, and if the electrolyte has returned to normal specific gravity, 1.225 or whatever may be normal for the particular battery being used, the battery can be considered fully charged. The other method is to use a voltmeter across each cell, and if it tests about 2 volts, or whatever the normal voltage is, for the particular cell, the battery is charged.

Lead storage batteries must be kept charged; otherwise, they will rapidly deteriorate. Whether a battery is used or not, it should be charged every two weeks.

Edison Battery.—An excellent battery for use in radio work is the Edison Storage Battery. The advantage of the Edison battery over the lead battery is that it is not injured so easily and does not require such constant care. This battery can be kept out of use almost indefinitely, without recharging, and it will not be injured. It is practically impossible permanently to injure an Edison battery, unless impure chemicals, or other foreign substances, be allowed to enter the electrolyte. The electrolyte of an Edison battery is made from a 20% solution of potassium hydroxide in distilled water, with a small percentage of lithium hydroxide added. The positive plate of the Edison battery consists of a number of perforated tubes loaded with nickel-hydrate. The negative plate consists of a steel grid, which supports a number of flat perforated steel containers or pockets. In these pockets is contained the active material, which is iron oxide or ordinary iron rust. Owing to the chemical nature of the Edison battery, it can be much more substantially built.

In the lead batteries which require an acid electrolyte, no iron or steel may be used in construction, for it would be quickly eaten away by the acid. The Edison cell, using potassium hydroxide or ordinary lye as an elec-

Fig. 134.—Standard B battery with plug and taps for varying voltage.

trolyte, is capable of being constructed of steel, because this type of electrolyte will not eat steel.

The voltage of the Edison battery is only 1.2 against a voltage of 2.08 volts in the lead cell.

The water in the electrolyte in storage batteries evaporates, and care must be taken that the plates are always submerged. When it becomes necessary to add water to a storage battery, only distilled water should be used, for the natural mineral salts contained in water have a deleterious effect on the plates.

In lead batteries, during the process of charging and discharging, hydrogen and oxygen gases are formed. These two gases, when mixed, are highly explosive, and great care should be taken not to bring a flame close to a storage battery when it is in action, as a disastrous explosion might take place.

B Battery.—The B battery is used to supply the voltage to the plate and usually consists of small flashlight batteries connected in series and sealed in a container. (See Fig. 134.) Small storage cells are sometimes connected in series and these have the advantage in being readily recharged. Owing to the relatively minute currents used in the plate circuit, the B battery has a long life, sometimes from six months to a year.

Using Alternating House Current.—The Bureau of Standards has designed a rectifier and transformer by which the ordinary 110 volt A.C. house current can be used in place of both A battery and B battery. A vacuum tube rectifier is used and filter condensers to smooth out the alternator hum. At this writing the Bureau has not made an announcement of this new device but the author has seen it in operation in Washington. When it is finally made public it will no doubt revolutionize the present methods of receiving, for there need be no more bother with troublesome storage batteries.

The apparatus is all inclosed in a small box and requires no regulating. A pair of binding posts are supplied for the 110 volts and two pair for the output of six volts for the filament and forty to sixty volts for the plate. The device operated perfectly and radiophone music came in just as clear as with the ordinary batteries.

Loud Speakers.—There are many kinds of loud speakers, which may be divided into three principal groups:

(*a*) A horn in which you place your own telephone receiver.

(*b*) A horn in which there is already a receiver.

(*c*) A device which requires additional current and actually amplifies the signals.

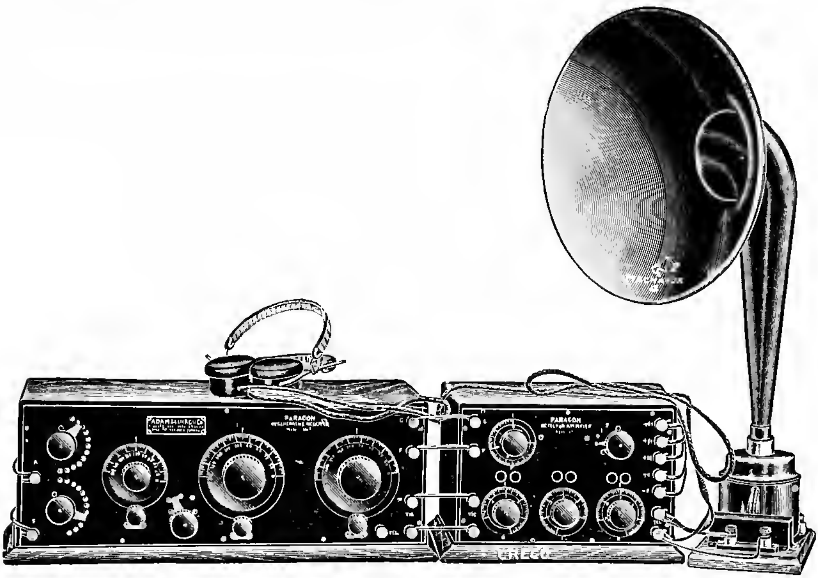


Fig. 135.—Paragon receiver complete with Magnavox Loud Speaker. The detector two-stage audio-frequency amplifier is separate from the tuner itself, which is of the two circuit regenerative short wave type.

Types (*a*) and (*b*) merely concentrate the signals in the head-set enabling them to be heard some distance away. Type (*c*) amplifies by means of transformers and movable coils and when used with power amplifiers will amplify the signals to almost any intensity. Fig. 135 shows one of the most widely used loud speakers of the type (*c*), attached to a complete receiving set.

Fig. 136 shows a diagram of this loud speaker showing operation of movable coil.

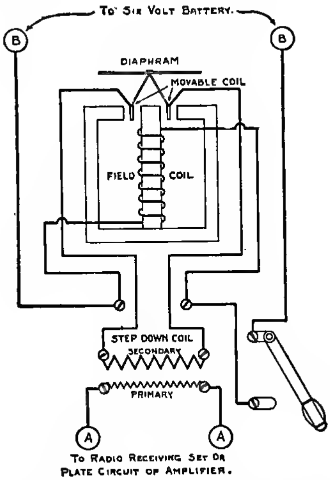


FIG. 136.—Diagram of connections and parts of the Magnavox Loud Speaker.

A new loud speaker has recently been put on the market which is supposed to eliminate the distortion usually found in loud speakers of type (*c*). Using power tubes in an audio-frequency amplifier, the new Western Electric apparatus will make signals audible over one mile from the receiver.

CHAPTER XI

HOW TO OPERATE A VACUUM-TUBE RECEIVING SET

Operating a single-circuit nonregenerative set—Operating a single-circuit regenerative set—The Westinghouse receiver—Hissing noise—Eliminating the whistling noise—Causes of whistling and howling—Too much filament current—The two-circuit regenerative receiver—Honeycomb coil receivers—Eliminating capacity effect of the body—Too much filament current shortens life of vacuum tube—Too much or too little plate voltage makes detector and amplifier less sensitive.

To get the best results from a receiving set, careful manipulation of the controls is necessary. Due to the greater selectivity and sensitiveness of vacuum-tube receivers, much more care must be observed in tuning than with a crystal detector receiving set.

Operating a Single-Circuit Nonregenerative Set.—The single circuit, nonregenerative vacuum set is the easiest to tune, as there need be but one control, besides the filament rheostat of the vacuum tube. Such an outfit is tuned to the desired signal by first lighting the vacuum tube to the approximate proper incandescence, and then adjusting the variometer until the desired signal comes in at maximum audibility. Then adjust the filament control to further increase the signal strength. If interference is severe, when the desired signal is at its maximum, further adjustment of the variometer will be necessary to tune out the interference. Sometimes, by receiving the desired signal slightly out of tune, interference that is on the same wave length as the desired station can be tuned out altogether. In single-circuit receivers having a variable condenser, as well as a variable inductance, the condenser must also be adjusted, for securing maximum signal strength.

Both the inductance and the variable condenser are usually calibrated, and, when the desired station is properly tuned in, a memorandum should be made of the calibrations at which the best results are obtained. It is then merely necessary to adjust the receiver to the noted calibrations at any time, when the same station is desired to be heard.

Operating a Single-Circuit Regenerative Set.—When a regenerative receiver is used, it is more difficult to tune properly, but once the proper adjustments are made, much louder signals are obtainable than with any other type of apparatus.

Fig. 137.—Westinghouse single circuit regenerative receiver.

The Westinghouse receiver, which is shown in Fig. 137, has three controls, not counting the controls of the detector and amplifier. The control marked "tickler" should be adjusted until a slight hissing noise is heard in the telephone receivers. The control marked "tuner" should be adjusted until the desired signals are heard at maximum intensity. Then the control marked "vernier," which is a small condenser connected in parallel to the main tuning condenser for making finer adjustments, should be adjusted to increase the intensity of the signal. Finally, the tickler should be readjusted, so that the hissing noise is practically eliminated, and the signal is clear.

That Whistling in the Head-Phones.—When receiving radiophones on this type of set, it is necessary to go through the procedure just described. Just before the voice is tuned in, there is usually a whistling sound in the telephone receivers. This indicates that you have tuned up to the wave length of the radiophone transmitter, but that your receiving set is so adjusted that the local oscillations of your vacuum tube have a slightly different frequency from the incoming oscillations, and the whistling noise is the beat note, due to the difference between the frequencies of the incoming and local oscillations. An explanation of this will be found in Chapter IX, page 105, where we discuss the subject of heterodyne. Usually, the whistling noise can be eliminated by diminishing, or increasing slightly, the coupling of the tickler. When properly adjusted, the voice should come in clear.

If, while diminishing the coupling of the tickler, a slight click should be heard in the phones, and the voice suddenly cease, it is an indication that you have diminished the coupling of the tickler too much, and have caused the local oscillations in the vacuum tube to cease. The local oscillations can again be started by increasing the coupling. If adjusting the tickler does not give you the desired result of eliminating the whistling noise, a slight change of adjustment on the vernier should be made.

The whistling noise heard when receiving radiophones is most annoying and at times is impossible to eliminate. Causes other than the one just mentioned, which can easily be eliminated, are numerous, amongst them being the heterodyne effect of two C.W. stations sending on wave lengths almost identical, when the slight difference in frequency causes a whistling beat note. Sometimes harmonics, from an arc station, will cause this trouble. Other times, another receiving set very close to yours, listening in on the same wave length, will radiate oscillations set up by its detector, and will produce a heterodyne effect in your own receiving set. The probabilities are that you are doing the same to him. When the whistling is caused by interference from other station, it can sometimes be eliminated by your tuning in the station you desire to hear, slightly off its wave length.

Two other causes of whistling and hissing sounds are too much filament current in the detector, and too much filament current in the amplifiers. When the filament of the detector is burning too brightly, it is emitting an excess of electrons. Reducing the filament current usually stops the whistling noise, but frequently also causes the detector tube to stop oscillating. When this happens, a slight increase in coupling of the tickler will usually start up the oscillations again. If this does not happen, then the filament current should be slightly brightened.

Maximum loudness of signals is usually attained by having the coupling of the tickler and the brilliancy of the filament at a critical adjustment, where the slightest change in adjustment would cause the tube to stop oscillating. Sometimes, by making an adjustment that is too critical, clearness of voice or music is sacrificed for loudness. This is not desirable and a less critical adjustment should be made.

The Two-Circuit Regenerative Receiver.—Less interference and finer tuning is had with two-circuit receivers. In receiving with the set having a vario-coupler, grid variometer, plate variometer and secondary variable condenser, first adjust the primary taps to the proper wave length. This can be ascertained by experimenting and the proper adjustment should be noted. Next, adjust the vario-coupler to a fairly close coupling. Then adjust the secondary condenser to the proper wave length, and turn your plate variometer until a slight hissing sound is heard. Then adjust the grid variometer until the voice is heard loudest. A final adjustment should then be made on the plate variometer to eliminate the hissing sound and clear up the voice. The plate variometer should be handled similarly to the tickler coil, described in one of the preceding paragraphs. If interference is experienced, gradually reduce the coupling of

FIG. 138.—De luxe receiving set containing single circuit regenerative receiver, detector, three stages of audio-frequency amplification, and loud speaker. This makes an almost ideal type of apparatus for home entertainment.

the vario-coupler, which will in turn probably require a small change to be made in the plate variometer.

Fig. 137 illustrates a complete two-circuit regenerative receiving set.

Fig. 139.—De luxe receiving set designed by the Westinghouse Company. Single circuit regenerative set with 3 stages audio-frequency amplification. Filaments of tubes regulated by ballast tubes instead of rheostats. Loud speaker contained in cabinet.

Honeycomb Coil Receivers.—Honeycomb coil receivers must first be coupled closely, then adjust the primary condenser and the secondary condenser, and finally the tickler coil should be gradually coupled more loosely, the same conditions concerning hissing and whistling noises applying here as in other types of receivers. When the tickler is properly adjusted, the primary coil should be coupled more loosely and finally the tickler should be slightly readjusted. The detector and amplifier adjustments are handled in the same manner for all types of receivers.

Eliminating Capacity Effect of Body.—It will be noted that when the hand is brought close to one of the control knobs on the receiver, the signal will be affected and, in fact, at times it will be completely tuned out or a whistling noise will be heard. This is due to the capacity effect that the body has. It serves to indicate the extreme sensitiveness of a modern receiver. To eliminate this it is necessary to shield the inside of the cabinet with metal and ground it. The better types of sets come already shielded.

A new broadcast receiver sold by the Radio Corporation of America has the controls mounted on a grounded metal panel, which eliminates all capacity effects from the body.

Precautions to Be Taken.—Care must be taken not to have the vacuum-tube filaments too bright or their life will be considerably shortened. No advantage is to be found in burning the filament too brightly. The Western Electric J Tube requires to be lit only to a cherry-red glow. Lighting a filament beyond its rating makes the tube less sensitive. Too much plate voltage as well as too little will also reduce the sensitiveness of the tubes.

CHAPTER XII

CONTINUOUS WAVE TRANSMITTERS

C.W., I.C.W. and radiophone—Simplest form of C.W. transmitting circuit—How to construct an experimental radiophone—A twenty-five to thirty mile radiophone—Rectifying the alternating current for use with this set—A sixty-mile radiophone.

Only advanced novices and amateurs are advised to undertake building or assembling continuous wave transmitters, whether they be pure C.W., I.C.W., radiophone, or a combination of the three. The pure C.W. are continuous waves that are not modulated, but are sent out in their true form and must be received by means of a tone-wheel or heterodyne. (See pages 92-105.) The I.C.W. transmitter is a continuous wave transmitter modulated or interrupted by means of a chopper, which is similar to a tone-wheel, or by means of a buzzer. This can be received without the tone-wheel, or heterodyne. In fact, it can be received with an ordinary crystal detector. The radiophone is a continuous wave transmitter modulated by the human voice, through a microphone.

The microphone transmitter (see Fig. 140) consists fundamentally of a diaphragm in contact with carbon granules. The voice makes the diaphragm vibrate, causing a variable change in the resistance of the circuit through the carbon granules, which in turn causes a variable current to flow, the variations of which correspond to the modulations of the voice and so modulate the continuous wave current radiated from the aerial.

There is so much apparatus made for C.W. transmission in its various forms that it would require a complete volume in itself to go into all the ramifications of this type of transmission.

Simplest Form of C.W. Transmitter.—The simplest form of C.W. transmitting circuit is the Arm-

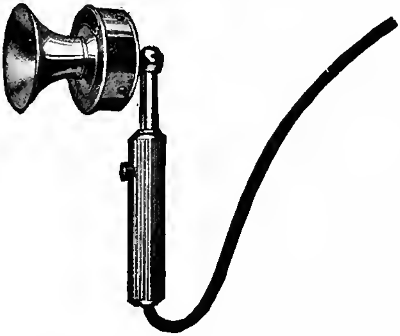
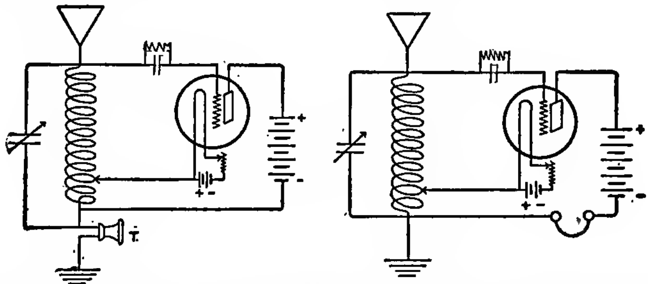


FIG. 140.—Microphone transmitter.

strong regenerative hook-up, similar to those used for reception, and which are described in Chapter IX. A simple diagram for this type of transmitter is shown in Fig. 141. Here we have placed the microphone in series with the ground.

To illustrate the similarity between this transmitter and a receiver, we show in Fig. 141-A the same hook-up used as a receiver, merely by eliminating the microphone in the ground circuit and placing a pair of receivers in the plate circuit. We then have a single-circuit, regenerative receiver. These circuits serve to illustrate the principle of the oscillating tube as transmitter and receiver.

An Experimental Radiophone.—Should the reader desire to experiment with this hook-up for short distance transmission, all that is required is a variable condenser of about .0005 mfd. maximum capacity, which can be borrowed from a receiving set, a microphone or telephone transmitter, and a simple inductance made as follows: Take a cardboard tube about 2½ inches in diameter and 4 inches long. Wind this with 35 turns



FIGS. 141-141-A.—Showing a transmitting circuit, and a receiving circuit, that are practically the same except for the substitution of headset for microphone transmitter.

of No. 14 or 16 double cotton-covered wire. After 18 turns have been wound, scrape about 2 inches of insulation from the wire and make a loop of it for a tap; then wind 17 more turns. The diagram clearly indicates how this inductance should be connected.

If any difficulty is met with in causing the voice to be transmitted, change the wave length by adding or reducing the number of turns at the top or bottom of the coil. For the B battery use from 60 to 120 volts, and for the A battery use the ordinary 6-volt storage battery. An ordinary detector tube, or, preferably, an amplifier tube, can be used in this experimental outfit, and the usual rheostat used on receiving sets will do for the filament controls.

For an aerial, it is recommended to use one of the transmitting aerials described in Chapter XIII, or a bed spring can be utilized, and with it very short distance transmission can be effected.

Fig. 142 is a hook-up of a C.W. transmitter employing three five-watt tubes, such as are shown in Fig. 146.

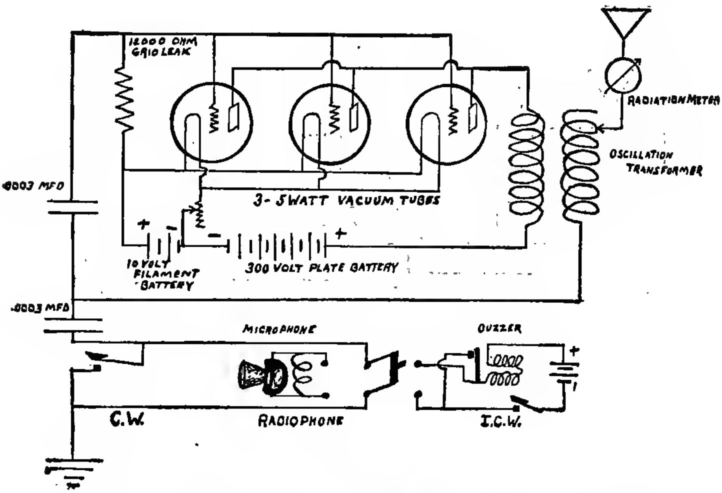


FIG. 142.—Transmitting circuit employing three 5-watt vacuum tubes.

Instead of a 300-volt battery for the plate, as indicated in the diagram, a motor generator set can be used delivering from 300 to 500 volts D.C. If batteries are employed, the standard B batteries may be used, but, of course, their life will not be long. Five hundred volts is preferable in the plate circuit, as the tubes operate more efficiently with the higher plate voltage.

The key to the left of the diagram is for straight

C.W. telegraphy. With the switch closed to the left, the microphone transmitter is in series with the ground and we can use the set as a radiophone transmitter. With the switch closed to the right we have buzzer modulation and can operate on I.C.W. so that receivers not equipped for C.W. telegraph can receive the signals.

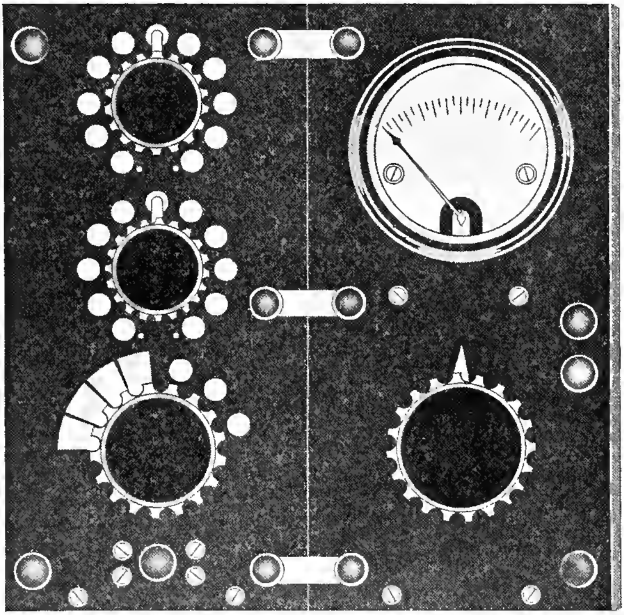


FIG. 143.—Front panel of a compact radiophone and C.W. transmitter.

The coil shunting the microphone consists of ten turns of No. 18 bare wire, wound on a tube about 2 inches in diameter with the turns spaced ½-inch. The purpose of this coil is to by-pass some of the high-frequency current to the ground, without passing through the microphone. One or two tubes may be used with this hook-up, if so desired.

Great care should be taken in handling direct currents of 300 volts and over, as a shock may be fatal.

Twenty-five to Thirty Mile Radiophone.—Fig. 143 shows a very interesting little transmitter that can be purchased for a reasonable sum, and will give good service to the novice who is satisfied with comparatively short range.

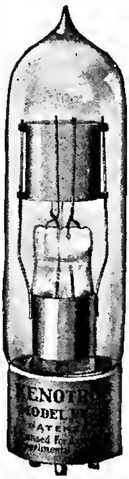


Fig. 144. — Kenotron rectifying tube for use in transmitting circuits where only A.C. is available.

The apparatus is mounted on two panels, each measuring only 9″ by 4½″. On the left panel is contained the grid, plate and antenna inductances, with their control switches. Also, the honeycomb coil choke, the send-receive transfer switch, and the variable antenna condenser. The right panel contains the vacuum-tube receptacles, a modulation transformer, a filament rheostat, radiation ammeter, grid-leak, grid-condenser, and a filament insulating condenser.

Using a 100-volt B battery on the plate, the set will radiate from .1 to .2 ampere, and the range is from 10 to 15 miles. With a plate voltage of 350, .3 to .4 ampere will be radiated, and the range will be from 25 to 30 miles. Five hundred volts on the plate will give an ammeter reading from .5 to .6 which will transmit from 35 to 50 miles.

For I.C.W. transmission, the addition of a buzzer and key will double the ranges above mentioned. Pure C.W. transmission, that is, without the buzzer modulation, will triple the ranges.

The filaments can be lighted with current from a 6-volt storage battery. The plate current can be supplied by B batteries, or where 110-volt direct current is available this can be used. If only A.C. is available a rectifier must be used.

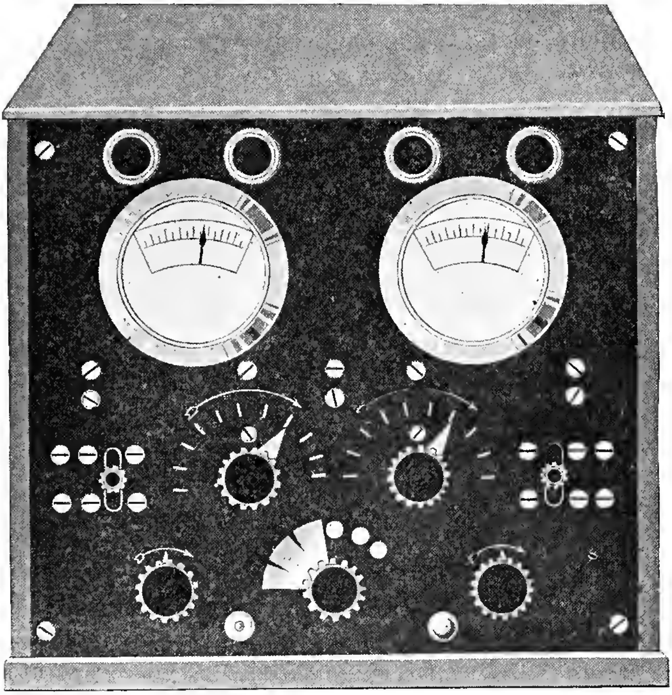


Fig. 145.—Radiophone and C.W. transmitter.

A good rectifier is of the two-element vacuum-tube type. Such rectifiers are sold under the name of "Kenotron" and other trade names. A rectifying bulb is shown in Fig. 144.

It is necessary to use a 50-watt power transformer in conjunction with the rectifier tube, and in order to eliminate as much as possible of the low-frequency alternating current hum, filter condensers are recommended.

A Sixty Mile Radiophone.—Another type of radiophone transmitter is shown in Fig. 145. This transmitter has a dependable range of distances up to 60 miles, and much greater distances can be covered under particularly favorable conditions. Transmission, up to distances of 200 miles, is not unusual with this type of apparatus.

FIG. 146.—Five Watt transmitting tube for use in transmitters, such as shown in Figures 143 and 145.

On the face of the panel are the plate current milliammeter, the radiation-meter, two filament rheostat knobs, a send-receive switch, and a switch for changing from speech to I.C.W. or to straight C.W., the antenna condenser switch, and a motor control switch. On the rear of the panel are filter condensers, constant current coil, high-frequency choke coil, grid condenser, plate condenser, filament insulating condenser, antenna condenser, grid-leak, 4 tube receptacles, modulation transformer, antenna inductance, and microphone resistance. Although a motor generator which will supply the plates with a potential of from 350 to 500 volts (preferably 500 volts) is recommended, rectified alternating current can also be used. For the filaments and microphone, use a 10-volt storage battery. The 4 tubes should be 5-watt transmitting tubes. (See Fig. 146.)

It will be noted from the description of the two transmitting sets that a great many more pieces of apparatus are utilized in transmitting than in receiving. With the exception of the experimental transmitting set described in the first part of this chapter, it is not recommended to the novice to make or assemble his own

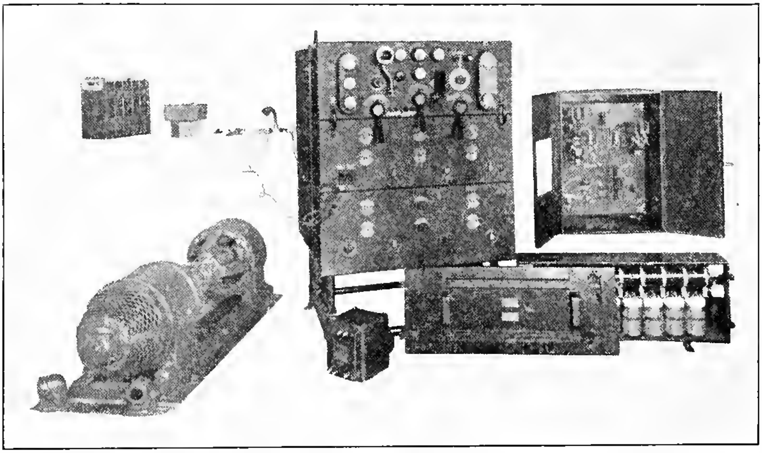


FIG. 147.—Complete commercial radiophone and C.W. telegraph set with a rating of 1½ K.W. The power tubes are in the rear of the panel. This type outfit and similar types are used for broadcasting.

transmitter. The wiring of a transmitter is most complicated, and expert knowledge of the many auxiliary pieces of apparatus used is necessary. The reader who wishes to go into the details of assembling his own C.W. transmitter is recommended to more advanced books, and to the various technical radio journals, which cater to the advanced amateur.

CHAPTER XIII

AERIALS AND GROUNDS, COUNTERPOISE AND LIGHTNING PROTECTION

Receiving aerials—Keep away from steel buildings and trees—Using trees as supports for aerial—Using a tree as an aerial—Inverted aerial—T aerial—Inclining aerial—Umbrella aerial—Fan aerial—Cage aerial—Insulation—Dimensions—Aerials on apartment houses—Keeping the antenna resistance at a minimum—Kind of wire to use—Precautions in erecting aerial—Keeping soot off insulators—Poor connections cause much trouble—The lead-in—Indoor aerials—Emergency aerials—Ground connections—Counterpoise—Protection from lightning—Using the electric light wires for an aerial according to Major-General Squier.

The problem of the aerial is usually easy to solve where a receiving station alone is to be considered, but requires a little more care when a transmitter is also desired. The receiving aerial is dependent, to a large extent, upon the instruments available for receiving purposes. When a crystal detector outfit is used, a reasonably good antenna is desirable so that the maximum signals can be heard. If a vacuum tube with audio-frequency amplification be used, then a less efficient antenna will do, and, if several stages of radio frequency and several stages of audio frequency are used, an indoor aerial or loop will work very well.

Receiving Aerial.—A receiving aerial consisting of more than two wires will not bring the signals in much louder, but will catch up all the available static and make receiving more difficult. It is not necessary to put up elaborate masts or towers for receiving aerials. A free space of from 50 to 100 feet between two points 30 to 60 feet above the ground will do. Of course, many variations to this can be made. Both points need not be an equal distance above the ground, nor need the aerial run absolutely straight, although these features should always be borne in mind, as it helps considerably in tuning to have a well-balanced aerial.

When a single-wire aerial is used, the lead-in should be taken from the end nearest to the stations most desired to be heard. If this is not possible, the lead can be taken from the middle of the aerial. When one end is higher than another, the lead should be taken if possible from the lower end, although good results have been had by dropping a wire out of the window of a high building and taking the lead from the top.

Care should be taken not to put the aerial where it will be interfered with by tall steel buildings or by trees. This cannot always be done; nevertheless, where possible, keep the aerial clear of such, for they absorb the signals and prevent the aerial from receiving the maximum impulses.

When trees are used as supports for aerials, let the supporting rope swing clear of all the branches before attaching the aerial wire. If the space between the tree and the other support is short, rather sacrifice more of this space than have the leaves of the tree touch the aerial wire. Trees are good aerials in themselves and absorb much energy. It is possible to drive a spike into a tree and use the tree as an aerial for receiving.

The author has found that for all-around receiving, that is, for receiving over a wide range of wave lengths, an aerial about 200 feet long is the most efficient. Fig. 148 gives the dimensions and appearance of the aerial that the author uses for receiving. It has two wires and is 200 feet long, 50 feet high in the center and 25 feet on each end. The wire is of the variety known as "stranded," and consists of seven strands of No. 20 tin-coated copper wire.

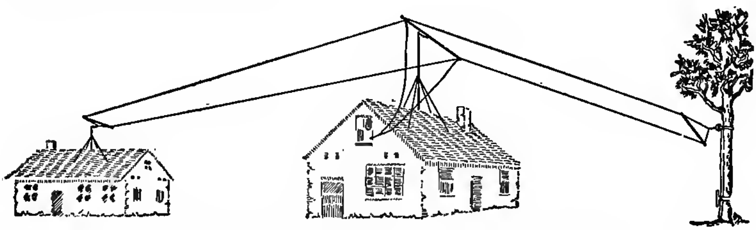


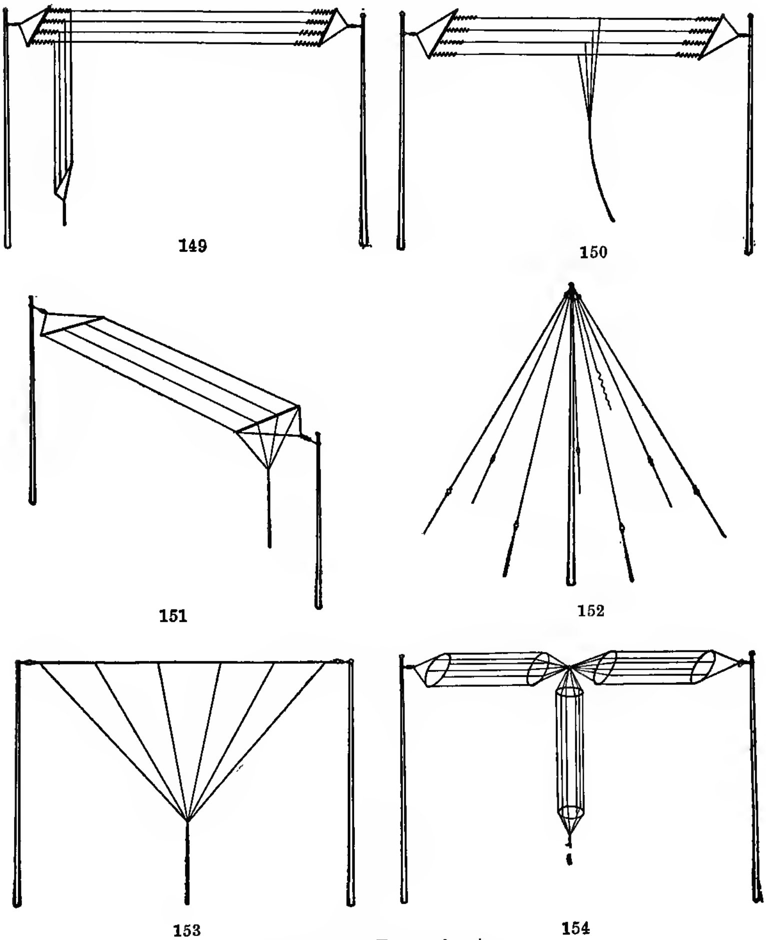
Fig. 148.—You can utilize almost any available location for an aerial, it not being necessary to erect tall poles or towers.

Aerials for Sending and Receiving.—Fig. 149 shows an inverted L aerial. This is directive and the lead-in should be taken from the end nearest the most desired stations.

Fig. 150 is what is known as a T aerial. This is similar to the one the author has, excepting that the top is straight and does not come to a point. The T aerial should be used only when the lead-in can be taken directly from the middle to the instruments, which should be situated underneath the antenna.

Fig. 151 is an inclining aerial, which can be used when it is possible to have only one highly elevated portion.

Fig. 152 is an umbrella aerial, which is perhaps the best all-round aerial, when no directional effect is



Figs. 149–154.—Types of antennæ.

wanted. The umbrella aerial can be made by using a mast about 60 feet high, and radiating ten to twelve wires from the top all around the mast. The wires should be insulated at the top and again about 10 feet from the bottom. The diameter can vary, in accordance with the wave length. An average diameter for amateur purposes would be 75 feet.

Fig. 153 shows a fan aerial. Twelve wires, spaced at equal distances from one another, on a wire seventy-five feet long, suspended between two masts forty feet high, coming to a point, makes a good transmitting aerial.

The best aerial for transmitting continuous waves is shown in Fig. 154. This is known as a cage aerial. The cage should be 50 feet high, if possible, and 75 feet long, for best radiation on 200 meter wave length. The diameter of the cage should be about 4 feet, and the wires used should be from 4 to 10, in proportion to the amount of energy to be supplied to the antenna. The lead-in can also be a cage, although this is not absolutely necessary; 2 feet in diameter is sufficient for the lead-in. The rings should be of metal and good connections should be made between them and the wires. The cage aerial can be either of the T type or the inverted L.

The best insulation for aerials is the usual corrugated composition insulators, such as shown in Fig. 155. For receiving, ordinary porcelain cleats can be used, providing the aerial is not too long and does not, therefore, cause too much mechanical strain.

Fig. 155.—Corrugated composition insulator for aerials.

For transmitting on 200 meter wave length with a spark, a good aerial is one of the T or inverted L type, consisting of four wires, 50 feet high and 80 feet long. The wires should be 4 feet apart. For this purpose, use two good stout wooden spreaders. Each wire should be insulated separately from the spreader and the spreader should be insulated from the mast.

The aerial should always be attached to the masts by rope and pulley, so that it is possible from time to time to take same down for repair work and general overhauling.

Aerials on Apartment Houses.—Aerials on apartment houses usually have to be of any type that is convenient to the conditions. The general rules just laid down apply to apartments. If possible, the same distance above the roof should be had, as though the aerial were being stretched between masts on the ground. The height of an aerial on the roof of an apartment house is not the height of the apartment, unless the lead-in runs to the ground floor. Roughly, the height is from where the lead-in is attached to the instruments, to the highest part of the aerial. Owing to the usual metal roofs on apartments which are grounded, it is necessary to raise the antenna well above this, if the best results are to be had. Particularly when transmitting, the roof will absorb considerable energy, unless the aerial is 20 or 30 feet above it.

The length of wire in an aerial and the height constitute the inductance, and the number of wires and the proximity to the ground constitute the capacitance. This, of course, is a generalization and, like most generalizations, is not accurate, but will suffice for general information and guidance. The nearer to the ground, the greater the capacitance, but the smaller the radiation.

The lead-in must be considered when figuring the height and length, as it is a part of the aerial.

Good radiation and small decrement in an aerial are dependent upon low resistance. Good connections, heavy wire and a good ground, keep the antenna resistance at a minimum.

As before mentioned, stranded wire makes the best aerials, but No. 14 copper wire, or aluminum or phosphor-bronze, can also be used. For receiving, insulated wire can be used, although there is no advantage, except where it happens to be available and the bare wire is not.

Precautions in Erecting Aerial.—In deciding the direction of an aerial, there is one feature that is of paramount importance and takes precedence over all other considerations, including the directional effect of pointing towards a desired station from which reception is wanted, and that is NOT TO RUN PARALLEL TO A POWER OR TRANSMISSION LINE. If an aerial runs parallel to a power line, the current will be induced into the aerial and a constant hum in the telephone receivers will prevent good reception of signals.

Whenever a power line is near an aerial, the aerial should be built at right angles to it. The same applies to bridges, steel trestles and, under certain circumstances, telephone lines. None of these in themselves carry troublesome currents, but they frequently have currents induced into them which cause trouble.

In erecting an aerial, never let it cross a power line or third rail, notwithstanding the care that may be used. It is not worth the risk, for no matter what precautions are taken, there is always the possibility of the aerial blowing down and causing a fire, or, as happened recently, an electrocution.

In cities where there is much soot, the insulators become heavily coated after a time and they should be lowered and cleaned or replaced to prevent heavy losses of energy when transmitting. Such losses will be noted from time to time by lower hot-wire ammeter readings for the same adjustments.

Poor connections in a receiving aerial cause much trouble which sometimes is never located. By soldering all connections, this danger is eliminated.

There are numerous ways of leading the aerial wires into a room. For receiving only, a heavily insulated wire running in through the window will often answer the purpose, but a better arrangement is shown in Fig. 160. Such an arrangement can be used for sending also, but if over 1/4 kilowatt is used, a special composition lead-in insulator should be bought.

Indoor Aerials.—There are times when an outdoor aerial is inconvenient, and something larger than a loop is desired. In such a case, an indoor aerial is possible, particularly if put in a frame house. A house with steel framework absorbs so much energy that it is impracticable to install an indoor aerial, but in a frame house, an aerial stretched the full length of the attic, consisting of a number of wires, is quite feasible for reception, although it cannot be used to cover very long distances, without suitable amplification. For transmission, it will answer the purpose for comparatively short distances.

An indoor aerial should be grounded for lightning protection for, while it does not run quite the same risk of being struck, precautions should be taken.

Sometimes, for receiving, an aerial is made by placing bell wire, or other insulated wire, in the molding around a room. Such an aerial in a frame house acts quite well, if sensitive receiving apparatus is used.

When a portable outfit is in use, emergency aerials are often wanted for different purposes. For instance, the author was visiting friends on Election Day, and happened to have with him a small, portable radio receiver. Being desirous of receiving the election returns, he used the spring of a bedstead for an aerial, and was successful in receiving the desired signals.

Another emergency aerial consists of a wire that is just dropped out of the window. The wire should be insulated, but even a bare wire will answer the purpose, providing it does not come in direct connection with any metal leading to the ground. Naturally, neither the bed spring, nor the wire dropped out of the window, is efficient.

Any aerial which can be used for reception, can also be used for transmission, but the range of transmission and efficiency are necessarily very much limited by the type of aerial. Radiophone transmission has been accomplished with small loops, but never over very great distances.

It is not recommended that indoor aerials, such as the type put in the molding, or bed spring, be used for transmission, particularly where high voltages are used, as a fire may be the result.

Ground and Counterpoise.—The ground connection is most important. The best and most convenient ground is a connection made to a water pipe. The connection should be made by means of a ground clamp such as is shown in Figs. 156 and 157. Grounds can be made to water pipes or heating systems, provided they are followed up to see that they themselves have perfect connections with the ground.

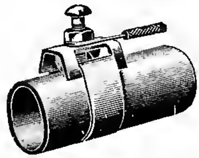


Fig. 156. — Ground clamp.

When it is not possible to make such ground connections as above described, metal plates can be buried in moist ground to which is soldered a heavy wire. Bare copper wire buried in the ground and covering a large area makes a good connection. The ground connection at Radio Central consists of one hundred and fifty miles of buried wire! The ground connection at the receiving station of Radio Central consists of two miles of wire at the bottom of a pond. Of course, such gigantic grounds are unnecessary for the amateur station, but nevertheless the importance of good ground connections is thus illustrated, and the experimenter is urged to be very careful of this important part of his installation.

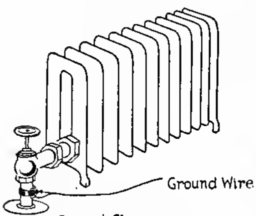


Fig. 157.—Ground connection made on a radiator.

The modern continuous wave transmitter works most efficiently when a counterpoise or capacity ground is used with or without the usual ground connection. A counterpoise consists of a number of wires insulated from the ground, usually running under the antenna. Fig. 158 shows a simple counterpoise. It is best to build the counterpoise about ten feet above ground, so as to clear any obstructions that might damage it, or be damaged by it.

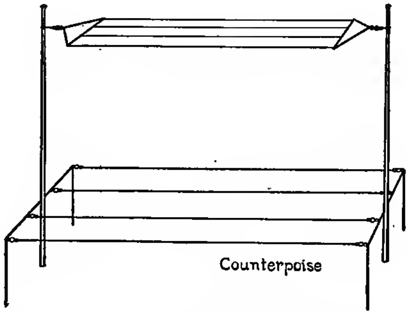


FIG. 158.—Aerial and counterpoise. The counterpoise is also known as a capacity ground. It is used instead of a ground in transmitting sets. Sometimes, it is used in conjunction with a ground.

The counterpoise, when used without a ground, is connected to the transmitter in the same manner as the ground. When used with a ground, it is connected as in Fig. 159.

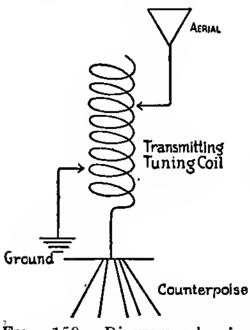


FIG. 159.—Diagram showing ground and counterpoise connections in transmitting circuit.

To tune the transmitter when both counterpoise and ground are used, it is necessary first to tune the aerial and ground to 200 meters and then to tune the aerial and counterpoise to 200 meters. How this is done can easily be ascertained by noting the diagram and referring back to Chapter VII, where we discussed the tuning of a transmitter.

The advantage of a counterpoise, or a counterpoise and ground, over a simple ground connection, is that the resistance of the antenna circuit is materially reduced. The above ground-and-counterpoise system is used at the transmitting station at Radio Central.

It is inadvisable to use a counterpoise for receiving, for, although tuning is sharper and static not quite so bad, the signals are much weaker than with the ordinary ground connection.

Although a counterpoise is not advisable in receiving, at times it is necessary, particularly where no good ground connection can be obtained. In dry regions, where there is sandy soil, a counterpoise is the only possible ground connection that can be had. In a case of this sort, it is not necessary to raise the counterpoise above the ground, but wires can be spread along the sand, either on the surface or a few inches or feet below the surface. This will take the place of the ground.

Naturally, in aeroplanes where no ground can be had, the counterpoise is used for both sending and receiving. Loops are also used in aeroplanes.

Underground Aerials.—Insulated wire buried underground has been successfully used as an aerial. The United States Post Office Department makes use of this device to reduce static interference and has equipped several stations with underground aerials for receiving.

Protection from Lightning.—Many people have been kept from installing radio receivers by a fear that an aerial is a source of danger in an electric storm. Such is not the case, when the aerial is properly grounded. In fact, when grounded, an aerial has the same effect as a lightning rod, and conducts the lightning to the ground without injuring the house.

When a transmitter is used, as well as a receiver, it is necessary to have a lightning switch on the outside of the house. It is customary, and in accordance with the regulations of the National Board of Fire Underwriters, to ground the aerial through a single-pole, double-throw switch made to carry 100 amperes of current at 600 volts. The outside ground connection is made through No. 4 copper wire, suitably insulated from the house by porcelain or glass knobs.

A good ground can be made by burying a piece of copper sheeting four feet square, three feet or more

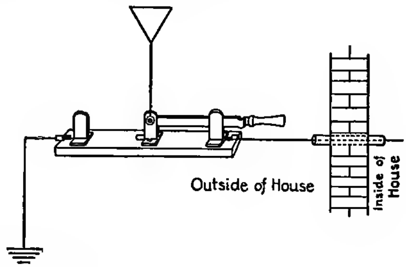


Fig. 160.—Lightning switch and lead-in insulator.

under ground in a damp soil. If, however, a connection can be made to a water pipe on the outside of the meter, a convenient and safe ground is secured. Those living in apartment houses had better consult the owners, who can take the matter up with their insurance agents, for there are different regulations, applying to large apartment houses, being promulgated from time to time.

Fig. 160 shows an outside ground using a 600-volt, 100-ampere single-pole, double-throw switch.

A radio set that is not properly grounded not only is in danger from an actual bolt striking the aerial, but also from induced high voltages due to near-by lightning flashes. The latter usually are accompanied only by minute currents, but nevertheless can cause a fire by sparking near inflammable material.

An interesting experiment can be carried on during an electrical storm, not without risk, however. It will be recalled that Franklin first demonstrated the nature of lightning by flying a kite during a thunderstorm, and drawing a spark from a key attached to the wet string that led from the kite. By disconnecting the aerial from the radio instruments and holding a pair of pliers or other metal near the lead-in, sparks several inches in length will jump, accompanied by a crackling noise and a slight sensation of electrical shock. This is in effect a repetition of Franklin's experiment. Should you be so unfortunate as to be conducting the experiment at a time when a bolt of lightning strikes the aerial, the Coroner will be called in to make the official report of the result.

There is another type of lightning protector that is convenient for receiving stations where no transmitting is done. This consists of a small spark gap, 3/16 inch wide, inclosed in a vacuum. The device is connected between aerial and ground on the outside of the house. The National Board of Fire Underwriters provides for this type of lightning protector in Rule 86, Section N C of their code, which reads as follows:

In radio stations used for receiving only, the grounding switch may be replaced by a similarly mounted and grounded short gap (1/8 inch or less), or vacuum type lightning arrester. The current-carrying parts of devices must be kept five (5) inches clear of the building wall.

A gap 3/16 inch wide in a vacuum is equivalent to approximately .001 inch in air, so that such a gap is quite in accordance with the Underwriters' regulations.

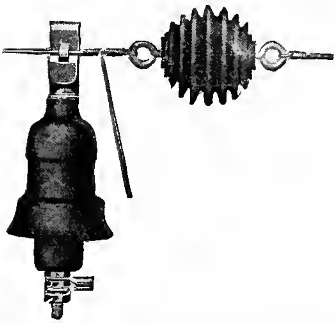


Fig. 161.—Brach outside vacuum gap for lightning protection. Gap is placed between aerial and ground and makes lightning switch unnecessary on receiving sets.

If you have only a receiving set, it is best to use this type gap, as it precludes the possibility of your forgetting to ground your apparatus, which is sometimes the case when a switch is used. The gap system works automatically, for, when the voltage in the aerial reaches a dangerous point, it discharges across the gap, whether you are using your apparatus or not. Figs. 161, 162 show two types of vacuum gaps.

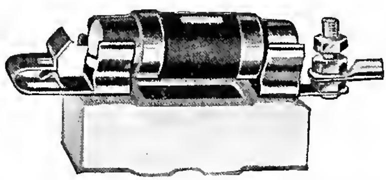


Fig. 162.—Brach inside vacuum gap.

In the appendix will be found the proposed new fire regulations for lightning protection. These will probably go into effect in January, 1923. They are much simpler to carry out than the present regulations.

Using the system of Major General Squier, no lightning grounding is required. This is discussed in the next chapter.

CHAPTER XIV

REDUCING INTERFERENCE FROM STATIC

What is static? No method yet devised completely to eliminate—Static most severe during summer—Sometimes necessary to close down station due to static—Reducing static interference with the loop antenna—What size loop to use—Convenient types—Collapsible loops—Long distant reception using loop—Beverage wave antenna—Wired wireless—Major General Squier demonstrates wired wireless to the author—How to use electric light circuit for aerial—The "peanut vacuum tube" for making portable loop receivers.

The principal difficulty experienced by those listening to radiophone concerts and other forms of broadcasting is the atmospheric disturbance known as static. This is caused by a difference of potential in the electric charges in the atmosphere and in the earth. Just as in a condenser, the two opposite charges seek to merge and finally discharge across a spark gap, just so does the atmospheric electricity seek the earth, and when a particularly strong charge discharges to the earth, we have a flash of lightning. Most of the time, these charges are not strong enough to cause lightning, but find an easier way to earth by discharging through some one's receiving antenna, which discharge is accompanied by a loud crackling noise in the telephone receivers.

However, it is not necessary for the discharge actually to take place in a receiving antenna, to cause disturbances. Discharges from cloud to cloud, and from atmosphere to earth, cause oscillations to be set up in the ether, which affect the receiver in similar manner to the oscillations purposely set up by transmitters. In fact, when a very low-frequency spark set is sending during severe static, it is difficult to distinguish the spark from the static. This accounts, in a measure, for the now general use of high-frequency spark and continuous wave signals.

Many ways have been devised to eliminate static. None has succeeded in so doing, although there are now a number of methods by which static may be so reduced that continuous radio communication is possible.

During the summer months, static is the most severe, and it is doubtful whether the broadcasting stations are going to be able to make themselves heard by as many people in the summer time as in the winter. In fact, even though a broadcasting station can be heard during severe static, there is not much pleasure in listening to some beautiful violin or vocal selection, when the ear drums seem to be giving way under the loud bombardment of static crashes, which at times completely drown out the music.

At times the author's experience with static, while listening to broadcasting stations, has been exasperating, and at the same time amusing.

One evening, a famous monologist was talking from one of the principal broadcasting stations. He told four or five humorous stories, or at any rate stories that promised to be humorous, for in each successive story, as he came to the point in which was the laugh, a loud burst of static would prevent the *dénouement* from being heard, and after a number of these stories literally went over the author's head, he abandoned the radio, with a mental vow never to go near it again. Needless to say, these mental vows were always broken. In this respect, there is quite a similarity between radio and golf.

Unless means are taken to eliminate some of the static, the average radio station must be temporarily closed during most of the summer, except, of course, if it is located in close proximity to the broadcasting station.

The Loop Antenna.—Probably the most feasible method of eliminating much of the static disturbance is by means of the loop, which, to be effective over any reasonable distance, requires both radio- and audio-frequency amplification. An ordinary receiver, with a vacuum-tube detector and two stages of audio-frequency amplification, can be used in conjunction with a loop for receiving broadcasting stations not over fifteen miles distant. A hook-up for such a circuit is shown in Fig. 104.

For greater distances, as before mentioned, it is necessary to use from one to three stages of radio-frequency amplification. Fig. 102 shows a loop hook-up using two stages of radio-frequency amplification, and one stage of audio-frequency amplification.

Static is in itself directional. A larger antenna receives the static from every direction. A loop will only receive static that comes from the direction in which the loop is pointed. Consequently, it is easy to understand that the loop will receive far fewer static impulses than will the ordinary aerial. In using a loop, it is necessary to point it in the direction of the station desired to be heard. If the loop is placed at right angles to the station, no signals at all will be heard. As it is revolved toward the direction from whence the signals come, they will gradually sound louder and louder in the telephone receivers until the loop is pointing exactly toward the transmitting station. It is this principle of the loop that is used in direction finders and in radio compass work.

Not only is much static eliminated through the use of a loop, but also radio telegraphic and telephonic interference or unwanted stations that are not in the plane of the loop will be largely eliminated.

Loops can be purchased or can be made to order. For those who wish to make loops themselves, it is a simple matter, and the following table is given for the construction of rectangular loops to receive the different wave lengths:

CONSTRUCTION OF LOOPS

Up to 200 meters	27″ × 40″	3 turns spaced 1/4″
Up to 600 meters	48″ × 48″	3 turns spaced 1/4″
Up to 6,500 meters	48″ × 48″	50 turns 3 1/2 layers
Up to 17,500 meters	48″ × 48″	70 turns 4 layers

Use 3 × 16 × 38 Litz wire, or No. 18 enameled copper wire. Fig. 163 illustrates an octangular loop antenna.

It is possible to make a large loop and take taps from same for tuning purposes, but it is more efficient to have a number of loops to cover different wave length ranges.

Messages have been received over four thousand miles on loop aerials, using, of course, radio- and audio-frequency amplification.

A loop receiving set placed in a building in the downtown section of New York, using three stages of radio frequency and two stages of audio frequency, was successful in copying messages from an amateur low-powered station in Texas.

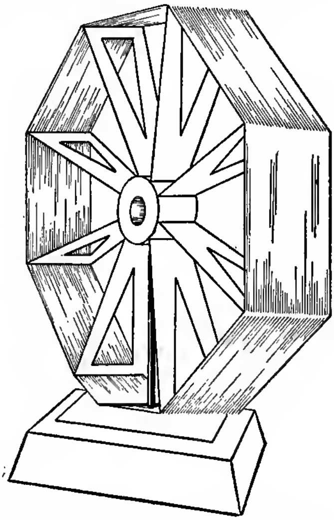


FIG. 163.—Type of loop antenna used by U. S. Army. During the Genoa Economic Conference in the spring of 1922 the entire proceedinga were received in Washington at the War Department with two of these loopa, one of which was pointed toward the Carnarvon Walea Radio Station, and the other toward the atation at Nauen, Germany. No outside aerial was used. The loops, of which the dimensiona are given in the text, are not octangular, as in this illustration, but rectangular.

Another advantage of the loop is that it is unnecessary to have wires on the outside of the house. This feature is particularly desirable to those who live in apartment houses, where there is either an overabundance of antennae on the roof or where the owners refuse to permit the erection of aerials.

For practical use in a parlor or drawing room, the loop can be made very attractive. Several manufacturers are now making receiving outfits which consist of a loop, neatly wound on a mahogany frame, supported by a lathe-turned stand. The receiver is contained in a case similar to a phonograph cabinet.

For the person who desires to make his own loop, and has a little ingenuity, fire screens can be made of a loop, and other pleasing decorative features of a room can contain the necessary wires for the loop aerial. This, no doubt, is the type of receiver that will ultimately be used for broadcast reception.

Loops can be placed on the outside of the house, but this does not add to their efficiency. For camping or traveling, collapsible loops can be made, and using the "peanut" or similar type vacuum tube, entire outfits, inclusive of the radio-frequency amplification, can be carried in a very small and compact case.

The traveling salesman of the near future will undoubtedly carry, as part of his equipment, portable radio telephone receiving outfits. In the evening, when he retires to his room, it can be set up in a couple of minutes, and market reports, and other information that might be useful to him in his business, can be picked out of the ether. The entertainment of the traveling salesman is by no means an unimportant part of his routine, for a certain amount of entertainment is necessary if he is to be alert and free from brain fag. The salesman may be in Omaha and his wife and family home in New York, and both of them listening to the same entertainment during the evening hours.

The various uses to which, even now, these practical receiving sets can be put are innumerable.

Do not be discouraged, if you are now using an outside aerial and you find that during certain seasons of the year you can get very little pleasure from your outfit. The sudden popularity of radio broadcasting and reception has taken the manufacturers unawares, and it will be some little time before all the proper equipment for continuous, enjoyable reception is available.

Beverage Wave Antenna.—Another method of static elimination, or rather static reduction, for none of these methods absolutely eliminates static, is the use of the Beverage Wave Antenna. This is quite feasible for stations in the country, where ample space is available for erecting the necessarily long aerial that this system provides for.

The Beverage Wave Antenna consists of one or two wires, whose length is equal to the wave length most

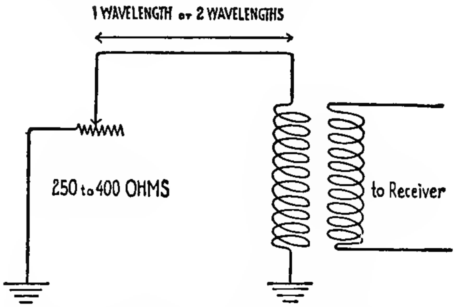


FIG. 164.—Beverage wave antenna hook-up.

desired to be received, or equal to twice that wave length. For receiving 200-meter wave lengths, the antenna must be about 650 feet, or about 1,300 feet long. The height should be from 15 to 30 feet above the ground. A non-inductive variable resistance of the order of 200 to 400 ohms is placed at the far end of the antenna, which should be pointing toward the station from which the desired signals are coming. The receiving end of the antenna is coupled to the usual vacuum tube circuits through an inductance of about one-tenth millihenry. A Wave Antenna circuit is shown in Fig. 164.

In using an antenna of this type, not only is static eliminated to a large extent, but most of the undesired signals as well. The set works most efficiently on waves of the same length as the antenna or multiples thereof.

According to Mr. Paul F. Godley's article in *Wireless Age* for March, 1922, an antenna of similar design was used in receiving the amateur messages in Ardrossan, Scotland, during the trans-Atlantic tests conducted by the American Radio Relay League.

Wired Wireless.—Major General Squier of the U. S. Signal Corps has recently announced a new method of radio broadcasting, which may in time revolutionize the present methods, and which will undoubtedly eliminate much static. This method is known as "wired wireless."

The system provides for the broadcasting station to transmit, over the ordinary electric light power line, radio impulses at a frequency which will in no way interfere with the lighting circuit, but which can be received by a suitably tuned receiver by merely plugging in on the ordinary electric light circuit.

Such a system will undoubtedly prove desirable in crowded cities where hundreds of thousands of people can be reached from the central power station. The use of this system will also eliminate the possible interference between such broadcasting stations and the radio telegraph and telephone systems.

Almost any number of wave lengths can be used in the "wired wireless" system, without interfering with each other, and so it will be possible to transmit various types of news, music, etc., over the same power circuits.

Recently, the author called on Major General Squier in Washington. The General, who is an enthusiastic radio "fan," demonstrated his wired wireless. Connecting a common electric light plug to a lamp, and connecting the other end of the wire to the receiving set (just an ordinary single-circuit receiver), clearly modulated music was heard from the loud speaker attached to the receiver.

In order to eliminate any danger of short circuiting due to grounding the power circuit through the receiver, several mica condensers are connected in series with the light circuit so that no electrical connection is made, but merely a capacity coupling.

General Squier explained the use of a power circuit as an aerial as follows:

Supposing the walls of this building should be taken away and only the wiring left, we would have a large cage of wires, which would make an admirable aerial. As a matter of fact, the concrete walls of the building do not exist, so far as the electric waves are concerned, and we therefore have substantially a large cage aerial which we are using for the purpose of reception.

The power wires used as an aerial eliminate much static because they are not as high in the air as the average aerial. The higher up you go the greater the potential of the atmospheric disturbances and consequently the more powerful the static discharges are in the receiving apparatus.

Not only can an ordinary lamp be utilized for the aerial, but both the filament and plate currents can be taken from it and it can be so arranged that the lamp shade can act as the louder speaker, so you can see how simple the radio receiver of the future is going to be. All these things can be accomplished now, in fact they have been accomplished, so the future of this type of reception cannot be far off. I expect to see hotels adopt this means of bringing entertainment to their guests.

General Squier was the first man to show that radio frequency currents can be directed along a metallic circuit. His invention is being utilized at the present time in multiplex long distance telephony. As many as eighty telephone messages are sent over one long distance telephone wire by means of General Squier's invention. General Squier has assigned his patents to the United States Government and, if the present litigation be decided in favor of the General and the Government, much money can be saved by the various Departments in Washington who are now paying $36 per mile per day for the use of special long distance telephone wires. It costs about $36,000 per day for the Government to have twenty-four hour service (exclusive) on a Washington to Chicago wire. If it is decided that the Government controls this invention, perhaps the cost of these wires will be considerably reduced.

Good results can be had by adopting the "wired wireless" principle for home receiving. Not only is some static eliminated, but in many cases an aerial need not be erected at all, saving expense and trouble. Fig. 165 shows the proper connections. Be sure and connect only one wire to one pole of the socket, otherwise there will be a short circuit. If good results are not obtainable at first disconnect the plug and connect it again, so that the wire is on the other pole of the lighting circuit. Be sure that the current is turned on in the lighting circuit, otherwise no connection will be had with the wiring system which acts as the aerial.

The "Peanut Vacuum Tube."—The vacuum tube is in the process of improvement at the present time and many startling innovations will soon be made public.

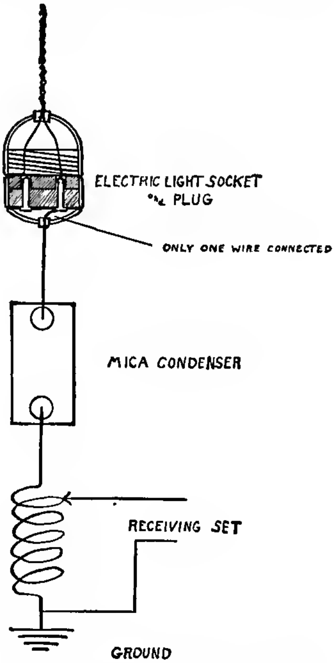


FIG. 165.—Method of using electric light circuit as aerial.

Perhaps the most recent improvement in vacuum tubes is the so-called "peanut" tube manufactured by the Western Electric Company. This tube is the usual three-element tube, built much smaller than the one now in common use, and instead of requiring five or six volts in the filament, it requires only one and a half volts, making it possible to operate it on dry cells; in fact, the peanut tube can be operated by means of the ordinary flashlight battery. At the present time, the "peanut" tube is not on the market for general use, but as soon as it makes its appearance a great change will undoubtedly be wrought in the manufacture of receiving equipment. It will then be possible to manufacture portable receivers that will be suitable for traveling and camping.

The present portable vacuum-tube receivers have the great drawback, with a few exceptions, of requiring a storage battery, which cannot readily be re-charged in the backwoods, many miles from a source of current. With the "peanut" tubes, it will be possible to carry a number of dry cells, which will supply filament current for long periods.

Great improvements will be made in static prevention, due to the use of these tubes, owing to the fact that radio-frequency amplification will be more accessible to the average person, when it is not necessary to consume large amounts of current in the filaments of the tubes, and thereby making it necessary to recharge the storage battery at frequent intervals.

FIG. 165-A.—Westinghouse single circuit vacuum tube receiver which operates on one dry cell.

CHAPTER XV

WHAT THE AMATEUR HAS DONE IN RADIO

Status of amateur prior to 1912—Efforts to eliminate him defeated —Freedom of the ether—Hiram Percy Maxim, president of the American Radio Relay League—3,500 amateur radio operators enlist in Army, Navy and Marine Corps when war with Germany is declared—How Sayville Radio Station was taken from the Germans—The romance of radio—How the A. R. R. L. is organized—Hartford to Los Angeles and back in 6½ minutes via amateur radio—Amateurs succeed in transmitting across Atlantic Ocean—Radiophoning from New Jersey to Scotland by an amateur—Regular amateur service between Hawaiian Islands and California—Amateurs keep communication open during blizzard in Northwest—Amateurs in Chicago save U. S. mail plane —When the *Titanic* went down!—Helping the newspapers.

When, just prior to the formulating of the present radio laws, in 1912, the right of the amateur radio enthusiast was being challenged, much was heard pro and con concerning the usefulness or uselessness of the private wireless station. Against the amateur wireless operator, it was stated that he was a nuisance, that he interfered with commercial stations and government stations, and that he pursued radio only to amuse himself, at the expense of the public in general. His opponents were unmerciful in their condemnation. The champions of the amateur were somewhat vague in their praise of him. "Embryo Engineers," "Inventors in the Making," "Future Commercial Wireless Operators," were some of the commendable appellations given him. Wild speculations as to his possible use, in case of war, were indulged in by those who sought to have the amateur protected by law. Just why the amateur finally did become a *protégé* of the United States Government is not clear, unless it was to defeat the somewhat selfish motives that prompted his opponents, for he was not particularly worthy, in those days, of government protection. Perhaps, however, our lawmakers were far-sighted, and had faith in American youth, and saw what lay hidden in Young America's apparently useless hobby.

Ten years have passed since Uncle Sam promulgated a law which forever assured to the American radio amateur certain definite rights. In no other country, is the private citizen allowed such freedom in radio as in the United States. Just as the Constitution of the United States provides for free speech, so the Radio Law of 1912 provides for free ether.

"What has the amateur done in the past ten years, to justify the privileges granted him by his government?" Such was the question the writer put to Hiram Percy Maxim, the inventor of the famous Maxim Silencer, and President of the American Radio Relay League, an organization of 10,000 amateur wireless operators. Seated around a small table in the grill of the Hotel Bond in Hartford, were Mr. Maxim, the writer, Kenneth B. Warner, Secretary of the League, and his assistant, R. L. Northrop. Mr. Maxim told the following story:

"Early in April, 1917, a Captain in the Army, with whom I was well acquainted, telephoned me and asked if I would call and see him. I called on him and he told me that in all probability war would be declared and they would require a great many radio operators. He further stated that the Army was faced with a shortage of radio operators, and that they did not have the proper machinery or organization to teach them. Owing to my connections with the American Radio Relay League, the Captain thought that I might be able to assist him. I promised to do what I could.

"As soon as war was declared, we appealed to the amateurs, through our official paper Q S T, to enlist. Their response was instantaneous and, in thirty days, we supplied 2,000 expert radio operators to the Army and Navy. Before the war was over, 3,500 members of the American Radio Relay League were serving Uncle Sam in the Army, Navy and Marine Corps."

Mr. Warner, at this point, interrupted in order to emphasize what it meant to the Army and Navy to have such a large number of trained radio operators ready for service.

["During the war" said Mr. Warner], "I was an instructor of radio operators. I found it difficult to turn out a good operator in less than six months. Had we not been able to draw in such large numbers from the amateur ranks, we would have been in a sorry predicament. British and French officers, whom I met in the course of my work, expressed admiration for our foresight in having such an army of radio operators ready for immediate call. The officers of these countries told me that they were severely handicapped in not having radio operators, and they blamed this on the fact that both their countries had very strict laws, practically prohibiting amateur radio, as it is practiced in the United States. These officers stated that they intended to bring pressure on their respective governments, in order that some of the restrictions which hampered the amateur might be lifted. France was somewhat successful in this, and now has a large number of amateurs."

Mr. Maxim then told how an amateur, Charles E. Apgar, of New Jersey, in the autumn of 1914, recorded the signals sent out from the German-owned radio station at Sayville, Long Island, on an Edison dictaphone, and caused the United States government to close down the German station, thus preserving our neutrality.

It seems that Apgar, shortly after the declaration of war in the summer of 1914, listened one evening to Sayville sending out messages to Nauen, Germany. One of the messages was as follows: "Ship 300,000 shovels express C.O.D." This message did not appear to Apgar as being "on the level." There was something peculiar about a shipment of 300,000 shovels to be expressed C.O.D. He decided to keep a record of what Sayville was sending, and with the ingenuity so often shown by American amateurs, he secured an old Edison dictaphone and connected it to his receiving apparatus. Every dot and dash sent out by Sayville was registered on the waxen cylinder. Cylinder after cylinder was impressed with Sayville signals. After having collected a great many, he took them to Radio Inspector Terrell. Inspector Terrell turned the cylinders over to the Secret Service. A few nights afterwards, Apgar was called on the telephone. It was Detective Burns of the Secret Service. Could Apgar see him? Certainly! Burns called on Apgar and arranged to receive further messages on the amateur's radio receiver. They bought a new dictaphone and recorded everything sent out by Sayville. A short time later, Detective Burns brought suit against the German wireless company, who owned the Sayville station, on the grounds that they were violating the neutrality of the United States. In a short time, the Sayville wireless station was taken over by the Government. Thus did the amateur again justify his existence.

One of the most useful features of amateur radio is the wonderful organization that has been built up, to a large extent through the efforts of Hiram Percy Maxim. Though a middle-aged man, with steel-gray hair, Mr. Maxim seems to be more the average American boy with a hobby, than an internationally-known inventor. In talking amateur radio with Mr. Maxim, you strike a sympathetic chord, and you are not surprised that 10,000 boys, girls, men and women have gathered around him to form one of the most typically American and useful amateur organizations in existence. Mr. Maxim does not claim the credit, which is surely his, for this achievement in organization. "It is the bond of the American Radio Relay League," he said. "There is an invisible link that binds all radio amateurs to one another, and to their organization. No doubt, it is the romance of radio that is the cause, for surely a man cannot sit in his room evening after evening, and exchange greetings, messages and ideas with a fellow man, five, six, seven, eight hundred, a thousand miles away, without feeling some tie to him, other than the ether waves."

"Just what is the purpose of the American Radio Relay League, Mr. Maxim?"

He turned to Mr. Warner, who recited the following, just as he might recite any creed which was almost a part of him: "A national, noncommercial organization of radio amateurs, banded for the more effective relaying of friendly messages between their stations, for legislative protection, for orderly operating, and for the practical improvement of short wave radio communication." The organization is divided into seventeen operating districts, covering the entire United States, Canada, Alaska, and the Hawaiian Islands. At the head of the Operating Department is F. H. Schnell of Hartford, Conn., who is the Traffic Manager. It might be mentioned here that Mr. Schnell and Mr. Warner are the only paid officers of the League, and they are paid because it is necessary for them to give their entire time to the League.

Each division is headed by a Division Manager, who has one or more assistants. The Manager has charge of all amateur radio communication in his district. There are also a District Superintendent and City Managers in each district. The personnel of the system of nation-wide relaying consists of 400 radio operators scattered over various trunk lines throughout the country. Every town and city in the United States has one or more radio stations, in consequence of which messages can be sent to almost any part of the United States *via* the American Radio Relay League's trunk lines and other amateur stations. No charge is made for any of this work.

Recently, a test was made for speed in handling traffic and a record was made by transmitting a message from Hartford, Conn., *via* the American Radio Relay League stations to Los Angeles, Calif., and transmitting a reply from Los Angeles to Hartford, which arrived there 6½ minutes after the first message had been sent. Whereas, this speed is not regularly accomplished, it indicates what can be done by amateurs in cases of emergency. In winter, rush messages *via* amateur radio can be counted on to average one hour across the continent. In summer, when atmospheric conditions are not so good, somewhat longer time is taken. An average of 30,000 messages are sent to various parts of the country *via* American Radio Relay League stations, every month.

Since the memorable achievement late in 1921 of American amateurs transmitting across the Atlantic Ocean on short wave lengths and with limited power, amateurs in France and in England are regularly picking up American Radio Relay League stations. Owing to the strict regulations, limiting amateur transmitting stations, actual exchange of messages is not, at the moment, possible. It is to be hoped, however, that the time is not distant when the governments of Great Britain, France and other European countries will recognize the value of amateur radio and lift some of the regulations that prevent long distance transmission.

Recently Mr. Maxim received a letter from General Ferrie of France, who has charge of radio in that country, saying that the French amateurs expected to attempt radio communication with America in a short time. How great a step toward international amity will be taken, when John Smith of Meriden, Conn., will be able to sit in his home of an evening, and carry on a conversation with his friend François in some little French village! Or, the rivalries of some international sporting event can be aired *via* ether waves between two amateurs, one in London and the other in New York. This is not a vague dream; it merely requires a change in government regulations abroad. America has done her part toward this end. Transmission of radio messages across the Atlantic has been accomplished by American amateur stations, using as little power as five watts, which is considerably less power than is required to light an ordinary electric lamp. On October 6, 1920, Messrs. Harold and Hugh Robinson of Keyport, New Jersey, were heard talking over their radiophone by a station in Aberdeenshire, Scotland.

Among the more recent accomplishments, Mr. Maxim told me of the extension of the American Radio Relay League relay system to the Hawaiian Islands. Mr. Clifford S. Dow, call letters 6ZAC, located at Wailuku, Maiu, Hawaii, handles the traffic for this outlying territory of Uncle Sam. Only the night previous had Mr. Maxim sent a message to Mr. Dow. "I transmitted it directly from Hartford to a station in West Virginia for relaying to Hawaii," said Mr. Maxim. "It was the first message thus routed, and I wager that the West Virginia amateur nearly fell off his chair when he saw the address." All this relay work is accomplished, using the limited wave lengths and power allotted to the amateur by United States regulation.

"Mr. Maxim, some people have the idea that amateur radio serves no useful end, other than the amusement it affords the amateur himself. Are you acquainted with any work done by the amateurs of your organization which can be considered of service to the public?"

Mr. Maxim's eyes sparkled as he replied, "The radio amateur is always ready to be of service and needs no prompting to show him his duty in time of need, as is shown in the following incident:

"During the latter part of February, 1922, a terrific sleet storm and blizzard visited Minnesota and near-by territory. Wire communication from Minneapolis and St. Paul, to the outside world, was completely destroyed. On the evening of February 22d, at 6 o'clock, the wire service went out of commission. Minneapolis was completely cut off from the rest of the country. No messages could reach the city, nor could any go out. The Minneapolis *Tribune* appealed to the University of Minnesota, which had a radio installation, and asked them to get news for its morning issue. Therefore, 9XI (those being the call letters of the University of Minnesota) attempted to get into communication with the outside world. They succeeded in communicating with 9ZS in Indianapolis, but, due to the terrific atmospheric disturbances, were unable to secure any news. At 2 o'clock in the morning, the University of Minnesota communicated with Morris MacCabe, station 9AXF, at No. 1223 Foster Ave., Chicago, Ill. Before any traffic was handled between these two stations, the Associated Press opened up line communication to Chicago by a roundabout series of connections, which took in Vancouver, Denver and St. Louis. Early on the morning of the 23d, this line also went out of commission, and with it the entire service of the American Telegraph and Telephone Company. The Telephone Company immediately set out to repair the lines, but requested that some of the Minneapolis and St. Paul amateur radio stations get in touch with Chicago. The University of Minnesota, another station with the call letters 9ZT, and Albert P. Upton, No. 2328 Taylor St., Minneapolis, Minn., all proceeded to establish communication. At 10 o'clock in the morning, the station of Donald Clair Wallace of No. 823 Snelling St., St. Paul, Minn., call letters 9DR, raised 9MF at St. Cloud, Minn., and also Ivan J. Bullock, No. 1004 North Ave., Fairmount, Minn.

"All these connections were made before noon. At noon, St. Cloud was in touch with Brainard, and also with 9BAC, some miles to the north. Fairmount had by that time gotten in touch with New Ulm, Minn., and before the end of the afternoon, a network had been established to Le Mars, Iowa. Every hour, the entire system was checked. From Le Mars, communication was had with Davenport, Iowa, and from there to Rood House, Ill. This network of amateur radio stations was the only communication to be had in the district until 4 o'clock in the afternoon, when the telephone line was reëstablished. Station 9XT and 9ZT not only succeeded in getting into communication with Chicago, but copied press from the Government Station at Arlington, Va., which they turned over to the local newspapers. Mr. J. F. Carpenter of the University of Minnesota, is the manager of the City of Minneapolis for the American Radio Relay League, and it was largely due to his direction that this network was formed. He stayed at his post, routing messages and keeping the ether clear, for 40 hours without sleep."

Various feats of this sort, accomplished by the American Radio Relay League, are published in their official organ Q S T, and serve as examples of how every amateur is expected to act in cases of emergency.

"At another time," said Mr. Maxim, "Kenosha, Wis., was completely isolated by a severe blizzard. All the wires were down. There were wrecks and snowdrifts blocking the railroads. Most of the power lines were down, and besides there was no coal for the power station. The factories stopped running and almost every amateur aerial was on the ground. Not to be daunted, however, several amateurs constructed emergency aerials in the attics of their houses, and one succeeded in putting an aerial on the roof of a mill. With spark coil and storage battery, they rigged up temporary transmitters and after a short time succeeded in communicating with a naval station at Manitowoc, Wis. Through the naval station, the outside world was made aware of Kenosha's plight, and relief was sent at once. The municipal authorities utilized the amateur stations to send messages of civic importance directing their rescuers. Through these amateur stations, the railroad was assisted in the work of reëstablishing its lines. Coal, food and medicine were requested and secured, due to the communications *via* radio; in fact, the entire situation was relieved, owing to the ingenuity and foresight of these amateurs."

One of the most striking examples of the value of having amateur radio stations scattered all over the country is illustrated in the following story:

The U. S. Mail Plane was delayed in Cleveland. The authorities would not let it leave the ground, owing to a break in the radio equipment which was being repaired. The impatient pilot, anxious to start, condemned the radio as being of no service to him in flights and requested that he be permitted to start without it. He was not allowed to do this, however, for the regulations are very strict in regard to mail airplanes. After further delay, the radio was fixed, and the plane left on its long flight to Chicago. The trip was uneventful, until the plane neared Chicago, where a heavy ground fog obscured both land and lake. Blind for all practical purposes, the aviator circled around and around, seeking the landing place. Through a slight rift in the fog bank below him, he caught a glimpse of Lake Michigan. This was not very reassuring and he was at a loss to know just where the landing field lay. After more circling about, their gas became almost exhausted, and in desperation he finally told his radio operator to send out a Q S T (general call) and ask any radio station who heard them to call the Mayfair landing field on the telephone and ask them to send up rockets. In an incredibly short time, rockets were seen piercing the fog bank below, and a safe landing was made. Upon inquiry, the pilot learned that six different amateurs had telephoned their message to the landing field.

Many other stories of amateur usefulness in times of trouble can be told. The author recollects a case of such assistance, which was rendered by amateurs on April 15, 1912. On the previous day, the *Titanic* had struck an iceberg and sunk with an appalling loss of life. Effort was being made to rush a list of the survivors to the newspapers, but owing to the severe atmospheric conditions, the scout cruiser *Salem* near the scene of the disaster was finding it difficult to get the names through to the naval stations at Newport, Rhode Island. This was prior to the radio law, and every evening around Greater New York, the air was full of pleasantries, foolishness, bantering, squabbling, quarreling, jamming in both the Morse and Continental codes, for at that time both of these codes were in use on the wireless. There was no organization then to line up the amateurs and keep them from interfering with the important work that was going on. But that invisible bond which binds them to one another, held them in check that night for the important work to which they were to contribute their share.

New York's little radio population was aghast the morning after, when they read of the horrible disaster. Each and every one thought unto himself, "How can I be of some assistance?" Little by little, news was arriving in New York, giving some of the details of the horrible event. Anxious relatives were awaiting word of the survival of their dear ones. The newspapers told them that the names of the survivors were being held up, due to the severe static disturbances in the ether, and when night came, only a partial list of the survivors had reached New York.

Without being told, and with no organization to get them together, the amateurs of New York and vicinity discovered the part that was allotted to them to render assistance in this tragedy of tragedies. At eight o'clock the evening following the sinking of the *Titanic,* when the author picked up his telephone receivers and tuned in on that little world of ether, he was not greeted by the usual din and noise, but in its stead was an oppressive, awful shroud of silence. Except for the mournful rumblings and grumblings of the static, not a sound was to be heard, and yet every amateur was at his post, with the self-imposed grim task of trying to copy the names of the survivors of the *Titanic* that the valiant little ship, the *Salem,* not far from the scene of the disaster, was trying to get through to the Newport Naval Station. 'Twixt static crashes, they were copying the names of those who were fortunate enough to be saved from a watery grave.

Hour after hour, they copied what little they could get, for the static would at times completely obliterate the signals from the *Salem.* Twice during the long period, the silence was broken; once by the German station in the Trinity Building on Broadway, TWT. Hardly had their loud spark been impressed upon the ether, when the stentorian spark of Dr. Hudson, the most prominent amateur at that time, warned them to keep out. Dr. Hudson was the self-appointed patrolman that night and his spark was the law and no one disputed its authority. Once again during the long night, an amateur sent out a call, but he also bowed to the reproving signals from old "D. R."

All through the night, they labored at their task, and when morning came, fragmentary records of the messages sent out by the *Salem,* pieced together with the messages copied by the Newport Naval Station, enabled the newspapers to bring cheer to the homes of many, by the publication of a full list of the survivors of the *Titanic.*

On many occasions, the amateur has been of aid to the newspapers. Owing to the law regarding the secrecy of messages, he must be very careful in giving out for publication that which he hears over the wireless. Some time ago an amateur of Farmington, Conn, overheard on his wireless set an S O S sent out by a United States submarine that was sinking in Long Island Sound. The distress call was answered by a naval station, and rescuers sent to its aid. The amateur communicated this story to a local newspaper, and enabled them to secure a "beat." Whereas, no particular harm was done in this instance, and it served to indicate the alertness of the amateur, still, such procedure is not strictly in accordance with United States regulation.

In 1914, shortly after the outbreak of the War, an amateur who had a station near Portland, Maine, kept the eastern part of the country in a furor with his tales of impending battles off the Atlantic Coast, between

British and German cruisers. At that time, the German cruisers *Dresden* and *Karlsruhe* were off the coast, receiving instructions from the German wireless station at Sayville, L. I. The British cruisers were communicating with Halifax and Bermuda. All communications were in secret cipher code, but this amateur discovered that by listening to these code messages over a period of many hours at a time, he could identify them, for, owing to the newness of the war codes to the operators on the British cruisers, they would, from time to time, through force of habit, sign the official call letters of their ships, instead of the secret calls which they were supposed to use, thereby divulging their identity. By constant attention, this amateur could tell the approximate position of the cruisers, owing to the change in signal strength, and soon he had a complete list of the British cruisers off the Atlantic Coast, and also the German cruisers. He supplied this information to the newspapers, who used it to decided advantage, and some really exciting stories were thus secured.

At another time, the same operator overheard a message sent out by the *Lusitania* asking for assistance and saying that she was being pursued by German cruisers. As he was afraid that it might be a violation of the law to utilize this message, he communicated by radio with the government station near by, and had the distress call from the *Lusitania* confirmed directly to him. Now possessing this information legally, he communicated the same to a newspaper, and to the Associated Press. Considerable excitement was caused by the news, which did not abate until it was discovered that the German cruisers, which the *Lusitania* thought were pursuing her, were in reality American warships. This occurrence took place in the late summer of 1914, nearly two years before the *Lusitania* was sunk by German submarines.

As before stated, such news-gathering activities by amateurs are only praiseworthy when strict observance of the laws of secrecy are adhered to.

Many more instances could be cited of amateur radio service to the public. Certainly the record which the amateur has made for himself makes him worthy of the assistance and protection given him by the United States Government.

CHAPTER XVI

"WHAT CAN I HEAR ON THE RADIO?"

Broadcasting stations—Ship and shore radiophoning—Radiophone at Santa Catalina—Across the continent—Political campaigning—Government health reports—News and sporting events broadcasted—Prominent men speak—Universities broadcast lectures—Dr. Steinmetz talks—Opera—Religious services—Concerts—An appeal for the Near East Relief by Dr. Stephen S. Wise—Broadcasting a complete show—Bedtime stories—After-dinner speeches.

The principal interest to a person who is about to install a receiving station is the question, "What can I hear?" Until the code has been mastered, reception will naturally be limited to radiophone. At the present time this limitation is not serious, for there are many radiophones to be heard.

Broadcasting Stations.—First of all, of course, are the broadcasting stations, some of which are in constant operation throughout the day and night, with the possible exception of a few hours after midnight, and even then with a sensitive receiver you can hear some entertainment from distant points due the difference in time.

A list of broadcasting stations will be found in the Appendix and, in the chapter on Government Radio, will be found some of the government stations that broadcast. The daily newspapers in most cities and towns are now giving a list of broadcasting stations with their programs from day to day. The Department of Commerce will also supply an up-to-date list.

At the present time, several department stores have installed radiophone broadcasting stations, and from time to time undoubtedly others will join the ranks. These broadcasting stations send out concerts and in-

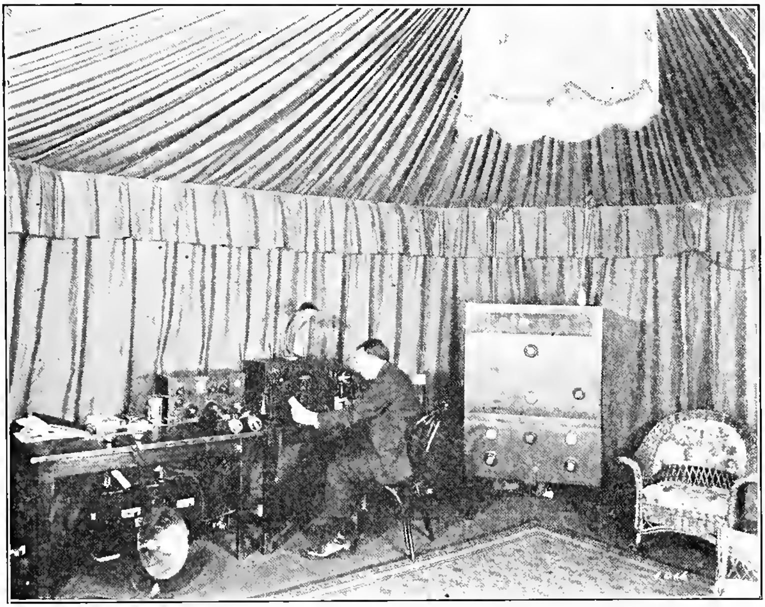


FIG. 166.—Interior of a broadcasting station. Note the hangings which are to prevent reverberation.

teresting information throughout the day and prove a source of entertainment and instruction to those who are able to listen in during these hours.

Ship and Shore Radiophoning.—Another interesting feature for those who do not know the code is the tests that are being conducted between shore stations and steamers over the radio telephone. The principal tests conducted thus far have been between the Deal Beach Station (2XJ) of the American Telephone and Telegraph Company and the *America* (KDOW). Conversations between these two stations have been heard by private stations at times until the steamer was 1,600 miles away. Connections were made between Deal Beach and the land telephone, and those who were fortunate enough to be listening in were able to hear many prominent men talk to passengers on board the steamer.

Of course, this type of listening in is not meant for the general public, although it is neither illegal nor unethical to intercept these conversations, providing any information learned by this means is kept strictly in confidence, for, notwithstanding the fact that it is possible for hundreds of thousands of people to listen to these conversations, the divulging of the same is considered, under the law, to be the same as tapping a telephone wire. We repeat, however, that for one's own personal pleasure, these conversations may be intercepted.

There are several appliances that have been invented which will make it difficult to overhear such radiophone conversations, but at the present time they have not been adopted, and in all probability the general public will be able to listen to private radiophone talks for some time to come.

Radiophone at Santa Catalina Island.—For those living in the far West and on the Pacific Coast, the conversations *via* radiophone from Santa Catalina Island to Los Angeles are a source of much interest. Here the radiophone serves as a link between the famous resorts at Santa Catalina and the mainland, and is a part of the regular telephone system. It is perhaps the first practical use to which the radiophone has been put for public communication.

Several years ago, a demonstration was made of the practicability of this link in long distance communication, when the telephone operator at Avalon talked to the *Gloucester,* one hundred miles out in the Atlantic Ocean, *via* radiophone to Long Beach, California, and long distance telephone to Deal Beach, New Jersey, and from there by means of radiophone to the steamer. The conversation was had in both directions, and the Captain of the *Gloucester* talked easily to the operator in California, notwithstanding the fact that the *Gloucester* was at the moment in the throes of a rather severe storm.

The instrument which made this feat possible was the vacuum tube, which not only supplied the power for transmitting the voice through the ether, but was also used for amplifying and transmitting the voice over the land line from coast to coast, and also for receiving the radiophone. To-day all long distance line telephony is accomplished with the assistance of the vacuum tube.

The system used at Santa Catalina Island is known as "duplex," that is, conversations can be had in both directions at the same time, without throwing switches, in the same manner as a conversation is had over the ordinary telephone.

Although the distance between the two radio stations in California is but thirty-one miles, it is necessary to use a fairly large amount of power, in order that the service may be constant. This power, which is just sufficient to carry on normal traffic during unfavorable atmospheric conditions, is sufficient under good conditions to transmit over great distances, and the Santa Catalina radiophone has been heard on a number of occasions on the Atlantic Coast, and has also been heard as far away as New Zealand, over five thousand miles from Avalon!

Political Campaigning.—Another feature of the radiophone that promises to be of interest is its use in political campaigning. Recently, Senator New was invited to talk at a political meeting in Indianapolis, and owing to his duties in Washington was unable to attend. However, this in no way daunted the campaign managers in Indianapolis. They arranged for Senator New to deliver his address in Washington and have it transmitted over the radiophone from the government broadcasting station at Anacostia, D. C., to the meeting hall in Indianapolis. This test was carried on successfully. It might be added that it gave the Senator's political opponents something to talk about in the Senate, for several senators vigorously objected to the use of the government radio service for political purposes. This illustrates some of the new problems that will be interjected into our national politics, due to the use of the radiophone.

Government Health Reports.—The Government Station at Anacostia, D. C., call letters NOF, broadcasts Government Health Reports which are of great interest to the public and in many cases serve as a substitute for the doctor in the prevention of sickness and even in the treatment of minor ailments. For instance, one evening the author listened to a talk on the care of the eyes of infants. Such instruction, given directly by the United States government to the people, is of inestimable value.

The broadcasting stations supply not only music and similar entertainment, but keep the public informed as to the latest news, local, national and international, and sporting events and also afford the opportunity for many people to hear prominent men speak. In Pittsburgh, almost every night some prominent local man talks on a problem which affects the public; bank presidents, insurance company officers, heads of charitable organizations, representatives of public welfare organizations all contribute to the education of the general public *via* radiophone.

Universities are commencing to broadcast lectures. Recently, Dr. Chas. P. Steinmetz, one of the greatest scientists in the world, gave a talk on certain electrical phenomena from the station of the General Electric Company at Schenectady, N. Y., call letters WGY.

Prominent impresarios, prior to the rendition of an opera or piece of music, over the radiophone, describe the technical features of the score, as well as giving a synopsis of the opera.

Well-known ministers deliver sermons from the broadcasting stations, and in Pittsburgh, at station KDKA, direct wire connection is had with several churches whose services are broadcasted. During the course of one of these services, which the author had the privilege of hearing at his station over 500 miles away, the minister, Dr. Van Etten of the Calvary Episcopal Church in Pittsburgh, read some of the letters that he received from people at distant points, in which they expressed their appreciation of being able to listen to services, although for various reasons they were unable to attend church. Some of these letters which came from bedridden invalids were pathetic.

One of the uses to which broadcasting can be put was illustrated by Dr. Van Etten when he told his unseen congregation, as well as his visible congregation in the church, how the telephone company at Carthage, N. Y., received one of his sermons and connected their instruments to the line telephone system and enabled every telephone subscriber in Carthage to listen to the services at a church over 600 miles away!

During the 1921 season of the Chicago Opera Company, every performance was broadcasted from the radio station KYW of the Westinghouse Company in Chicago. This enabled tens of thousands of people, who otherwise would not have been able to attend the opera, to hear the prominent artists of the Opera Company.

At Pittsburgh frequently connections are made with the Carnegie Music Hall, so that the vast radio audience may listen to the prominent musicians. This is also done at times at station WBZ in Springfield, Mass., as well as at other stations.

Recently, Dr. Stephen S. Wise made an appeal on behalf of the relief of Armenian children for the Near East Relief, and the number of people that his appeal reached, and the response, were indeed gratifying.

The broadcasting of Ed Wynn's Broadway show, "The Perfect Fool," was a milestone in radiophone entertainment. Not only were all of the songs and dialogues distinctly heard over an immense area, but even the dancing was broadcasted, by having the dancers wear special clogs and leaving the visualizing of the dances itself to the imagination of the audience.

The rapid sophistication of our babies has been given a rather severe blow. Infantile skepticism regarding the existence of a man in the moon and of fairies is rapidly being shaken, for who would not believe in fairies when he is able to hear them talk every evening at bedtime, and when "the man in the moon" talks over the telephone, surely that is sufficient proof that he exists! "Brer Rabbit" and all the other such animals have also proven their existence.

After the little ones are in bed, Father need not don his dinner clothes, in order to hear the Honorable Mr. So-and-So, who is to be the principal speaker at some banquet, but can sit comfortably at home and listen to the speech over the radiophone, and if, due to the Volstead Act or other causes, the speech proves to be boring, it is not necessary that he torture himself and sit through it in its entirety a mere turn of a switch will bring in some other form of instruction or entertainment which may be more suitable to the listener's mood.

The instruction and entertainment that can be had over the radiophone without knowing the code is considerable, but, by learning the code, so much more entertainment can be had, and so much more that is useful can be brought into the home, that it will amply repay any one who installs a radiophone to learn the code as soon as possible.

At school, we learned how Uncle Sam endeavors to take care of his people and in a more or less abstract way we attempted to visualize the benefits which our government affords the people. The radiophone and radio telegraph have taken government helpfulness from an abstract generality into the realm of personal helpfulness. The following chapters are devoted to Government Radio Service.

CHAPTER XVII

UNITED STATES GOVERNMENT RADIO SERVICE WAR AND NAVY DEPARTMENTS

Captain Samuel W. Bryant, U.S.N., in charge of all naval radio—Lines of communication cover over half the globe—Great chain of British and French government stations—"Navy is peculiarly indebted to amateurs," says Capt. Bryant—Naval radio school at Harvard University—Amateurs serve on sub-chasers and other auxiliary naval vessels during war—Navy first to realize contact to be had with people through radio—Marconi brings radio to United States in 1899 for reporting race between *Shamrock* and *Columbia*—Navy becomes interested—Installs several ship stations—First shore station at Atlantic Highlands—Present naval radio system—$23,000,000.00 invested in naval radio equipment—President Roosevelt appoints interdepartmental board to consider government radio organization—Public service work of naval radio—List of stations sending time signals—Following sun around the world—Weather reports and marine information—Long distance naval radio circuits—Air service—Land stations—Radio compass stations—Light ship stations—Radio service in War Department.

While in Washington the author had the pleasure of meeting Captain Samuel W. Bryant, U.S.N., who is in charge of all radio communication of the Navy Department. Capt. Bryant is most enthusiastic over the work of the U S. Navy in radio. On a large globe, which he has in his office, he showed the writer the lines of radio communication of the United States government, which cover over half the surface of the globe. No country has a more complete system of communication with its outlying territories, than has the United States. The magnitude of this is described further on in this chapter.

Captain Bryant pointed out the great chain of radio stations of the British Government, which keeps London in communication with all the colonies. France also is kept in communication with all her territory by means of radio. The combined chains of radio communication of these three great countries reach almost every corner of the globe.

The writer asked Captain Bryant whether he considered the amateur radio activities in the United States an advantage or a disadvantage to the Navy. Captain Bryant smiled and pointed to a large photograph on the wall opposite him. "The Navy is peculiarly indebted to the amateur," he said. "All those young men in uniform in that picture, numbering about 500, are ex-amateurs, who, after a short course in the Naval Radio School temporarily established at Harvard University during the Great War, were ready for service on transports, submarine chasers and other auxiliary naval vessels. Without the amateur, we would not have had sufficient radio operators to properly man our ships during the war. The Navy Department will do all in its power to further the interests of the amateur and to assist in building up this potential strength of a most important branch of the Navy."

The U. S. Navy was the first to realize the contact that can be had, by means of radio from Washington, with each and every inhabitant of our great country.

Long before the radio broadcasting station came into existence, Uncle Sam was using the radio telegraph as a means of keeping in close touch with the people. His principal concern, in the earlier stages of radio, was for those on board his ships, either the Navy or the Merchant Marine, and many services were rendered by the government to the ships, *via* radio. Time signals, hydrographic reports, press service, all of these and many other features, were to be had without cost.

Many people believe that the government is opposed to amateur activities in radio telegraphy. This is far from the fact, as, for a number of years, the government has been broadcasting news and helpful information to the amateur, and in fact installed the radio station at Anacostia, D. C., principally in order to carry on experiments with the amateur.

Naval Radio in Early Days.—A few words as to the magnitude of the Government Radio Service will no doubt be of interest.

The Navy Department was the first department of the government to interest itself actively in radio matters. In 1899, Guglielmo Marconi brought some radio apparatus to the United States to be used by the New York *Herald* for reporting the international yacht races between the *Shamrock* and the *Columbia*. The Navy Department appointed a board of four officers to observe and report the working of this new system of telegraphy. The Department thought sufficient of the results to place the armored cruiser *New York*, the battleship *Massachusetts*, and the torpedo boat *Porter* at the disposal of Marconi for further experiments with a shore station established near Sandy Hook at the entrance to New York Harbor.

This first government station consisted of an antenna attached to a flagpole near the dwelling of the lighthouse keeper at Atlantic Highlands. It was the first radio shore station used in the United States. Somewhat later, a commercial station was erected near the same spot, with an antenna 165 feet high. This was destroyed by fire in November, 1905. In 1903 a naval station was built near the same site, and was abandoned in 1906. This was the modest beginning of the now extensive system of radio stations controlled by the Navy Department.

Present Naval Radio System.—The present Naval Radio System embraces 183 shore stations and about 500 ship installations, with every known type of apparatus from the most powerful long distance equipment to the smallest portable outfits, and is by far the most extensive single radio organization in this country, if not in the world. Its outlook upon the whole radio field in the political, as well as in the commercial and technical aspects, is much wider than that of any other domestic organization. By virtue of its large material establishment, it is the natural recipient of the first presentations of new developments in the art made by commercial companies and individual experimenters. The phenomena observed and the problems encountered in so wide a field of activity present much material for research work that never comes to the attention of even the largest commercial concerns. So far as the Navy Radio establishment can be compared to any similar

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effect. This put the control of all the coast radio stations virtually under the jurisdiction of the Navy Department, and, from that time to this, no other department has operated coast stations, with the exception of a few Signal Corps Stations in Alaska, which are a part of the Washington-Alaska-Military Cable and Telegraph System.

Naturally, with a chain of radio stations such as this, other uses than those merely based on military considerations were found, and the stations were soon being devoted largely to the shipping interests. This service includes transmission of news to ships while at sea, also weather reports, dangers to navigation, and also for handling distress calls from ships at sea.

The entire coast line of the United States and its possessions is covered by Naval radio stations, so that it is possible for any vessel fitted with radio apparatus of normal power to be always in communication with the shore and from the shore to all parts of the world served by telegraphs and cables.

In the vicinity of the principal ports of the Atlantic, Gulf and Pacific coast are situated Naval radio compass stations, by means of which vessels are enabled to have their positions fixed to guide them safely in to the various harbors, during foggy or thick weather. Aircraft passing along the coast are enabled to keep in constant communication and may obtain bearings by means of the Naval coast stations and Naval radio compass stations.

The position of ships in distress may be fixed by means of the Naval radio compass stations, thus enabling assistance to reach them without loss of time, due to incorrect reckoning on the part of the ship in distress. This has actually occurred in many instances.

Naval radio stations send out time signals for the use of the mariner in checking chronometers, and, incidentally, all places inland where receiving sets are available and are in range use these time signals to check their clocks.

Information concerning dangers to navigation is sent out by coast stations at regular times.

Meteorological information collected and compiled by the Weather Bureau is sent out on regular daily schedules for the information of mariners and any interested activities inland.

Naval Coast Radio stations receive and forward positions of ships to a central office in New York, where this information is compiled and published by the Naval Communication service in the Daily Shipping Bulletin (a publication containing information as to location of ships in all parts of the world.)

Time Signals.—In 1905, the transmission of time signals to vessels at sea was commenced by the United States and has extended with much improvement to this time. The service is of great value to mariners, furnishing, as it does, a means by which the standard time can be compared with the ship's chronometer, and the error of the chronometer discovered. By means of similar comparison over a duration of time, the rate of gain or loss by the chronometer can be ascertained and corrected.

According to Admiral W. H. G. Bullard, U. S. N., in a paper delivered before the Institute of Radio Engineers at Washington, D. C., the following method of transmitting time signals is used: "The noontime signal on the Atlantic Coast is sent out through the United States Radio Stations by connection with Western Union Telegraph lines from the U. S. N. Observatory at Washington, D. C. By the operation of proper relays in electrical circuits, the beats of the seconds of a standard clock in the observatory are sent out broadcast, as a series of radio dots, commencing five minutes before the time of the final signal. By omitting certain dots in a series, the comparison between the dots and the beats of the chronometer seconds can be checked until the instant of local noon (75th meridian time) is reached. This is marked by a longer dot which gives the time of exact noon. A comparison with the chronometer time at that instant gives its error, referred to 75th meridian time. Applying the difference in longitude, namely 5 hours, between the 75th meridian and Greenwich, which is standard meridian (or 0° longitude), the error of the chronometer referred to Greenwich mean time is determined.

Time signals are now sent out through the stations listed on the following page.

In case of failure, for any reason, of the Arlington high-power station, the signals can be sent out by a small set in the same station, and the stations at Boston, Newport, Norfolk and Chicago are notified, and they each send the signals broadcast. Any ship, whether it has a complete radio installation or not, can receive time

Radio Stations Sending Time Signals

Station	*Call*	*Wave Length*	*Time*
Annapolis, Md.	NSS	17,000 Arc	Noon, 10:00 p.m. 75th meridian standard time
Washington, D. C.	NAA	2,500	Noon, 10:00 p.m. 75th meridian standard time
Key West, Fla.	NAR	1,500	Noon, 10:00 p.m. 75th meridian standard time
New Orleans, La.	NAT	1,000	Noon, 75th meridian standard time
Darien, C. Z.	NBA	7,000 (undamped)	1:00 p.m. & 5:00 a.m., 75th meridian standard time
Honolulu ....Arc	NPM	800	From 2,355 to 2,400 GMT.
Cavite, Philippine Is...	NPO	952	From 0,255 to 0,300 GMT and from 1,355 to 1,400 GMT.
Pt. Arguello, Cal.[1]	NPK	1,512	Noon, 120th meridian standard time
North Head, Wash.[1] ..	NPE	2,800	Noon, 120th meridian standard time
San Francisco, Cal.	NPG	2,400 Spark	Noon, 120th meridian standard time
San Francisco, Cal.	NPG	4,800 Arc	Noon, 120th meridian standard time
Great Lakes, Ill.	NAJ	1,512	11:00 a.m. 90th meridian standard time
Eureka, Cal.	NPW	2,000	Noon, 120th meridian standard time
Balboa	NBA	7,000 (undamped-Chopper)	1 p.m. and 5 a.m., 75th meridian standard time
Colon	NAX	1,500	1 p.m. and 5 a.m., 75th meridian standard time
San Diego, Cal.	NPL	2,400 Spark	Noon, 120th meridian standard time
San Diego, Cal.[1]		9,800 Arc	Noon, 120th meridian standard time
Pearl Harbor, T. H. ...	NPM	11,200 Arc	At 180th meridian, mean noon
Pearl Harbor, T. H. ...	NPM	600 Spark	At 180th meridian, mean noon

[1] Time signals not sent on Sundays and holidays.

signals. Simple receiving outfits, such as are described in this book, will suffice for such reception.

All private receiving stations that can tune to the various wave lengths for time reception can make use of this service of the government, and it is a decided convenience, in the average home, to be able to have the clocks keep accurate time. Careful study of the wave lengths and method of transmission, that is, spark or arc, should be made by the prospective installer of a receiving outfit, so that the apparatus installed has sufficient range of wave lengths to receive the time signals from some station within range. With vacuum-tube sets and a range of wave lengths up to 17,000 meters, all the time signals in the United States and territories should be received.

The author made the experiment recently of following the sun around a good portion of the globe. Starting with the noon signal at Arlington, he listened successively to the noon signal at Darien, Canal Zone, which was sent out at 1:00 o'clock Eastern Standard Time, the noon signal at San Diego, California, which was sent out at 3:00 P. M. Eastern Standard Time, and then the noon signal from Honolulu, Hawaiian Islands, which was sent out at 7:00 P.M. Eastern Standard Time.

It is also possible to hear the European stations sending out time signals, and to follow the sun more than half around the earth. The Eiffel Tower in Paris, call letters FL, sends out the time daily on 2,500 meters wave length commencing at 9:56 A.M. Greenwich time. The station at Nauen, Germany, POZ, sends out time signals at 11:56 P.M., 12:00 midnight, on 3,000 meter wave length. The station at Funabashi, Japan, call letters JJC, sends the time signals on 3,500 meters, starting 8:59 P.M. Central Japanese time, 135 east meridian. The Japanese station does not send time signals on Sunday.

Listening for the time signals over great distances is most interesting, and is perhaps one of the more vivid means of realizing the enormous distances covered by the radio.

Some of the radiophone broadcasting stations send out time signals *via* radiophone, so that the stations that are unable to tune to as high wave length as is used for transmitting time signals will be able to correct their watches. This transmission is really a form of relaying: the broadcasting station receives on another aerial the time signals, and amplifies them sufficiently to transmit by means of the microphone transmitter of the radiophone.

Weather Reports.—At noon and 10:00 P.M., 75th meridian time, Arlington, NAA, broadcasts the weather immediately after the time signals, on 2,500 meters, as well as a special bulletin on weather conditions along the coast. After this, a special forecast of the probable winds to be experienced several hundred miles off shore is made by the United States Weather Bureau. This also includes warnings of severe storms along the coast.

At 10:00 A.M. and 10:00 P.M. (90th meridian time), reports of the same character are sent by Great Lakes (NAJ) on 1,512 meters, and at 10:00 P.M. (120th meridian time) by North Head, Wash., San Francisco, Cal., and San Diego, Cal., immediately after time signals. The Pacific Coast stations broadcast the information first on their working wave, next on 952 meters, and then on 600 meters. These reports are preceded by "USWBSF," the "SF" standing for San Francisco. At Great Lakes, storm warnings are sent out as soon as received, and are broadcasted every four hours the next day.

Weather reports are also broadcasted by all Pacific Coast Stations at 8:00 A.M., Noon, 4:00 P.M. and 8:00 P.M. Cape Blanco broadcasts Totoosh, North Head and Eureka weather after local report. At 8:00 A.M. and 8:00 P.M., Eureka broadcasts the 6:00 A.M. and 6:00 P.M. weather conditions at Farrallones; Farallones broadcasts the 6:00 A.M. and 6:00 P.M. weather conditions at Eureka, and 7:00 A.M. and 7:00 P.M. conditions at Pt. Arguello, while, at the same time, Pt. Arguello broadcasts the 7:00 A.M. and 7:00 P.M. weather conditions at the Farallones.

The following system is used for weather reports: After the time signals, the letters USWB are sent. Then the weather conditions are transmitted by a number of groups of five figures, preceded by one or two letters which indicate the point from which the weather conditions are reported, as follows:

Atlantic Coast	
Sydney	S
Nantucket	T
Delaware Breakwater	DB
Hatteras	H
Charleston	C
Key West	K
Pensacola	P
Bermuda	B

Great Lakes	
Duluth	DU
Marquette	M
Sault Ste. Marie	U
Green Bay	G
Chicago	CH
Alpena	L
Detroit	D
Cleveland	V
Buffalo	F

PACIFIC COAST

Totoosh	T
North Head	NH
Eureka	E
San Francisco	SF
San Diego	SD

The first three figures of each group are the last three figures of the barometer reading. The fourth figure is the direction of the wind, where 1 indicates north wind, 2 indicates northeast wind, 3 east, 4 southeast, 5 south, 6 southwest, 7 west, 8 northwest. The fifth figure is the force of the wind, according to the Beaufort Scale, which is as follows:

0—Calm	0 to 3 miles per hour
1—Light air	8 miles per hour
2—Light breezes	13 " " "
3—Gentle breezes	18 " " "
4—Mild breezes	23 " " "
5—Fresh breezes	28 " " "
6—Strong breezes	34 " " "
7—Mild gale	40 " " "
8—Fresh gale	48 " " "
9—Strong gale	56 " " "
10—Whole gale	65 " " "
11—Storm	75 " " "
12—Hurricane	90 miles per hour or over

Let us take, for instance, a code signal DB00352. DB stands for Delaware Breakwater; the figure 003 stands for a barometer reading of 30.03 inches; the next figure, 5, shows the direction of the wind which is south; and the last figure represents the velocity of the wind, which is "light breezes," 13 miles per hour.

Information concerning wrecks, derelicts, icebergs, and other dangerous obstructions to navigation, is broadcasted from naval stations four times a day: at

8 A.M., noon, 4 P.M. and 8 P.M., as well as after the time signals. The International Convention on Safety of Life at Sea, which convened in London on November 12, 1913, probably due to the then comparatively recent disaster that overtook the *Titanic,* invited the Government of the United States to undertake the management of the services of derelict destruction, and other services connected with the study and observation of ice conditions, and the water patrol in the North Atlantic. By the terms of this convention, the master of every ship which meets with ice or derelicts is bound to communicate the information to the ships in the vicinity, and to authorities at the first point of the coast, with which he can communicate by radio or signal. This information is forwarded to the hydrographic office in New York and is made known to the maritime exchanges, and also is forwarded to headquarters at Washington, to be broadcasted from the Arlington Radio Station and from other naval stations.

Whenever a Naval Radio Station receives information from a branch hydrographic office concerning any danger to navigation or wreck or light vessel off station, that radio station immediately broadcasts the information for the benefit of shipping in the vicinity, and again thereafter at the usual hours, as before stated.

About 500 naval vessels are equipped with radio apparatus. It is hardly necessary to state that these are necessary to our fleets' efficiency, inasmuch as the whole structure of modern naval war operations, and to a large extent, the routine peace administration of the fleets, rest upon a foundation of efficient radio communication. The Naval Radio system is an integral part of the navy and it must be maintained and operated during peace in the same manner and for the same reasons that the floating Navy itself must be so maintained. The radio stations on Naval vessels are of necessity operated by Naval personnel.

The Naval Radio Service on the Great Lakes consists of a network of 17 stations extending from Buffalo to Duluth and Chicago. These stations are primarily concerned with the handling of commercial traffic and between vessels on the Lakes. The station at the Great Lakes Training Station handles P.O. air mail traffic, and the Cleveland Station is also equipped to do so. Time signals and weather forecasts are sent out from certain of these stations on regular daily schedules for the benefit of ships or inland stations capable of receiving the reports by radio.

Long Distance Naval Communication.—The Naval Communication Service maintains communication by radio between the United States (continental limits) and all outlying island possessions, to

The Virgin Islands	Hawaiian Islands
Porto Rico	Samoan Islands
Canal Zone	Mariana Island
Aleutian Islands—Pribilof Islands	Philippine Islands

Service to other government departments is furnished free of charges to the above points from the appropriate United States Naval coast station on the Atlantic and Pacific Coasts.

The Naval Communication service furnishes service by radio between all of the above possessions.

Two Naval radio circuits to Alaska are maintained and operated by the Navy, for Government, commercial and press traffic. These serve as alternate routes when the War Department's Alaskan cable is interrupted. Numerous canning companies in Alaska with radio stations at their establishments handle their messages via the nearest Naval radio stations, from which the messages are forwarded.

Service to foreign countries by means of Naval radio stations is maintained as follows:

France
Italy
Belgium (receiving)
Turkey (Constantinople receiving)
Santo Domingo
Haiti
Cuba (Guantanamo)
Nicaragua
Guatemala
Panama
Colombia
Java
French Indo-China
Siberia (Vladivostok and Auadyr)
China (Peking)
Fiji Islands
Papeete—Tahiti

In Europe, the Naval Communication Service supervises personnel at London, Paris, Poitiers, Vienna, Warsaw, Budapest, Prague, Mahrisch, Ostrau, Constantinople, for handling United States Army and Naval communications as well as those of the American Relief Administration and Reparations Commission, American Commercial concerns in the Near East, Near East Relief Association, American Embassies and Legations, American Red Cross, Joint Distribution

Committee, Newspapers (American-European Edition) and the United States Shipping Board. This entire system comes under the Navy for operation, as a result of special arrangements made after the Armistice.

Air Service Communications.—The Naval Communication Service provides special facilities for communication with all aircraft equipped with radio apparatus. All Naval air stations have their own radio stations, used for communication with aircraft exclusively. Whenever a flight is to be made, advance notice is sent to all radio and radio direction finding stations along the route. One or more stations guard each flight on a previously designated wave length, until the aircraft arrives at its destination. Notice of each flight is sent through the District Communication Office of each district covered by the flight, as well as time of departure, progress of flight and arrival of plane. It is, therefore, the purpose of the Communication Service to keep in touch with all aeroplanes in flight, by means of its radio stations, forwarding all information along the route. On numerous occasions, Naval radio stations have forwarded reports on weather conditions to planes in flight, thus informing them in advance of the weather along the line of flight.

In addition to handling all communications to and from aircraft, all direction finding stations cut in the position of planes, and report their positions to all district radio stations. By means of its coastal telephone connections with Coast Guard Stations, the Communication Service is enabled immediately to report any planes in distress to the coastal life-saving stations in the vicinity of the plane.

All the facilities of the Naval Communication Service for aircraft are available for all Government planes and for all civilian aviators, if they so desire.

Coöperation of the Post-Office Air Mail Service.—By agreement with the Post Office Department, naval radio stations are used wherever available to handle post office air mail radio traffic.

At present, naval radio stations at Washington, Philadelphia (weather only), Cleveland, Great Lakes, and San Francisco are handling post-office air mail traffic.

Daily Shipping Bulletin.—The Naval Communication Service issues at 39th Street Ferry Building, foot Whitehall Street, New York City, a publication known as the *Daily Shipping Bulletin.* This publication gives the daily movements, so far as can be obtained, of all ships in the world. The movements of ships are received in New York by means of cable, land wire and radio, the latter being employed to such good advantage to effect saving of tolls, that the movements of ships from all over the world are obtained at a reasonable expense.

In addition to the movements of vessels in and out of American and foreign ports, reports from ships at sea are received by all Naval Radio Stations on the coasts of the United States, and relayed to New York.

The subscribers to the *Daily Shipping Bulletin* are the large importers and exporters and large firms interested in maritime affairs. Although the field of subscribers is limited, they are willing to pay almost any price for the information obtained. It is thought that no other service in the United States could publish such a book as the *Daily Shipping Bulletin,* except at a prohibitive cost.

Number of shore to ship stations in operation by the Navy Department:

(*a*)	Atlantic Coast	44
(*b*)	Pacific Coast	20
(*c*)	Gulf Coast	10
(*d*)	Great Lakes Coast	17
(*e*)	Alaska	10
(*f*)	Outlying possessions	28
	Total	129

Number of shore to ship stations engaged in commercial work:

(*a*)	Atlantic Coast	16
(*b*)	Pacific Coast	13
(*c*)	Gulf Coast	8
(*d*)	Great Lakes Coast	17
(*e*)	Alaska	10
(*f*)	Outlying possessions	25
	Total	89

Number of radio compass stations:

(*a*)	Atlantic and Gulf Coasts	30
(*b*)	Pacific Coast	20
	Total	50

Names and location of all radio stations operated by the Navy Department; those engaged in commercial business are indicated by an *X*:

(*a*) ATLANTIC COAST

1. Sea Wall, Maine } *X*—2,400 meters only
2. Otter Cliffs, Maine }
3. Otter Cliffs (receiving), Maine }
4. Portland, Maine
5. Portsmouth, New Hampshire
6. Chelsea, Massachusetts
7. Boston, Massachusetts
8. North Truro, Massachusetts
9. Siasconsett, Massachusetts
10. Melville, Rhode Island
11. Newport, Rhode Island
12. Montauk, New York
13. Sayville, New York
14. Fire Island, New York
15. Rockaway, New York
16. Brooklyn, New York
17. Mantoloking, New York
18. New York City, New York
19. Philadelphia, Pennsylvania
20. Cape May, New Jersey
21. Baltimore, Maryland *X*
22. U. S. Naval Academy, Maryland *X* (when manned)
23. Annapolis, Maryland
24. Radio, Virginia
25. Navy Yard, Washington, District of Columbia
26. Anacostia, District of Columbia
27. Navy Dept. (receiving), Washington, D. C. *X*
28. Indian Head, Maryland
29. Dahlgren, Virginia

30. Blackistone Island, Maryland
31. Quantico, Virginia
32. Virginia Beach, Virginia *X*
33. Norfolk, Virginia *X*
34. Hampton Roads (receiving), Virginia *X*
35. Cape Hatteras, North Carolina *X*
36. Moorehead City, North Carolina *X*
37. Navy Yard, Charleston, South Carolina
38. Charleston (receiving), South Carolina *X*
39. Port Royal, South Carolina
40. Savannah, Georgia X
41. Jacksonville, Florida *X*
42. St. Augustine, Florida *X*
43. Jupiter Inlet, Florida *X*
44. Miami, Florida *X*

(*b*) PACIFIC COAST

1. Tatoosh, Washington *X*
2. Seattle, Washington *X*
3. Keyport, Washington *X*
4. Puget Sound, Washington *X*
5. Westport, Washington *X*
6. North Head, Washington *X*
7. Astoria, Oregon *X*
8. Marshfield, Oregon *X*
9. Eureka, California *X*
10. Mare Island, California *X*
11. South San Francisco, California *X*
12. Yerba Buena, California *X*
13. Farallones, California *X*
14. Point Arguello, California *X*
15. Avalon, California *X*
16. San Pedro, California *X*
17. Inglewood, California *X*
18. Chollas Heights, California *X*

19. Point Loma, California *X*
20. North Island, California *X*

(*c*) GULF COAST

1. Key West, Florida *X*
2. Key West (receiving), Florida *X*
3. St. Petersburg, Florida *X*
4. Pensacola, Florida *X*
5. Pensacola (receiving), Florida *X*
6. Mobile, Alabama *X*
7. New Orleans, Louisiana *X* Limited service with Grand Island Comp. Station
8. Port Arthur, Texas *X*
9. Galveston, Texas *X*
10. Point Isabel, Texas X

(*d*) GREAT LAKES COAST

1. Buffalo, New York *X*
2. Ashtabula, Ohio *X*
3. Cleveland, Ohio *X*
4. Detroit, Michigan *X*
5. Alpena, Michigan *X*
6. Detour Point, Michigan *X*
7. Manistique, Michigan *X*
8. Mackinac Island, Michigan *X*
9. Frankfort, Michigan *X*
10. Ludington, Michigan *X*
11. Chicago, Illinois *X*
12. Great Lakes, Illinois *X*
13. Milwaukee, Wisconsin *X*
14. Manitowoc, Wisconsin *X*
15. White Fish Point, Michigan *X*
16. Eagle Harbor, Michigan *X*
17. Duluth, Minnesota *X*

(*e*) ALASKA

1. St. Paul, Alaska *X*
2. St. George, Alaska *X*
3. Dutch Harbor, Alaska *X*
4. Kodiak, Alaska *X*
5. Seward, Alaska *X*
6. Cordova (Hanscom), Alaska *X*
7. Cordova (Eyak), Alaska *X*
8. Juneau, Alaska *X*
9. Sitka, Alaska *X*
10. Ketchikan, Alaska *X*

(*f*) OUTLYING POSSESSIONS

1. Guantanamo, Cuba *X*
2. Guantanamo (receiving), Cuba *X*
3. Nevassa Island, Cuba *X*
4. Port au Prince, Haiti *X*
5. Port au Prince (receiving), Haiti *X*
6. Cayey, Porto Rico *X*
7. San Juan, Porto Rico *X*
8. St. Thomas, Virgin Islands *X*
9. St. Croix, Virgin Islands *X*
10. Darien, Canal Zone *X*
11. Balboa, Canal Zone *X*
12. Coco Solo, Canal Zone *X*
13. Colon, Canal Zone *X*
14. Cape Mala, Panama *X*
15. La Palma, Panama *X*
16. Puerto Obaldia, Panama *X*
17. Managua, Nicaragua *X*
18. Pearl Harbor, Oahu *X*
19. Heeia Point, Oahu *X*
20. Wailupe, Oahu *X*
21. Tutuila, Samoa *X*

22. Guam (Yigo) *X*
23. Guam (Asan) *X*
24. Cavite, Philippine Islands *X*
25. Los Baños, Philippine Islands *X*
26. Olongapo, Philippine Islands *X*
27. Peking, China *X*
28. Russian Islands (Vladivostok), Russia *X*

RADIO COMPASS STATIONS

Maine
Otter Cliffs
Cape Elizabeth

Massachusetts
Gloucester
Deer Island
Fourth Cliff
Cape Cod
Chatham
Surfside

Rhode Island
Prices Neck

New York
Montauk
Fire Island
Rockaway Beach

New Jersey
Sandy Hook
Mantoloking
Cape May

Delaware
Cape Henlopen
Bethany Beach

Virginia
Hog Island
Cape Henry

North Carolina
Foyner's Hill
Cape Lookout
Cape Hatteras

South Carolina
North Island
Morris Island

Florida
Jupiter Inlet
Key West
Pensacola

Louisiana
Grand Island
Pass a Loutre
Burrwood

California
Imperial Beach
Point Loma
Avalon
Point Fermin
Point Hueneme

RADIO COMPASS STATIONS—*Cont.*

California—Cont.
Point Arguello
Eureka
Point Montara
Bird Island
Farallon Island
Point Reyes

Oregon
Empire
Fort Stevens

Washington
Smith Island
Tatoosh Point
Westport
Ocean Park
Cattle Point
New Dungeness
Port Angeles

LIGHTSHIP RADIO STATIONS

Installed and Operated by the Navy Department

	No.	Naval District
Portland	74	First
Boston	54	First
Nantucket Shoals	85	First
Handkerchief Shoals	3	First
Hen and Chickens	42	First
Stone Horse	5	First
Cross Rip	30	First
Brenton's Reef	39	First
Vineyard Sound	41	First
Pollock Rip	47	First
Great Round Shoals	66	First
South Shoal	90	First
Pollock Rip Slue	72	First
Relief	4	First
Relief	86	First
Cornfield	48	Third
Fire Island	68	Third
Ambrose Channel	87	Third
Scotland	11	Third
Fenwick Shoal	52	Fourth

LIGHTSHIP RADIO STATIONS—*Cont.*

	No.	Naval District
Five Fathom Bank	79	Fourth
Northeast End	44	Fourth
Overfalls	69	Fourth
Winter Quarter	91	Fourth
Cape Charles	101	Fifth
Cape Lookout Shoals	80	Fifth
Diamond Shoals	72	Fifth
Brunswick	84	Sixth
Charleston	34	Sixth
Frying Pan Shoals	94	Sixth
Martins Industry	1	Sixth
Heal Bank	81	Eighth
South Pass	102	Eighth
Blunts Reef	83	Twelfth
San Francisco	70	Thirteenth
Swiftsure	93	Thirteenth
Umatilla Reef	67	Thirteenth
Relief	92	Thirteenth

Total operators now on board 14
Total complement 45
Total vessels 39

Number and names of radio stations of the Navy Department engaged in transoceanic (long distance) work and circuits now operated:

1. Otter Cliffs (receiving)
2. Sayville
3. Annapolis
4. Navy Department (receiving)
5. San Diego
6. North Island (receiving)
7. Mare Island
8. Yerba Buena (receiving)

9. Keyport
10. Bremerton (receiving)
11. Astoria
12. Ketchikan
13. Cordova (Hanscom)
14. Cordova (Eyak receiving)
15. St. Paul
16. Russian Island
17. Pearl Harbor
18. Heeia Point
19. Wailupe (receiving)
20. Guam (Asan)
21. Guam (Yigo receiving)
22. Tutuila
23. Cavite
24. Los Baños

Circuits

Annapolis .... Nauen
Annapolis .... Lyons
Annapolis .... Rome
Annapolis .... San Diego
Annapolis .... Brussels (receiving). One way schedule.
Annapolis .... Flagship, Naval Forces Europe (receiving). One way schedule.
Annapolis (Trans.) .... Constantinople (receiving). One way schedule.

Cayey .... Sayville
Atlantic Fleet .... Sayville
Cayey .... Balboa
Pt. Isabel .... Guatemala

San Diego .... Pearl Harbor
San Diego .... Pacific Fleet
San Diego .... Balboa

CIRCUITS—*Cont.*

San Francisco ....Heeia Point

Keyport ....Cordova
St. Paul ....Russian Island (Vladivostok)

Astoria ....Ketchikan

Pearl Harbor ....Tutuila
Pearl Harbor—Guam ......Cavite
Cavite ....Russian Island
Cavite ....Peking
Russian Island ....Peking
Tutuila ....Fiji (via Apia)
Tutuila ....Papeete (via Apia)

Pearl Harbor ....Tutuila
Pearl Harbor ....Java
San Francisco—Pearl Harbor—Cavite—Saigon (Indo-China)

Press (news despatches) is handled on the following circuits:

Annapolis ....Lyons (France)
Annapolis ....Nauen (Germany)
Annapolis ....Porto Rico
San Francisco ....Honolulu
San Francisco ....Guam (thence via cable to Tokyo)
San Francisco ....Manila (thence broadcasted and copied in China)

RADIO SERVICE OF THE WAR DEPARTMENT

The Radio activities of the War Department may be divided into six phases or classes as follows:

1.—Stations in Alaska.

2.—Coast Defense Radio Stations including station at Fort Wood.

3.—Mexican Border Stations.

4.—Stations for use in connection with certain war plans.
5.—Air Service Radio Stations.
6.—Temporary field stations in connection with combat organizations.

Fifteen radio stations in Alaska form a part of the Alaskan communication cable and land line system. These stations are scattered throughout Alaska, connecting many far distant and isolated points with the outer world. From reports which have been received from the high officials of the Alaskan territorial government, the service has been efficient and very satisfactory to the sections which these stations are serving.

The Coast Defense Radio Stations, as the name implies, are a part of the Coast Defense systems of communication, their chief function being their use for fire control purposes and keeping its several forts in touch with Navy vessels and scouting ships. These stations are part of the Coast Defense of the land forces. The work of these stations is purely of a military character and cannot well be combined with commercial traffic.

Stations which form the radio net for certain war plans intercommunicate as far as possible between Corps Areas, holding periodic tests and exchanging official business where practicable. The training section of the Signal Corps plans to have these stations communicate with as many amateur operators as possible for cooperation with Army stations in time of internal strife or other emergency. The location, type, and range of these stations is as follows:

ARMY STATIONS

Location	*Approximate Range in Miles*	
	Radiotelegraph	*Radiophone*
1st Corps, Boston	100	15
2d Corps, Fort Wood	1,000	150
3d Corps, Fort Howard	1,000	150
4th Corps, Fort McPherson	1,000	150
Camp Benning	100	15
5th Corps, Fort Benjamin Harrison	1,000	150
6th Corps, Fort Sheridan	1,000	150
Fort Wayne, Mich.	100	15
7th Corps, Fort Crook (at Fort Omaha)	1,000	150
Jefferson Barracks	1,000	150
8th Corps, Fort Logan	100	15
9th Corps, Presidio of San Francisco	1,000	150
Fort Douglas	1,000	150
Fort D. A. Russell	1,000	150

In addition to the above, certain of the Army net stations, namely, Fort Benjamin Harrison, Fort Sheridan, Jefferson Barracks, Fort D. A. Russell, Fort Douglas and the Presidio of San Francisco, Cal., take over, to a large extent, the functions of the present temporary air mail radio stations, now existing at these points.

ARMY STATIONS ALONG THE MEXICAN BORDER

	Power	*Range*
Brownsville, Texas	5 KW	1,000 mi.
Fort Bliss, Texas	30 KW	3,000 mi.
Fort Huachuca, Arizona	10 KW	500 mi.
Fort McIntosh, Texas	10 KW	500 mi.
Marfa, Texas	10 KW	500 mi.
Fort Sam Houston, Texas	30 KW	3,000 mi.

Air-Service Radio Stations

Langley Field, Hampton, Va.
Mather Field, Sacramento, Calif.
Mitchel Field, Mineola, L. I.
Kelly Field, San Antonio, Texas
Rockwell Field, San Diego, Calif.
Ellington Field, Houston, Texas
Carlstrom Field, Arcadia, Fla.
Crissy Field, San Francisco, Calif.
Selfridge Field, Mt. Clemons, Mich.
Chanute Field, Rantoul, Ill.
Camp Lewis, Washington
Camp Bierne, Fort Bliss, Texas
Ross Field, Arcadia, Calif.
Scott Field, Belleville Ill.
Post Field, Fort Sill, Okla.

CHAPTER XVIII

UNITED STATES GOVERNMENT RADIO SERVICE—POST OFFICE DEPARTMENT AND DEPARTMENT OF AGRICULTURE

Broadcasting of market and crop reports—Location of broadcasting stations—Post Office air mail service—Schedule of Post Office Department air mail service for broadcasting crop reports—J. C. Edgerton, Superintendent of Radio Service of the Post Office Department—Piloting the first mail plane in United States—First letter sent by air—Photograph of letter with President Wilson's autograph—Radio makes possible night flying—How radio is used in airplanes for direction finding—Field localizing—Post Office Department may ultimately control all nonmilitary radio service of Government—Postmaster General Work tells of Mr. Edgerton's service to the Post Office Department—Department of Agriculture—Secretary Wallace discusses future of radio with the author—Says, "Farmers are installing their own receiving sets to get crop reports"—Radio in the forest service—How radio kept communication open in Idaho after great forest fire.

Uncle Sam takes care of his people on dry land, just as well as he does at sea, and for those who live in the interior, or who are dependent on the land for their living, he has provided a most useful service.

Broadcasting Crop and Market Reports.—In May, 1915, the United States Bureau of Markets and Crops was inaugurated, to give estimates on conditions covering the markets for live stock, vegetables, meats, dairy and poultry products, hay, feed, seed, etc. This information is secured by the Bureau's keeping in constant touch with all the agencies that have information of interest to the markets. For instance, the agricultural organizations and clubs, boards of trade, state agricultural departments.

This information was given to the public through many different channels, until on December 15, 1920, a radio service for broadcasting this information was commenced; the radio stations of the Post Office Department being located at Washington, D. C., Cincinnati, Ohio; Omaha, Nebraska; North Platte, Nebraska; Rock Springs, Wyoming; Elko, Nevada; Reno, Nevada. These reports are sent by means of the radio codes of dots and dashes, in a special form which can be supplied by the government. This form is in many ways similar to the form used by the United States Weather Bureau in sending out weather reports, and makes unnecessary the sending of lengthy messages. Unless supplied with this, the reports cannot be understood.[1] Copies of the form may be obtained from the United States Bureau of Markets and Crop Estimates, Department of Agriculture, Washington, D. C. The reports are sent at the rate of 15 words per minute, which is a speed that is not difficult for the novice to attain and, within a comparatively short time, any one who studies the code will have at his command sufficient knowledge to secure these government reports.

The information received from these stations is distributed by commercial clubs, banks, commercial exchanges, farmers' organizations, etc., but in many cases, wide-awake amateurs in farming districts copy these

[1] Copies of these forms are to be found in Appendix V.

reports and transmit them to the farmers by telephone or other means at their disposal. On many farms, where one or more members of the family have learned the code, the reports are received directly, and, naturally, it is of great advantage to a farmer to be able to receive

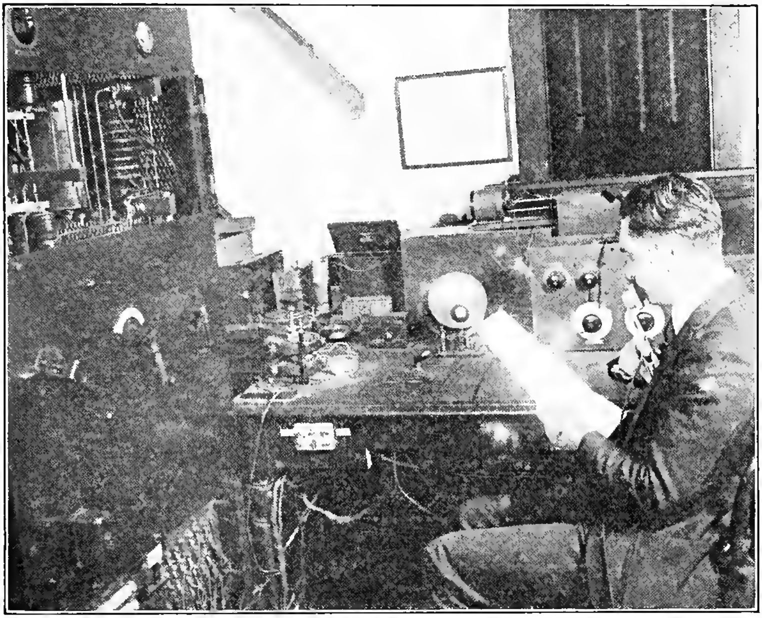

FIG. 168.—J. C. Edgerton, broadcasting a crop report from the radio broadcasting station of the Post Office Department in Washington, D. C.

instantaneously from his government conditions of the market for the products which he raises.

The post-office air-mail service stations were primarily intended for communication with the transcontinental and other mail planes, but inasmuch as their time is not entirely taken up with post-office business, the Bureau of Markets and Crop Estimates has made use

SCHEDULE OF AIR MAIL RADIO SERVICE

Station and Call Letters	*Nature of Reports*	*Form Used*	*Time of Transmission*	*Type of Transmission*
Washington, D. C.			*Eastern Time*	
	Washington Wholesale Fruits & Vegetable Reports	Press	10:30—10:50 a.m.	Phone, 1160 meters
	Live Stock Receipts, St. Louis and Chicago Hog Opening	41	12:30—12:50 p.m.	Tele. 1980 meters Tube C.W.
W W X	Live Stock, St. Louis and Chicago Close	20	2:15— 2:25 p.m.	Tele. 1980 meters Tube C.W.
	General Fruits and Vegetables	60A 60B	3:30— 3:40 p.m.	Tele. 1980 meters Tube C.W.
	Dairy Products, New York and Chicago	59	5:00— 5:10 p.m.	Phone, 1160 meters
	Grain	Press	5:00— 5:10 p.m.	Tele. 1980 meters Tube C.W.
	Live Stock and Grain	43	7:30— 7:40 p.m.	Phone, 1160 meters
	Fruits and Vegetables	60	8:00— 8:10 p.m.	Phone, 1160 meters
Omaha, Neb.			*Central Time*	2500 meters
	Live Stock Receipts	42	9:00— 9:15 a.m.	
	Chicago Live Stock	20	11:00—11:30 a.m.	
	Omaha Live Stock	20	12:00—12:30 p.m.	
K D E F	Kansas City Live Stock	20	1:00— 1:30 p.m.	arc (undamped)
	Grain	40	2:00— 2:15 p.m.	
	Chicago Live Stock	Press	4:30— 4:45 p.m.	
	Kansas City Live Stock	"	7:00— 7:15 p.m.	
	Omaha Live Stock	"	7:30— 7:45 p.m.	

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Fig. 169 is a photograph of the first letter to be sent by air mail. The letter was mailed in Washington and delivered in New York. It will be noted that the stamp was cancelled by President Wilson with his autograph.

Mr. Edgerton explained to the writer how airplanes are able to find their landing places during the night or

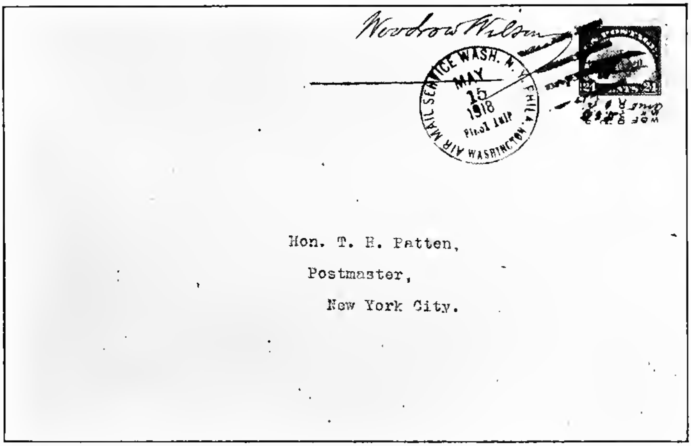

FIG. 169.—The envelope of the first letter sent by air mail in the United States. The stamp was canceled by President Wilson, who affixed his autograph to the envelope. It will be noted that the postmark contains the words, "May 15th, 1918—First Trip." This interesting envelope is part of the collection of U. S. stamps owned by Mr. Noah W. Taussig of New York.

during a fog. This method works out so well that, according to Mr. Edgerton, the Post Office Department plans shortly to inaugurate night flying, which will considerably shorten the time of the transcontinental flight, which now is accomplished in the remarkable time of about 35 hours. Mr. Edgerton explained that radio direction finders and other radio devices have been used for some time, to assist airplanes to land during the night, during fog or at other times when there is poor visibility.

Direction Finding by Radio in an Airplane.—The usual method of using radio to accomplish this purpose is to transmit from an ordinary elevated antenna, situated at the landing field, radio signals which are received on a direction finder carried on the airplane.

On small planes, the direction finder may be merely a coil of wire wound on the fuselage. On larger planes, it is customary to mount a small rotatable coil vertically in the after part of the plane. This method, while it gives the direction of the landing field, does not give accurate information as to its distance, when the airplane is flying close to the landing field.

Several years ago, the Post Office Department called upon the Bureau of Standards to assist in developing a method by which airplanes could accurately locate the landing field, when the airplane was flying close to it. The idea was to develop a means by which a good signal would be audible over a comparatively large area, when the airplane was at comparatively high altitudes, and would be localized within a small area when the airplane was near the ground.

Locating the Landing Field by Radio.—It can easily be understood that the accurate location of the landing field is most important to an airplane when nearing the ground. The method which they evolved, and which is now in use, is as follows: Two horizontal coils are placed, one above the other. The coils are identical in construction and are placed so that their axes coincide.

A high-frequency current in one coil flows in opposite direction to the current in the other. A current of about 300,000 cycles is used. The radiation from these coils is such that the signals are heard the strongest by the airplane flying in a given horizontal plane, whenever the plane is inside a comparatively small ring-shaped area located over the landing field. Signals are received on the airplane only when it is nearly above and in the immediate vicinity of the landing field. A vertical coil antenna is used for reception on the airplane, and if the airplane is flying horizontally, the maximum signal is received when the line joining the airplane to the transmitting coils makes an angle of 30 degrees with the vertical. The space over the landing field, in which the signal can be detected by the receiving instruments of the airplane has the form of an inverted cone. If a plane be drawn through the cone at any distance above the ground, the central part of the circle thus produced, would not give any audible signals, but toward the circumference of the circle there would be a condition of maximum audibility. Beyond the circumference, the signals would vanish. The limit of the region within which the signal is audible is dependent upon the sensitivity of the receiving apparatus, and is not as clearly defined as the bounding conical surfaces. When the airplane is directly over the transmitting station, the signal vanishes; also, when the airplane passes without the bounding conical surfaces, the signal vanishes. It is, therefore, easy to see how an airplane arriving at this inverted cone of electric waves can spiral to the desired point of the landing field by merely keeping within the zone of audibility. This system works out perfectly in practice.

The method just described works only when the airplane is over the field. For distant work, several other methods are used. One method is to equip the plane with a rotating coil, in addition to the coil used for field localizing. This rotating coil is a direction finder. The plane, flying between two points, let us say Washington and New York, wishes to determine its location. By using the rotating direction finder and pointing it toward the signals coming from the radio station in New York, the pilot is able to draw a line on a chart in the direction which the airplane bears to the landing field at New York. By the same means, he then takes bearings on, let us say, Pittsburgh, and then on Washington. His chart will then show three converging lines, and the intersection of these lines will be the exact position of the airplane.

Another method is as follows: the plane sends out signals to two or three direction finders at different points. These direction finding stations send the bearing of the plane by radio and the lines of direction are plotted out on the chart and the location is thus determined. Mr. Edgerton has worked out several charts with positions marked off in blocks, so that it is a simple matter for the operator on the plane to advise the landing field of his position at any time, by merely referring to the blocks on the chart.

Sometimes, only one operator is on a plane, and it is inconvenient to utilize the two methods just described. Such planes are now being equipped with a stationary coil, horizontal to the length of the airplane. The landing field station sends out a series of prearranged signals, in a manner similar to the flashing of a lighthouse. The pilot keeps these signals at maximum audibility by pointing the plane toward the station. When the plane has finally reached a point near enough to the landing field, he utilizes the other coil in the plane, previously described, for getting signals from the field localizer and is thereby enabled to make an accurate landing. Such a procedure is called "beacon flying."

Post Office Department May Take Over All Government Nonmilitary Radio.—Mr. Edgerton was a member of the conference which was called by Secretary Hoover to consider general questions concerning the regulation of radio communication. He is considered one of the best posted men on radio in Washington. Together with Postmaster General Work, Mr. Edgerton is preparing a bill to be introduced jointly in the Senate and the House of Representatives, which, if passed, will bring all civil activities of government radio under the jurisdiction of the Post Office Department. Mr. Edgerton believes that, whereas the War and Navy Departments should have absolute freedom in taking care of the military aspects of radio, the nonmilitary features should be under the jurisdiction of the Post Office Department, which is, after all, primarily the department of communications. The bill to be introduced will propose, firstly, to give to the Post Office Department, the complete control over all Government broadcasting, and, inasmuch as much of this work is now being done by this Department, it is not expected that many difficulties will be encountered in turning over to them this branch of government radio communication. Ultimately, it is hoped that the Post Office Department can take over the leased wires of the other Departments, which are not being used for military purposes, as well as all such radio stations.

Postmaster General Work expressed himself as being decidedly in favor of this plan. In telling the writer of Mr. Edgerton's work along these lines in the Post Office Department, he said: "Mr. Edgerton and I, together, know everything about radio in the Post Office, and I know nothing about it."

Department of Agriculture.—The Post Office Department carries on practically all the radio work for the Department of Agriculture. Secretary of Agriculture Wallace is heartily in favor of the Government's turning over its civil radio activities to the Post Office Department. In discussing with the writer the activities of the Post Office Department for the Department of Agriculture, Secretary Wallace said:

The farmers and ranchers in the Far West are finding the radiophone broadcasting of great value, for, owing to the relative inaccessibility of the rural population of the country, it has always been difficult for the Weather Bureau and other bureaus effectively to disseminate its information in these districts.

In certain rural sections, the commercial telephone has been employed for these purposes, but on ranches in the Far West, the service is not sufficiently organized to properly reach these people. By means of the radiophone, it is now possible to get important weather information into the hands of farmers, which is of great value to them in conducting farm operations, planting, harvesting, and in taking protective measures against cold waves and other injurious storm conditions. The Weather Bureau considers this means of quick communication of great importance, and especially does this become invaluable in times of violent disturbances like floods and hurricanes, which often interrupt communication in a way that not only prevents the collection of observations and reports, but also the dissemination by the Weather Bureau of valuable information into communities which are severed from the ordinary wire connection with the outside world.

At the time of the great Ohio Valley flood of 1913, many districts in Ohio and Indiana were cut off from telegraphic communication for many days, by the damages due to the flood. Radio stations in operation at that time would have been of inestimable benefit to the stricken communities.

According to Secretary Wallace, the farmer is installing his own radio receiving apparatus, and he believes that, in a comparatively short time, most of the farmers will have receiving stations of their own. Where this is not done, they will probably erect a community receiving station, so that all reports of value to the farmer can be received at this point and then disseminated.

A short time ago, when the Post Office Department radio station in St. Louis, which had been broadcasting crop and market reports, as well as weather reports, was shut down, about two thousand letters of protest were received by the Department. This indicates how dependent the farmers had become on this service, during its short duration.

Secretary Wallace believes that the radiophone fad will die out to some extent in the larger cities, where amusement and information are obtainable by other means, but it is his firm conviction that in the sparsely settled districts amongst the farmers and the ranchers, the use of the radiophone will steadily increase, as its benefits become more and more realized.

Radio in the Forest Service.—The author was unable to secure any information from the Department of Agriculture in Washington, regarding the use to which they were putting radio in their forestry work. Finally, he took the matter up with Mr. Fred Morrell, District Forester at Missoula, Montana, who was kind enough to supply him with the facts concerning the work that was being accomplished with radio in the forest service.

In January, 1919, the Forester, Mr. H. S. Graves, detailed Mr. R. B. Adams, Telephone Engineer of the Forest Service, to make a study of the possibilities of wireless telephone communication in the National Forest. Mr. Adams went to Washington, conferred with officers of the Army and Navy, together with manufacturing concerns, and borrowed from the War Department four low-powered wireless telephone sets for experimental purposes. Two of these were shipped to his headquarters in Missoula and two to the headquarters of District Six, in Portland, Oregon.

On June 26, Mr. Adams took these two sets to Lolo Hot Springs, Montana, at which place one station was erected. On July 11, one set was taken to Beaver Ridge, Idaho, which is across the main range of the Bitterroot Mountains from Lolo Hot Springs, a distance by trail of 30 miles. The estimated air line distance between the two points, Beaver Ridge and Lolo Hot Springs, is approximately 12 miles. This station was installed and everything made ready for a test.

The power problem was a big one, it being necessary to pack on horses a storage battery from Lolo Hot Springs to Beaver Ridge to operate a set in this back country. Three different attempts were made to get this battery in, and each time, on the first two trials, an accident happened whereby the battery was lost or destroyed in transit, due to the roughness of the trail and other peculiar difficulties. On the third trial, however, the battery arrived safely and on the morning of July 19, at eight o'clock, successful telephone communication was established between the two points. These sets remained operating and were used for every purpose for which the telephone would have been called upon until the last of August, when, due to severe fires in this country, Beaver Ridge, on which the set was located, became almost entirely surrounded by fire. It then seemed as if the lookout structure on top and everything would be destroyed.

The operator dismantled the set, carried it down the hill to a small lake where he built a raft and floated it out into the lake to protect it from destruction. The men fighting the fire were finally able to put it under control and the set was taken up again on the lookout, placed in service and the outside world informed of what had happened. This is given in contrast to what happened that same day on another part of the Clearwater National Forest where several miles of telephone line was destroyed and it was a week or ten days before communication was reëstablished. On the strength of these experiments, the following year additional equipment was obtained through the Navy Department in the form of 50 watt telephone transmitting sets. These were used during the summer of 1921 very successfully between Buffalo Hump, Idaho, and Warren, Idaho. These two stations were separated, air line, between 40 and 45 miles. The topographic conditions between these two stations are extremely rough, and a telephone line would have proved very expensive. The wireless telephone closed the gap and rendered excellent service during the entire fire season of 1921; the service being started early in July and not abandoned until September.

Another station which was operated in conjunction with these two stations was located at Edwardsberg, Idaho. This station was in service only a short time, due to an accident to the equipment, which was not the fault of the apparatus in any way, but due entirely to outside means. However, as long as this set was operated, excellent service was obtained from it. It is interesting to note that prior to the installation of the wireless between Buffalo Hump and Warren, it required the best part of two days to get a message between these two points, while during the summer of 1921, fire calls were handled between these points in about four minutes.

The big problem confronting the Forest Service in the operation of these sets is the power problem, as it is absolutely necessary to take everything into this back country by pack horse and as the weight a horse can carry is limited to about 150 pounds, special equipment had to be designed in the form of gasoline charging plants to enable them to secure adequate power for charging storage batteries in this back country.

Many theories were advanced by radio engineers that they might have considerable trouble due to the placing of the sets in mineral zones and in the heavy timber. These questions, however, were readily solved and no bad results were noticed in the operation of the equipment, although one of the sets was located down in a hole in a mineral country and the other was located in heavy timber and was also close to another mineralized zone.

The wireless telephone has a large field of usefulness in Forest Service work, and, while it may not be a substitute for permanent telephone lines in all cases, it undoubtedly will be in some localities, especially where construction costs are high and maintenance costs extreme.

CHAPTER XIX

UNITED STATES GOVERNMENT RADIO SERVICE DEPARTMENT OF COMMERCE

Department of Commerce administers acts of Congress—Secretary Hoover, a radio enthusiast—Tells about his son, who is an amateur—Author discusses work of radio conference with Secretary Hoover and Congressman White of Maine—Hoover for the amateurs—Tells some amusing stories—Bureau of Navigation—Licenses radio stations—Commissioner of Navigation D. B. Carson—Tells author he receives stack of mail three feet high every morning asking radio questions—Tells of rivalry among newspapers to install radio broadcasting stations—Tells interesting story—Safeguarding navigation—Radio beacons being installed in lighthouses—F. W. Dunmore of Bureau of Standards on radio direction finding—Radio compass may be located either on shipboard or on shore—How the steamship *Alaska* would have been saved, had she been equipped with radio compass—D. W. Terrell, Chief Radio Inspector of the United States, says amateurs are law-abiding—Bureau of Standards—Dr. S. W. Stratton, Director—Radio activities of Bureau.

The Department of Commerce administers the acts of Congress requiring wireless apparatus on ships and regulating radio communication (including the International Radio Telegraph Convention of 1912), affords wireless aids to navigation, and conducts scientific research into the principles of radio communication.

If, as a result of the conference held in Washington, for the purpose of framing new regulations for radio communication, the proposed regulations are made laws by Congress, the Department of Commerce will take over further powers for radio control, and the Secretary of Commerce will be substantially the Director of all radio in the United States.

Secretary Herbert Hoover.—Secretary Hoover, like most of the other officials in Washington, has become a radio enthusiast, although, unlike the others, he sometimes seeks to conceal the fact. The writer asked him whether it was true that he was a radio "fan." He replied, "I am only interested in radio from an official standpoint, although it is true that I have a receiving outfit in my home for social purposes. As to the present wave of enthusiasm, I believe it will die out."

Secretary Hoover somewhat belied his merely official interest in radio when, with poorly concealed pride, he remarked, "My son, in Leland Stanford University, California, has installed a radiophone set and is transmitting radiophone messages to Honolulu. I think that is going a little bit too far, sending messages over such distances, and besides, he is probably using too much power. I guess we will have to stop him."

In discussing the conference, Secretary Hoover expressed great satisfaction over the work that it had accomplished, and thought it to be one of the most successful that he had ever attended. Inasmuch as all the confrères, who represented every phase of radio activity in the United States, had been unanimous in their approval of all the decisions at which the conference had arrived, the Secretary thought there would be no difficulty in having the bill promptly drawn up, introduced in Congress, and passed.

Later, while discussing the matter with Congressman Wallace H. White, Jr., of Maine, also a member of the conference, who intends to introduce the bill into Congress, the writer was informed that certain changes in the proposals would have to be made before he would undertake to sponsor the bill. Representative White admitted that, whereas he had joined with the others in unanimous approval of the proposals, he found several clauses that, upon reconsideration, would have to be changed before he would introduce it. Appendix III gives the complete report of the conference which was in session from February 27th to March 2d. This report is of considerable interest, not only as a description of probable new laws and regulations, but also for certain valuable notes, which it contains.

Secretary Hoover stated that radio was a rather delicate subject to be handled, for it involved, to a considerable extent, the foreign relations of the United States. In reply to the writer's question as to his attitude concerning the amateur, he said, "We gave the amateur every leeway in the conference. In fact, we bent backward and gave him much more than he asked for. It is proposed to allocate to him a band of wave lengths from 150 to 275 meters, and he can do pretty nearly what he pleases within these limits."

The writer told the Secretary that from all sources with which he had any contact, only favorable remarks had been made regarding the work of the conference. Secretary Hoover replied that he had heard some criticisms and complaints and that he received complaints concerning radio broadcasting frequently. Among the radio difficulties which are put up to Mr. Hoover to solve was a letter from a man in Cuba who, being a Methodist, wrote to the Secretary objecting to the broadcasting of a sermon every Sunday in Savannah, Georgia, by a Presbyterian minister. Another complainant wrote to the Secretary, stating that broadcasting the crop report interfered with the baseball scores, and requested that the Government please stop sending crop reports.

The Bureau of Navigation.—The Bureau of Navigation administers the acts of June 24, 1910, and July 23, 1912, requiring American and foreign ships carrying 50 or more persons departing from ports of the United States to be provided with wireless apparatus and operators. For the year ended June 30, 1920, its inspectors inspected apparatus and operators at 5,410 ship departures and 1,170 departures of ships voluntarily equipped. The Bureau of Navigation also administers the act of August 13, 1912, to regulate radiocommunication, which gave effect to the London International Radiotelegraph Convention of 1912. Under this act on June 30, 1920, 2,802 commercial ship stations were licensed, 90 commercial land stations (including transoceanic), 145 experiment stations and 5,719 amateur stations. The number is steadily increasing, 32,285 radio operators were licensed, of whom 13,020 were commercial operators, 17,843 amateurs and the balance miscellaneous.

Commissioner D. B. Carson.—While in Washington, the author called on D. B. Carson, Commissioner of Navigation. Commissioner Carson also is a radio enthusiast. His position makes it difficult for him to escape contagion from the radio fever which is at the present time raging throughout the United States. "Every morning," said the Commissioner, "I find mail stacked three feet high on my desk, almost all of which

FIG. 170.—A typical spark transmitting ship station, this particular station being on one of the Luckenbach steamers.

contains letters asking questions concerning radio, most of which I turn over to Chief Radio Inspector, W. D. Terrell, and to the Bureau of Standards, who answer them. We have an immense amount of applications from all over the country, for licenses to install radio broadcasting stations. At the present time, we issue limited commercial licenses, for broadcasting radio stations, which are authorized to use a wave length of 360 meters for broadcasting news, entertainment, lectures, sermons and such matters. The wave length of 485 meters is for broadcasting United States government reports, such as market and crop estimates and weather forecasts. In view of the contemplated change in the radio laws and regulations, these licenses are now issued for a period of only three months, but may be renewed at the expiration of this period upon submission of a new application to the district radio inspector.

"There is considerable rivalry among the newspapers of certain cities to be the first to install radio broadcasting stations in their respective cities. The editors of the Atlanta *Constitution* and the Atlanta *Journal,* both of whom are personal friends of mine, applied to me for licenses to erect broadcasting stations at about the same time. In order to be impartial, I issued both licenses at the same time. Upon receipt of the same, each sent a wire asking me to telegraph his paper, congratulating it for being the first to install radio broadcasting outfits."

Commissioner Carson emphasized the fact that the safeguarding of navigation was by far the most important benefit of radio, and that he believed all other considerations should be subordinate to this one fundamental purpose. Given a sufficient appropriation by Congress, the Bureau of Navigation could do much toward developing radio apparatus for the safeguarding of lives at sea. The Bureau should have in its employ, an expert radio engineer, whom it should be willing to pay well. It is all a question of securing a sufficiently large appropriation from Congress. The Bureau of

Lighthouses is now engaged in installing lightships and buoys with wireless apparatus to serve as beacons.

These operate in a similar manner to lighthouses, sending out a characteristic series of signals, which enable the mariner to identify the beacon.

Much experimental work on radio beacons has been done by the Bureau of Standards.

F. W. Dunmore of that Bureau has prepared an interesting paper on this subject, parts of which are used in this chapter. Mr. Dunmore has carried on many experiments on behalf of the Bureau of Standards for the Lighthouse Service. The question has arisen whether the radio compass should be installed ashore or on board ship. After considering both sides of the question the conclusion is that the radio compass is more useful aboard ship.

Radio Compass.—The essential part of a radio direction finding equipment or "radio compass" consists of a coil of wire usually wound on a frame from four to five feet square, so mounted as to be rotatable about a vertical axis. Suitable radio receiving apparatus is connected to this coil for the reception of the radio beacon signals.

The "radio compass" may be located either on shipboard or on shore.

The method employing the direction finder on shore usually consists in the use of two or more radio direction finder station installations on shore, each of these compass stations being connected by wire to a controlling transmitting station. A ship's navigator wishing to know his position orders the radio operator to call the control station by radio and make a request for bearings, the signals "Q.T.E." being used for such a request. If the direction finder stations are not busy taking bearings on some other ship, the radio operator on the ship in question is requested to transmit the signal letters "M. O." for a period of one minute, during which time each of the compass stations takes radio bearings. These bearings, if satisfactory, are then transmitted by wire to the control station where they are plotted and checked and retransmitted by radio from the control station to the ship and turned over to the navigator, by the radio operator. Should one of the three radio compass stations on shore fail for any reason to obtain a satisfactory bearing, the ship is requested to repeat the "M.O." signal until a bearing is obtained. Single stations on shore are also used to furnish bearings only.

At the time that the development of this system was started, it was the only immediately feasible method of direction finding, since very few ships were equipped with direction finders, and in a time of military exigency it was not possible to install such equipment on all ships. Also, the method of direction finding on shipboard had not been developed to its present state of efficiency.

The method which makes use of the direction finder on shipboard and transmitting radio beacon stations on shore, for instance, at lighthouses, or moored light vessels, has been developed by the United States Bureau of Standards in coöperation with the United States Lighthouse Service. The Bureau of Standards, in developing this system of direction finding, has so simplified the apparatus that the direction finder is put directly in the hands of the navigating officer on shipboard. At lighthouses or other suitable places on shore, radio transmitting equipment is installed which operates automatically when once set in motion. These transmitting stations are placed in operation during fog, and at stated times given in a published schedule. At present, four such beacons are in operation, one on Fire Island Light Vessel, another on Ambrose Channel Light Vessel, a third at Sea Girt Lighthouse, Sea Girt, N. J., and a fourth on San Francisco Light Vessel. When funds are available, further installations are planned for the important light vessels and lighthouses on the Atlantic and Pacific coasts. These radio beacons operate automatically on a wave length of 1,000 meters, each beacon sending a different distinctive characteristic signal at given intervals, the intervals being different for each neighboring beacon. The signals are of a group-dot nature and are as easily recognized by the untrained ear, as the characteristic light flashes at a lighthouse are differentiated by eye. Neighboring beacons are operated on slightly different wave lengths in order to reduce the interference between beacons. The ship's navigator desiring to determine his position, or the line of direction to a light vessel or lighthouse radio beacon, turns to the radio direction finder which is usually installed in the pilot house, closes a switch and adjusts a single tuning condenser until the desired beacon signal characteristic is heard. The radio compass coil is then rotated to the point of signal extinction, the radio bearing being then read directly with respect to magnetic north on the card of a magnetic compass, which forms part of the direction finder equipment.

There are certain disadvantages of having a direction finder on shore. The service rendered is very limited, for, at a given harbor entrance, only one ship at a time may obtain bearings, it being necessary for the others to wait in turn. It will readily be seen that this is a handicap, for in time of fog when the radio compass is most useful, many ships need bearings and need them frequently. This congestion involves loss of time, which, especially in the case of large passenger ships, means considerable expense to the shipping companies.

A ship's navigator is inclined to put less confidence in bearings obtained by another observer on shore than in those which he may take himself. The responsibility of the navigation of a ship is very great, and should be left entirely in the hands of the navigating officer who should take his own observations and bearings. Just as the responsibility of reading the sextant, pelorus and magnetic compass are in his hands, in a like manner it is logical that the operation of the radio compass should be his responsibility.

Considerable expense is involved in erecting and maintaining radio compass stations on shore. The cost of maintaining special personnel and buildings is considerable. It is also difficult to keep personel in many of the isolated places, where direction finder stations are usually installed.

The possibility for personal error is greatly increased.

To obtain a single bearing (not a "fix") the information must pass through five stages, as follows:

(*a*) The radio bearing must be read from the radio compass scale.
(*b*) It must be correctly transmitted by wire to the control station.
(*c*) It must be correctly received by the operator at the control station.
(*d*) It must be accurately sent by radio to the ship.
(*e*) Finally it must be received correctly by the operator on shipboard and turned over to the navigator.

Ships many miles at sea cannot make use of this system as they are beyond the range for good direction finder work. It is only within a range of 100 to 200 miles of the land direction finder stations that a ship may make use of them. When a ship is far at sea, they are of little use.

In time of war, a vessel transmitting to the direction finder stations would also be giving her position away to the enemy, who could locate her with their own direction finders installed on shipboard.

A neighboring ship, or ship in distress, cannot be located by another ship by means of this method. In case a ship is in distress, it is necessary for the land direction finder station to obtain a fix on the ship in distress, transmit the information to a neighboring ship, get a fix on that ship in case its location is uncertain, and then the latter ship may proceed to the one in distress. It will be apparent that this is a rather roundabout method. Furthermore, the location of a ship in distress, if distant from land, is impossible to obtain from shore direction finder stations, but the direction of such a ship can be obtained by other ships equipped with direction finders. The location of a neighboring ship in distress is one of the most important applications of the direction finder, and it is important that the quickest and most accurate methods be employed.

It is impossible for a vessel to keep constantly in touch with the shore direction finding station and thus keep check on its course after it has once obtained its position. This can be done with direction finder on shipboard, as bearings may be taken on beacons whenever desired.

Another disadvantage of direction finding stations on shore is the lack of control of the decrement of the transmitting apparatus on the ships from which the bearings are obtained. A transmitting set emitting a broad wave will transmit a signal from which it is more difficult to obtain an accurate radio bearing.

There are a number of advantages in having a direction finder on shore: The cost of a direction finder installation on shipboard is eliminated. This cost is, however, negligible as compared to the value of such an installation, even in a single instance where the time saved may result in the saving of many lives.

A direction finder installed on shore should require but one calibration. This is true except in cases where power or telephone lines are installed in the neighborhood after a calibration has been made.

Any ships with a radio transmitting set may obtain bearings. This is a most valuable feature at the present time, since most ships have transmitting sets but no direction finder.

The radio compass on shore is fixed in position, making possible more accurate bearings than can be obtained on a ship in a heavy storm. For marine navigation an accuracy of two or three degrees is sufficient, since a ship cannot hold a course any closer than this.

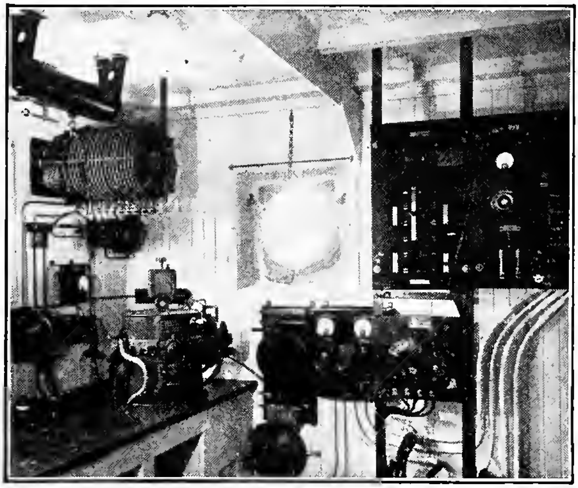

FIG. 171.—An arc ship station, typical of the radio equipment on the United States Shipping Board steamers.

The radio compass bearings on the vessel may be made simultaneously by two or more shore stations and in that manner the vessel may fix its bearings from several stations at the same instant.

In time of war, it would be possible to limit the furnishing of positions to friendly vessels. But, by transmitting the required signals, the ship is in danger of disclosing her position to enemy ships equipped with direction finders.

There are a number of disadvantages in having a direction finder on shipboard. In very rough weather, the bearings obtained are perhaps not quite as accurate as those obtained by means of the shore system. The only error in direction finder bearings caused by a heavy sea is the possible error of a degree or two in reading the magnetic compass. The operation of the radio direction finder itself is but little affected. Bearings taken under such circumstances are, however, sufficiently accurate for navigational purposes. The effect of this error is less as the beacon is being approached. This is especially true as a light vessel beacon at a harbor entrance is approached. In other words, the nearer the approach to danger (land), the greater the accuracy.

In some cases where wooden ships carry a metallic cargo, it may be necessary to recalibrate with the cargo on board. If the ship has a metallic hull, which most ships do, a metallic cargo inside this hull should not alter the calibration, since the distortion of the wave front should be practically the same in both cases. Wooden ships that carry such cargo must swing ship any way to correct the magnetic compass, so a radio compass calibration could be made at the same time.

Lack of Radio Beacons.—At the present time (March, 1922), the fact that there are only four radio beacon installations is somewhat of a handicap, but, as stated previously, many more beacon installations are planned for by the Lighthouse Service, as soon as funds are available.

Interference Caused by Two or More Radio Beacons Operating Simultaneously.—Some interference is experienced between the different beacons where more than one is installed at a harbor entrance and the ship is approximately equidistant from any two. This is overcome to a great extent by giving each beacon a different time interval of transmission, so that they will never get in step, and periods of time will occur when one may be heard operating alone. Also, by the use of modern transmitting apparatus, the sharpness of tuning is increased so that a slight difference in operating wave length of the three beacons will make possible the elimination of interference by tuning. Different tone frequencies are of help. Also, as a beacon is approached, interference is not objectionable on account of the increased signal strength.

There are also certain advantages in having a direction finder on shipboard. One of the chief advantages of locating the direction finder on board ship with beacons on lightships and lighthouses is that any number of ships may obtain bearings simultaneously, as often as desired, and when desired, without the necessity of waiting in turn. Also the necessity of any transmission other than that of the radio beacons is eliminated, thus reducing the ever-increasing interference problem. This advantage is a valuable one, especially in congested harbor entrances such as New York and other large ports.

The navigator, being the operator of the radio direction finder himself, becomes familiar with its accuracy and is thereby able to judge its merits and is consequently made more confident in his own bearings than he would be in those furnished him from shore, which he played no part in obtaining.

No extra personnel or houses are required. The radio direction finder as developed by the Bureau of Standards in coöperation with the Lighthouse Service is of such a simple type as to be readily operated by the navigating officer of the ship, who may have no knowledge of radio. The system is easily installed and no knowledge of the International, Morse or other telegraph code is needed. The apparatus may need occasional attention, which may be given by a port inspector who could take care of a number of direction finder installations. The design of the radio beacons is such that they are entirely automatic in operation and are put into service by the lighthouse keeper by merely pressing a button. An occasional inspection of these beacons is necessary, which may be made by one man hired for that purpose. The radio direction finder is installed in the pilot or chart house and the beacons on light vessels and lighthouses, so no extra housing structures are needed.

The possibility for error in getting a bearing is greatly reduced as the information is handled but once, the bearing being read directly on the magnetic compass by the navigating officer. It will be noted also that this method is a great time-saver, as the information is obtained directly in contrast to the other method, where it must be handled five times.

This method gives the ship the advantage of the use of radio bearings when far at sea, for, by means of long-range radio beacons, bearings may be obtained when many miles out.

This method has strategic military advantages, in that a ship may obtain her own position by means of the signals from the radio beacon stations, without thereby disclosing her position to the enemy.

A leading bearing may be obtained on light-vessel radio beacons stationed at harbor entrances, thus enabling the ship to approach the harbor entrances without the necessity of a "fix" or 3 point bearing. Leading bearings may also be given by radio beacons located on shore.

In special cases, the radio direction finder may be used by the ship's radio operator as a means of eliminating an interfering station when it is desired to receive an urgent message.

By means of low-power beacon signals sent from ships at intervals during fog, vessels equipped with direction finders will be able to keep clear of all other ships sending these beacon signals, thereby avoiding collision.

With the direction finder on shipboard, the navigator may keep in almost constant touch with the radio beacon, rechecking the bearings as often as desired, and thus eliminate any possible chance of errors of any but negligible magnitude. Furthermore, in using a leading bearing, no matter how faulty the adjustment of the magnetic compass may be, it will result in no error in the ship's course, if the radio bearing is taken and the ship navigated from the same compass.

Paramount among the advantages to be gained by using the direction finder on shipboard, instead of ashore, will be the value of such an installation in times of disasters at sea. By means of a few radio signals from a ship in distress, a second ship equipped with a radio direction finder may obtain a leading bearing to the vessel in distress and thereby proceed immediately and directly to the rescue, either in fog or clear weather. When the scene of disaster is reached, if lifeboats are adrift in the fog and full of survivors from the wreck, they may be located and picked up by means of beacon signals from low-powered hand-operated radio transmitting sets installed on the lifeboats. No knowledge of the code is necessary. The importance of the use of the direction finder for this purpose will be apparent when it is realized that many instances have occurred where lifeboats adrift in the fog in the open ocean were not located until it was too late to save those aboard, and cases are on record where boats full of survivors were never found.

The Alaska Disaster.— A striking example of the need and advantage of installing the direction finder on shipboard is shown by the following incident:

About 9:15 on the night of August 6, 1920, the steamship *Alaska* from Portland to San Francisco, carrying 136 passengers and a crew of 84, struck Blunt's Reef, off Cape Mendocino in northern California, in a heavy fog and sank in about 30 minutes. Throughout this time, the *Alaska* sent out distress signals and the steamship *Anyox* reached the scene of the wreck from a distance of about 10 miles at about 11:15 P.M., and, with the assistance of other boats which came later, rescued many persons. Forty-two lives were lost. The *Anyox* had a barge in tow, which made it extremely difficult for her to stop or start or maneuver around in the fog. The steamship *Wahkeena* was only about fourteen miles from the *Alaska* and responded promptly at the time that the first distress signal was transmitted, but did not reach the scene of the disaster until 7:30 A. M. the next day. For two hours prior to the grounding of the *Alaska* its radio operator had been trying to obtain radio bearings by transmitting to the radio compass station on shore, at Eureka, California, but had been unable to get in communication with that station. The failure to obtain radio bearings was due in part to the fact that a large number of ships were endeavoring to obtain radio bearings at the same time. The *Wahkeena* did not rescue any persons. Neither the *Alaska,* the *Anyox,* nor the *Wahkeena* was equipped with a radio compass.

If the steamship *Alaska* had been provided with a radio compass, and radio beacon transmitting stations had been established on the light ships and on shore, the radio operator on the *Alaska* could have determined her position at frequent intervals, and the wreck would probably never have occurred. If the *Anyox* had been provided with a simple radio compass, it could probably have reached the *Alaska* before it sank, instead of requiring two hours. If the *Wahkeena* had been equipped with a very simple type of radio compass, her radio operator could have very promptly determined the direction of the *Alaska,* so that the *Wahkeena* could have reached the *Alaska* in about an hour. The installation of radio compass equipment could thus have in all probability saved many lives and valuable property. The provision of radio compass equipment on board ship is obviously of particular importance in cases in which there are uncharted currents, since in such cases the setting of a course by dead reckoning in a fog may be disastrous.

As a result of experience with both systems of direction finding, it is believed that the place for the direction finder, like the magnetic compass and other navigating instruments, is on shipboard in the hands of the navigating officer.

Chief Radio Inspector of the United States.— D. W. Terrell is the chief Radio Inspector of the United States. It is perhaps due to him, rather than to any other person, that the American amateurs are in the aggregate such a law-abiding group of citizens. Chief Radio Inspector Terrell's sympathy with the amateur, his fairness, his knowledge of radio and his enthusiasm, are known to a vast number of amateurs, in consequence of which they respect him and the laws which it is his duty to enforce. "I have no complaint to register against the amateur radio operators. They not only endeavor to confine their radio activities within the limits of the law, but assist us in keeping the few unruly ones lined up," he said. Chief Radio Inspector Terrell has under him nine district chiefs, each of whom has jurisdiction over his local district. It is their duty to enforce the radio laws, and to inspect land and ship stations.

Bureau of Standards.— The Bureau of Standards is one of the most interesting Bureaus in Washington. Consisting of a number of beautiful buildings on the outskirts of Washington, it has the appearance of a university campus. An entire book could be devoted to the works and activities of this institution. Chemicals, weights, measures, machinery, scientific apparatus, chemical processes, etc., are standardized here. Authorities in almost every branch of science are constantly solving problems of interest and value to technical industries. In radio they have done much research work and their aid to other Government departments has been considerable.

Dr. S. W. Stratton.—The director of this Bureau is Dr. S. W. Stratton. The writer asked him about the work of the Bureau in radio. He said that their sole object was to improve the art of radio. They do not actively participate in broadcasting as do the other departments, but they constantly experiment to design better apparatus.

Dr. Stratton was well pleased with the work of the amateurs who helped the Bureau in their tests to determine the nature and the cause of fading signals. Amateurs from all parts of the country assisted the Bureau in these tests.

"The amateur," said Dr. Stratton, "has always been willing to give this bureau assistance in every way possible and we have found many who are decidedly well equipped to help us in making valuable experiments."

In return for what the amateur is doing the Bureau helps him in many ways. At the present time they are engaged in testing all apparatus that is being offered to the amateur and will soon issue a report in which the qualities of receiving sets will be honestly tabulated.

When this is done the amateur will not be imposed upon as he now is.

Some manufacturers are coöperating with the Bureau to the extent of giving them apparatus for testing purposes, but in most instances the Bureau purchases them.

The writer is indebted to Mr. J. H. Dellinger of the Bureau of Standards for his courtesy in showing him through the radio laboratories and for giving him access to various records that he required. Those who go to the Bureau for assistance in radio matters will find willing, kindly and learned experts at their service.

The Bureau has designed two simple receiving sets for novices which are to be found in the appendix of this book. They also have prepared many scientific papers on radio and will gladly send a list of all these upon request. Most of the papers can be secured from Superintendent of Documents, Government Printing Office, Washington, D. C., for a nominal amount. Those who wish to keep in touch with the publications of the Bureau of Standards as they are released can do so by subscribing to the *Radio Service Bulletin* published monthly by the Bureau of Navigation, Department of Commerce. The subscription price is 25c per year and should be sent to the Government Printing Office. Every one interested in radio is advised to subscribe to this Bulletin as much interesting matter is to be found therein. It is the best medium through which to keep in touch with the new broadcasting stations.

CHAPTER XX

RADIO IN EUROPEAN COUNTRIES

Postmaster General Hays sends Mr. R. B. Howell to Europe to investigate radio—Mr. Howell finds a telephone newspaper in Budapest that has been in operation since 1894—Broadcasting in England—Broadcasting in British East Africa—Radiophone on twenty-five meters—Short Wave Telegraphy and telephony—Marconi experiments with a one meter wave—Broadcasting from the German Government Station at Königswursterhausen, near Berlin—The Telefunken Radio Museum—Receiving radio at the rate of 2,000 words per minute!—"Telefon Hirmondo" in Hungary—Listening to Wagner's "Walkyrie" on the "Telefon Hirmondo" as being produced at the Budapest Opera House—Very little being done in radio in Austria—Receiving time signals from Eiffel Tower in Paris on a six inch loop antenna—Vacuum tubes much cheaper in France—Radio on the Bourse in Amsterdam—Some interesting data on vacuum tubes abroad as compared to this country.

After having discussed radio as practiced in the United States and the liberal manner in which the Government is developing the art for the use of the people, it is well to glance at Europe and see what is being done there. In most European countries the amateur and novice have few rights. Radio is looked upon to a considerable degree as a weapon of espionage, and therefore suspicious European countries take good care to control every phase of it.

Postmaster General Hays, before his resignation, undertook to find out just what Europe was doing in radio and in broadcasting in particular. He therefore sent Mr. R. B. Howell abroad to make a report on what was happening over there.

When the author explained to Postmaster General Work his intention of showing, by comparison, the liberality of the United States in the matter of radio, the Postmaster General was kind enough to let him have Mr. Howell's report, which heretofore had not been made public. Mr. Howell visited England, Germany, Hungary, Austria, France, and Holland where, through the courtesies extended to him as a representative of the United States government, he secured much interesting information.

In most of the countries there are no amateurs, although considerable agitation in England and France may cause the restrictions against amateurs to be lessened. In Holland the government is more liberal toward the amateur.

Mr. Howell found: That the "Telefon-Hirmondo"—a real telephone newspaper—was in operation in Budapest, as it has been constantly since its inception in 1894, and he was informed that three other European cities, following the example, had initiated similar enterprises.

That broadcasting of news by radiophone had been recently initiated by the German Post Office Department from its Königswursterhausen Station, from which all portions of Germany were to be served, including the Lake Constance region, some 360 miles distant. That the Amsterdam Bourse had established a radiophone station in the Bourse building from which, since the 5th of January, 1921 (without any interruption whatever), Bourse quotations had been instantly supplied throughout Holland to some two hundred banks and brokerage houses. This is accomplished by a stentor, stationed on the floor of the Bourse, repeating the quotations into a microphone connected with a radiophone apparatus in a room above.

That American producers of radio apparatus are evidently abreast with European developments, and quite able to compete with foreign manufacturers. Especially are they far in advance in the matter of amateur apparatus.

It was further found that, in the opinion of the government officials and radio experts interviewed, there is no question as to the practicability of broadcasting with the radiophone; moreover, that it was their common belief that this service is one of the radiophone's great, if not its greatest, field of usefulness.

England.—Through the courtesy of the American Embassy, Mr. Howell was introduced to Mr. F. J. Brown in charge of radio under the British Post Office Department, who placed him in contact with his technical force. About a year previously, the Marconi Company, under the auspices of the Department, experimented with the broadcasting of news from a station in the vicinity of London, a 12 kilowatt vacuum-tube sending set being utilized. Although the general results were satisfactory, except for the interference of shipping signals, nothing further has been done by the Post Office Department. However, a member of the technical force expressed the opinion that broadcasting by telephone would not be so generally useful in England as it might prove in the United States because Britishers have difficulty in understanding every other Britisher over a telephone, due to differences in pronunciation of the English language. He noted not a little irritation respecting the evident or assumed attempt of the private radio interests in England, France, Germany and the United States to control the radio patent situation and thus paralyze or bankrupt, independent manufacturers of radio apparatus, by litigation if necessary, where other means of eliminating competition failed. In closing the interview, Mr. Brown made a significant remark to the effect that, whereas others might control the patents, the government would still control the ether. Through Mr. Brown, Mr. Howell met Dr. Eccles, a consulting engineer of the Department. The Doctor expressed great interest in plans for broadcasting in the great American basin between the Allegheny and Rocky Mountains. He regarded this application of the radiophone as, perhaps, its chief field of usefulness. For covering, under all conditions, an area having a radius of 200 miles, he recommended the installation of a vacuum-tube sending set having an output of about 2½ kilowatts.

From other sources he learned that a project was on foot for the establishment of a radio telephone broadcasting station at Nairobe, British East Africa, where it is proposed to install a 10 kilowatt set, this energy being provided because of the absorptive power of the jungle regions. The enterprise is to be a semi-coöperative affair supported by English farmers and ranchmen of that region.

In an interview with the Chief Engineer of the Marconi Company, Mr. Howell was assured that the Marconi Company would guarantee service under all conditions within a radius of 140 miles with a telephone sending set having a one-half kilowatt output equipped with an antenna supported by seventy-foot masts. The cost of such a set was quoted at about $4,000 including generator. The Marconi Company has recently been making some interesting experiments with the radio telephone between England and Holland, using a wave length of but 25 meters. The success achieved was attributed largely to the fact that the transmission was across the open sea. The Marconi Company and two other independent concerns with which he came in contact, supply amateur, vacuum-tube receiving sets, similar to those offered in the United States. The price quoted by one of the independent companies for a set with a detector and two steps of amplification, including tubes, accumulator and a B battery, was about $60. The tubes furnished with this apparatus were of French manufacture, extras being supplied at about $2 each.

Radio with Wave Length under Fifteen Meters.—Experiments have been conducted in England for some time on the transmission of radio signals on very short waves. At a joint meeting of the American Institute of Electrical Engineers and the Institute of Radio Engineers, held in New York on June 20th, 1922, Senatore Guglielmo Marconi delivered an interesting paper, in which he dealt in some detail on the subject of short wave radio work.

In 1895 and 1896, Marconi conducted experiments on short waves and obtained some promising results with waves not more than a few inches long. However, until comparatively recently, little has been done in short wave work.

The study of short waves dates from the time of the discovery of electrical waves themselves, when Hertz conducted his original experiments. He used reflectors to prove the characteristics of the waves and showed, among many other things, that the waves obeyed the ordinary optical laws of reflection.

In 1896, when Marconi first went to England, he demonstrated to the late Sir William Preece, then Engineer-in-Chief of the British Post Office, the transmission and reception of intelligible signals over a distance of 1¾ miles, by means of short waves, using reflectors.

As far back as 1899, in a paper read before the Institute of Electrical Engineers in London, Marconi showed that it was possible by means of short waves and reflectors, to project the rays in a beam in one direction only, instead of allowing them to spread all around, in such a way that they could not affect any receiver which happened to be out of the angle of propagation of the beam.

After a lapse of many years, Marconi again took up the investigation of the subject of short wave radio in Italy, early in 1916, with the idea of using these short waves for certain war purposes. He was assisted by

Mr. C. S. Franklin of the British Marconi Company, who has since followed up the subject with much thoroughness.

Short wave radio makes very interesting experimenting, for at such low wave lengths as two or three meters, there is absolutely no interference from other radio stations, thus resembling the conditions in the early days of radio. Static is practically nonexistent. Strangely enough, there is some interference which is caused by the ignition apparatus of automobiles, motorcycles and motor boats. Such machines emit electrical waves from near zero to about forty meters in length.

In his address before the Institute of Radio Engineers, Senatore Marconi referred to a conversation he had had with Dr. Alfred N. Goldsmith in reference to this interference. Dr. Goldsmith suggested that a receiving apparatus should be designed that could be tuned to the ignition on the motorcycles of policemen patrolling for speeding motorists. Dr. Goldsmith thought that such an arrangement might prove of interest to many habitual speeders, who frequently find themselves in trouble.

In 1919, Mr. Franklin conducted experiments using a fifteen-meter wave length, generated by an electron tube. After many tests at lesser distances, a maximum of ninety-seven miles across land was spanned by radiophone. This was between London and Birmingham. Reflectors were used at both ends, and good, clear speech was exchanged at all times between the two places. Seven hundred watts power was used. About three hundred watts were actually radiated. The particular advantage of this type of short wave telephony was the excellence of the modulation and the fact that it was so directed that a station would have to be in an almost direct line with the transmitter, to pick up the signals.

At the present time, by means of suitable electron tubes, it is practicable to produce waves from about twelve meters upwards, utilizing a power of several kilowatts. Probably the most practical use to which this short wave transmission has been put is for marine protection. Trials are being carried out under the supervision of Mr. Franklin with a revolving reflector erected at Inchkeith Island in the Firth of Forth, near Edinburgh. The transmitter and reflector revolving act as a kind of wireless lighthouse or beacon, and, by means of the revolving beam of electrical waves, it is possible for ships, when within a certain distance, to ascertain in foggy weather the bearing and position of the lighthouse.

During the autumn of 1920, this experimental revolving reflector was erected and the first tests were carried out with the steamer *Pharos*. Using a four-meter wave length spark transmitter, a reflector and a single tube receiver, properly tuned on the ship, a working range of seven miles was obtained. The reflector was arranged so as to make a complete revolution every two minutes, and a distinctive signal was sent every half point of the compass. On the steamer it was ascertained that this enabled the bearing of the transmitter to be accurately determined within one-quarter point of the compass.

By means of a clock-work arrangement, a distinctive letter is sent out every two points and short signs mark intermediate points and half points. This is done by having contact segments arranged on the base of the revolving reflector so that a definite signal is transmitted at every half or quarter point of the compass.

One of the most interesting features of short-wave transmitting is that the strength of the signals is so regular at different points, that by means of a potentiometer, measuring the strength of the signals, a steamer can judge the distance it is from such a radio lighthouse by observing the strength of the signals. Of course, this latter characteristic of the short-wave transmitter will have to be carefully studied, so that standard apparatus can be produced for measuring distances.

Not only can these short waves be directed, but they can be reflected and deflected by metallic objects miles away. It should, therefore, be possible to design apparatus by means of which a ship could radiate or project a divergent beam of these rays in any direction, which rays, if coming across a metallic object, such as another steamer or ship, would be reflected back to a receiver screened from the local transmitter on the sending ship, and thereby immediately reveal the presence and bearing of the other ship in foggy or thick weather.

Just prior to the conclusion of Senatore Marconi's address, he demonstrated the working of a roughly constructed, one-meter, wave transmitter and reflector. The demonstration showed, conclusively, that the waves are directed very much in the same manner as a searchlight directs a beam of light. Unless the reflector was pointed toward the receiver, no signals were heard in the receiver.

In order to secure a reflector or antenna sufficiently large for use with higher power, and yet transmit on these exceptionally low wave lengths, it is necessary to make the reflector or antenna with many small metallic strips, which are each tuned to the transmitting wave length and are inductively coupled to one another and to the transmitter.

The reflector with which Senatore Marconi demonstrated, consisted of many of these small strips. The complete reflector was a concave form, about six feet in diameter, and two and a half feet high.

At this writing, experiments are still being conducted on short-wave transmission and reception, in England.

Germany.—Upon arriving in Berlin, Mr. Howell was placed in contact, through the courtesy of the American Consulate, with Herr Lindow, head of the telegraph and telephone bureau of the German Post Office Department, from whom and his assistant, Dr. Arendt, he learned that the broadcasting of news has been recently initiated at the government's Königswursterhausen station some thirty miles distant from Berlin. Bulletins supplied by a news agency were being radiophoned in accord with a fixed daily program of some fifty-one receiving stations located throughout Germany, and it was expected that this number would be increased to about 1,000 stations by the first of the year. Subsequently, when at the Telefunken Office he was afforded the opportunity of listening in, broadcasting then being in progress, and heard distinctly the details of a recent murder. Under German regulations, no one is allowed to operate a sending station or install a receiving set without a license from the government, and this license is only granted for receiving stations to those who pay for the service afforded. It is proposed to radiate different classes of news with different wave lengths respectively, each receiving set being permanently adjusted to receive the particular kind of news desired, thus enabling the government to charge subscribers, desiring more than one class of news, in accord with the service rendered. Of course, this means a self-supporting broadcasting service, a development possible where the government absolutely controls the installation and use of receiving apparatus. The German Post Office Department considers broadcasting as one of the most promising developments in connection with the radio telephone, and believes that through the control of receiving stations the greatest possible results will be assured. As may be assumed, there has been little or no development of amateur wireless in Germany, the manufacture of receiving sets being largely confined to the so-called commercial types. A series of experiments were conducted by the Department with a 10-kilowatt set, prior to the initiation of regular telephone broadcasting from which were adduced the following facts:

1. That the efficiency of service depends much upon the stentor's quality of voice, enunciation and training.

2. That men and women are about equally effective as stentors.
3. That 100% results were obtained at the farthest limits of Germany, while stations nearer dropped below par, due probably to the personal equation at the receiving station, atmospheric conditions or both.
4. That receiving sets equipped with detectors alone were not satisfactory beyond 150 miles.
5. That a vessel on its way to South America heard this station until more than 2,100 miles distant.

Experiments at the Nauen Station, using a high-frequency alternator and 130 kilowatts in the antenna, demonstrated that speech and music could be rendered clearly audible throughout Europe from Madrid to Bucharest without the use of amplifiers.

Through the courtesy of Dr. Arendt, Mr. Howell was shown through the radio museum of the Telefunken, the chief radio concern of Germany, and there saw the latest model of a receiving set that is to be installed by the Post Office Department. It consists of an upright panel, rising above a small desk, to which is attached the apparatus, which, after being so tuned as to leave but one adjustment for the operator, is locked and the key retained by an inspector. At the top of the panel is an additional apparatus controlling a relay bell which can be rung from the sending station by a series of dots and dashes, thus rendering it possible to announce extra news, or news afforded at times other than as provided in the regular program. The price of this receiving apparatus is about $350. The Telefunken also offered a one-kilowatt telephone sending set including one rectifying tube, two transmitting tubes of 500 watts each, with motor-generator and switchboard, for $6,125.

While visiting the laboratory of Dr. Erick F. Ruth, he learned for the first time that the Amsterdam Bourse in Holland was broadcasting Bourse news. This laboratory offered their type 13 CLT sending station, for both telephone and telegraph, one-kilowatt output, wave lengths from 500 to 1,000 meters, guaranteed range over 200 miles, for $6,500. This apparatus was complete including a receiving set and spare parts. A similar apparatus having a 250 watt output, wave lengths 375 to 600 meters, was $2,250. The price of a three-tube receiving set claimed to be fool proof, designed for wave lengths from 375 to 2,000 meters, without batteries, was quoted at about $60, but they would not sell this apparatus until after consultation with New York. At this laboratory, Mr. Howell also witnessed the operation of a recently perfected electro-static apparatus for receiving and recording telegraph messages sent either by wire or wireless, that would register telegraph code letters on a tape at a rate as high as 2,000 per minute. Subsequently, in Vienna, he was told by a radio engineer that he considered this apparatus the most striking development presented at the recent Jena Conference of Germanic physicists. The apparatus was not regularly on the market, but the price therefor, when offered, will be about $800.

Hungary.—With the exception of government telegraph installations, there was no radio development evident in Budapest. Mr. Howell did find, however, the Budapest Telephone newspaper, known as the Telefon Hirmondo, to be still flourishing after some twenty-seven years of "publication."

This enterprise consists of forty-two wire-telephone party lines, among which are distributed some 6,000 subscribers who, though unable to call central, can all be talked to at one and the same time by a man in the central office, called a stentor. News, instruction, and entertainment is afforded by this "newspaper" in accord with a regular daily program. The service begins at nine in the morning and continues until ten o'clock at night. Besides, short or continued stories are read to subscribers each afternoon, supplemented on several days of the week, by story telling for children. Likewise, lectures and speeches may be heard by those who prefer to stay at home. During the war, an hour of instruction in the French language was afforded each afternoon, but recently English has supplanted French in the Hirmondo's curriculum, and the course is immensely popular. Under the Empire, the Royal Band gave afternoon concerts and the music was transmitted to the Hirmondo's subscribers through microphones stationed at the band stand, but as there is no longer such an imperial organization to discourse, this service has been necessarily terminated. However, opera is afforded each evening to every home served by this enterprise. Mr. Howell was in the offices of the Hirmondo at five o'clock in the afternoon, or about an hour before opera begins in that city, and heard the stentor reading into the microphone the personnel of the artists on the program that evening. Later, upon the invitation of the manager, he went to his home where they listened to Wagner's "Walkyrie" communicated from microphones located in and about the stage of the Budapest Opera House. He found listening to opera under such conditions highly pleasing, as a human touch was communicated, such as is not possible with a phonograph, in fact, one could shut one's eyes and almost imagine the stage in front. Plans were on foot for the radio reception of opera from Berlin and to transfer the same directly to the Hirmondo's wires. The cost of this service prior to the war was sixty-one cents per month, each subscriber having two receivers; however, more receivers could be had at a slightly increased cost. Because of the depreciation of Hungarian currency, at a rate more rapid than the Hirmondo has been able to increase its charges, the cost per month is now only about four cents. The Manager stated that there is a great demand for extensions of the Hirmondo's lines, but unfortunately capital is not available for the purpose. It was also stated that similar enterprises have been initiated in Lyons, France; Milan and Rome, Italy. However, such developments in these cities are in their infancy.

On inquiry in regard to using the system for advertising purposes, it was stated that this had been attempted but that subscribers resented what they deemed an interference with the service and, as a consequence, the idea has all but been abandoned. Advertisers, however, are quite willing to use the service in a measure. In fact, the opera house authorities and various Gypsy bands look upon the advertising opportunity offered by the Hirmondo as of so much value that they grant the privilege of placing microphones for the transmission of their music and entertainment, practically without charge.

Austria.—That the Austrian government officials in charge of telegraphs and telephones had given little attention to the use of the radiophone, was evidenced by the interview afforded through the courtesy of the American Embassy in Vienna. The difficulties of the Department, due to a large deficit and a further depreciation of the currency, seemed to have rendered even the thought of new developments out of the question. It was stated that Berlin opera had been received at the government telegraph stations within the city with highly satisfactory results but further than this nothing of value was elicited.

Mr. Howell found but one manufactory of radio apparatus in Vienna and that was rather a laboratory than a manufacturing plant and produced tubes and receiving sets only. These sets were elaborate and designed to utilize a loop rather than an antenna, with which it was claimed that all of the large radio telegraph stations in Europe could be heard. One receiving set offered consisted of a panel, pyramidal in form, surmounted by a revolving loop five feet square and equipped with two detector tubes, a five step high frequency and a three step low frequency amplifier. The price of this apparatus complete, including tubes, accumulators and B battery, was $391. Additional tubes would be supplied at $1.60 each.

France.—The Naval Attaché's office in connection with the American Embassy in Paris gave every possible facility at its command, for investigations in Paris, affording a personal introduction to M. Laffont, Under-Secretary of State for the French Post Office Department, and M. Brouin, director of telegraph exploitation for that Department. From these gentlemen, it was learned that there had been no development of broadcasting in France by the radio telephone though the radio telegraph was being used therefor to a limited extent, principally in connection with weather reports. General Ferrie, Chief of Radio for the French Army, who was subsequently interviewed, expressed his approval of the idea of broadcasting news by radio telephone, and pronounced it wholly feasible. He stated that in France there were three systems of wiring utilized for receiving sets—the Marec, the de Bellescise and the Levy. He expressed no preference for any one of these systems, adding that all were good, each having special advantages and disadvantages. As to receiving tubes, he stated that the French government paid therefor twelve francs each, or about ninety cents. In his office, there was a very small and compact receiving set, consisting of a crystal detector with two amplifying tubes, equipped with a loop about six inches square, dry batteries being used for both filaments and plates. This set rendered signals from the Eiffel Tower clearly audible throughout the room.

Through the courtesy of Commandant Brenot, Chief Engineer of the Compagnie Générale de Télégraphie a visit was afforded to the company's plant in the outskirts of Paris, where Mr. Howell inspected a number of sending and receiving sets and heard the reproduction of a song by Melba that had been transmitted by radio from London a year previously and impressed upon a phonographic disk. Commandant Brenot also expressed his unqualified belief in the feasibility of broadcasting by the radio telephone and suggested that the receiving problem might be simplified by installing powerful sending stations and utilizing crystal detectors for receiving, with tube amplification where necessary. He stated there was no doubt that a 2½ kilowatt sending set would suffice under all conditions for 200 miles, and cited some of the company's recent experiments over water with but 35 watts in the antenna. Crystal detectors, without amplification, rendered verbal messages clearly audible at a distance of 150 miles which can be considered excellent work.

The Société Indépendante de Télégraphie afforded quotations for apparatus as follows:

A one-kilowatt tube station, with cabinet including sending and receiving apparatus, complete, except accumulators and antenna, about $4,500.

The quotations for vacuum tubes were: 250 watt oscillators about $21 each; tubes for detection and amplification about $1.75 each. This was the only concern from which quotations could be secured, others referring to their American representatives.

Holland.—Although Mr. Howell had passed through Holland on his way to Germany, it was determined to return and visit Amsterdam for the investigation of rumors that had subsequently reached him, of broadcasting from that city. Due to the courtesy of the

American Consul at that point, he was promptly put in touch with the officials of the Amsterdam Bourse and found that the broadcasting of Bourse news had been carried on without interference for the previous ten months, thus serving some 200 banks and brokerage establishments throughout Holland. The sending equipment of this station is located in a small room on the floor above the Bourse, and consists of a motor-generator affording a current of 400 volts, which is stepped up to 4,000 volts for the plates. The panel is equipped with two rectifying tubes, three one-kilowatt oscillators, a one-kilowatt modulator and two one-kilowatt amplifiers, affording an output of about 1½ kilowatts in the antenna. The operating force consists of an electrician at the apparatus and a stentor on the floor of the Bourse. Within a radius of twelve miles, Galena crystal detectors are used, from twelve to thirty miles, tube detectors, and beyond thirty miles, tube detectors with one or more amplifiers, as may be necessary. The sending apparatus was installed by the Holland branch of the Marconi Company which receives a rental therefor of about $1,700 a year. The receiving sets are also supplied, installed and maintained by the company at an annual charge of about $66 per station. The Bourse charges for its service about $34 per annum, making the total charge to each subscriber $100 per annum. After paying the rental for sending apparatus to the Marconi Company, there remains for the Bourse about $5,000 per year to pay salaries of technician, stentor, for replacement of tubes, and for energy. The service afforded has been highly satisfactory, it having been continuous during the sessions of the Bourse without exception, since the 5th day of January, 1921.

Vacuum Tubes.—The vacuum tube, or so-called radio valve, which is largely responsible for the present-day, practical development of wireless telephony, is still covered by patents in the United States, but it may be manufactured freely in nearly all other countries of the world. The result is that a 500 watt oscillator, selling in this country for $175, can be purchased in England for about $36. Likewise receiving tubes are quoted here at from $6 to $7.50, while the French government buys detectors and amplifiers at $.90 each. And the irony of the situation is that, so far as the general public is concerned, excluding shipping, there are probably more tubes purchased by this class of users in the United States, than in all of the rest of the world combined.

No foundation could be discovered for the rumor that tubes with metal instead of glass envelopes were in course of development. However, it was found that the Mullard Radio Valve Company of London, an independent concern, was producing fused quartz oscillators of about one-half the size of ordinary glass tubes of the same power. The life of the filaments of the tubes, offered by this concern, was about eight hundred hours; however, the filaments could be renewed, the expense of such renewals being about 25 per cent of the tubes' first cost. Mr. Howell learned that the Marconi-Osram Valve Company had made oscillators up to 10 kilowatts in size, and expected to produce them as large as 16 kilowatts. He did not learn anything regarding so-called "Cold Electrode" tubes. However, the two companies above referred to are producing low temperature filament tubes, the characteristics of three types of which are as follows:

MARCONI-OSRAM COMPANY

Type	*Amperes*	*Volts*	*Life*	*Price*
A. R. Tube ..	.4	1.7	1,000 hours	—
I. A. Tube...	.12	1.7	1,000 hours	—

MULLARD COMPANY

Type	*Amperes*	*Volts*	*Life*	*Price*
L. F.	.4	1.5	2,000 hours	$5.75

CHAPTER XXI

THE WORLD'S GREATEST WIRELESS STATION

Wireless in 1898—Marconi's first message across the English Channel—In 1898 Ray Stannard Baker speculates on possible uses of radio in the Spanish-American War—Some actual accomplishments during the Great War—A visit to radio central—Immense towers—High frequency generator—Transmission controlled from New York—How it is done—Receiving station at Riverhead, Long Island—Receiving four different stations on one aerial!—Listening to Europe—An ink recorder—Reducing Static—Engineers at receiving station have their own amateur station near by.

In 1898 a book was written by Ray Stannard Baker, published by McClure, Phillips and Company, called *The Boy's Book of Invention.* Among the various new inventions with which the book deals is wireless telegraphy. It is interesting to read a few pages from this book, before going into the details of that marvel of marvels, "Radio Central." That which we quote, was considered at the time a most remarkable feat. It must be remembered that this was the greatest event that had then taken place in wireless telegraphy, less than twenty-five years ago.

We now come to that historic week in March, 1898, when the system of wireless telegraphy was put to its most severe test in experiments across the English

Channel between Dover and Boulogne. These were undertaken by request of the French government, which was considering a purchase of the rights to the invention in France. At five o'clock on the afternoon of Monday, March 27th, everything being ready, Marconi pressed the sounding-key for the first cross-channel message. The transmitter sounded, the sparks flashed, and a dozen eyes looked out anxiously upon the sea. Would the message carry all the way to England? Thirty-two miles seemed a long way!

Marconi transmitted deliberately a short message, telling the Englishmen that he was using a two-centimeter spark, and signing three V's at the end. Then he stopped, and the room was silent with a straining of ears for some sound from the receiver. A moment's pause, and then it came briskly, and the tape rolled off its message. There it was, short and commonplace enough, yet vastly important, since it was the first wireless message sent from England to the Continent: First "V," the call; then "M," meaning "Your message is perfect"; then, "Same here, 2 c m s. V V V.," the last being an abbreviation for two centimeters and the conventional finishing signal.

And so the thing was done; a marvelous new invention was come into the world to stay.

Limitations of Radio in 1898.—The following "stray into the realm of speculation" less than twenty-five years ago is extremely interesting. We quote from the same book:

If you care to stray a little into the realm of speculation, said the engineer, I will point out a rather sensational rôle that our instruments might play in military strategy. Suppose, for instance, you Americans were at war with Spain, and wished to keep close guard over Havana harbor without sending your fleet there. The thing might be done with a single fast cruiser in this way. Supposing a telegraphic cable laid from Key West, and ending at the bottom of the sea a few miles out from the harbor. And supposing a Marconi receiving instrument, properly protected, to be lying there at the bottom in connection with the cable. Now, it is plain that this receiver will be influenced in the usual way by a Marconi transmitter aboard the cruiser, for the Hertzian waves pass well enough through water. With this arrangement, the captain of your cruiser may now converse freely with the admiral of the fleet at Key West or with the President himself at Washington, without so much as quitting his deck. He may report every movement of the Spanish warships as they take place, even while he is following them or being pursued by them. So long as he keeps within twenty or thirty miles of the submerged cable-end, he may continue his communications, may tell of arrivals and departures, of sorties, of loading transports, of filling bunkers with coal, and a hundred other details of practical warfare. In short, this captain and his innocent-looking cruiser may become a never-closing eye for the distant American fleet. And it needs but little thought to see how easily an enemy at such disadvantage may be taken unawares or be led into betraying important plans.

President Wilson Uses Radio During Great War.— Compare this "stray into the realm of speculation" with the realities of 1914-1918, when the President of the

United States conducted a war over three thousand miles away "without so much as quitting his desk," and then in 1919 when the President felt the necessity to leave his desk in Washington and travel across the Atlantic to the Peace Conference, he kept in telephonic communication with Washington all the way across the Atlantic Ocean while on board the *George Washington,* and, when that steamer docked in Brest, France, she was still in direct communication with Washington.

All the wonders of radio that have transpired within the last twenty-five years seem to have been collected and concentrated at Rocky Point, Long Island (seventy miles from New York), which we shall now visit.

Radio Central.—A photograph of the Antenna of Radio Central gives one the impression that it has an appearance of a transmission line. This, however, is not the case on actual approach. The impressiveness of those twelve giant towers cannot adequately be portrayed in a photograph, nor indeed can mere words do them justice. The two completed antennæ, consisting of six 450 foot high towers, bearing sixteen wires on 150 foot cross bars, stretch for three miles in an almost straight line. "Sentinels of World Wide Wireless," the Radio Corporation calls them, and they certainly look the part.

Approaching the power house from the main road by automobile over the private road of the Radio Corporation, aptly called "Jonah Road," one loses some of the enthusiasm that the first sight of the towers inspired. Wallowing in mud up to the hubs of an automobile, and getting stuck every now and then, leaves one in somewhat of a diffident attitude regarding the wonders of modern science. Once inside of the power house, however, and cordially received by Chief Engineer G. L.

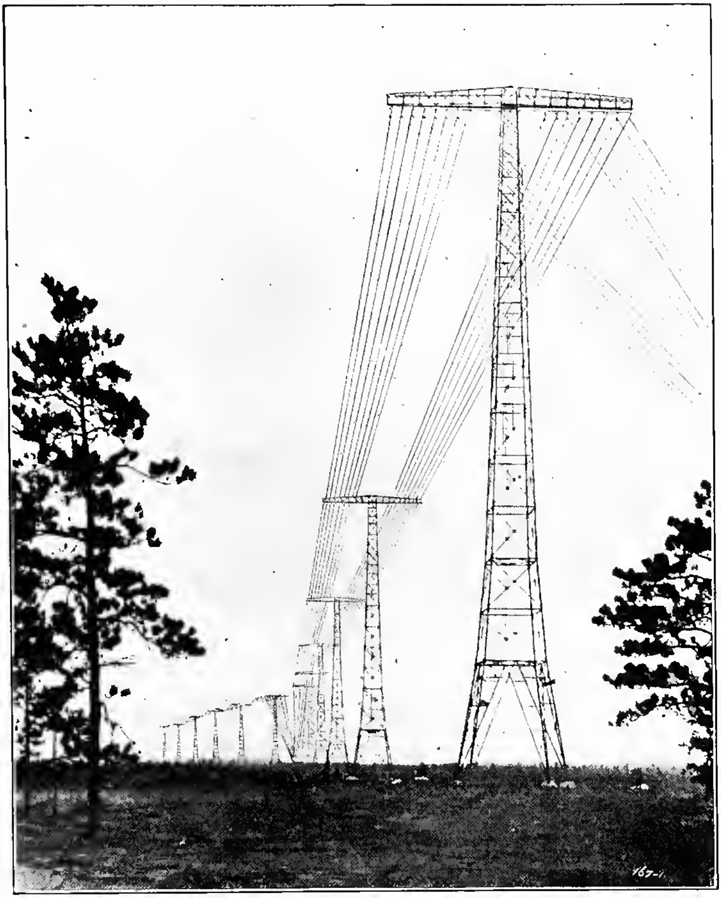

FIG. 172.—Two of the immense antennæ at Radio Central.

Usselman and his assistant, Mr. F. A. Blanding, the disagreeable features of Jonah Road are soon forgotten.

The reader who has heard the loud crashing of a small 1 kilowatt spark transmitter on board a ship, no doubt would expect to be greeted with an almost deafening roar as 200 kilowatts of energy were hurled into the massive antenna and thence across the seas. This is not the case at Radio Central; merely the steady hum of the generator such as can be heard at any lighting power station. First appearances strike one as being commonplace and uninteresting. No undue noise, no excitement, nothing dramatic; surely this cannot be the transmitter of the greatest wireless station in the world! This quiet, businesslike way of doing miraculous things, soon becomes a source of wonderment and admiration in itself. It is the characteristic way that the Radio Corporation has of doing things.

The Big Alternators.—The first objects that attract attention are the two 200 kilowatt, high-frequency Alexanderson alternators (see Fig. 173), which make this whole system of trans-Atlantic radio telegraphy possible. One is in operation, and the other is held in reserve for the second antenna now nearing completion. These generators produce 100 amperes of current at 2,000 volts, with a frequency of 18,000 cycles. From the generator, the current goes into a high-frequency air core transformer where the voltage is stepped up to 7,000 volts. From here, the current is led out of the power house to an immense helix or tuning coil (see Fig. 174), to which is attached the lead-in of the antenna. At the second, third, fourth, fifth, and sixth towers, leads are taken from the antenna and led to the ground through similar tuning coils. Such an

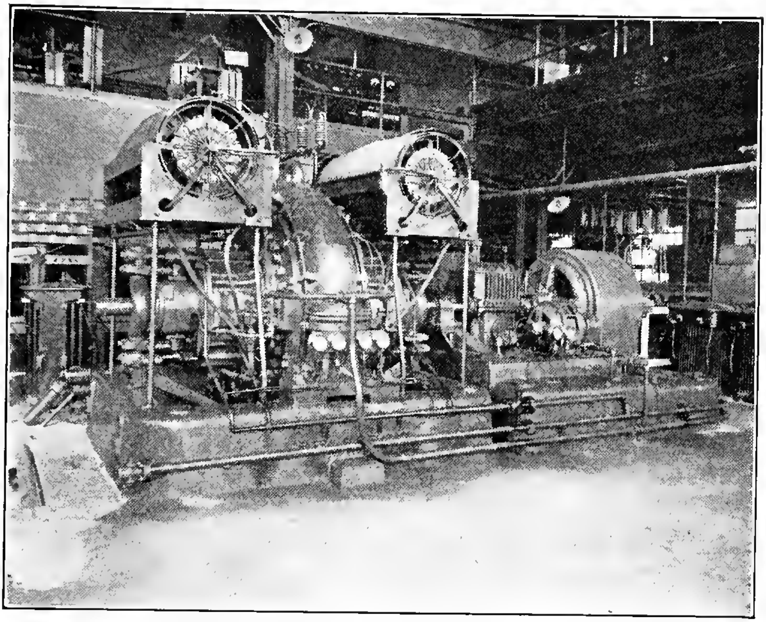

Fig. 173.—An Alexanderson high-frequency alternator, capable of putting 700 amperes of high-frequency current into the antenna.

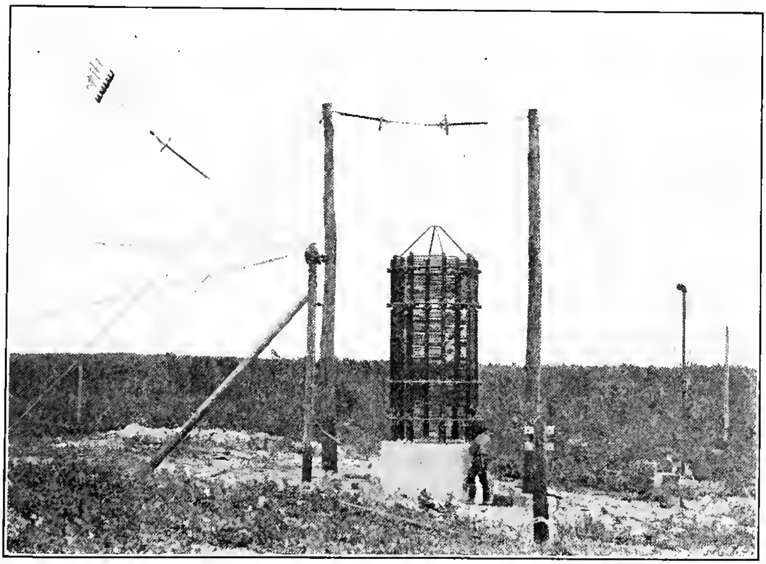

Fig. 174.—An immense transmitting tuning coil at Radio Central. Note the size, compared with the man standing at its base.

arrangement is called a multiple-tuned antenna. It distributes the energy throughout the entire antenna system with a minimum of loss. Fig. 175 shows a schematic diagram of the antenna system, as it will be when completed.

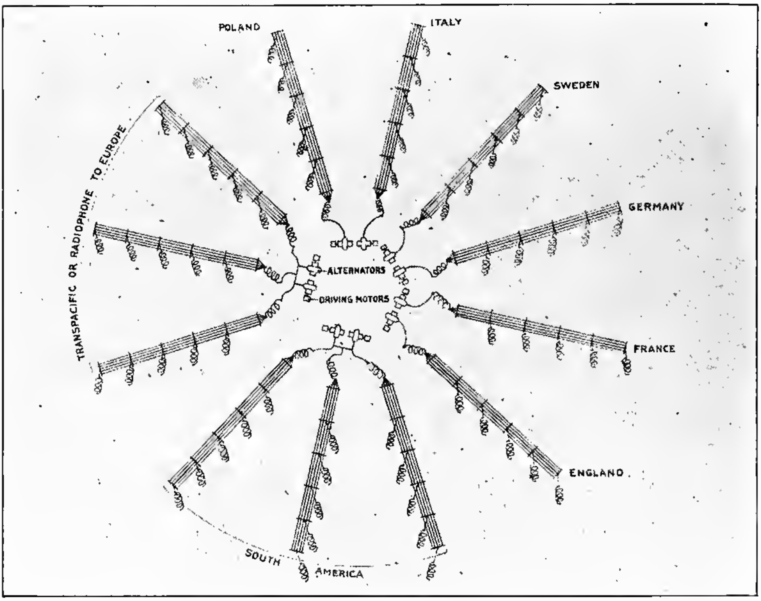

Fig. 175.—Schematic diagram of the antenna system at Radio Central, as it will look on completion.

All the transmission from Radio Central is done through New York, at 64 Broad Street. Here are the automatic tape transmitters, as well as the ordinary hand keys. The messages are sent by relay over a land line to Radio Central, where they automatically operate a relay which in turn controls three other relays, two of which control the power compensation, and the third controls the magnetic modulator which sends out the dots and dashes.

The magnetic modulator is inductively coupled to the high-frequency alternators through the air-core trans-

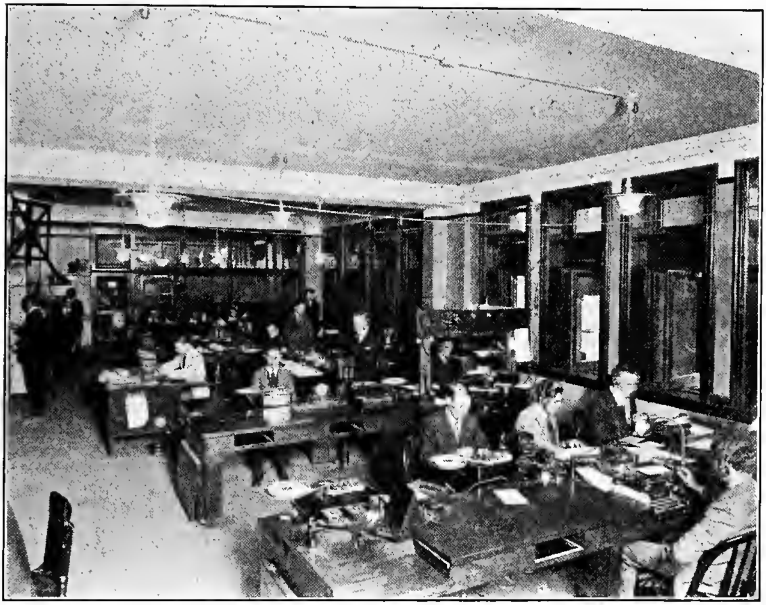

FIG. 176.—In this commonplace looking telegraph room at 64 Broad Street, New York, all the radio trans-Atlantic traffic in the U. S. is directly controlled. One-fifth of the entire telegraphic communication between the U. S. and Europe is carried on in this office.

former, before mentioned. The modulator consists of two coils of wire on an iron core. Through one coil is passed the high-frequency alternating current. Through the other, is passed a direct current. The amount of direct current that flows through the coil of the modulator is so fixed that the impedance of the circuit prevents the passage of the high-frequency current into the antenna. By reducing the direct current, the impedance is reduced, and consequently less resistance is offered to the high-frequency current, and a larger amount flows into the antenna.

It requires but a comparatively small amount of direct current to effect a large amount of high-frequency

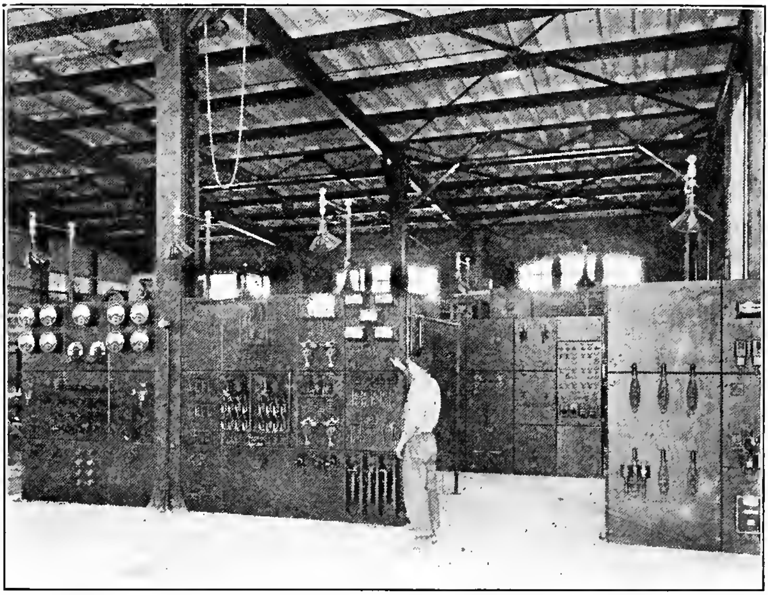

Fig. 177.—The control panels of the transmitting station at Radio Central.

current, so that the current going into the antenna can be easily controlled by a relay. When the key in New York is depressed, the direct current in the modulator is reduced, and 100 amperes of high-frequency current is put into the aerial. When the key is released, the relay causes the direct current to flow into the modulator, increasing the impedance and reducing the high-frequency current to about 3 amperes.

The sudden load that is put upon the alternator whenever the key is depressed is taken care of through power compensation by means of saturation coils all controlled by relays at the moment of pressing the key in New York. Mr. Blanding demonstrated the ease with which these large variances in current were handled, by switching the transmitter control from the New York relays, and by closing a small key, such as amateurs might use on spark coils, impressed 100 amperes into the antenna circuit. Due to the multiple-tuned antenna, 700 amperes are thus radiated.

Removing Sleet from Antenna.—One of the most interesting features of the station is the method by which sleet, that might form on the 25 miles of aerial wire in each aerial, is removed. With an antenna of such magnitude, the question of sleet on the wires is serious. This is taken care of by passing a current of 250 amperes at 1,500 volts through the antenna wires. Sufficient heat is generated to melt even the most severe ice formations on the wires in ten minutes. Small high-capacity condensers are connected in series with the antenna and tuning coils, to prevent the heat producing current from becoming grounded. The condensers have sufficient resistance to the 60 cycle current used for the above purpose, but readily allow the high-frequency current of the transmitter to pass through.

As before mentioned, the control of this station is entirely in the office at 64 Broad Street, New York, where not only the messages from Radio Central are sent, but also the messages from all the transmitting stations of the Radio Corporation on the Atlantic Coast. The high-powered transmitters at Tuckerton, N. J., New Brunswick, N. J., and Chatham, Mass., are directly controlled from the New York office.

Radio Central is not yet completed, there being only two of the proposed twelve antennæ erected. When completed, the twelve directive antennæ will be capable of being operated simultaneously with twelve different countries. Should, for any reason, additional power be required than that which can be radiated from each antenna separately, any desired number of antennæ will

Fig. 178.—An airplane view of Radio Central on Long Island, as it will look when completed.

be connected together and a total of 2,400 kilowatts of energy could be radiated! As the Radio Corporation has thus far had no trouble in carrying on its European traffic with 200 kilowatts, the necessity of using additional power for that service is remote, but it is possible that when the South American service is inaugarated, additional power may then be necessary.

The Receiving Station.—The receiving part of Radio Central is located at Riverhead, Long Island, seventeen miles from the transmitter at Rocky Point. At Riverhead, not only is the receiving done for Radio Central transmitters, but also all the other trans-Atlantic receiving for the Radio Corporation. The actual translating of the code messages is done at 64 Broad Street, the Riverhead station merely tuning in the European stations and then automatically sending the signals over land lines to New York.

There are many novel features at the receiving station. The house in which the receiving is done is but a small cottage situated in the woods. The casual passerby would hardly notice it and surely would never suspect that one fifth of the trade of the United States with Europe is practically conducted in this little cottage. The uninitiated would also be considerably perplexed to find the antenna.

The antenna is nine miles long and only thirty feet high, and is carried on telegraph poles, so that one is apt to mistake it for an ordinary telephone line. This type of antenna is called a wave antenna. It is highly directional and eliminates a large amount of static. So efficient is it, that during the nine months that it has been in operation, there has not been a single moment when the service had to be suspended. The receivers can even be operated during thunderstorms.

The wave antenna is the same length as the waves sent out by the Radio Station at Carnarvon, Wales, 14,000 meters. The waves coming in from European stations are picked up by the wave antenna which is pointed in their direction. An oscillating current is set up in the

FIG. 179.—The house in which the Radio Corporation has all its receiving sets for trans-Atlantic communication. All the commercial trans-Atlantic stations in Europe are received by instruments in this house, using one antenna.

antenna which is transformed at the farther end of the antenna by a special form of transformer. The current then returns over the nine miles of antenna to the receiving instruments. For this purpose, the antenna acts as a transmission line. The powerful oscillations that come from the transmitting station at Rocky Point, seventeen miles away, come to the antenna from the opposite direction to those which come from the European stations. These oscillations are balanced out through the transformer at the far end of the antenna and do not reach the receiving apparatus.

The wave antenna, being aperiodic, is capable of being used for receiving more than one station at a time. All the trans-Atlantic traffic of the Radio Corporation is received over this one antenna. At the present time, there are four receiving sets in operation, although the receiving house is built to handle nine complete receivers for nine different stations. The present outfits receive from Carnarvon, Stavanger, Nauen and Bordeaux.

The four receivers are all of the same type. (See Fig. 180.) The incoming oscillations are received in circuits corresponding to their respective wave lengths and then, by a complex system of "traps," are purified of all unwanted signals, including most of the static disturbances. They are then passed through three stages of radio-frequency amplification, then rectified by means of a special two-element vacuum tube which is part of what is called a synchronous detector, and finally through two stages of audio-frequency amplification, from which point the message is transmitted over the land lines where it is either received through the usual telephones or, if the message is being sent at a greater rate than 30 words per minute, it is received on a tape by machine. These messages are sometimes handled at the speed of one hundred words per minute.

Mr. Tyrell, the Acting Chief of the station, was kind enough to connect his receiving machine, which he had at the station for emergency purposes, to the receiver and let the author see the messages from Carnarvon being received. The little pen which jigs up and down

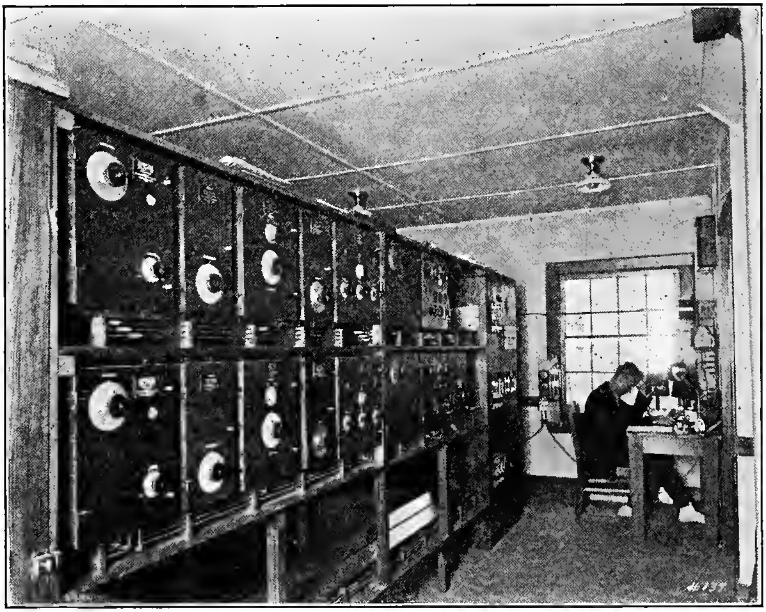

FIG. 180.—Each of the two shelves in this photograph contains a complete receiving set for receiving radio telegraph messages from Europe. This is part of the trans-Atlantic receiving station of the Radio Corporation, located at Riverhead, L. I.

on the tape marking off the dots and dashes is being moved by someone three thousand miles across the ocean and as you watch this little device, which is being controlled by a human being so far away, you cannot help feeling strong admiration for those master minds that fathomed these natural secrets for the benefit of mankind.

When the telephones were connected to the receiving sets, the signals came in so loud that they could be heard all over the room and the signals from Stavanger, Norway, 4,000 miles away were too loud to be able to keep the telephones on the ears with comfort. None of these experiments, in any way, interfered with the regular receiving of the messages in New York. The operators in attendance in Riverhead test the signals from time to time to see that everything is O.K. and when the static becomes a little too strong, they make the necessary adjustments of the traps to minimize it. The static never prevents the reception of messages, although when it becomes very severe, it is necessary for the European station to be requested to send a little more slowly.

If the operator in New York finds that the static is getting bad, he advises Riverhead over the land line wire to tune it out, if possible. If this cannot be done, the New York operator then advises the transmitting operator in the same office in New York to advise the European station to send somewhat slower. The European operator receives these instructions and sends them over a land line to the transmitting station where they are received and followed. All this is a matter of but a few moments.

The practicality and efficiency of the whole system is amazing. It operates year in and year out, twenty-four hours per day without any interruption. Business men say that the service is equal in every way to the cables and in some cases better, particularly where there are no direct cables.

In his visit to the radio central transmitting and receiving station, the author came across a rather interesting bit of local color, which is perhaps peculiar to radio alone.

Diversion of a Radio Engineer.—In nearly all lines of business, when business hours are over, the individual seeks something totally different as a means of relaxation. While wandering around the radio station at Rocky Point, the author noticed a small aerial running from the Community House, where the engineers are quartered, to a small mast, some 150 feet away. On inquiring what this was, he was told that after watches, the engineers listen in on their own radio apparatus to the broadcasting stations and other types of radio traffic. One would think that after many hours spent on duty in the most powerful radio station of the world, the engineers would be glad to forget, at least for the time being, that such a business as radio existed.

At the receiving station at Riverhead, they go to an even greater extreme. About 200 yards from the receiving house, Mr. Tyrell and his associates have installed a complete amateur continuous wave station. All spare moments of the various operators of the receiving station are spent at their own amateur apparatus. Naturally, with such engineers as those caring for all the trans-Atlantic receiving apparatus of the Radio Corporation, a very efficient and modern amateur station can be expected.

Interchanges of messages between their station, call letters of which are 2BML and 2EH, and points as far distant as Oklahoma City, Okla., have been had, and this station also was one of the first whose signals reached across the Atlantic during the tests between the United States and Ardrossan, Scotland. Mr. Tyrell, however, is not satisfied to spend his spare time during the day at this amateur station, but when he goes home he takes great pleasure in operating a receiving station that he has installed for the amusement of his family. At this station, he particularly picks up broadcasting stations and supplies the family with various forms of entertainment.

As before stated, there is perhaps no profession in which such interest is taken. Many of the ship operators have their own radio stations at home, and they make it their business, immediately after arriving at home from a long sea voyage, to rush off to their apparatus and commence to send and receive messages for their own amusement.

The author has again and again seen operators on board ship connect up an extra pair of telephones, after their watch is done, and listen in with the operator then on watch, for hours, in addition to the time actually required of them.

CHAPTER XXII

UNITED STATES AND CANADIAN GOVERNMENT REGULATIONS

Scope—Wave length limitation—Secrecy of messages—Interference—Transmitting false signals—Use of pure wave—Distress signals—Use of unnecessary power—Special stations—District inspectors—Amateur call letters—Miscellaneous information—Proposed new law—Radio in Canada.

Prior to June 24, 1910, there were no regulations governing radio communication. On June 24, 1910, the first radio laws of the United States were promulgated. On July 23, 1912, and on August 13, 1912, and on July 8, 1913, the laws governing radio communication as of the present day were made.

It is not necessary to go into the details of these laws for the general information of those who intend to operate their own radio stations, but certain features of the law should be known and observed.

For those who desire a complete set of laws, a letter addressed to the Superintendent of Documents, Government Printing Office, Washington, D. C., inclosing fifteen cents and requesting a copy of "Radio Communication Laws of the United States and the International Radiotelegraphic Convention," will secure same.

We quote Section 1 from the Radio Act, which indicates the scope of the law:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That a person, company, or corporation within the jurisdiction of the United States shall not use or operate any apparatus for radio communication as a means of commercial intercourse among the several States, or with foreign nations, or upon any vessel of the United States engaged in interstate or foreign commerce, or for the transmission of radiograms or signals the effect of which extends beyond the jurisdiction of the State or Territory in which the same are made, or where interference would be caused thereby with the receipt of messages or signals from beyond the jurisdiction of the said State or Territory, except under and in accordance with a license, revocable for cause, in that behalf granted by the Secretary of Commerce upon application therefor; but nothing in this Act shall be construed to apply to the transmission and exchange of radiograms or signals between points situated in the same State: Provided, That the effect thereof shall not extend beyond the jurisdiction of the said State or interfere with the reception of radiograms or signals from beyond said jurisdiction; and a license shall not be required for the transmission or exchange of radiograms or signals by or on behalf of the Government of the United States, but every Government station on land or sea shall have special call letters designated and published in the list of radio stations of the United States by the Department of Commerce. Any person, company, or corporation that shall use or operate any apparatus for radio communication in violation of this section, or knowingly aid or abet another person, company, or corporation in so doing, shall be deemed guilty of a misdemeanor, and on conviction thereof, shall be punished by a fine not exceeding five hundred dollars, and the apparatus or device so unlawfully used and operated may be adjudged forfeited to the United States.

That part of the law which limits the amateur station to 200 meter wave length, is as follows:

No private or commercial station not engaged in the transaction of bona fide commercial business by radio communication or in experimentation in connection with the development and manufacture of radio apparatus for commercial purposes shall use a transmitting wave length exceeding two hundred meters, or a transformer input exceeding one kilowatt, except by special authority of the Secretary of Commerce contained in the license of the station: Provided, That the owner or operator of a station of the character mentioned in the regulation shall not be liable for a violation of the requirements of the third or fourth regulations to the penalties of one hundred dollars or twenty-five dollars, respectively, provided in this section unless the person maintaining or operating such station shall have been notified in writing that the said transmitter has been found, upon tests conducted by the Government, to be so adjusted as to violate the said third and fourth regulations, and opportunity has been given to said owner or operator to adjust said transmitter in conformity with said regulations.

No amateur station, as above mentioned, situated within five nautical miles of a government or military station, shall use a transmitting wave length exceeding

200 meters, or a transformer input exceeding 1 kilowatt.

One of the most important regulations has to do with the secrecy of messages. Frequently this law is disobeyed, and for the good of amateur radio in general, and in order that the people may retain the radio privileges, which, by the way, no other government is as liberal with as the United States Government, it is advised that the regulation governing secrecy of messages be strictly adhered to:

No person or persons engaged in or having knowledge of the operation of any station or stations, shall divulge or publish the contents of any messages transmitted or received by such station, except to the person or persons to whom the same may be directed, or their authorized agent, or to another station employed to forward such messages to its destination, unless legally required so to do by the court of competent jurisdiction or other competent authority. Any person guilty of divulging or publishing any message, except as herein provided, shall, on conviction thereof, be punished by a fine of not more than two hundred and fifty dollars or imprisonment for a period of not exceeding three months, or both fine and imprisonment, in the discretion of the court.

Be it understood that broadcasted Government Weather Reports, and other messages that are definitely addressed to every one, are not considered private messages, but the messages, be they radio telegraph or radiophone conversations, between government or private stations, and addressed to some individual or individuals, are to be held in strict confidence.

Frequently, messages which the newspapers would be glad to use and for which they would pay large sums, if they could use them legally, must be kept in confidence by the recipient. A number of newspapers throughout the country have their own radio receiving outfits but they are very careful not to use any information that is not meant for them.

The secrecy of messages applies not only to the licensed station, but to those stations that do not require licenses as well, that is, the receiving station alone.

The law says the following about malicious interference:

That every license granted under the provisions of this Act for the operation or use of apparatus for radio communication shall prescribe that the operator thereof shall not willfully or maliciously interfere with any other radio communication. Such interference shall be deemed a misdemeanor, and upon conviction thereof the owner or operator, or both, shall be punishable by a fine of not to exceed five hundred dollars, or imprisonment for not to exceed one year, or both.

Prior to the promulgation of the law, there was no penalty for transmitting false signals and on several occasions practical jokers found particular pleasure in sending out SOS signals and gave latitude and longitude, so that government vessels were needlessly sent to these positions. Not only does the law provide for such cases, but, by means of a direction finder, the guilty parties can now be detected. The law regarding false signals is as follows:

That a person, company, or corporation within the jurisdiction of the United States shall not knowingly utter or transmit, or cause to be uttered or transmitted, any false or fraudulent distress signal or call or false or fraudulent signal, call, or other radiogram of any kind. The penalty for so uttering or transmitting a false or fraudulent distress signal or call shall be a fine of not more than two thousand five hundred dollars, or imprisonment for not more than five years, or both, in the discretion of the court, for each and every such offense, and the penalty for so uttering or transmitting, or causing to be uttered or transmitted, any other false or fraudulent signal, call, or other radiogram shall be a fine of not more than one thousand dollars or imprisonment for not more than two years, or both, in the discretion of the court, for each and every such offense.

The use of a "pure wave" and the use of a "sharp wave" are defined in the following clauses in the regulations:

At all stations if the sending apparatus, to be referred to hereinafter as the "transmitter," is of such a character that the energy is radiated in two or more wave lengths, more or less sharply defined, as indicated by a sensitive wave meter, the energy in no one of the lesser waves shall exceed ten per centum of that in the greatest. At all stations the logarithmic decrement per complete oscillation in the wave trains emitted by the transmitter shall not exceed two-tenths, except when sending distress signals or signals and messages relating thereto.

On a number of occasions, private stations have heard distress signals and were the means of securing aid for the vessel in distress. It is therefore advisable for the private station to know the regulations, which are as follows:

The distress call used shall be the international signal of distress ... — — — . . .

When sending distress signals, the transmitter of a station on shipboard may be tuned in such a manner as to create a maximum of interference with a maximum of radiation.

Every station on shipboard, wherever practicable, shall be prepared to send distress signals of the character specified in regulations fifth and sixth with sufficient power to enable them to be received by day over sea a distance of one hundred nautical miles by a shipboard station equipped with apparatus for both sending and receiving equal in all essential particulars to that of the station first mentioned.

All stations are required to give absolute priority to signals and radiograms relating to ships in distress; to cease all sending on hearing a distress signal; and, except when engaged in answering or aiding the ship in distress, to refrain from sending until all signals and radiograms relating thereto are completed.

Regarding the use of unnecessary power, the law provides that

In all circumstances, except in case of signals or radiograms relating to vessels in distress, all stations shall use the minimum amount of energy necessary to carry out any communication desired.

The following are the regulations concerning experimental technical and the various type amateur stations:

CLASS 3—Experimental Stations.—The Secretary of Commerce is authorized by section 4 of the act to grant special temporary licenses "to stations actually engaged in conducting experiments for the development of the science of radio communication, or the apparatus pertaining thereto, to carry on special tests, using any amount of power or any wave lengths, at such hours and under such conditions as will insure the least interference with the sending or receipt of commercial or Government radiograms, of distress signals and radiograms, or with the work of other stations." Applicants for such licenses should state any technical result they have already produced, their technical attainments, etc. The fact that an applicant desires to experiment with his equipment does not justify or require a license of this class. Most experiments can be made within the limitations of general and restricted amateur station licenses or by use of an artificial antenna to prevent radiation.

Experiment stations may be operated by a person holding an experiment and instruction grade license or higher.

CLASS 4.—Technical and training-school stations will be licensed, according to the degree of technical training attained and imparted and to local conditions.

The grade of operators required will be specified when the license is issued.

CLASS 5—Special amateur stations may be licensed by the Secretary of Commerce to use a longer wave length and a higher power on special application. Applications for this class from amateurs with less than two years' experience in actual radio communication will not be approved. The application must state the experience and purpose of the applicant, the local conditions of radio communication, especially of maritime radio communication in the vicinity of the station, and a special license will be granted only if some substantial benefit to the art or to commerce apart from individual amusement seems probable. (Sec. 4, fifteenth regulation, act of Aug. 13, 1912.)

Special amateur coast stations must be operated by a person holding a commercial second-grade license or higher. Inland stations may be operated by persons holding amateur second-grade licenses or higher.

CLASS 6.—General amateur stations are restricted to a transmitting wave length not exceeding 200 meters and a transformer input not exceeding 1 kilowatt. (Sec. 4, fifteenth regulation, act of Aug. 13, 1912.)

CLASS 7.—Restricted amateur stations, within 5 nautical miles of a naval or military station, are restricted to a wave length not exceeding 200 meters and to a transformer input not exceeding one-half kilowatt. (Sec. 4, sixteenth regulation, act of Aug. 13, 1912.)

Amateur first or second grade operators or higher are required for general and restricted amateur stations.

The license does not specify the number of operators required, but provides that the station shall at all times while in operation be under the care of an operator licensed for that purpose. The grade and number of operators as required by law are determined by the service of the station.

Any transmitting station, no matter how small it is, requires both a station license and an amateur license. For securing an amateur license, first grade, the regulations are as follows:

The applicant must have a sufficient knowledge of the adjustment and operation of the apparatus which he wishes to operate and of the regulations of the International Convention and acts of Congress in so far as they relate to interference with other radio communication and impose certain duties on all grades of operators. The applicant must be able to transmit and receive in Continental Morse at a speed sufficient to enable him to recognize distress calls or the official "keep out" signals. A speed of at least 10 words per minute (five letters to the word) must be attained.

For an amateur license, second grade, the law reads:

The requirements for the second grade will be the same as for the first grade. The second-grade license will be issued only where an applicant can not be personally examined or until he can be examined. An examining officer or radio inspector is authorized in his discretion to waive an actual examination of an applicant for an amateur license, if the amateur for adequate reasons can not present himself for examination but in writing can satisfy the examining officer or radio inspector that he is qualified to hold a license and will conform to its obligations.

The Department of Commerce has established for the purpose of enforcing, through radio inspectors and others, the acts relating to radio communication and the International Convention, the following districts, with a principal office for each district at the Custom House of the port named. Communications intended for radio inspectors should be addressed as follows:

Radio Inspector,
Custom House,
City,
State.

Communications for the Bureau of Navigation should be addressed as follows:

Commissioner of Navigation,
Department of Commerce,
Washington, D. C.

The following are the districts for the control of radio throughout the United States:

1. Boston, Mass.: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut.
2. New York, N. Y.: New York (county of New York, Staten Island, Long Island, and counties on the Hudson River to and including Schenectady, Albany and Rensselaer) and New Jersey (counties of Bergen, Passaic, Essex, Union, Middlesex, Monmouth, Hudson and Ocean).
3. Baltimore, Md.: New Jersey (all counties not included in second district), Pennsylvania (counties of Philadelphia, Delaware, all counties south of the Blue Mountains, and Franklin County), Delaware, Maryland, Virginia, District of Columbia.
4. Savannah, Ga.: North Carolina, South Carolina, Georgia, Florida, Porto Rico.
5. New Orleans, La.: Alabama, Mississippi, Louisiana, Texas, Tennessee, Arkansas, Oklahoma, New Mexico.

6. San Francisco, Calif.: California, Hawaii, Nevada, Utah, Arizona.
7. Seattle, Wash.: Oregon, Washington, Alaska, Idaho, Montana, Wyoming.
8. Detroit, Mich.: New York (all counties not included in second district), Pennsylvania (all counties not included in third district), West Virginia, Ohio, Michigan (Lower Peninsula).
9. Chicago, Ill.: Indiana, Illinois, Wisconsin, Michigan (Upper Peninsula), Minnesota, Kentucky, Missouri, Kansas, Colorado, Iowa, Nebraska, South Dakota, North Dakota.

The call letters of all amateur, special amateur and technical stations throughout the United States are preceded by the number of the district in which the radio station is located.

The following miscellaneous information which appears in the Department of Commerce book, *Radio Communication Laws of the United States and the International Radiotelegraphic Convention,* will be of service to all those operating receiving or sending stations:

Stations equipped to receive only do not require licenses.

Operators of receiving stations do not require licenses, but all persons are required to maintain secrecy in regard to messages, as provided in the act of August 13, 1912, nineteenth regulation of section 4.

Distances under the radio laws are computed in nautical miles.

No fees are charged for any operator or station license.

Licensed stations must be operated by or under the direct supervision of properly licensed operators.

No person shall transmit or make a signal containing profane or obscene words or language.

The general wave length for all amateur communication is 200 meters, and very few special permits are issued for a wave in excess of this. The broadcasting stations are limited to a wave length of 360 meters. This wave length, as well as many others that have been fixed by the government, are in the process of being revised. Up to the present time, no revision has taken place, but recommendations for changing the wave lengths of the different types of radio service have been made, in order that a minimum of interference and a maximum of efficiency may be had in radio communication. These recommendations were made at a conference held in Washington, at which representatives of all those interested in radio communication were present, including, among others, the amateurs. For proposed new regulations see Appendix III.

Radio in Canada.—The Canadian Government is quite liberal in its attitude toward the radio experimenter and the novice, providing by law for their well-being. The latest available information shows a total of 904 radio stations, of which 582 are amateur experimental stations.

All transmitting stations must be licensed, and the following regulations must be observed by the amateur experimental station:

The power used, measured at the terminals of the transformer, must not exceed ½ kw. The wave lengths which may be used, vary with the distance between the amateur station and any commercial coast or land station or a route of navigation. Stations located within five miles of a commercial station or a route of navigation must not transmit on a wave length exceeding fifty meters. Stations located more than five but less than twenty-five miles from a commercial station or route of navigation must not transmit on a wave length of over one hundred meters. Stations located more than twenty-five miles but less than seventy-five miles from a commercial station or route of navigation must not transmit on a wave length of over one hundred and fifty meters. Stations located more than seventy-five miles from a commercial station or route of navigation must not transmit on a wave length of over two hundred meters.

Amateur Experimental Certificate.—An amateur radio station must be worked by a person holding an amateur certificate of proficiency. To secure such a certificate, it is necessary to take an examination in the following subjects: The adjustment and operation of the apparatus it is proposed to operate; knowledge of the departmental regulations governing the working of amateur stations; parts of the International Radiotelegraphic Convention of London, applicable to the working of stations and particularly Section 6, Articles 20 to 35, entitled, "Transmission of Radiotelegrams."

The examination is a practical one and is usually verbal. The candidates are also given a code test of not less than five words per minute. They must be able to distinguish the signals SOS and STP (stop sending) and the call letters of their own station at a speed of ten words per minute. Those desiring to apply for a certificate are advised to write to the Department of the Naval Service, Ottawa, for particulars as to where the examination can be taken and also for the "Postmaster-General's Handbook for Wireless Telegraph Operators" and the "International Radiotelegraph Convention of London," which can be had for twenty and ten cents, respectively, post free.

Further Regulations.—The waves emitted from a transmitting station must be as little damped as possible, and in no case should the logarithmic decrement of a complete oscillation exceed two-tenths. (This is the same as the United States Regulations.) The coupling between the primary and the secondary of the oscillation transformer should not be closer than that which gives a difference of five per cent between the mean wave length and either of the two waves emitted by the coupled circuits.

A distinctive call signal is allotted to each station, commencing with a figure, such as, 3 AA, etc. The law provides that the call signal must be repeated at least three times at the end of each transmission.

The amateur must observe the regulations of the Radiotelegraph Convention. Every precaution must be taken to prevent interference with other stations. When an amateur station hears the signal STP, he must immediately stop transmitting, as the signal indicates that he is interfering with commercial business. This signal is made use of only by certain authorized government stations and is not used unless absolutely necessary. Whenever possible, the signal STP will be preceded by the call signal allotted to the amateur experimental station to which the interference is attributed and will be followed by the call signal of the government station. On receipt of the STP signal, all amateur experimental stations should cease to operate, until the government station gives the signal, cancel STP.

The aerial must not be connected to the transmitting apparatus, when the spark is being tested, or when practicing sending. This is in order to prevent unnecessary interference.

Amateur stations in the vicinity of a commercial station should have local telephone connection, so that instant communication may be established with them, in case of interference.

Technical and Training School Licenses.—Technical and training school licenses are granted to stations intended for educational purposes. Such stations will be afforded every facility for the work they propose to undertake, compatible with any special local condition, such as the existence of a commercial or coast station in their vicinity. In general, this class of station is subject to the same conditions as amateur experimental and experimental stations.

Experimental Licenses.—Experimental licenses are granted to stations intended for experimental purposes, and operated with a view to the advancement of the art of radio telegraphy and telephony. Such licenses are only granted to those properly qualified technically to carry on experimental work. For this type of work, three bands of wave lengths are provided; below 200 meters, below 450 meters and above 1,900 meters.

A small fee is charged for licenses.

Canadian Radio Broadcasting Stations.—A band of wave lengths of from 400 to 450 meters has been reserved for broadcasting stations in Canada. At the present writing, thirty-seven such stations have been licensed. The fee for broadcasting licenses is $50.00 per annum.

In Appendix VI will be found a list of Canadian broadcasting stations.

CHAPTER XXIII

LEARN THE CODE!

Self-instruction—Join a radio club—Learn the code on the phonograph—Copying press—Learning code by cadence of each letter—How to grip the key—Four stages of progress in reception—Copying messages—Learn the numerals first.

It usually is not long after the novice commences to receive broadcasting radiophones that he acquires a longing to understand the dot and dash methods of the radio telegraph. Perhaps it is his desire ultimately to install a transmitter, or it may be that he desires to experiment in long distance reception, which cannot be done without the ability at least to read the call signals of the stations received.

There are many ways to learn the code. Self-instruction is quite practicable. It is desirable, if possible, to join a class. In many of the large cities, there are radio schools. Many people who are interested in learning the code have neither time nor inclination to go to a school. For them, there are three alternatives; one is to join a radio club, or form one. There are many hundreds of radio clubs throughout the country and if one is not sufficiently advanced in the art to join a club, almost any club will be glad to assist a group of novices to learn the code by delegating one of its members as an instructor. A second method that is open to those who do not care to join a class, is provided by a set of phonograph records, which have been produced by the Radio Corporation and Victor Talking Machine Company in combination. The lessons are on six records, and will fit any disc machine. Not only do the records offer practice for straight reception, but also for reception under working conditions, such as, static, and interference from other stations. The third method is to tune to a high wave length, say from 10,000 to 20,000 meters on your receiving set, and to listen to some of the Transatlantic stations, which at times send very slowly.

After the novice has progressed a little in his study of the code, good practice can be obtained by attempting to copy the press sent out by the Arlington, Va., Naval Station, shortly after 10 o'clock every evening, as well as the press sent out by other stations on schedules that can be easily ascertained.

The first step in mastering the code is, of course, to learn the alphabet and the numerals. A great mistake is frequently made, in attempting to learn the code, by visualizing same as a combination of dots and dashes. This is entirely an incorrect method, for, once learned in this manner, great difficulty will be found in acquiring speed, as it is necessary to translate the sound into a mental dot-dash picture, and thence into a letter or numeral. The proper method for learning the code is to recognize each letter by its own particular sound or cadence. Do not group your letters in accordance with the arrangements of dots and dashes as so many books of instruction recommend. It may assist temporarily to recognize the code by sight, but it will be of no assistance in oral reception. The letter A, for instance, is not to be learned as dot, dash, but rather as the cadence, dit, dah. The letter B, is not to be learned as dash, 3 dots, or dash, dot, dot, dot, but as a cadence, dah, dit, dit, dit.

No matter what method is used in learning to receive, a practice buzzer with a key should be set up in the home. Mount the telegraph key on a board or table, far enough back so that the entire right arm can rest on a table. The key should be grasped by the thumb and first three

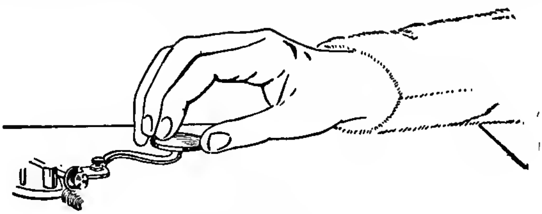

FIG. 180-A.

fingers, as in Fig. 180-A. The grip on the key should be firm, but a flexible wrist movement should always be maintained. Dots should be produced with a firm but staccato movement of the wrist. Dashes should be held sufficiently long to distinguish them from the dots. If the code is memorized in accordance with the cadence of each letter, no difficulty will be found in producing the dots and dashes in their proper proportion, for each letter will be made as a complete letter in itself, rather than as a group of dots and dashes. The buzzer, to be connected in series with the key and the battery, should be of the high-frequency type, similar to the one illustrated in Fig. 53.

Form 772 a.

DEPARTMENT OF COMMERCE

BUREAU OF NAVIGATION

RADIO SERVICE

INTERNATIONAL RADIOTELEGRAPHIC CONVENTION

LIST OF ABBREVIATIONS TO BE USED IN RADIO COMMUNICATION

ABBREVIATION	QUESTION	ANSWER OR NOTICE
PRB	Do you wish to communicate by means of the International Signal Code?	I wish to communicate by means of the International Signal Code.
QRA	What ship or coast station is that?	This is.........
QRB	What is your distance?	My distance is.........
QRC	What is your true bearing?	My true bearing is.........degrees.
QRD	Where are you bound for?	I am bound for.........
QRF	Where are you bound from?	I am bound from.........
QRG	What line do you belong to?	I belong to the.........Line.
QRH	What is your wave length in meters?	My wave length is.........meters.
QRJ	How many words have you to send?	I have.........words to send.
QRK	How do you receive me?	I am receiving well.
QRL	Are you receiving badly? Shall I send 20? .. · · · — · for adjustment?	I am receiving badly. Please send 20. · · · — · for adjustment.
QRM	Are you being interfered with?	I am being interfered with.
QRN	Are the atmospherics strong?	Atmospherics are very strong.
QRO	Shall I increase power?	Increase power.
QRP	Shall I decrease power?	Decrease power.
QRQ	Shall I send faster?	Send faster.
QRS	Shall I send slower?	Send slower.
QRT	Shall I stop sending?	Stop sending.
QRU	Have you anything for me?	I have nothing for you.
QRV	Are you ready?	I am ready. All right now.
QRW	Are you busy?	I am busy (or: I am busy with.......). Please do not interfere.
QRX	Shall I stand by?	Stand by. I will call you when required.
QRY	When will be my turn?	Your turn will be No.........
QRZ	Are my signals weak?	Your signals are weak.
QSA	Are my signals strong?	Your signals are strong.
QSB	Is my tone bad? .... / Is my spark bad?	The tone is bad. / The spark is bad.
QSC	Is my spacing bad?	Your spacing is bad.
QSD	What is your time?	My time is.........
QSF	Is transmission to be in alternate order or in series?	Transmission will be in alternate order.
QSG	....	Transmission will be in series of 5 messages.
QSH	....	Transmission will be in series of 10 messages.
QSJ	What rate shall I collect for.........?	Collect.........
QSK	Is the last radiogram canceled	The last radiogram is canceled.
QSL	Did you get my receipt?	Please acknowledge.
QSM	What is your true course?	My true course is.........degrees.
QSN	Are you in communication with land?	I am not in communication with land.
QSO	Are you in communication with any ship or station (or: with.........)?	I am in communication with......... (through.........).
QSP	Shall I inform.........that you are calling him?	Inform.........that I am calling him.
QSQ	Is.........calling me?	You are being called by.........
QSR	Will you forward the radiogram?	I will forward the radiogram.
QST	Have you received the general call?	General call to all stations.
QSU	Please call me when you have finished (or: at.......o'clock)?	Will call when I have finished.
*QSV	Is public correspondence being handled?	Public correspondence is being handled. Please do not interfere.
QSW	Shall I increase my spark frequency?	Increase your spark frequency.
QSX	Shall I decrease my spark frequency?	Decrease your spark frequency.
QSY	Shall I send on a wave length of......... meters?	Let us change to the wave length of......... meters.
QSZ	....	Send each word twice. I have difficulty in receiving you.
QTA	....	Repeat the last radiogram.
QTE	What is my true bearing?	Your true bearing is ..... degrees from .....
QTF	What is my position?	Your position is .... latitude .... longitude.

*Public correspondence is any radio work, official or private, handled on commercial wave lengths.

When an abbreviation is followed by a mark of interrogation, it refers to the question indicated for that abbreviation.

11—6860

Form 773 a.

DEPARTMENT OF COMMERCE

BUREAU OF NAVIGATION

RADIO SERVICE

INTERNATIONAL MORSE CODE AND CONVENTIONAL SIGNALS

TO BE USED FOR ALL GENERAL PUBLIC SERVICE RADIO COMMUNICATION

1. A dash is equal to three dots.
2. The space between parts of the same letter is equal to one dot.
3. The space between two letters is equal to three dots.
4. The space between two words is equal to five dots.

A	· —
B	— · · ·
C	— · — ·
D	— · ·
E	·
F	· · — ·
G	— — ·
H	· · · ·
I	· ·
J	· — — —
K	— · —
L	· — · ·
M	— —
N	— ·
O	— — —
P	· — — ·
Q	— — · —
R	· — ·
S	· · ·
T	—
U	· · —
V	· · · —
W	· — —
X	— · · —
Y	— · — —
Z	— — · ·

Ä (German)	· — · —
Á or A (Spanish-Scandinavian)	· — — · —
CH (German-Spanish)	— — — —
É (French)	· · — · ·
Ñ (Spanish)	— — · — —
Ö (German)	— — — ·
Ü (German)	· · — —

1	· — — — —
2	· · — — —
3	· · · — —
4	· · · · —
5	· · · · ·
6	— · · · ·
7	— — · · ·
8	— — — · ·
9	— — — — ·
0	— — — — —

Period	· · · · · ·
Semicolon	— · — · — ·
Comma	· — · — · —
Colon	— — — · · ·
Interrogation	· · — — · ·
Exclamation point	— — · · — —
Apostrophe	· — — — — ·
Hyphen	— · · · · —
Bar indicating fraction	— · · — ·
Parenthesis	— · — — · —
Inverted commas	· — · · — ·
Underline	· · — — · —
Double dash	— · · · —
Distress Call	· · · — — — · · ·
Attention call to precede every transmission	— · — · —
General inquiry call	— · — · — — · —
From (de)	— · · ·
Invitation to transmit (go ahead)	— · —
Warning—high power	— — · · — —
Question (please repeat after......)—interrupting long messages	· · — — · ·
Wait	· — · · ·
Break (Bk.) (double dash)	— · · · —
Understand	· · · — ·
Error	· · · · · · · ·
Received (O. K.)	· — ·
Position report (to precede all position messages)	— · — ·
End of each message (cross)	· — · — ·
Transmission finished (end of work) (conclusion of correspondence)	· · · — · —

11—6860

If it is desirable for a number of people to practice receiving on the same buzzer system, a good method is to put the primary of a small induction coil in series with the buzzer. Shunt the secondary with a small coil of wire, and connect the desired number of telephone receivers in series across this shunt coil. The high-frequency tone in the buzzer will be reproduced in the telephone receivers, and with a good operator at the key, excellent practice in reception may be had.

In reception, four stages of progress will be noted. The first is to learn to recognize each letter by its sound. The second is grouping the letters into words and learning the simpler words as units in themselves. Such words as, you, the, and, have, had, etc., are soon recognized without first receiving the letters separately and then mentally translating the combination into a word. The third stage is when complete sentences can be copied without undue effort or strain. The fourth stage is reached when the operator can keep two or three words behind the transmitter, thus enabling him to copy messages on a typewriter.

Copying of messages should always be in printing and not in script. The use of script leads to error, for a misformed letter in script is more difficult to determine than a possibly misformed letter in print. In the Navy, all copying must be done in print, until the operator is sufficiently proficient to use a typewriter. A neat copy is much to be desired. All letters should be printed with one stroke; this will assist in acquiring speed, notwithstanding that the form of the letters may be somewhat altered from the usual.

Good transmission and reception, after a while, become almost automatic. The ear, the brain, and the wrist work simultaneously and without conscious effort. The author has seen an expert radio operator receive on a typewriter, a message sent at a speed of over 40 words per minute, and at the same time carry on a verbal conversation, entirely unrelated to what he was copying.

For a beginner who desires to get some benefit out of his code practice before he can actually receive messages, it is recommended that he learn the numerals first. He will then be able to listen to the amateur stations, and by catching the numerals before each call letter, he will know the approximate geographical location of the station transmitting, thus enabling him to listen in for distant stations. If the novice happens to be in the East, and hears a station sign its call with a prefix of the numeral 6, indicating that the station is on the Pacific Coast, he will perhaps get his first real radio thrill, and the seeds of the amateur radio telegrapher will have been planted.

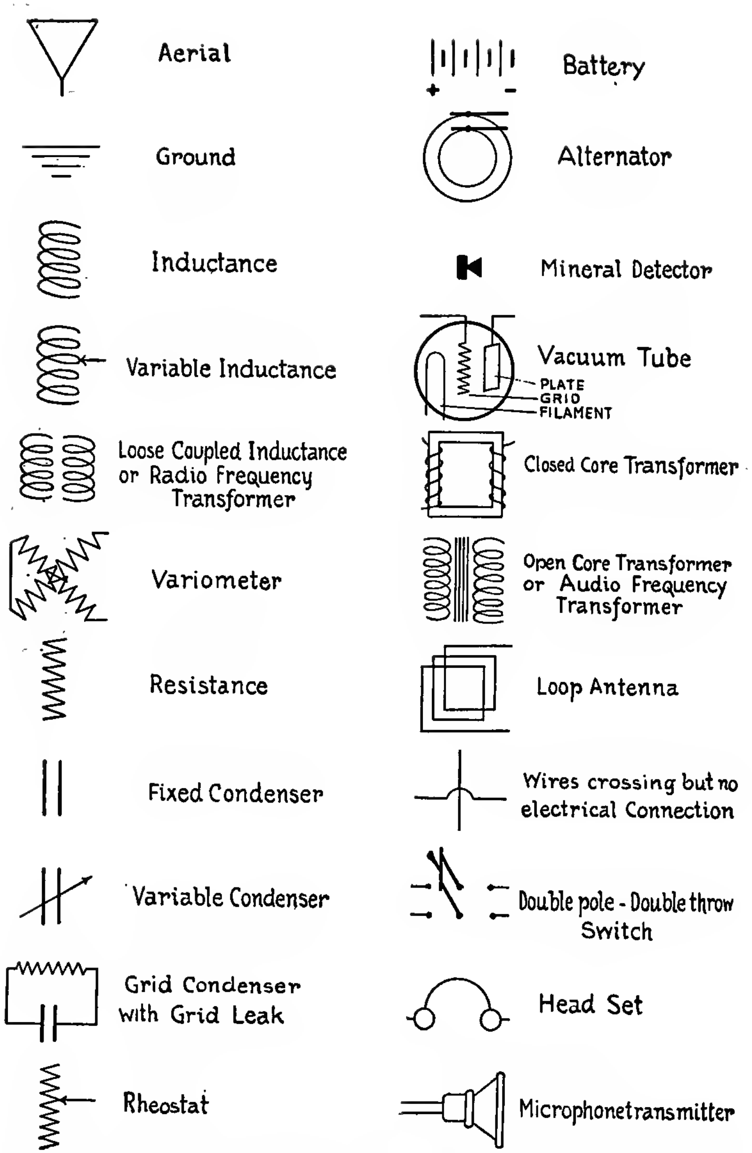

FIG. 181.—Symbols used in the schematic drawings, representing various parts of radio sets.

CHAPTER XXIV

A RADIO DICTIONARY

Words Used Frequently in Radio with Their Meanings

Aerial.—One or more wires suspended above the ground and insulated therefrom, used for receiving or radiating electric waves. The word "antenna" is used interchangeably with aerial.

Aerial Circuit.—Commences at the free ends of the aerial and includes all coils, condensers, etc., between it and the ground or counterpoise.

Alternating Current.—A current which changes the direction of its flow periodically.

Alternator.—A machine for generating alternating current.

Ammeter.—An instrument which measures the flow of current in amperes through a given circuit.

Ampere.—The electrical unit of current flow.

Ampere-hour.—The flow of one ampere of current for the period of one hour. Term is used to indicate current capacity of a storage battery. Thus an 80 ampere-hour battery will discharge one ampere continuously for 80 hours or ten amperes for eight hours.

Amplifier.—A device used to increase or magnify the waves or sounds in a radio receiving set.

Amplitude.—The highest point reached by a wave or oscillation, usually indicated by curves, as the peak above or below a basic line.

Antenna.—See "Aerial."

Aperiodic.—That which has no definite period of its own—an aperiodic receiver is one that will respond to all waves, whatever their period may be.

Armstrong Circuit.—A circuit by which the otherwise wasted oscillations in a vacuum-tube circuit are fed back from the plate circuit to the grid circuit, thereby increasing the energy of the original signal.

Atmospherics.—Will probably become the official designation of what is now known as static, strays or X's. Caused by natural electrical discharges in the air, similar to lightning, although not necessarily as heavy. As they set up electric oscillations in the ether, they are a source of interference in radio receiving.

Audio Frequency.—Frequencies below 15,000 cycles per second, which are audible to the human ear. (See "Radio Frequency," "Frequency.")

Audion.—A name sometimes used to designate a vacuum tube —was the name adopted by Dr. de Forest for his original three-electrode vacuum tube. (See "Vacuum Tube" and "Valve.")

Battery.—A collection of elements or units—a collection of cells, consisting of a positive and negative element in an electrolyte, forms an electric battery.

"A" Battery.—The battery used for lighting the filament of a vacuum tube, usually a storage battery.

"B" Battery.—The battery used for supplying the plate current of a vacuum tube. This battery usually consists of a number of small dry cells, such as are used in pocket flashlights, having comparatively high voltage for its size, but very low in the amount of current it will produce in a given time. (See "Ampere Hour.")

Dry Battery.—Battery which has as an electrolyte, chemicals in a comparatively dry form. The B Battery just described is an example of a dry battery. Ordinary dry cells, such as are used for electric bells and ignition work, have a voltage of from 1½ to 2 volts. These are sometimes used as batteries in vacuum tube circuits, but have not as long a life as a storage battery. Dry batteries connected in series, that is, the positive pole of one battery to the negative pole of another, increase in voltage in direct proportion to the number of cells thus connected. Batteries connected in parallel,that is,like poles together,increase the ampere hourage in direct proportion to the number of cells thus connected. Batteries connected in multiple series, that is, a combination of parallel and series connections, increase both the voltage and the ampere hourage. The individual dry battery is more properly called a cell, but common usage has made the terms "cell" and "battery" synonymous.

Storage Battery.—Sometimes called "secondary battery," or accumulator, consists of two elements, positive and negative, in an electrolyte. The storage battery is capable of being charged with electricity after having been discharged.

Broadcasting.—In radio work, this means the sending by radiophone, for the benefit of all receiving stations within radius of the transmitter. Radio telegraph broadcasting is usually preceded by the international abbreviation Q S T.

Buzzer.—A small piece of apparatus for producing feeble oscillations, usually to test the condition of sensitiveness of a mineral detector, or for use in calibrating wave meters, or receiving sets. The buzzer is also used for practicing code, in connection with a telegraph key.

Brush Discharge.—An electric discharge having a feathery form which occurs when a condenser, aerial or other device has a surplus charge.

Capacity (abbreviated C).—The property to store electrical energy. It is measured by the number of coulombs (quantity of electricity) that the condenser will hold when the difference of potential between the two extreme plates is one volt. The capacity is measured by a quantity called the "farad," but in radio work "microfarad" is usually used, owing to the small capacity utilized in radio—a microfarad is one millionth of a farad, and is abbreviated "mfd."

Cascade Amplification.—Amplifying radio signals by means of vacuum tubes connected together. Each stage of amplification passes the signals from one to the other for further amplifications.

Characteristic Curve.—A curve (which may be a straight line) drawn in reference to two axes, at right angles to one another. The curve shows the variation of a property of some type of apparatus, when submitted to a gradually increasing influence that produces the variation.

Choke-Coil.—A coil so wound that it has considerable self-induction. Such a coil has a high resistance to high-frequency alternating currents, and in such a circuit is called "impedance."

Circuit.—The path in which an electric current flows.

Open Circuit.—An uncompleted circuit.

Closed Circuit.—A completed circuit.

Oscillating Circuit.—A circuit in which oscillations are or can be produced.

Compass, Radio.—A name given to a radio direction-finder.

Commutator.—Movable contacts, usually insulated segments on a drum, used to change or regulate the polarity of a current or to interrupt it.

Condenser.—Two or more conducting surfaces, placed close together, but separated by insulating material called "dielectric"—condenser is used for collecting and storing electrical energy. Varying the capacity of the condenser in an oscillating circuit varies the frequency, and, consequently, it is used for tuning.

Fixed Condenser.—A condenser whose capacity is fixed.

Variable Condenser.—A condenser whose capacity is variable.

Air Condenser.—A condenser whose dielectric is air.

Mica Condenser.—A condenser whose dielectric is mica.

Conductor.—As used in radio and electricity, a substance or material which will permit the flow of electricity through it.

Continuous Wave (abbreviated C W).—A form of electric wave having a constant amplitude, which is produced continuously, in contradistinction to discontinuous waves produced by the damped oscillations, caused by spark discharges.

Counterpoise.—One or more wires stretched beneath an aerial and used instead of a ground connection, or in conjunction with a ground connection. Sometimes called "capacity ground." It is always insulated from the ground.

Coupler.—A device for transferring electrical energy from one circuit to another; usually two coils of wire in proximity to one another.

Auto-Coupler.—A single coil of wire, part of which is contained in one circuit, and part in another circuit.

Loose-Coupler.—A coupling device in which the secondary coil slides in and out of the primary coil.

Vario-Coupler.—A coupling device in which either the primary or secondary coil rotates within the other, so that an extreme range of inductance can be had.

Coupling.—The act of bringing two circuits in proximity to each other, so that the electrical energy can be transferred from one to the other.

Inductive-Coupling.—Coupling by means of two coils which act upon each other inductively, but have no direct electrical connection.

Capacity-Coupling.—Coupling by means of condensers.

Resistance-Coupling.—Coupling through resistance.

Crystal-Detector.—See "Detector."

Current.—The flow of electricity through a conductor. (See "Ampere.")

Cycle.—A period of time in which certain phenomena occur repeatedly in the same order. In electricity, the period of time which is taken for an alternating current to rise from zero to its maximum potential, and return to zero again, in one direction, and then to go from zero to maximum potential and return to zero in the opposite direction.

Damping.—The process of withdrawing energy from a rhythmically-moving system, reducing little by little the amount of its movements. An example of damping is to be found in a swing, which, when no longer given motion, gradually dies down. Oscillations with decreasing amplitudes are said to be damped.

Decrement.—Measure of the rate of the electric oscillations under the influence of damping. According to the U. S. Laws, the decrement of a transmitter must be under 0.2.

Decremeter.—An instrument for measuring decrement.

Detector.—That part of a receiving set which transforms the oscillations into audible or visible signals. Amongst the various types of detectors are: crystal detector, vacuum-tube detector, both of which are in common use; the electrolytic detector and magnetic detector are obsolete.

Dielectric.—An insulating material such as glass, mica, paper, etc., used between the plates of a condenser.

Dielectric Strength.—The strength that a dielectric has, to stand up under electrical strain, produced by high voltage currents.

Direct Current (abbreviated D C).—An electric current which flows continuously in one direction.

Duplex Radio Telegraphy.—A system by which radio stations can send and receive radio telegraphic messages at the same time.

Duplex Radio Telephony.—Same as above applied to telephony.

Earth Connection.—See "Ground."

Electro-magnetic Waves.—The component part of an electric wave resulting from the flow of current in an oscillatory circuit. The other component of the electric wave is the electro static component, which is the result of electrical stress, in an oscillatory circuit.

Electron.—The smallest particle of matter carrying a negative charge of electricity. The incoming radio oscillations controlling the flow of electrons in a vacuum tube causes the change of current in the telephone receivers, which in turn causes a signal to be heard. The electron is considered to be a subdivision of the atom.

Electron Tube.—The designation by which the vacuum tube will probably become officially known.

E. M. F.—The abbreviation commonly used for electromotive force or electrical pressure, also called potential.

Ether.—A hypothetical medium pervading all space and matter. Ether has great elasticity, and, when set into wave motion, transmits light, heat and electricity. Although still the accepted hypothesis of radio transmission, the Einstein theory has shattered the theory of ether, and no less an authority than Charles P. Steinmetz has accepted the Einstein theory.

Frequency.—Denotes the number of complete changes or movements in any form of rhythmical change or rhythmical motion in a given length of time. The frequency of electrical currents is the number of complete reversals in an alternating or oscillating current in one second. (See "Audio and Radio Frequency.")

Fuse.—A short piece of low fusing-point metal, which is introduced into an electric circuit, to provide against damage that might be caused in the circuit through overloading with too great a current. The fuse is designed to melt and break the circuit, when the current passing through it reaches a dangerous point.

Galvanometer.—An instrument for indicating and measuring a small electrical current.

Grid.—One of the electrodes in a vacuum tube.

Grid-leak.—A high noninductive resistance connected between the grid and the filament of a vacuum tube, or across the grid-condenser, permitting excessive charges caused by incoming oscillations to leak off the grid to an external source, which keeps the electrionic flow under proper control.

Ground.—The ground or earth is the connection made on the opposite side of the receiving circuit from the aerial. The ground of land stations is usually a connection with the earth or with a lake or river. On shipboard the ground connection is made with the hull of the steamer, which in turn is in contact with the ocean. (See "Counterpoise.")

Harmonics.—In radio, the harmonic is a wave incidental to the fundamental wave, radiated by a transmitting station. The harmonic is a multiple of the fundamental wave. Due to harmonics, a long wave transmitting station can frequently be heard in a receiver tuned for short waves. Harmonics are particularly noticed in the vicinity of arc transmitters.

Henry.—The unit of inductance.

Hertzian Waves.—Electrical waves named after the discoverer, Dr. Heinrich Hertz, in 1887. Hertzian waves are the waves produced in radio telephony and telegraphy. (See "Electro-magnetic Waves.")

Honeycomb Coil.—A specially-wound coil which, owing to the method of winding, has a low distributed capacity, high inductance and comparatively small physical dimensions.

Hook-up.—Term used in radio work to designate the diagrams of connections of wireless apparatus.

Hot Wire Ammeter.—An instrument used for measuring current in amperes. It is principally used in connection with alternating current and in the aerial or ground circuits of radio transmitters. The hot wire ammeter is based on the principle that wire expands in proportion to the heat generated in it, which heat is proportionate to the current flowing in the wire. The expansion of the wire is made to move an indicator over a calibrated index, which gives a direct reading of the amount of current passing through the circuit, in which the hot wire ammeter is contained.

Impedance.—The amount of resistance offered to an alternating current passing through a wire, or coils of wire, due to the resistance or counter-electromotive force. (See "Choke Coil" and "Reactance.")

Inductance.—Electrical inertia, which tends to oppose the change in direction of an alternating current passing through a circuit. Every alternating current circuit has inductance, but those containing coiled wire have the greatest inductance. The frequency of an oscillating circuit is determined by the amount of capacity and inductance. Therefore, in circuits subject to tuning, a variable inductance in the form of a helix, or coil of wire, is usually included. The unit of inductance is the henry, but in radio work the micro-henry is most frequently used.

Induction.—The transfer of electric or magnetic current from an electrified or magnetized body to a nonelectrified or nonmagnetized body by comparative, close proximity, but without actual contact.

Induction Coil.—Two coils of wire in close proximity making use of the phenomenon of induction. An intermittent current passed through one coil, called the "primary," produces a current with a higher voltage in the secondary coil.

Inductive Coupling.—(See "Coupling.")

Insulator.—Material through which electricity will not pass.

Interrupter.—A piece of apparatus designed to interrupt a continuous current and cause it to become a more or less rapidly pulsating current.

Ionization.—The breaking up of the molecules into ions in an electrolyte, air or gas, and the consequent conductivity of the medium to electric current.

Key.—An instrument used in telegraphy to break a current and thereby produce signals.

Kilowatt.—One thousand watts. (See "Watt.")

Leyden Jar.—A glass jar coated inside and out with foil or copper plate and used for storing static electricity. (See "Condenser.")

Loop.—Designation of loop-antenna. A small frame wound with wire and used for receiving or transmitting signals in place of aerial and ground.

Loose-Coupler.—See "Coupler."

Loud-speaker.—A receiving device designed to make signals sufficiently loud not to require a headphone for reception.

Magnavox.—A loud-speaker of special design, requiring local battery current, which amplifies signals to considerable extent.

Microphone.—An instrument which converts and magnifies sound. A telephone transmitter is a type of microphone. It generally consists of a loosely packed mass of carbon granules, through which an electric current is passed. By subjecting the granules to varying pressure, due to voice vibrations on a diaphragm, the resistance of the circuit is varied, and consequently the current. The varying current, when passed through a telephone receiver, reproduces the voice.

Milliampere.—The thousandth part of an ampere.

Morse Inker.—A device for recording the dots and dashes of the code on a strip of moving paper.

Multiple Tuned Antenna.—An antenna that is tuned at different points along its length by grounding through an inductance.

Ohm.—The unit of electrical resistance.

Ohm's Law.—A fundamental law of electricity, stating that the current in amperes in a circuit is equal to the pressure in volts, divided by the resistance in ohms.

Oscillations.—Alternating currents of very high frequency.

Period.—One complete cycle of change in a system undergoing rhythmical change.

Periodic.—A system acting in or subject to rhythmical changes. A receiver which will respond only to the wave length to which it is tuned is said to be periodic. (For antonym, see "Aperiodic.")

Potential.—Electrical pressure or voltage. (See "E.M.F." and "Volt.")

Potentiometer.—An instrument used for regulating the electrical potential between two points. Not to be confused with rheostat. (See "Rheostat.")

Radiation.—The transmission of energy from an aerial or loop as electric waves. The amount of high-frequency current being delivered to the aerial by the transmitter is called radiation.

Radio Frequency.—Frequencies above audibility, that is, over 15,000 cycles per second. (See "Frequency" and "Audio-Frequency.")

Reactance.—See "Impedance."

Rectifier.—Apparatus used for the purpose of changing alternating current into direct current or into a pulsating unidirectional current.

Regenerative Circuit.—See "Armstrong Circuit."

Relay.—An apparatus by which a small current is made to control a larger current, turning it off and on.

Reluctance.—Resistance to a magnetic field.

Resistance.—The opposition to the flow of electricity through a conductor. (See "Ohm.")

Resonance.—When the natural frequency of a circuit is the same as the frequency of the oscillations that are being impressed upon it, then the two circuits are said to be in resonance.

Rheostat.—A variable resistance used to regulate the flow of current in a circuit. (Not to be confused with potentiometer.)

Selectivity.—The property of a receiver to pick out the waves that it wants to receive and exclude those not wanted.

Sharp Tuning.—The ability to tune desired signals in and undesired signals out with but slight changes in adjustment of the receiver.

Static.—See "Atmospherics."

Telephone Receiver (head-set).—A device for receiving audible electric vibrations.

Train of Waves.—A group of damped oscillations. The number of trains per second determine the audible frequency.

Transformer.—A device for transferring energy from one circuit to another. Some transformers transfer energy with an increase in voltage. These are known by the generic name of step-up transformers. Transformers that transfer electrical energy with a decrease in voltage are known as step-down transformers. There are also transformers that transfer with no change of voltage. Transformers are known more specifically in accordance with their uses, as amplifying transformers, oscillation transformers, power transformers, telephone transformers, etc.

Telephones.—Instruments used for making audible signals received on radio usually consist of two shells about the size of a man's watch, and twice as thick, in which is contained a pair of electro-magnets which act upon a movable diaphragm. The variation of currents in the windings of electro-magnets cause movement in the diaphragm, which produces audible sound.

Tikker.—An instrument for breaking the C.W. oscillations into audible pulses.

Tikler (or Tickler) Coil.—A coil in the plate circuit of a vacuum tube regenerative receiver used to feed back the oscillations inductively into the grid circuit.

Tone-Wheel.—See "Tikker."

Tuning.—The changing of capacity or inductance or both for the purpose of causing both primary and secondary of a transmitter or receiver to be in resonance with each other. In a transmitter, the adjustments are made for any wave desired to be transmitted. In a receiver, the adjustments are made so as to tune the receiver to the same wave length as the desired incoming signals.

Undamped Oscillation.—High-frequency oscillations of constant amplitude, producing continuous waves.

Vacuum Tube (abbreviated V.T.).—In radio, a glass tube exhausted of air. It contains a filament, plate and grid. The filament is heated to incandescence, and produces emanations of electrons which flow from the filament to the plate. The potential of the grid, which is between the plate and filament, is changed by the incoming oscillations and checks or increases the number of electrons that flow between the filament and plate. A local battery in the plate circuit causes a current to flow through telephone receivers in the same circuit, which current varies proportionately to the number of electrons flowing between the filament and plate. The voltage in the local battery being considerably greater than the voltage of the incoming signals, causes a current to flow through the telephone receivers, which is greater than the current of the incoming oscillations.

Valve.—The term used in England for vacuum tube. In this country usually used to denote a two-element vacuum tube that is, a vacuum tube containing only plate and filament, without the grid. Sometimes called Fleming valve, after the inventor.

Vario-Coupler.—See "Coupler."

Variometer.—An instrument used for varying the inductance in a current. Consists of two coils of wire, electrically connected, but wound on different bases. The one revolves within the other. The fixed coil is called the "stator" and the movable coil the "rotor." When the coils are closely coupled, so that the windings of the stator and rotor are in the same direction, the maximum inductance is secured. The rotor is then rotated through an arc of 360 degrees, gradually decreasing the inductance until it is at a minimum, when the windings of the stator and the rotor are in the opposite direction.

Volt (abbreviated V).—The unit of electric pressure.

Voltmeter.—An instrument for measuring voltage.

Watt (abbreviated W).—The unit of electric power. To figure the number of watts in a given circuit, multiply the voltage by the current in amperes—746 watts is equal to 1 H.P.—1,000 watts equals 1 kilowatt (K.W.).

Waves.—An undulating motion in the ether, by which in accordance with the present theory, light, heat and electricity are transmitted.

Wave Length.—The distance between any point in a wave, and the corresponding point in the wave immediately preceding or following in the same wave train.

X.—The term sometimes used for static.

APPENDIX I

A SIMPLE HOME-MADE RADIO RECEIVING OUTFIT DESIGNED BY THE BUREAU OF STANDARDS

This appendix describes the construction and operation of a simple and inexpensive radio receiving outfit, that will enable any one to hear radio code messages or music and voice sent out from medium-power transmitting stations within an area about the size of a large city, and from high-power stations within 50 miles, provided the waves used by the sending stations have wave frequencies between 500 and 1,500 kilocycles per second; that is, wave lengths between 600 and 200. This equipment will not receive uninterrupted continuous waves. Occasionally much greater distances can be covered, especially at night. Sets constructed according to these instructions have given clear reception of music transmitted by radiotelephone from stations 300 miles distant. The total cost of the outfit can be kept below $10, or if an especially efficient outfit is desired, the cost may be about $15.

The Antenna, Lightning Switch and Ground Connection.—The antenna is simply a wire suspended between two elevated points. The antenna should not be less than 30 feet above the ground and its length should be about 75 feet. (See Fig. 36.) This figure indicates a horizontal antenna, but it is not important that the antenna be strictly horizontal. It is in fact desirable to have the end where the pulley is used as high as possible. The "lead-in" wire or drop wire from the antenna itself should run as directly as possible to the lightning switch. If the position of the adjoining building or trees is such that the distance between them is greater than about 85 feet, the antenna can still be held to a 75 foot distance between the insulators by increasing the length of the piece of rope D to which the far end of the antenna is attached. The rope H tying the antenna insulator to the house should not be lengthened to overcome this difficulty, because, by so doing, the antenna "lead-in" or drop wire J would be lengthened.

Details of Parts.—The parts will be mentioned here by reference to the letters appearing in Figs. 36 and 182.

A and I are screw eyes sufficiently strong to anchor the antenna at the ends.

B and H are pieces of rope 1/4 or 3/8 inch in diameter, just long enough to allow the antenna to swing clear of the two supports.

D is a piece of 1/4 or 3/8 inch rope sufficiently long to make the distance between E and G about 75 feet.

C is a single-block pulley which may be used if readily available. The pulley should not allow the rope to catch.

E and G are two insulators which may be constructed of any dry hardwood of sufficient strength to withstand the strain of the antenna; blocks about 3/4 by 1 by 10 inches will serve. The holes should be drilled as shown in Fig. 36, sufficiently far from the ends to give proper strength. If wood is used, the insulators should be boiled in paraffin. Precautions in regard to melting the paraffin are given in the paragraph under "Accessories." If porcelain insulators are available, they may be substituted for the wood insulators. Porcelain cleats can be used. Regular antenna insulators are available on the market, but the two improvised types mentioned will be satisfactory for an amateur receiving antenna.

F is the antenna about 75 feet long between the insulators E and G. The wire may be No. 14 or 16 copper wire either bare or insulated. The end of the antenna farthest from the receiving set may be secured to the insulator E by any satisfactory method, but care should be taken not to kink the wire. Draw the other end of the antenna wire through the insulator

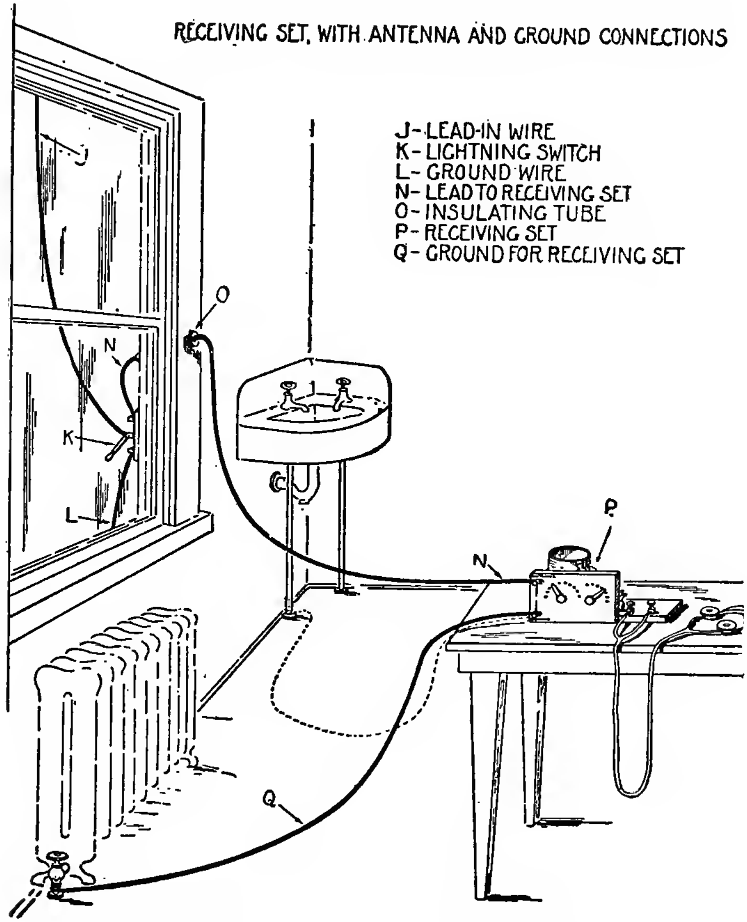

FIG. 182.—Receiving set, with antenna and ground connections.

G to a point where the two insulators are separated by about 75 feet and twist the insulator G so as to form an anchor, as shown in Fig. 36. The remainder of the antenna wire J, which now constitutes the "lead-in" or drop wire, should be just long enough to reach the lightning switch.

K is the lightning switch. For the purpose of a small antenna, this switch may be the ordinary porcelain-base, 30 ampere, single-pole double-throw battery switch. These switches as ordinarily available have a porcelain base about 1½ by 4 inches. The "lead-in" wire J is attached to this switch at the middle point. The switch blade should always be thrown to the lower clip when the receiving set is not actually being used, and to the upper clip when it is desired to receive signals.

In some stations there is no lightning switch outside the building, but instead a lightning arrester is connected to the antenna lead-in just inside the building; that is, as close as possible to the point where the lead-in leaves the porcelain tube. This lightning arrester has two binding posts, one of which is connected to the antenna lead-in, and the other is connected to a suitable ground connection. The type of lightning arrester used should be a protective device approved by the Underwriters Laboratories or from local insurance inspection departments. For the ground connection, a water pipe or a steam pipe may be used; a gas pipe should not be used. The use of the lightning switch outside the building as above described is perhaps a little preferable to the use of the lightning arrester inside the building.

L is the ground wire for the lightning switch. The ground wire may be a piece of copper wire, No. 14 or larger, and should be of sufficient length to reach from the lower clip of the lightning switch K to the clamp on the ground rod M. The use of a large size of copper wire, such as No. 6, or of copper strap, will give added mechanical strength and minimize the danger of accidental breakage of the ground wire.

M is a piece of iron pipe or rod driven 3 to 6 feet into the ground, preferably where the ground is moist, and extending a sufficient distance above the ground so that the ground clamp may be fastened to it. The pipe should be free from rust or paint. Special care should be taken to see that the pipe is clean and bright where the ground clamp is connected.

N is a wire leading from the upper clip of the lightning switch through the porcelain tube O to the receiving set binding post marked "antenna."

O is a porcelain tube of sufficient length to reach through the window casing or wall. This tube should be mounted in the casing or wall so that it slopes down toward the outside of the building. This is done to keep the rain from following the tube through the wall to the interior.

Fig. 182 shows the radio receiving set installed in some part of the house.

P is the receiving set which is described in detail below.

N is a wire leading from the antenna (upper) binding post of the receiving set through the porcelain tube to the upper clip of the lightning switch. This wire, as well as the wire shown at Q, should be insulated and preferably flexible. Unbraided lamp cord will serve for these two leads.

Q is a flexible wire leading from the receiving set binding post marked "ground" to a water pipe, heating system, or some other metallic conductor to the ground. If there are no water pipes or radiators in the room in which the receiving set is located, the wire should be run out of doors and connected to a special ground below the window. The ground for the lightning switch should not be used for this purpose. It is essential that for the best operation of the receiving set this ground be of the very best type. If the soil near the house is dry, it will be necessary to drive one or more pipes or rods sufficiently deep to encounter moist earth. The distance between the pipes will ordinarily not exceed 6 feet. Where clay soil is encountered, the distance may be 3 feet; in sandy soil it may be 10 feet. Some other metallic conductor, such as the casing of a drilled well, not far from the window, will be a satisfactory ground.

Tuning Coil, Detector and Phone.—The phone and certain parts of the apparatus will have to be purchased. The other parts may be obtained at home.

Tuning Coil.—This coil (R, Fig. 183) is a length of cardboard tubing with copper wire wound around it. The cardboard tubing may be an oatmeal box. Its construction is described in detail below. A cylinder of wood or other nonmetallic substance may also be used.

Crystal Detector.—The crystal detector (S, Fig. 183) may be of very simple construction. A number of different kinds of crystals are suitable for use as detectors; these are discussed in Chapter IV. A galena crystal which will be satisfactory can usually be conveniently secured. Silicon is usually not as sensitive as galena, but is sometimes more easily obtained, and sensitive spots are often more easily located on silicon. It is important that a selected crystal be used.

The crystal detector can be made up of the tested crystal, three wood screws, a short piece of No. 16 copper wire or a nail, a piece of fine copper wire such as No. 28 or 30, a set-screw type binding post, and a wood knob or cork.

The crystal may be held in place on the wood base by three brass wood screws as shown at 1, Fig. 183. A bare copper wire is wrapped tightly around the three brass screws for connection.

A metal called "Wood's metal," which has so low a melting point that it will melt in boiling water, may be purchased in many stores. If this metal is available, it may be used for mounting the crystal, but a metal of higher melting point, such as ordinary solder, should not be used because it may seriously injure the crystal. A shallow hole of size suitable to hold the crystal and leave most of the crystal projecting may be bored in the wooden base, and melted Wood's metal poured into the

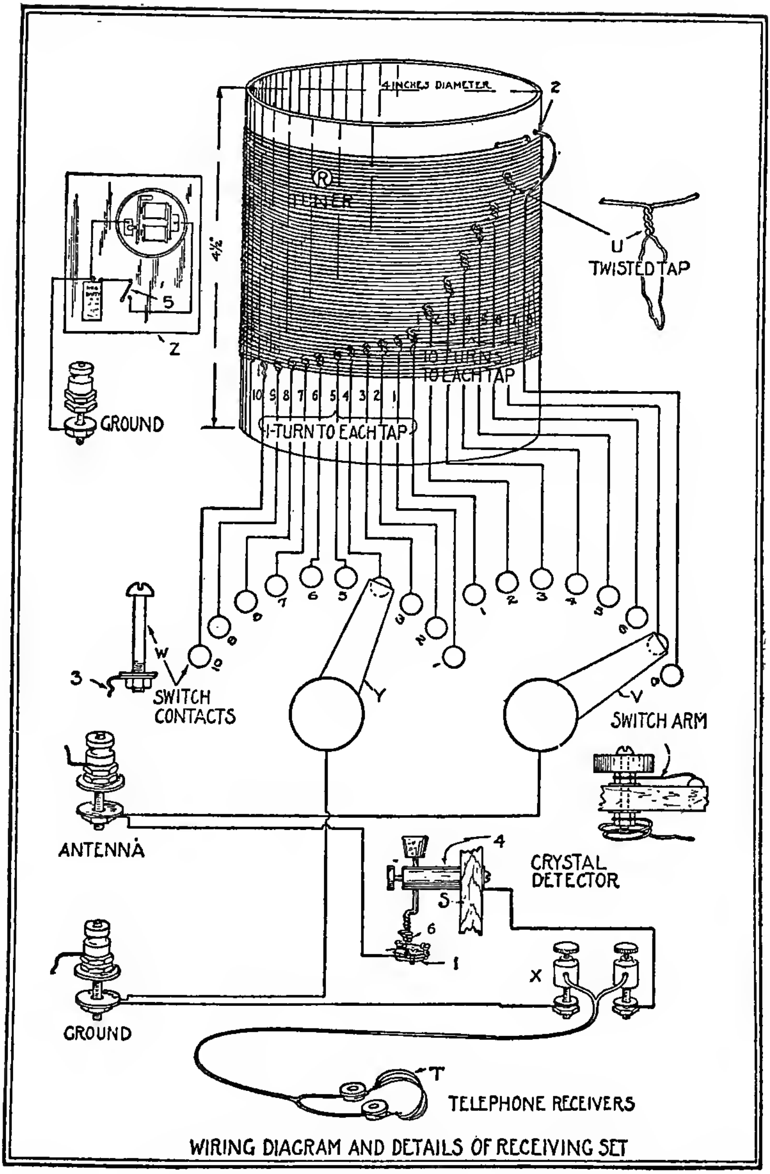

FIG. 183.—Wiring diagram and details of receiving set.

hole so that the crystal is held in place. The wire which is to make connection with the crystal should terminate in the hole so that it will be embedded in the Wood's metal. Instead of being mounted in a hole bored in the base, the crystal may be mounted in a small brass cup such as is found on the positive terminal of some kinds of dry batteries.

The binding post may be mounted on the back of the upright panel near its edge, as shown in Fig. 184. It may be found more convenient to mount the binding post on a small vertical piece of wood screwed to the base at another point, so that the detector will be more accessible. A long slender nail, or a piece of copper wire of a size such as No. 16, about 2 inches long, is bent as shown, about ½ inch from one end, with an offset depending on the size of the crystal used. Ordinarily the offset may be about ¼ inch. This nail or piece of wire is inserted in the binding post as shown. To the upper end a small cork or wooden knob is attached. To the lower end a short piece of fine copper or brass wire is attached and the free part of the wire is wound into a small spiral of several turns. For this fine wire, it will be found best to use No. 26, No. 28, or No. 30. For galena the smaller wire such as No. 30 will usually be found best.

Phone.—It is desirable to use a pair of telephone receivers connected by a head band, usually called a double telephone headset (T, Fig. 183). The telephone receivers may be any of the standard commercial makes, having a resistance of between 2,000 and 3,000 ohms. The double telephone receivers may cost more than all the other parts of the station combined, but it is desirable to get them, especially if it is planned to improve the receiving set later. A single 1,000 ohm telephone receiver with a head band may be used but with less satisfactory results.

Accessories. Under the heading of accessory equipment may be listed binding posts, switch arms, switch contacts, test buzzer, dry battery, and boards on which to mount the complete apparatus. The binding posts, switch arms, and switch contacts may be purchased from dealers who handle such goods, or they may be readily improvised at home. The pieces of wood on which the equipment is mounted may be obtained from a dry packing box and covered with paraffin to keep out moisture. Care should be taken in melting the paraffin not to get it too hot. For this reason, it is a good plan to melt it in a pan set in boiling water. When the paraffin just begins to smoke, it is at the proper temperature. When the wood parts have been drilled and cut to size, they should be soaked in the melted paraffin, or the paraffin may be applied quickly with a small brush. When cold, the excess paraffin must be carefully scraped off with a straight piece of metal such as the brass strip in the edge of a ruler.

Details of Construction.—The following is a description of the method of winding the tuning coil and the construction of the wood panels:

Tuning Coil.—The cardboard tubing is 4 inches in diameter by 4½ inches long. One end of the tube should have the cardboard cover glued securely to it. About 2 ounces of No. 24 (or No. 26) double cotton-covered copper wire is used for winding the coil. Punch three holes in the tube ½ inch from one end as shown at 2 in Fig. 183. Weave the wire through these holes in such a way that the end of the wire will be firmly anchored, leaving about 12 inches of the wire free for connecting. Start with the remainder of the wire to wind the turns in a single layer about the tube, tightly and closely together. After 10 complete turns have been wound on the tube, hold these turns tight and take off a tap. This tap is made by twisting a 6 inch loop of the wire together at such a place that it will be slightly staggered from the first connection. This method of taking off taps is shown clearly at U, Fig. 183. Proceed in this manner until 7 twisted taps have been taken off—one at every 10 turns. After these first 70 turns have been wound on the tube, take off a 6 inch twisted tap for every succeeding single turn until 10 additional turns have been wound on the tube. After winding the last turn of wire, anchor the end by weaving it through two holes punched in the tube as at the start, leaving about 12 inches of wire free for connecting. It is to be understood that each of the 18 taps is slightly staggered from the one just above, so that the taps will not be punched along one line on the cardboard tube. (See Fig. 183.) It might be advisable, after winding the tuning coil, to dip the tuner in hot paraffin. This will help to exclude moisture. It is important to have the paraffin heated until it just begins to smoke, as previously explained, so that when the tuner is removed it will have only a very thin coat of paraffin.

Upright Panel and Base.—Having completed the tuning coil, set it aside and construct the upright panel shown in Fig. 184. This panel may be a piece of wood approximately 1/2 inch thick, 4 1/2 inches wide, and 8 inches long. This panel can be used with apparatus to be described in Appendix II. For this reason, it is desirable to have the last contact an inch from the right end of the panel. (See Fig. 184.) It is also desirable to have the contact points near the top of the panel. The position of the several holes for the binding posts, switch arms, and switch contacts may first be laid out and drilled. The antenna and ground binding posts may be ordinary 8/32 brass machine screws about 1 1/2 inches long with three nuts and two washers. The first nut binds the bolt to the panel, the second nut holds one of the short pieces of stiff wire, while the third nut holds the antenna or ground wire, as the case may be. The switch arm with knob shown at V, Fig. 183, may be purchased in the assembled form, or it may be constructed from a 3/8 inch slice cut from a broom handle and a bolt of sufficient length equipped with four nuts and two washers, together with a strip of thin brass somewhat as shown. The end of the switch arm should be wide enough so that it will not drop between the contact points, but not so wide that it cannot be set to touch only a single contact. The switch contacts (W, Fig. 183) may be of the regular type furnished for this purpose, or they may be $\frac{6}{32}$ brass machine screws with one nut and one washer each; they may even be nails driven through the panel with the indi-

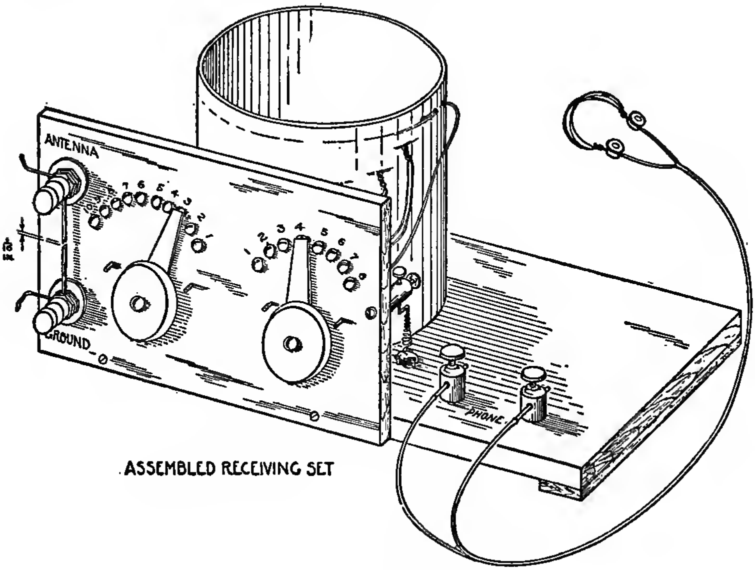

Fig. 184.—Assembled receiving set.

vidual tap fastened under the head or soldered to the projection of the nail through the panel. The base is of wood approximately ¾ inch thick, 5½ inches wide, and 10½ inches long.

The telephone binding posts should preferably be of the set-screw type as shown at X, Fig. 183.

Instructions for Wiring.—After the several parts mentioned have been constructed and (with the exception of the tuning coil) mounted on the wood base, the wires may be connected to the switch arms and binding posts, and the taps may then be connected to the switch contacts. A wire is connected to the back of the left-hand switch-arm bolt (Y, Fig. 183) twisted into a spiral of one or two turns like a clock spring, and then led to the back of the binding post marked "ground." Connection is made to the binding post by removing the insulation from the wire and clamping between the nut and washer. The same wire is now passed through a small hole and run underneath the base to the left-hand binding post marked "phone." A wire is then run from underneath the right-hand binding post marked "phone" to the binding post 4, Fig. 183, which is part of the crystal detector. The copper wire, which was wrapped tightly about the three brass wood screws that hold the crystal in place, is led underneath the base, up through a small hole, and is then connected to the back of the binding post marked "antenna." Another wire is connected to the back of the right-hand switch-arm bolt (V), twisted into a spiral of one or two turns like a clock spring, and then connected to the back of the same binding post.

The taps leading from the tuner should now be connected to the switch contacts. Scrape the cotton insulation from the loop ends of the 16 twisted taps as well as from the ends of the two single wire taps coming from the first and last turns. Fasten the bare ends of these wires to the proper switch contacts as shown by the corresponding numbers in Fig. 183. Be careful not to cut or break any of the looped taps. The connecting wires may be fastened to the switch contacts by binding them between the washer and the nut as shown at 3, Fig. 183. After all the wires from the tuner have been connected, the tuner should be fastened to the base by two or three small screws passing through the cardboard end. The screws should be provided with washers.

Directions for Operating.—After all the parts of this crystal-detector radio receiving set have been constructed and assembled, the first essential operation is to adjust the fine wire so that it rests on a sensitive point on the crystal. This may be accomplished in several ways; one method is to use a buzzer transmitter. Assuming that the most sensitive point on the crystal has been found by the method described in paragraph below, "The Test Buzzer," the rest of the operation is to adjust the radio receiving set to resonance or in tune with the station from which the messages are sent. The tuning of the receiving set is accomplished by adjusting the inductance of the tuner. That is, one or both of the switch arms are rotated until the proper number of turns of wire of the tuner are made a part of the metallic circuit between the antenna and ground, so that together with the capacity of the antenna, the receiving circuit is in resonance with the particular transmitting station. It will be remembered that there are 10 turns of wire between adjacent contacts of the 8 point switch and only 1 turn of wire between adjacent contacts of the 10 point switch. The tuning of the receiving set is best accomplished by setting the right-hand switch arm on contact (1) and rotating the left-hand switch arm over all its contacts. If the desired signals are not heard, move the right-hand switch-arm to contact (2) and again rotate the left-hand switch arm throughout its range. Proceed in this manner until the desired signals are heard.

It will be advantageous to know the wave frequencies (wave lengths) used by the radio transmitting stations in the immediate vicinity. A lower frequency (greater wave length) requires more turns of the coil.

The Test Buzzer.—As stated, the more sensitive spots on the crystal can be found by using a test buzzer (Z, Fig. 183). The test buzzer is used as a miniature local transmitting set. This is shown at Z, Fig. 183. The buzzer, dry battery, and switch (5) may be mounted on the table or a separate board. The binding post marked "ground" may be one terminal of the dry cell. The current produced by the buzzer will be converted into sound by the telephone receivers and the crystal, the loudness of the sound depending on what part of the crystal is in contact with the fine wire. To find the most sensitive spot, connect the binding post marked "ground" of the receiving set to the test buzzer binding post marked "ground," close the switch (5, Fig. 183), and if necessary adjust the buzzer so that a clear note is emitted; set the right-switch arm on contact point No. 8 and connect the telephone receivers to the binding posts. Loosen the set-screw of the binding post (4) slightly and change the position of the fine wire (6, Fig. 183) to several positions of contact with the crystal until the loudest sound is heard in the phones; then slightly tighten the binding post set-screw (4). The single wire connection between the test buzzer and the receiving set is all that is necessary to give a good test signal when the crystal detector is adjusted to a sensitive spot.

After the construction of the set has been completed, a test should be made for broken wires or poor contacts. Connect one terminal of the dry battery to the binding post marked "antenna." Connect the other battery terminal to one terminal of the buzzer, and from the other buzzer terminal run a wire to the binding post marked "ground." Turn the left-hand switch arm to the extreme left and the right-hand switch arm to the extreme right. If the buzzer operates, the metallic circuit of the coil is complete.

To make sure that the cords of the telephone receiver are all right, put the telephone receivers over the ears and touch the two cord tips to the two terminals of the dry battery. If a click is heard in both receivers, the cord is all right.

Approximate Cost of Parts

The following list shows the approximate cost of the parts used in the construction of the receiving station. The total cost will depend largely on the kind of apparatus purchased and on the number of parts constructed at home.

Antenna	
Wire, copper, bare or insulated, No. 14 or 16, 100 to 150 feet	$ 0.75
Rope, 1/4 or 3/8 inch, 2 cents per foot	
2 insulators, porcelain	.20
1 pulley	.15
Lightning switch, 30 ampere battery switch	.30
1 porcelain tube	.10
Ground Connections	
Wire (same kind as antenna wire).	
2 clamps	.30
1 iron pipe or rod	.25
Receiving Set	
2 ounces No. 24 copper wire, double cotton covered	.75
1 round cardboard box.	
2 switch knobs and blades complete	1.00
18 switch contacts and nuts	.75
3 binding posts, set screw type	.45
2 binding posts, any type	.30
1 crystal, tested	.25
3 wood screws, brass, 3/4 inch long	.03
2 wood screws for fastening panel to base	.02
Wood for panels (from packing box).	
2 pounds paraffin	.30
Lamp cord, 2 to 3 cents per foot.	
Test buzzer	.50
Dry battery	.30
Telephone receivers	4.00
Total	$10.70

If the switches are constructed as directed and a single telephone receiver be used, the cost may be kept well below $10.

If a head set consisting of a pair of telephone receivers instead of a single telephone receiver is used, the cost of this item may be about $8 instead of $4. Still more efficient and expensive telephone receivers are available at prices ranging up to about $20.

APPENDIX II

TWO-CIRCUIT RADIO RECEIVING EQUIPMENT WITH CRYSTAL DETECTOR DESIGNED BY THE BUREAU OF STANDARDS

This chapter describes the construction and operation of a simple receiving set, which has about the same receiving range as the one described in Appendix I and will respond to the same wave lengths. The advantage of this set is that it is more "selective," which means that it is easier to distinguish the message from one of two radio transmitting stations, when both of the transmitting stations are using wave lengths that are nearly the same. This greater selectivity is brought about through the use of two complete electric circuits, both of which are tuned to the incoming waves. This is in contrast to the single-circuit equipment, as described in Appendix I.

The total cost of this equipment can be kept down to about $15. Most of the equipment mentioned in Appendix I can also be used with this set, and the cost of the additional apparatus will be about $5.

Essential Parts of Receiving Station

Antenna, Lightning Switch, Ground Connections and Telephone Receivers.—These are completely described in Appendix I. The other essential part of the equipment is the receiving set, which is made up of the following parts:

Coupler.—This is composed of a fixed section and a movable section. (See Fig. 185.) The fixed section is made up of the coil tube P, the upright support J, the contact panel K and the base B. The movable section is composed of the coil tube S, the supporting contact panel M and the base L. The movable section is so arranged that the coil tube S slips inside of the coil tube P when M is pushed to the left. The coil tubes are made by winding wire on cardboard tubing.

Variable Condenser.—The variable air condenser (C, Figs. 185, 186) should have a maximum capacity rating between 0.0004 and 0.0005 microfarads (400 to 599 micromicrofarads).

Crystal Detector.—This is essentially the same crystal detector (D, Figs. 185, 186) as was described in Appendix I, except that a few improvements have been made in its construction.

Accessories.—Under the heading of accessory equipment may be listed binding posts, switch arms, switch contacts, test-buzzer, dry battery, and boards on which to mount the complete apparatus. The binding posts, switch arms, and switch contacts may be purchased from dealers who handle such goods, or they may be readily improvised at home. The pieces of wood on which the equipment is mounted may be obtained from a dry packing box and covered with paraffin to keep out moisture. Care should be taken in melting the paraffin not to get it too hot and it should not be heated beyond the point where it just begins to smoke. The paraffin may be melted in a pan set in boiling water in order to eliminate the possibility of getting it too hot. When the wood parts have been drilled and cut to size, the paraffin should be applied quickly with a small brush. When cold, the excess paraffin should be carefully scraped off with a straight piece of metal, such as the brass strip in the edge of a ruler.

Details of Coupler Construction

Movable Coil Tube, Coil Tube Support and Base.—The coil tube (S, Fig. 185) is a piece of cardboard tubing 3⅝ inches in diameter and 4 inches long. A round cardboard table-salt box which can be obtained at a grocery store is about 3⅝ inches in diameter and can be used for this purpose. One of the cardboard ends or caps should be securely glued to the box. This tube is wound with No. 24 (or No. 26) double cotton-covered copper wire.

The method of winding the wire is much the same as described in Appendix I. Punch two holes in the tube ⅜ inch from the

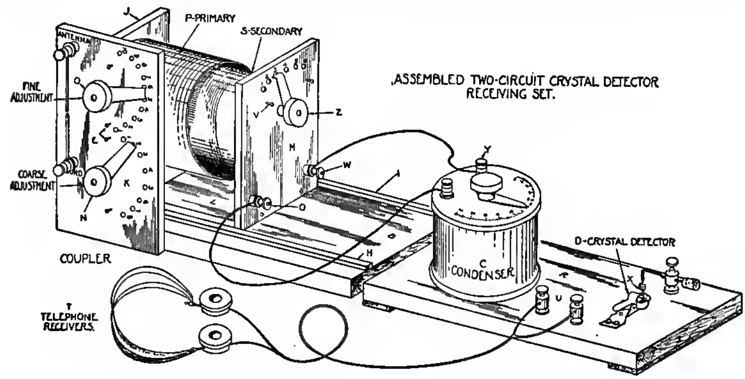

Fig. 185.—Assembled two-circuit detector receiving set.

open end, as shown at R, Fig. 185. Weave the end of the wire through these holes so that it is firmly anchored and has one end extending about 10 inches inside the tube. Punch a hole F about ⅝ inch from the other end (which has the cardboard cover secured to it) in line with the holes punched at R. Draw the free end of the wire through the inside of the tube and thread it out through the hole at F. Now wind on 10 turns of wire and take off a 6 inch twisted tap, as described in Appendix I. Hold the turns tight and punch a hole B directly underneath this tap. Insert the end of the tap in the hole and pull it through the inside of the tube so that the turns are held in place. The hole for this tap should be slightly staggered from the first two holes which were punched. Punch another hole L, 5/8 inch from the other end of the tube and in line with the hole B. Thread the twisted tap out through this hole and pull it tight. Wind on 10 more turns and bring out another twisted tap; then 10 more turns and another tap; 15 turns and another tap; 15 more turns and another tap. Finally, wind on 20 more turns and bring out the free end of the wire in the same manner as the taps were brought out. The tube now has 80 turns of wire wound on it and there are 5 twisted taps and two single wires projecting through the row of holes at the closed end of the tube. The position of the wires inside the coil tube is shown by the dotted lines.

The contact panel (M, Fig. 185) which supports the coil tube is a piece of dry wood 5½ inches high, 4 inches wide and ½ inch thick. The contacts, switch arm and knob, and binding posts are described in Appendix I. The end of the switch arm should be wide enough so that it will not drop between the contact points, but not so wide that it cannot be set to touch only a single contact. Having located the hole for the switch-arm bolt, the switch arm should be placed in position and the knob rotated in such a manner that the end of the contact arm will describe an arc upon which the contact points are to be placed. The holes for the contacts should next be drilled, the spacing depending upon the kind of contacts which are to be used.

The movable base L is a square piece of dry wood 4 inches long, 4 inches wide and about ¾ inch thick. Care should be taken to have the edges of this block cut square with respect to the sides.

The panel M should now be screwed to the movable base L, as shown in Fig. 185. Care should be taken to have the edges of the blocks M and L evenly lined up so that the two edges of the block L (Fig. 185), which slide along the inside edges of the strips H and I, will be smooth, continuous surfaces.

Fixed Coil Tube and Panel.—The coil tube P (Fig. 185) is essentially the same as the tuner described in Appendix I, and the tuner used there may be made a part of P, of this set. The cardboard cover should be glued to the end of the tube where the single turn taps are taken off. This tube is 4⅛ inches in diameter and 4 inches long. If a new coil tube is constructed, it may be improved by using a somewhat different arrangement of the twisted taps. (See coil marked "Tuning Coil" in Fig. 183.) Instead of taking off taps in a line from the upper right corner to the lower left corner of the figure, start at the upper left corner and progress downward to the lower right corner. The end of the coil tube where the 10 turn taps are taken off should have the cardboard cover glued to it. This is the top of the coil tube as it is shown in the diagram. (See Fig. 186.) In all other respects, the tube is wound exactly as described in Appendix I.

The panel which was described in Appendix I may also be used for the panel K. (See Fig. 185.) If the receiving set described there has not been constructed, this panel may be made from a board 7½ inches long by 4½ inches wide and about ½ inch thick. The position of the contacts can best be determined by inserting the switch arms in their respective holes and turning the knobs so that the ends of the switch arms will describe arcs, as previously explained. The contacts, and switch arms and knobs are described in Appendix I.

Fixed Base and Coil Tube Support.—The fixed base B is a piece of dry wood 5½ inches wide, 11 inches long and between ¾ and ⅞ inch thick. The support J for the fixed coil tube is 5½ inches wide (the width of the base), 6 inches long and about ½ inch thick. This board should be screwed to one end of the base so that it is held securely in a vertical position. It will then project about 5 inches above the base G.

A strip of wood I, 11 inches long, 5/16 inch wide and about ¼ inch thick is now fastened to the base by cigar-box nails or small brads so that it is even with the rear edge, as shown in the drawing. (See Fig. 185.) The upright panel M having been fastened to the movable base L, as previously explained, is placed in position as shown. The next step is to locate the strip H in such a position that the block L will slide easily back and forth the entire length of the fixed base B. Having found this position, this strip is secured in the same manner as the strip I. It is, of course, understood that neither the movable coil tube S nor the switch contacts and binding posts have, up to the present time, been mounted on the upright panel M. The wooden parts for the loose-coupler are now finished and should be covered with paraffin according to instructions given under "Accessories."

It might be advisable after winding the coil tubes P and S, to dip them in hot paraffin. This will help to exclude moisture. It is important to have the paraffin heated until it just begins to smoke, as previously explained, so that when the coils are removed they will have only a very thin coating of paraffin.

Variable Condenser and Crystal Detector

Variable Condenser.—The variable air condenser (C, Figs. 185, 186) should have a maximum capacity of between 0.0004 and 0.0005 microfarads (400 to 500 micromicrofarads). The type pictured in Fig. 185 is inclosed in a round metal case, but the "unmounted" type may also be used. A person adept with the use of tools can make the variable air condenser, but a discussion of the method is not within the scope of this book. The variable condenser is mounted on a board R (Fig. 185) about 10 inches long, 5½ inches wide and ¾ inch thick. This board is similar to the baseboard used for the set described in Appendix I. The strips of wood are fastened under the ends, so that wires may be run underneath for connections. After the holes for the detector binding post, and also the holes for the telephone binding posts U have been drilled, the board should be coated with paraffin, as previously described.

Crystal Detector.—The galena crystal may be mounted as described in Appendix I, or it may be mounted as pictured in Figs. 185 and 186. The holder for the crystal is a metallic pinch-clip such as the ordinary battery test clip or paper clip. This clip should be bent into a convenient shape, so that it may be fastened to the base.

The wire X which makes contact with the crystal is a piece of fine wire (about No. 30) which is wound into the form of a spring and attached to a heavy piece of copper wire (about No. 14). This heavy wire is bent twice at right angles, passes through the binding post, and has a wood knob or cork fixed to its end as shown. It is desirable to have the fine wire of springy material, such as German silver, but copper wire may be used if necessary.

The importance of securing a tested galena crystal cannot be emphasized too strongly, and it should be understood that good results cannot be obtained by using an insensitive crystal.

Instructions for Assembling and Wiring

Coupler.—The movable portion of the coupler should be assembled first. As shown in Fig. 185, the fittings making up this part of the set are the movable base L, the coil tube support M and the coil tube S. Insert in M the 6 switch contacts (machine screws), the switch arm, and the binding posts, in the proper holes which have been drilled. Adjust the switch arm until it presses firmly on the contact points (bolt-heads) and fasten the bare end of a No. 24 copper wire between the nuts on the end of the switch-arm bolt 2 (Figs. 185 and 186) which projects through the panel M. Wind this wire into the form of a spiral of two or three turns like a clock-spring, leaving a few inches of the wire for connection. Insert two small screws V (Fig. 185) in the panel M so that the switch arms will not drop off the row of contact points when the knob is turned too far.

The coil tube S is now ready to be fastened in position on the panel M. Cut a 1 inch hole in the cardboard end of the coil tube and place it with the closed end next to the panel M in such a position that it will be just below the row of nuts and washers (switch contacts) and in the center of the panel M with respect to the sides. Fasten it to the panel with short wood screws. The switch-arm bolt with the spiral wire con-

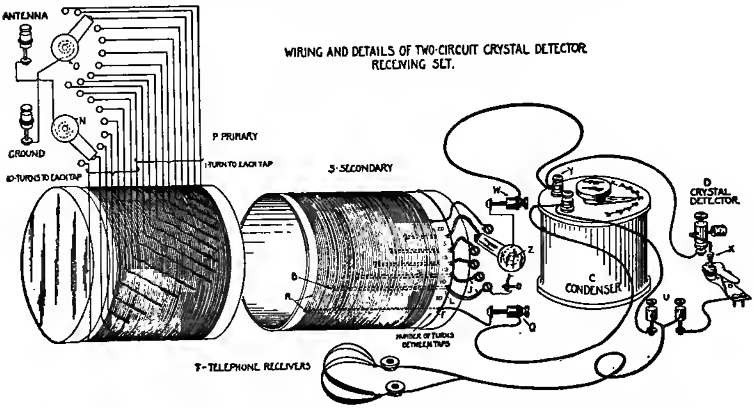

FIG. 186.—Wiring and Details of two-circuit crystal detector receiving set.

nected to it should project through the hole cut in the end of the coil tube. Thread the end of this wire through a hole punched near the end of the coil tube next to the panel and connect this wire to the back of the binding post W. (See Figs. 185, 186.) The wire F (Fig. 186) is now connected to the back of the binding post Q. There now remain 5 twisted taps and 1 wire to be connected to the 6 switch contacts. The taps should be cut off about 1½ inches from the coil tube and the insulation removed from the pairs of wires thus formed. Each pair of wires should be twisted together, as shown at J, Fig. 186. The connections are now made by clamping the 5 taps and also the end of the single wire between the nuts and washers on the contact bolts. The connections are clearly shown in the diagram.

We are now ready to assemble and wire the fixed portion of the coupler, composed of the base B, coil support J, panel K and coil tube P. As previously mentioned, the panel K is practically the same as the panel shown in Appendix I, except that for this purpose the original panel is mounted so that the lower edge now becomes the left-hand edge. This brings the series of 10 contacts at the top of the panel in our present set. When the panel is turned to this position, the two binding posts will be at the top. Change the position of the right-hand binding post, so that the two are arranged as shown in Fig. 190. Connections between the binding posts and switch arms are made as described in Appendix I. Two short pieces of wire should now be fastened under the binding posts at the front of the panel. These wires are arranged so that there is a very short space between their ends, as explained in Appendix I. Screw the panel K to the base B and to the support J, meanwhile allowing the coil tube P to lie on the base so that the connecting wires will not be broken.

If the panel has been made especially for this coupler, as described in this chapter, it should be mounted according to the following instructions:

Screw the panel to the base and to the support J and insert the binding posts, switch arms and bolts, and contact bolts in the proper holes. The switch arms should now be adjusted so that they make firm contact on the heads of the bolts. Now insert 4 small screws (E, Fig. 185) in the front of the panel so that the switch arms will not drop off the row of contact points when the knobs are turned too far. Insert a wire between the nuts on the end of the lower switch-arm bolt N where it projects through the back of the panel K. (See Fig. 185.) Wind the wire into a spiral of 1 or 2 turns like a clock-spring and connect the end to the upper binding post which is marked "Antenna." These connections will be understood by referring to the upper left-hand corner of Fig. 186.

In the same manner, connect another wire from the upper switch-arm bolt to the lower binding post which is marked "Ground." (See Fig. 186.) The connecting wires should be insulated except where a connection is needed and should not touch each other. Two short pieces of wire are now fastened to the binding posts in the front of the panel, as previously explained.

The coil tube P should now be laid on the base in about the same position as it is shown in Fig. 185. The 16 twisted taps and also the 2 single wires from the ends of the winding are now to be connected to the back of the 18 contacts on the panel, following the method given in Appendix I. The order of connecting the taps may be understood by referring to Fig. 186.

The following instructions will apply whether the coil tube P was made according to the description in Appendix I, or was made according to instructions given in this appendix.

Carefully raise the coil tube P against the support J to such a position that when the coil tube S of the movable section of the tuner is pushed in the coil tube P, the space between the two tubes will be equal all around. Mark this position of the coil tube P on J, and fasten it to J with short wood screws.

Condenser and Crystal Detector.—The mounting of the condenser C and the crystal detector D on the base R is clearly shown in Fig. 185. Crystal detectors have been previously described in this appendix and in Appendix I. A wire is run from the binding post Y on the variable condenser C, through a small hole in the base R, and is then connected to the under side of the detector binding post. Another wire is now run from the clip which holds the galena crystal, through a small hole in the base, and is then connected to the under side of the right-hand binding post U. The left-hand binding post U is next connected to the binding post on the variable condenser which has no wire attached to it, by running a wire under the base and up through a small hole. The wiring will be understood by referring to the right-hand portion of Fig. 186. The wires may be the same size as were used for winding the coil tubes and should be insulated. Two pieces of wire should now be connected from the binding posts W and Q (Figs. 185, 186) to binding posts on the variable condenser. The telephone receivers T are now connected to the binding posts U and the receiving set is complete except for connecting to the antenna and ground.

The connection of the antenna lead and ground wire to the binding posts marked "Antenna" and "Ground" respectively is made as shown in Fig. 184 in Appendix I.

The coil tube P is usually called the "primary" and the coil tube S is usually called the "secondary."

Directions for Operating

Push the coil tube S (secondary) about half way into the coil tube P (primary) and set the switch 2 on contact point 4. The primary switch N is set on contact point 8. The primary switch O may be left in any position. The crystal detector can be adjusted most easily by the use of the test buzzer, which is described below. If the test buzzer is not used, the wire which rests on the crystal must be placed lightly at different points on the crystal until the transmitting station is heard when the set is adjusted as described below.

Having adjusted the crystal detector to a sensitive point, the next thing is to adjust the switches on the coil tube P (primary), the switch on the coil tube S (secondary) and also the variable condenser C, so that the apparatus will be in "resonance" with the transmitting station. Set the primary switch N on contact point 1 and while keeping it in this position move the other primary switch O over all of its contacts, stopping a moment at each one. Care should be taken to see that the ends of the switch arms are not allowed to rest so that they will touch more than one contact point at a time. If no signals are heard, set the switch arm N on contact point 2 and again move the switch arm O over all of its contacts. Proceed in this manner until the transmitting station is heard. This is called "tuning" the primary circuit.

The tuning of the secondary circuit is the next operation. Set the secondary switch Z on contact point 1 and turn the knob of the variable condenser C so that the pointer moves over the entire scale. If no signals are heard, set the switch 2 on contact point 2 and again turn the knob of the variable condenser so that the pointer moves over the entire scale. Proceed in this manner until the signals are loudest, being careful to see that the ends of the switch arms touch only one contact point at a time. Next slide the coil tube S (secondary) in and out of the coil tube P (primary) until the signals are made as loud as possible. This operation is called changing the coupling. When the coupling which gives the loudest signal has been secured, it may be necessary to readjust slightly the position of the switch arm O, the position of the movable coil tube S and the "setting" of the variable condenser C.

The receiving set is now in resonance with the transmitting station. It is possible to change the position of one or more of the switch arms, the position of the movable coil tube and the setting of the variable condenser in such a manner that the set will still be in resonance with the same transmitting station. In other words, there are different combinations of adjustments which will tune the set so that it will respond to signals from the same transmitting station. The best adjustment is that which reduces the signals from undesired stations to a minimum and still permits the desired transmitting station to be heard. This is accomplished by decreasing the coupling (drawing coil tube S farther out of coil tube P) and again tuning with the switch arm O and the variable condenser C. This may also weaken the signals from the desired transmitting station but it will weaken the signals from the undesired stations to a greater extent, provided that the transmitting station which it is desired to hear has a wave frequency which is not exactly the same as that of the other stations. This feature is called "selectivity."

The Test Buzzer.—As mentioned above, it is easy to find the more sensitive spots on the crystal by using a test buzzer. This has been described in Appendix I and is shown at Z, Fig. 183, therein. Referring to this figure, the binding post marked "ground" should be connected by a flexible wire to the binding post W, which is shown in Fig. 190 in this appendix.

The operation of the test buzzer has been described in Appendix I.

Approximate Cost of Parts

The following parts are used in the equipment described in Appendix I, and are needed also for the two-circuit set described in this appendix:

Antenna	
Wire—copper, bare or insulated No. 14 or 16, 100 to 150 ft., about	$ 0.75
Rope—1/4 or 3/8 inch, 2 cents per foot.	
2 insulators—porcelain	.20
1 pulley	.15
Lightning switch—30 ampere battery switch	.30
1 porcelain tube	.10
Ground Connections	
Wire (same kind as antenna wire).	
2 clamps	.30
1 iron pipe or rod	.25

Receiving Set

3 ounces No. 24 double cotton-covered copper wire	$ .40	
1 round cardboard box.		
2 switch knobs and blades, complete	1.00	
18 switch contacts and nuts	.75	
3 binding posts—set-screw type	.45	
2 binding posts—any type	.30	
1 crystal—tested	.25	
3 wood screws—brass, 3/4 inch long	.03	
2 wood screws for fastening panel to base	.02	
Wood for panels (from packing box).		
2 pounds paraffin	.30	
Lamp cord—2 to 3 cents per foot.		
Test buzzer	.50	
Dry battery	.30	
Telephone receivers	4.00	to $ 8.00
Total	$10.35	to $14.35

The following additional parts will be required:

3 ounces No. 24 double cotton-covered copper wire	$ 0.40	
1 round cardboard box.		
1 switch knob and blade, complete	.50	
6 switch contacts and nuts	.25	
2 binding posts—any type	.30	
1 battery clip for crystal	.10	
Miscellaneous screws	.30	
1 variable condenser—0.0004 to 0.0005 microfarads (400 to 500 micromicrofarads)	3.00	to $ 6.00
Total additional cost	$ 4.85	to $ 7.85

APPENDIX III

REPORT OF DEPARTMENT OF COMMERCE CONFERENCE ON RADIO TELEPHONY

This Conference was called by Secretary Hoover to consider general questions concerning the regulation of radio communication.

The following were invited to serve as members of the Conference, the representatives of the Government departments being selected by their several departments:

Dr. S. W. Stratton, Chairman (Director of Bureau of Standards).

Mr. Edwin H. Armstrong, Columbia University, New York.

Capt. Samuel W. Bryant, U. S. N., Navy Department.

Mr. D. B. Carson, Commissioner of Navigation, Department of Commerce.

Mr. J. C. Edgerton, Supt., Radio Service, Post Office Department.

Dr. Alfred N. Goldsmith, Secretary, Institute of Radio Engineers, New York, N. Y.

Prof. L. A. Hazeltine, Stevens Institute of Technology, Hoboken, N. J.

Mr. R. B. Howell, Metropolitan Utilities District, Omaha, Neb.

Prof. C. M. Jansky, Jr., University of Minnesota.

Mr. Hiram Percy Maxim, President, American Radio Relay League, Hartford, Conn.

Major General George O. Squier, War Department.

Representative Wallace H. White, Jr., of Maine.

Mr. W. A. Wheeler, Bureau of Markets and Crop Estimates, Department of Agriculture.

The Conference was in session from February 27 to March 2, 1922, at the end of which time a Tentative Report was prepared. This report was sent to all persons who requested it, and to representatives of various interests, which in the judgment of the Department of Commerce were interested. A large number of suggestions and comments were received. The Conference had subsequent sessions on April 17, 18, and 19. All comments were considered, the general effect of the comments being to approve the substance of the preliminary report with a very few exceptions. The report as finally amended and adopted is given herewith.

In addition to preparing a report on technical matters, the Conference made recommendations as to essential points required in legislation to give the Secretary of Commerce authority necessary to accomplish the ends recommended, through the power to make and enforce regulations.

General Resolutions Adopted by the Radio Telephony Conference

Resolved, that the Conference on Radio Telephony recommend that the radio laws be amended so as to give the Secretary of Commerce adequate legal authority for the effective control of:

1. the *establishment* of all radio transmitting stations except amateur, experimental and government stations.

2. the *operation* of nongovernmental radio transmitting stations.[1]

Resolved, that it is the sense of the Conference that radio communication is a public utility and as such should be regulated and controlled by the Federal Government in the public interest.

[1] It was the desire of the Conference that the present authority of the Secretary of Commerce over the operation of radio transmitting stations be extended and that the Secretary of Commerce be granted authority to control the erection or establishment of certain classes of radio stations.

Resolved, that the types of radio apparatus most effective in reducing interference should be made freely available to the public without restriction.

1. Allocation of Wave Bands for Radio Telephony

A. It is recommended that waves for radio telephony be assigned in bands, according to the class of service (see table).

Throughout this report, both wave lengths and wave frequency are given. Wave length in meters is 300,000,000 divided by wave frequency in kilocycles per second.

Wave bands marked *exclusive* can be used for no other type of service; those marked *nonexclusive* are available for other types of radio communication, subject to regulation.

Use	*Wave Length Meters*	*Wave Frequency Kilocycles (1000) Per Second*
1. Transoceanic radio telephone experiments, nonexclusive. (See Note 3)	6,000 5,000	50 60
2. Fixed service radio telephony, nonexclusive. (See Note 4)	3,300 2,850	90.9 105.2
3. Mobile service radio telephony, nonexclusive	2,650 2,500	113.2 120
4. Government broadcasting, nonexclusive. (See Note 1)	2,050 1,850	146 162
5. Fixed station radio telephony, nonexclusive. (See Note 5)	1,650 1,550	181.8 193.5
6. Aircraft radio telephony and telegraphy, exclusive	1,550 1,500	193.5 200
7. Government and public broadcasting, nonexclusive	1,500 1,050	200 285.7
8. Radio beacons, exclusive. (See Note 6)	1,050 950	285.7 316
9. Aircraft radio telephony and telegraphy, exclusive	950 850	316 353

Use	*Wave Length Meters*	*Wave Frequency Kilocycles (1000) Per Second*
10. Radio compass service, exclusive. (See Note 7)	850 750	353 400
11. Government and public broadcasting, 200 miles or more from the seacoast, exclusive.	750 700	400 428
12. Government and public broadcasting, 400 miles or more from the seacoast, exclusive.	700 650	428 462
13. Marine radio telephony, nonexclusive. (See Note 8)	750 650	400 462
14. Aircraft radio telephony and telegraphy, exclusive. (See Note 8)	525 500	572 600
15. Government and public broadcasting, exclusive	495 485	606 618
16. Private and toll broadcasting. (See Note 9)	485 285	618 1,052
17. Restricted special amateur radio telegraphy, nonexclusive. (See Note 10)	310	968
18. City and state public safety broadcasting, exclusive. (See Note 11)	285 275	1,052 1,091
19. Technical and training schools shared with amateur. (See Note 12)	275 200	1,091 1,500
20. Amateur telegraphy and telephony (exclusive, 150 to 200 meters). (Shared with technical and training schools, 200 to 275 meters.) (See Note 13)	275 150	1,091 2,000
21. Private and toll broadcasting, exclusive	150 100	2,000 3,000
22. Reserved	below 100	above 3,000

Note 1. The terms used in the above schedule are defined as follows:

Broadcasting.—Signifies transmission intended for an unlimited number of receiving stations without charge at the receiving end. It includes:

1. *Government broadcasting* signifying broadcasting by departments of the Federal Government;

2. *Public broadcasting* signifying broadcasting by public institutions, including state governments, political subdivisions thereof, and universities and such others as may be licensed for the purpose of disseminating informational and educational service;

3. *Private broadcasting* signifying broadcasting without charge, by the owner of a station, as a communication company, a store, a newspaper, or such other private or public organization or person as may be licensed for the purpose of disseminating news, entertainment and other service; and

4. *Toll broadcasting* signifying broadcasting where a charge is made for the use of the transmitting station.

Note 2. A station carrying on two or more of the broadcasting services specified in classes 2, 3, and 4 must be licensed for each class of service.

Note 3. When transoceanic radio telephone experiments are to be conducted the Department of Commerce should endeavor to arrange with other countries for the use of the wave band 5,000 to 6,000 meters assigned for this purpose.

Note 4. The wave band from 2,850 to 3,300 meters may be used for fixed service radio telephony only, provided it does not interfere with service using continuous wave telegraphy.

Note 5. The wave band from 1,550 to 1,650 meters is for use of radio telephone communication over natural barriers, but is not exclusive of other services.

Note 6. Radio beacons are radio transmitting stations which transmit signals from which a mobile direction finding station may determine its bearing or position.

Note 7. Radio compass service is here used to signify a direction finding service in which a mobile station transmits to one or more fixed stations which in turn transmit back the bearing or position of the mobile station.

Note 8. The wave band from 525 to 650 meters is reserved for marine radio telegraphy, exclusive.

Note 9. Assignment of waves in band 16 will, in general, involve keeping the zones from 285 to 315 and from 425 to 475 meters open in coastal regions. Furthermore, in border regions, account should be taken of the wave lengths used in neighboring countries, and these should be suitably protected by a locally unused band of adjacent wave lengths.

Note 10. The restricted special amateur wave of 310 meters is for use by a limited number of inland stations and only where it is necessary to bridge large, sparsely populated areas or to overcome natural barriers.

Note 11. City and state public safety broadcasting should in small cities be conducted by interrupting the broadcast service of classes 2, 3, or 4 in case of emergency. In large cities this service will ordinarily have its own stations and will use the wave band, 275 to 285 meters, assigned to such service. Private detective agencies desiring to operate radio telephone broadcasting service should be required to coöperate with municipal or state services in the use of the wave band 275 to 285 meters, assigned to the latter service.

Note 12. By "technical and training school" in this report, is meant a school which in the judgment of the Secretary of Commerce is carrying on sufficient instruction of the proper character for training men for the radio profession to warrant the granting of a station license for that purpose.

Note 13. An amateur is one who operates a radio station, transmitting, receiving, or both, without pay or commercial gain, merely for personal interest or in connection with an organization of like interest.

Note 14. The Conference is of the opinion that broadcast transmitting stations should not in coastal regions be permitted on wave lengths closely adjacent to those assigned in the marine traffic and believe that its recommendations provide for adequate protection of such marine traffic. The Conference recommends the assignment of wave lengths adjacent to those used in the marine traffic to inland stations under such conditions as to avoid interference with the marine traffic.

B. It is recommended that the Secretary of Commerce assign a specific wave length to each radio telephone broadcasting station (except Government and amateur stations), this of course being within the band pertaining to the particular service of that station.

C. It is recommended that the wave band assigned to amateurs, 150 to 275 meters, be divided into bands according to the method of transmission, damped wave stations being assigned the band of lowest wave lengths, interrupted or modulated continuous wave radio telegraph stations the next band, radio telephone stations the next band, and finally unmodulated continuous wave radio telegraph stations the band of highest wave lengths. It is recommended that amateurs be permitted to carry on broadcasting within the wave length band assigned by the Secretary of Commerce to amateur radio telephony.

A damped wave is one composed of successive trains in which the amplitude of the oscillation after having reached its maximum decreases gradually. This refers to waves from spark transmitters or other types of transmitters having characteristic decrement similar to spark transmitters. Transmitters employing continuous wave oscillators in which the variation in frequency or amplitude is abrupt (as with the use of a chopper), are classed as damped wave transmitters.

An interrupted or modulated continuous wave is one in which the amplitude or the frequency is varied according to a simple periodic law of audible frequency. (This is commonly referred to as the interrupted continuous waves, or I. C. W.) A continuous wave transmitter employing a rectified plate voltage which is not a substantially constant direct voltage is classed as an interrupted or modulated continuous wave transmitter. Note: This included transmitters in which the variation in amplitude or frequency is effected in a gradual way only. (For abrupt variation see damped wave.)

An unmodulated continuous wave is one in which the permanent state is periodic and has substantially constant amplitude and frequency. (This includes waves in which the amplitude variation is effected simply by the manipulation of a key. This is commonly referred to as a continuous wave, or C. W.)

D. It is recommended that the present regulations governing experimental stations remain in effect. An experimental station is one operated exclusively for technical or scientific investigations.

E. 1. The Conference experienced the greatest difficulty in providing even partly for the generally demanded services. The Conference therefore disapproved of the elimination of essential services by the introduction of direct advertising which might be expected to require extensive assignment of wave bands if permitted at all.

2. Many services for which radio telephony might otherwise be desirable cannot practically be conducted by this means on account of the interference which such use would cause with other services of a more essential nature or for which there is great public demand.

3. In view of the demand for broadcast service by the general public, it is not desirable to disseminate information over wide areas for purposes of point-to-point communication except where that communication cannot be effectively maintained by other means.

4. A radio service in which a message is addressed or intended for a prescribed number of particular stations is not a broadcast service and is to be classed as a "multiple telegram" or "multiple telephone service." It was not thought advisable to use the much demanded short wave bands for communications of this nature as they would serve a relatively small number. The available wave lengths for such multiple service messages are bands 2 and 5.

5. The Conference is of the opinion that the use of radio communication for "point-to-point" communication over land in most cases constitutes an uneconomic use of the available wave bands and it is recommended that at the present state of the art such communication should be carried on by other means, in so far as possible.

6. The Conference very carefully considered the proximity of wave bands assigned to amateurs and broadcast services but deemed it essential to utilize all of the available wave bands.

7. It was felt that waves longer than 275 meters should not be assigned to technical and training school stations because of the needs of broadcast services greatly desired by a large portion of the public in that zone, and because the extension of amateur wave lengths and the organization of their use will enable their effective employment by the technical and training school stations.

II. Power Limitation, Geographical Distribution, and Hours of Operation of Broadcasting Stations

A. It is recommended that the Secretary of Commerce assign to each radio telephone broadcasting station a permissible power based on the normal range of the station, such normal ranges for the different classes of service to have the following average values, larger or smaller values being discretionary where conditions warrant.

Government broadcasting stations, 600 (land) miles.

Public broadcasting stations, 250 miles.

Private and toll broadcasting stations, 50 miles.

Normal range is the average reliable daytime ranges over which satisfactory communication can be obtained with good available receiving apparatus.

The Conference recommends that broadcasting stations should not be allowed to use unlimited power because of the fact that this will limit the number of services which can be rendered within a given area to an undesirable extent.

(Note: The Bureau of Standards of the Department of Commerce should make a study of the relation between the normal reliable range of a station and the antenna power on the basis of the use of good available receiving apparatus. It is recognized that this relation may change with the development of the radio art.)

B. It is recommended that the same wave (or overlapping wave bands) be not assigned to stations within the following distances from one another, except these distances may be lowered if the normal ranges of the stations are correspondingly lowered.

For government broadcasting stations, 1,500 miles

For public broadcasting stations, 750 miles.

For private and toll broadcasting stations, 150 miles.

(Note: The Bureau of Standards should make a study of the width of wave band—expressed in cycles per second—required for satisfactory radio telephony. It is recognized that this width depends on the methods of transmission and reception employed.)

C. It is recommended that the Secretary of Commerce cause an immediate study to be made of the best geographical distribution of broadcasting stations with the view of attaining the best service with a minimum of interference.

D. It is recommended that in cases where congestion of radio telephone broadcasting traffic exists, or threatens to exist, the Secretary of Commerce assign suitable hours of operation to existing or proposed radio telephone broadcasting stations.

III. Considerations to be Followed in Granting Licenses

A. It is recommended that in the case of conflict between radio communication services first consideration be given to the public not reached, or not so readily reached, by other communication services.

B. It is recommended that subject to public interest and to the reasonable requirements of each type of service the order of priority of the services be Government, Public, Private, Toll.

C. It is recommended that the degree of public interest attaching to a private or toll broadcasting service be considered in determining its priority in the granting of licenses, in the assignment of wave frequencies, and in the assignment of permissible power and operating time, within the general regulations for these classes of service.

D. It is recommended that toll broadcasting service be permitted to develop naturally under close observation, with the understanding that its character, quality and value to the public will be considered in determining its privileges under future regulations.

E. It is recommended that direct advertising in radio broadcasting service be absolutely prohibited and that indirect advertising be limited to a statement of the call letters of the station and of the name of the concern responsible for the matter broadcasted, subject to such regulations as the Secretary of Commerce may impose.

F. It is recommended that when all available wave frequencies in any geographical region are already assigned, no further licenses for broadcasting be granted in that region until cause arises for the revocation of existing licenses.

G. It is recommended that private or toll broadcasting stations transmitting time signals shall transmit only official time signals and with authorization from and under conditions approved by the Secretary of Commerce.

H. It is recommended that the transmission of signals of such character or wave length as to interfere deliberately with the reception of official time signals constitutes grounds for the revocation or suspension of the transmitting station or operator's license.

I. It is recommended that license requirements for the operator of a radio telephone transmitting station include a knowledge of radio transmitting and receiving apparatus and of the International Morse Code, sufficient to receive at a rate of not less than 10 words per minute.

J. It is recommended that the establishment at any later date of any commercial transmitting stations having more than 1 k.w. input to the antenna may, at the discretion of the Secretary of Commerce, be prohibited within 25 land miles of a Government or commercial station or in regions where congestion of radio traffic shall warrant such prohibition.

K. It is recommended that the sharpness of the emitted wave of the transmitting station affect the privileges extended to such station.

IV. Recommendations Relative to the Amateur

A. It is recommended that the status of the amateur be established by law and that the limits of the wave band allotted to the amateur as given above in section I, be specified in the law.

B. It is recommended that the amateur continue to be under the jurisdiction of the Department of Commerce.

C. It is recommended that for the purposes of self-policing among the amateurs, amateur Deputy Radio Inspectors be created, elected from their number of the amateurs of each locality; that upon receipt of notice of such election the Radio Inspector in charge of the district in which such amateurs are located shall appoint the person chosen a Deputy Radio Inspector, serving without compensation or for the sum of one dollar per year if compensation is legally required; that the duty of such amateur Deputy Inspector shall be to endeavor to the best of his ability to accomplish, under the direction of the District Radio Inspector, observance of the Radio Communication Laws and the Regulations of the United States and the observance of such local coöperative measures as are agreed to in each community for the minimization of interference between the various groups of the public interested in radio; that such Amateur Deputy Inspectors be clothed with whatever authority may be necessary in the opinion of the District Radio Inspector.

V. Technical Methods for the Reduction of Interference

A. It is recommended that the Secretary of Commerce at his discretion prohibit at any time the use of existing radio transmitting apparatus and methods which result in unnecessary interference, provided that such action should not be taken unless more satisfactory apparatus and methods are commercially available at reasonable prices and until an adequate time interval is allowed for the substitution of the more satisfactory apparatus.

B. It is recommended that the Secretary of Commerce at his discretion prohibit at any time the use of existing radio receiving apparatus which cause the radiation of energy, provided that such action should not be taken unless more satisfactory apparatus and methods are commercially available at reasonable prices and until an adequate time interval is allowed for the substitution of the more satisfactory apparatus.

Note: "Certain forms of oscillating receivers cause the feeble radiation of continuous waves and may therefore be a source of local interference."

C. It is recommended that the Bureau of Standards make a study of the technical methods for the reduction of interference, with a view to publishing their findings, giving special attention to the following:

1. The reduction of the rate of building up (increment) of oscillations in radiating systems. (This rapid building up of oscillations occurs in damped wave and interrupted continuous-wave transmitters, and may, of course, be eliminated by the substitution of other types of transmitters. It may, however, be reduced in these types by proper circuit arrangements.)

2. The reduction of harmonics in continuous wave transmitters and of irregularities of oscillation. ("Mush" in arc transmitters and "swinging" of the frequency in some continuous wave transmitters not employing a master oscillator.) "Mush" signifies small sudden irregularities occurring in the antenna current of arc transmitters. Swinging signifies relatively slow changes in the frequency of a transmitted wave.

A harmonic of a wave is a wave whose frequency is a multiple of that of the given wave. (The wave length of a harmonic is thus a sub-multiple of the wave length of the given wave.) It is often convenient to include as harmonics, frequencies which are dependent on the frequency of the transmitter but which are not exact multiples.

3. The comparison of the variable amplitude method with the variable frequency method of continuous wave telegraphy.

4. The preferable methods of telephone modulation to avoid changes in the frequency of oscillation.

5. The proper circuit arrangements of regenerative (including oscillating) receivers to avoid radiation of energy (as by the use of a radio-frequency amplifier with an untuned antenna or with a coil aerial).

6. The use of highly selective receiving apparatus, including a list of approved forms. Note: A selective receiver is one which enables the user to hear a desired signal and to exclude the undesired signals. The more perfectly this is accomplished, the more highly selective is the receiver.

7. The use of receiving coil aerials instead of antennæ, with special reference to high selectivity.

8. The reduction of interference with radio communication of other electrical processes, such as the operation of X-ray apparatus and electrical precipitation.

9. The study and standardization of wavemeters. Note: A wavemeter is an instrument for measuring wave frequency or wave length.

At a subsequent meeting of the full conference called by Secretary Hoover on April 17, 18, and 19, 1922, it was agreed to add to Section 1 C the provision that the operation of Government stations be conducted in such a manner as not to interfere with the commercial traffic and broadcasting, and that whenever Government-owned stations are used for the transmission of commercial traffic and broadcasting, they shall conform to the regulations established by the Secretary of Commerce.

It was agreed to add a provision for the appointment by the President of an Advisory Committee to the Secretary of Commerce to consist of not more than twelve members, half of whom shall be from the Government, and half from outside the Government.

APPENDIX IV

PROPOSED REVISION OF RULE EIGHTY-SIX OF THE NATIONAL ELECTRICAL CODE ON RADIO EQUIPMENT

Discussion and explanation prepared by the Radio Laboratcry of the Bureau of Standards.

The following report of the Technical Sub-Committee on Radio Equipment (National Electrical Code Rule 86) has been approved by the Standing Committee on Signal Systems, Wireless and Lightning, and in coöperation with Mr. Dana Pierce, Chairman of the Electrical Committee, is promulgated in order to produce field experience to substantiate the wisdom of the proposed rules before final submission to the Electrical Committee for incorporation into the 1923 edition of the National Electrical Code. Neither the Standing Committee nor the Electrical Committee has authority to suspend or replace the present rule 86 of the National Electrical Code, but this report is issued by the authority granted to the Chairman of the Standing Committee and the Chairman of the Electrical Committee for the information of inspection departments having jurisdiction over the application of the Code.

Suggestions for improvements in these proposed rules should be sent to William S. Boyd, Chairman, 175 W. Jackson Boulevard, Chicago, not later than September 1, 1922.

The following requirements are submitted as proposed revisions of Rule 86 National Electrical Code:

86 Radio Equipment.

NOTE:—These rules do not apply to Radio Equipment installed on shipboard.

IN SETTING UP RADIO EQUIPMENT ALL WIRING PERTAINING THERETO MUST CONFORM TO THE GENERAL REQUIREMENTS OF THIS CODE FOR THE CLASS OF WORK INSTALLED AND THE FOLLOWING ADDITIONAL SPECIFICATIONS:

For Receiving Stations Only.

Antenna:

a. Antennæ outside of buildings shall not cross over or under electric light or power wires of any circuit of more than six hundred (600) volts, or railway trolley or feeder wires, nor shall they be so located that a failure of either antenna or of the above-mentioned electric light or power wires can result in a contact between the antenna and such electric light or power wires.

Antennæ shall be constructed and installed in a strong and durable manner and shall be so located as to prevent accidental contact with light and power wires by sagging or swinging.

Splices and joints in the antenna span, unless made with approved clamps or splicing devices, shall be soldered.

Antennæ installed inside of buildings are not covered by the above specifications.

Lead-in Wires:

b. Lead-in wires shall be of copper, approved copper-clad steel or other approved metal which will not corrode excessively, and in no case shall they be smaller than No. 14 B. & S. gauge except that approved copper-clad steel not less than No. 17 B. & S. gauge may be used.

Lead-in wires on the outside of buildings shall not come nearer than four (4) inches to electric light and power wires unless separated therefrom by a continuous and firmly fixed nonconductor that will maintain permanent separation. The nonconductor shall be in addition to any insulation on the wire.

Lead-in wires shall enter building through a noncombustible, nonabsorptive insulating bushing.

Protective Device:

c. Each lead-in wire shall be provided with an approved protective device properly connected and located (inside or outside the building) as near as practicable to the point where the wire enters the building. The protector shall not be placed in the immediate vicinity of easily ignitable stuff, or where exposed to inflammable gases or dust or flyings of combustible materials.

The protective device shall be an approved lightning arrester which will operate at a potential of five hundred (500) volts or less.

The use of an antenna grounding switch is desirable, but does not obviate the necessity for the approved protective device required in this section. The antenna grounding switch if installed shall, in its closed position, form a shunt around the protective device.

Protective Ground Wire:

d. The ground wire may be bare or insulated and shall be of copper or approved copper-clad steel. If of copper the ground wire shall be not smaller than No. 14 B. & S. gauge and if of approved copper-clad steel it shall be not smaller than No. 17 B. & S. gauge. The ground wire shall be run in as straight a line as possible to a good permanent ground. Preference shall be given to water piping. Gas piping shall not be used for grounding protective devices. Other permissible grounds are grounded steel frames of buildings or other grounded metallic work in the building and artificial grounds such as driven pipes, plates, cones, etc.

The ground wire shall be protected against mechanical injury. An approved ground clamp shall be used wherever the ground wire is connected to pipes or piping.

Wires Inside Buildings:

e. Wires inside buildings shall be securely fastened in a workmanlike manner and shall not come nearer than two (2) inches to any electric light or power wire unless separated therefrom by some continuous and firmly fixed nonconductor making a permanent separation. This nonconductor shall be in addition to any regular insulation on the wire. Porcelain tubing or approved flexible tubing may be used for incasing wires to comply with this rule.

Receiving Equipment Ground Wire:

f. The ground conductor may be bare or insulated and shall be of copper, approved copper-clad steel or other approved metal which will not corrode excessively under existing conditions and in no case shall the ground wire be less than No. 14 B. & S. gauge except that approved copper-clad steel not less than No. 17 B. & S. gauge may be used.

The ground wire may be run inside or outside of building. When receiving equipment ground wire is run in full compliance with rules for Protective Ground Wire, in Section *d*, it may be used as the ground conductor for the protective device.

For Transmitting Stations.

Antenna:

g. Antennæ outside of buildings shall not cross over or under electric light or power wires of any circuit of more than six hundred (600) volts, or railway, trolley or feeder wires, nor shall it be so located that a failure of either the antenna or of the above mentioned electric light or power wires can result in a contact between the antenna and such electric light or power wires.

Antennæ shall be constructed and installed in a strong and durable manner and shall be so located as to prevent accidental contact with light and power wires by sagging or swinging.

Splices and joints in the antenna span shall, unless made with approved clamps or splicing devices, be soldered.

Lead-in Wires:

h. Lead-in wires shall be of copper, approved copper-clad steel or other metal which will not corrode excessively and in no case shall they be smaller than No. 14 B. & S. gauge.

Antenna and counterpoise conductors and wires leading therefrom to ground switch, where attached to buildings, must be firmly mounted five (5) inches clear of the surface of the building, on nonabsorptive insulating supports such as treated wood pins or brackets equipped with insulators having not less than five (5) inch creepage and air gap distance to inflammable or conducting material. Where desired approved suspension type insulators may be used.

i. In passing the antenna or counterpoise lead-in into the building a tube or bushing of nonabsorptive insulating material shall be used and shall be installed so as to have a creepage and air-gap distance of at least five (5) inches to any extraneous body. If porcelain or other fragile material is used it shall be installed so as to be protected from mechanical injury. A drilled window pane may be used in place of bushing provided five (5) inch creepage and air-gap distance is maintained.

Protective Grounding Switch:

j. A double-throw knife switch having a break distance of four (4) inches and a blade not less than one-eighth (1/8) inch by one-half (1/2) inch shall be used to join the antenna and counterpoise lead-ins to the ground conductor. The switch may be located inside or outside the building. The base of the switch shall be of nonabsorptive insulating material. Slate base switches are not recommended. This switch must be so mounted that its current-carrying parts will be at least five (5) inches clear of the building wall or other conductors and located preferably in the most direct line between the lead-in conductors and the point where ground connection is made. The conductor from grounding switch to ground connection must be securely supported.

Protective Ground Wire:

k. Antenna and counterpoise conductors must be effectively and permanently grounded at all times when station is not in actual operation (unattended) by a conductor at least as large as the lead-in and in no case shall it be smaller than No. 14 B. & S. gauge copper or approved copper-clad steel. This ground wire need not be insulated or mounted on insulating supports. The ground wire shall be run in as straight a line as possible to a good permanent ground. Preference shall be given to water piping. Gas piping shall not be used for the ground connection. Other permissible grounds are the grounded steel frames of buildings and other grounded metal work in buildings and artificial grounding devices such as driven pegs, plates, cones, etc. The ground wire shall be protected against mechanical injury. An approved ground clamp shall be used wherever the ground wire is connected to pipes or piping.

Operating Ground Wire:

l. The radio operating ground conductor shall be of copper strip not less than three-eighths (3/8) inch wide by one-sixty-fourth (1/64) inch thick, or of copper or approved copper-clad steel having a periphery, or girth (around the outside) of at least three-quarters (3/4) inch (for example a No. 2 B. & S. gauge wire) and shall be firmly secured in place throughout its length. The radio operating ground conductor shall be protected and supported similar to the lead-in conductors.

Operating Ground:

m. The operating ground conductor shall be connected to a good permanent ground. Preference shall be given to water piping. Gas piping shall not be used for ground connections. Other permissible grounds are grounded steel frames of buildings or other grounded metal work in the building and artificial grounding devices such as driven pipes, plates, cones, etc.

Power from Street Mains:

n. When the current supply is obtained directly from street mains, the circuit shall be installed in approved metal conduit, armored cable or metal raceways.

If lead covered wire is used it shall be protected throughout its length in approved metal conduit or metal raceways.

Protection from Surges, etc.:

o. In order to protect the supply system from high-potential surges and kick-backs there must be installed in the supply line as near as possible to each radio-transformer, rotary spark gap, motor in generator sets and other auxiliary apparatus one of the following:

1. Two condensers, each of not less than one-half (½) microfarad capacity and capable of withstanding six hundred (600) volt test in series across the line and mid-point between condensers grounded; across (in parallel with) each of these condensers shall be connected a shunting fixed spark gap capable of not more than one-thirty-second (1/32) inch separation.

2. Two vacuum tube type protectors in series across the line with the mid-point grounded.

3. Noninductively wound resisters connected across the line with mid-point grounded.

4. Electrolytic lightning arresters such as the aluminum cell type.

In no case shall the ground wire of surge and kick-back protective devices be run in parallel with the operating ground wire when within a distance of thirty (30) feet.

The ground wire of the surge and kick-back protective devices shall not be connected to the operating ground or ground wire.

Suitable Devices:

p. Transformers, voltage reducers, keys, and other devices employed shall be of types suitable for radio operation.

Discussion and Explanation of the Above Proposed Revision of Rule 86 on Radio Equipment

These rules do not apply to radio equipment installed on shipboard, but have been prepared with reference to land stations.

Receiving Equipment.

Antenna:

a. Indoor receiving antennæ are not included within the requirements of this proposed rule, which provides for the protection of radio equipment against lightning. Indoor receiving antennæ and auxiliary apparatus are, however, included in the general requirements covering the wiring of signal systems, for it is obviously desirable to insure, for example, the freedom of all receiving apparatus from contact with electric power circuits either inside or outside of buildings.

It is desirable that electrical construction companies install radio antennæ and apparatus for persons who are not familiar with electric wiring. This will tend to insure the installation of antennæ and apparatus in a strong and durable manner. It is important that antenna wire be used in such size and tensile strength as to avoid its coming in contact with any electric power wires whatsoever.

The size and material of which the antenna is made should depend, to some extent, upon the length of the span which the antenna must bridge. It is suggested that for the ordinary receiving antenna about 100 feet long No. 14 B. & S. gauge soft drawn copper wire can safely be used. If other materials are used, the size which is chosen should be such as to insure tensile strength at least equal to that of the No. 14 soft copper wire suggested above.

The requirements covering splices and joints in the antenna span are for the purpose of avoiding accidental falling of such wires upon light or power wires, of less than 600 volts where it is found necessary to cross such lines. The rules, it will be noted, permit crossings with lines of 600 volts or less, if they do not happen to be trolley wires or feeders to trolley wires. In such a case, it is desirable to use wire of a larger size than No. 14 B. & S. gauge in order to minimize the chance of accidental contact of the antenna with the power wires.

The interchangeable use of copper and of approved copper-clad conductor is suggested on account of the fact that these two kinds of wire are practically equivalent in their conductivity for high-frequency current.

Lead-in Wires:

b. No mention is made of the insulation from the building of the receiving antenna or lead-in wire except that this lead-in wire should be run through a bushing. The latter provision is chiefly to protect the wiring against the possibility of short-circuiting with electric power lines which may run in the wall and whose location may be unknown to the persons installing the radio equipment. This requirement serves also to protect the antenna lead-in wire against contact with metal lath or other metal parts of the building.

From a signaling standpoint, it is desirable to use insulators for receiving antennæ in order that wet weather may not cause the antenna to become partly short-circuited to the ground.

Protective Device:

c. The requirement for a protective device to be connected between the antenna and ground terminals of the receiving set is for the purpose of carrying lightning discharges or less violent discharges caused by induction or by atmospheric electricity to the ground with a minimum chance of damage to the receiving apparatus, building, or operator. A fuse is not required as a part of the protective device, though lightning arresters which are provided with fuses will not necessarily fail to receive approval. If a fused lightning arrester is used, it makes it less likely that the antenna terminal of a receiving set will be put at a high voltage in case the antenna falls upon an electric light or power wire. The absence of the fuse, on the other hand, makes it possible for the antenna, if it accidentally falls across the power wires, to become fused at the point of contact and thus fall to the ground and eliminate the hazard. The antenna terminal of the receiving set should be connected to the point of junction of the fuse with the arrester.

Lightning arresters may be used inside the building, and in such a case they will receive better protection from moisture and mechanical injury than lightning arresters placed on the outside of a building wall.

Protective devices of reliable manufacture are approved by the Underwriters' Laboratories, and can be depended upon to operate at the required voltage. The use of a cheaply constructed homemade arrester is not recommended, since it may easily get out of order and fail to operate at the low voltage which is desirable. Arresters should be inclosed in such a way as to protect the breakdown gap from dust. One disadvantage of the vacuum-tube type of arrester is that it may cease to function without giving warning that it is inoperative. A list of the approved protective devices and ground clamps is contained in the "List of Inspected Electrical Appliances," published by the Underwriters' Laboratories. This list is revised semi-annually and may be consulted upon application to the principal office of the Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago, Ill., and at offices and agencies throughout the United States and Canada.

While an arrester connected between the antenna and ground is regarded by many as sufficient protection, it is somewhat safer to install a switch in parallel with it as an added protection. Particularly if the arrester is inside of the building and the ground connection is made to a radiator, it is desirable to use in addition the outside ground connection.

If the antenna is properly connected to the ground, such connection prevents the antenna from becoming a hazard to the building and its contents and may act to supplement the protection given by lightning rods. The arrester should have the most direct connection to the ground which it is feasible to make, otherwise the antenna may become a hazard with respect to lightning.

Protective Ground Wire:

d. While it is desirable to run the protective ground wire in as direct a line to ground as possible, it is more important to provide a satisfactory contact at the ground itself than to avoid a few bands in the ground wire.

Receiving Equipment Ground Wire:

e. If the ground wire of a receiving set passes through a wall, it should be insulated for the same reasons as the antenna lead-in wire referred to above.

If the ground wire is exposed at all to mechanical injury it should be of larger size than the minimum permitted under the rules and certainly not smaller than No. 10 B. & S. gauge. It should, for mechanical protection, be inclosed in wood molding or other insulating material. Ground wires should not be run through iron pipe or conduit because of the choking effect at radio and lightning frequencies.

Transmitting Equipment.

Protective Ground Switch:

f. On account of the larger size of the ordinary transmitting antenna, it is more likely to be subject to damage from lightning; and on account of the high voltages produced by radio transmitting equipment, it is desirable to provide for the use of a double-throw switch for connecting the antenna either to the transmitting apparatus or to the ground. The use of this switch makes it possible entirely to disconnect the antenna from the transmitting apparatus when not in use.

The objection to slate-base switches is chiefly from the radio engineering viewpoint, on account of the absorption of water by many kinds of slate and the presence of conducting streaks.

Under this rule one has the choice of the standard 100 ampere 600 volt single-pole, double-throw switch or a special antenna switch using 60 ampere copper which has an air-gap distance of at least four inches.

Protection from Surges, etc.:

g. On account of the difficulty which has been experienced by the induction of voltages in the supply lines of a transmitting station, it is advisable to use a protective device across the terminals of each machine or transformer connected to this power line. It would also seem desirable to connect a similar protective device across the power line and near the point of its entrance to the building and on the house side of the meters.

It is desirable that research on the performance of protective devices and the means for avoiding surges and "kick-backs" in the power supply lines be promoted.

For further suggestions regarding good and bad practice in the installation and maintenance of signal wires and equipment, reference should be made to "National Electrical Safety Code, 3d edition, October 31, 1920, Bureau of Standards Handbook No. 3" and especially Section 39. This is obtainable for 40 cents from the Superintendent of Documents, Government Printing Office, Washington, D. C.

The 1920 edition of the "National Electrical Code" which contains the regulations of the National Board of Fire Underwriters, including Rule 86, which is now the rule in effect covering radio signaling apparatus, may be referred to at any local inspection department of the fire underwriters or may be purchased by sending 10 cents to the National Board of Fire Underwriters, 76 William Street, New York City.

APPENDIX V

Form MI-41 Live Stock Receipts (Eastern)

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF MARKETS AND CROP ESTIMATES

RADIO MARKET NEWS SERVICE

Q S T de..............

U. S. Bureau of Markets and Crop Estimates Form 41

ESTIMATED RECEIPTS OF LIVE STOCK AT PUBLIC STOCK YARDS

(for..............192..)

	Cattle	*Calves*	*Hogs*	*Sheep*
Chicago	(FA)——00	(FB)——00	(FC)——00	(FD)——00
Kansas City	(GA)——00	(GB)——00	(GC)——00	(GD)——00
Omaha	(HA)——00	(HB)——00	(HC)——00	(HD)——00
St. Paul	(KA)——00	(KB)——00	(KC)——00	(KD)——00
East St. Louis	(LA)——00	(LB)——00	(LC)——00	(LD)——00
Buffalo	(MA)——00	(MB)——00	(MC)——00	(MD)——00
Cincinnati	(NA)——00	(NB)——00	(NC)——00	(ND)——00
Indianapolis	(OA)——00	(OB)——00	(OC)——00	(OD)——00
Pittsburgh	(PA)——00	(PB)——00	(PC)——00	(PD)——00
Jersey City	(RA)——00	(RB)——00	(RC)——00	(RD)——00

All numbers transmitted are given in the nearest hundreds. Items of fifty or less are omitted.

The above estimates are made in advance of the time that complete data are available; therefore, they should not be used for statistical purposes.

OPENING HOG MARKET

Chicago (ZA) ....

....

....

St. Louis (ZB) ....

....

....

Form MI-61

Fruits and Vegetables (Middlewestern)

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF MARKETS AND CROP ESTIMATES
RADIO MARKET NEWS SERVICE

Q S T de..............

*U. S. Bureau of Markets and Crop Estimates Form MI-*61

......p.m.,...............192..

FRUITS AND VEGETABLES
(Quotations in Consuming Markets)

Potatoes: Market (VA) ....

....

....

Northern Round Whites, Sales to Jobbers, sacked per 100 lbs...	Cincinnati	(VB)	——to——
	Pittsburgh	(VC)	——to——
	Chicago	(VD)	——to——
	St. Louis	(VF)	——to——
Receipts, all kinds, carloads.....	Cincinnati	(VG)	——to——
	Pittsburgh	(VH)	——to——
	Chicago	(VK)	——to——
	St. Louis	(VL)	——to——
Apples: New York, Winter Varieties, A 2½ inches, per bbl.	Cincinnati	(VM)	——to——
	Pittsburgh	(VN)	——to——
	Chicago	(VO)	——to——
	St. Louis	(VP)	——to——
Cabbage: New York, Danish type, bulk per ton	Cincinnati	(VQ)	——to——
	Pittsburgh	(VR)	——to——
	Chicago	(VS)	——to——
	St. Louis	(VU)	——to——
Onions: Northern Yellow Globes, sacked, per 100 lbs.	Cincinnati	(VW)	——to——
	Pittsburgh	(VX)	——to——
	Chicago	(VY)	——to——
	St. Louis	(VZ)	——to——
Sweet Potatoes: Southern Nancy Halls, per bushel hamper	Cincinnati	(XA)	——to——
	Pittsburgh	(XB)	——to——
	Chicago	(XC)	——to——
	St. Louis	(XD)	——to——
Virginia, Eastern Shore, Yellow Varieties, per bbl.	Cincinnati	(XF)	——to——
	Pittsburgh	(XG)	——to——
	Chicago	(XH)	——to——
	St. Louis	(XK)	——to——

Additional Fruits and Vegetables: (XL)....................

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....

Form MI-42

Live Stock Receipts
(Western)

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF MARKETS AND CROP ESTIMATES

Radio Market News Service

Q S T de..............

U. S. Bureau of Markets and Crop Estimates Form 42

Estimated Receipts of Live Stock at Public Stock Yards

for................192..

	Cattle	*Calves*	*Hogs*	*Sheep*
Chicago	(FA)—00	(FB)—00	(FC)—00	(FD)—00
Kansas City	(GA)—00	(GB)—00	(GC)—00	(GD)—00
Omaha	(HA)—00	(HB)—00	(HC)—00	(HD)—00
St. Paul	(KA)—00	(KB)—00	(KC)—00	(KD)—00
East St. Louis...	(LA)—00	(LB)—00	(LC)—00	(LD)—00
Denver	(SA)—00	(SB)—00	(SC)—00	(SD)—00
Ft. Worth	(UA)—00	(UB)—00	(UC)—00	(UD)—00
Oklahoma	(VA)—00	(VB)—00	(VC)—00	(VD)—00
St. Joseph	(XA)—00	(XB)—00	(XC)—00	(XD)—00
Sioux City	(YA)—00	(YB)—00	(YC)—00	(YD)—00

All numbers transmitted are given in the nearest hundreds. Items of fifty or less are omitted.

The above estimates are made in advance of the time that complete data are available; therefore, they should not be used for statistical purposes.

Opening Hog Market

Chicago (ZA) ....
....
....

Omaha (ZC) ....
....
....

Form MI-40 Grain

U. S. DEPARTMENT OF AGRICULTURE
Bureau of Markets and Crop Estimates
RADIO MARKET NEWS SERVICE
Q S T de..............................
......p.m., ...192....
GRAIN REPORT

Market (DA) ....
....
....
....

Receipts (cars) ....

Wheat—	Chicago	(DB)——	Corn	Chicago	(DR)——
	Kansas City	(DC)——		Kansas City	(DS)——
	Omaha	(DF)——		Omaha	(DU)——
	St. Louis	(DG)——		St. Louis	(DV)——
	Minneapolis	(DH)——		Minneapolis	(DW)——

Demand for Wheat (*   ) ....

Milling—	Strong	(DK)——	For Export *	Strong	(DX)——
	Fair	(DL)——		Fair	(DY)——
	Poor	(DM)——		Poor	(DZ)——

Demand for Corn (*   ) ....

Strong	(DN)——
Fair	(DP)——
Poor	(DQ)——

* Information obtained at point where report is prepared.

Closing Cash Grain Prices

Wheat:	*Chicago*	*Minneapolis*	*Omaha*	*Kansas City*	*St. Louis*	*Cincinnati*
No. 2 Nor. Spr.	(GA)——	(GD)——	(GK)——	(GN)——	(GR)——	(GV)——
No. 2 Hard W.	(GB)——	(GF)——	(GL)——	(GP)——	(GS)——	(GW)——
No. 2 Red W.	(GC)——	(GH)——	(GM)——	(GQ)——	(GU)——	(GX)——

Corn:						
No. 3 Mixed	(HA)———	(HC)———	(HF)———	(HK)———	(HM)———	(HO)———
No. 3 Yellow	(HB)———	(HD)———	(HG)———	(HL)———	(HN)———	(HP)———
Oats:						
No. 3 White	(HQ)———	(HR)———	(HS)———	(HU)———	(HV)———	(HW)———

Closing Future Grain Prices

		Chicago	*Kansas City*	*St. Louis*	*Minneapolis*
Wheat (MA)	Higher at	(MB)———	(MF)———	(MK)———	(MP)———
	Lower at	(MC)———	(MG)———	(ML)———	(MQ)———
	Same at	(MD)———	(MH)———	(MO)———	(MR)———
Corn (OA)	Higher at	(OB)———	(OG)———	(OM)———	(OS)———
	Lower at	(OC)———	(OH)———	(OP)———	(OU)———
	Same at	(OD)———	(OL)———	(OQ)———	(OW)———

Form MI-20 Live Stock.
5/12/21

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF MARKETS AND CROP ESTIMATES

RADIO MARKET NEWS SERVICE

Q S T de..............

U. S. Bureau of Markets Form 20

......a.m.,................192..

LIVE STOCK MARKET REPORT

for (AB) ....

Hogs: Estimated receipts today (AC).... Holdover (AD)....
Market (AF) ....
....
....
....

Top	(AG)——
Bulk of Sales	(AH)——to——
Heavy weight (250 lbs. up) Medium, Good & Choice	(AK)——to——
Medium weight (200-250 lbs.) Medium, Good & Choice	(AL)——to——
Light weight (150-200 lbs.) Common, Medium, Good & Choice	(AM)——to——
Light lights (130-150 lbs.) Common, Medium, Good & Choice	(AN)——to——
Packing Sows (250 lbs. up) Smooth	(AO)——to——
Rough	(AP)——to——
Pigs (130 lbs. down) Medium, Good and Choice	(AQ)——to——
Stock Pigs (130 lbs. down) Common, Medium, Good and Choice	(AU)——to——

Cattle: Estimated receipts today (BA) ....
Market (BC) ....
....
....
....

Beef Steers: Medium and heavy weight (1,100 lbs. up):
Good, Choice and Prime...... (BD)——to——
Common and Medium........ (BF)——to——
Light weight (1,100 lbs. down):
Good, Choice and Prime...... (BG)——to——
Common and Medium......... (BH)——to——
Butcher Cattle: Heifers: Common, Medium, Good and Choice ...... (BK)——to——
Cows: Common, Medium, Good and Choice ...... (BL)——to——
Bulls: Bologna and Beef... (BM)——to——
Canners and Cutters: Cows and Heifers ..... (BN)——to——
Canner Steers .... (BO)——to——
Veal Calves: (Light and medium weight): Medium, Good & Choice .... (BP)——to——
Feeder Steers: Common, Medium, Good and Choice .... (BQ)——to——
Stocker Steers: Common, Medium, Good and Choice .... (BR)——to——
Stocker Cows and Heifers: Common, Medium, Good and Choice .... (BS)——to——
Stocker Calves: Common, Medium, Good and Choice .... (BU)——to——
Western Range Cattle: Beef Steers: Medium, Good and Choice .. (BV)——to——
Cows and Heifers: Medium, Good and Choice .... (BW)——to——

Sheep: Estimated receipts to-day (CA) ....
Market (CB) ....
....
....

Lambs: (84 lbs. down): Medium, Good, Choice and Prime .... (CD)——to——
(35 lbs. up): Medium, Good, Choice and Prime .... (CF)——to——
Culls and Common .... (CG)——to——
Spring Lambs: Medium, Good and Choice .... (CH)——to——

Yearling Wethers: Medium, Good, Choice and Prime	(CK)——to——
Ewes: Medium, Good and Choice	(CL)——to——
Culls and Common	(CM)——to——
Breeding Ewes: (Full Mouths to Yearlings)..	(CN)——to——
Feeder Lambs: Medium, Good and Choice	(CO)——to——
Goats	(CP)——to——

APPENDIX VI

PARTIAL LIST OF BROADCASTING STATIONS IN THE UNITED STATES AND CANADA

UNITED STATES

List of Some of the Stations Broadcasting Market or Weather Reports (485 meters) and Music, Concerts, Lectures, etc. (360 meters).

Owner of Station	*Location of Station*	*Wave Lengths*	*Call Signal*
Alabama Power Co.	Birmingham, Ala.	360	WSY
Aldrich Marble & Granite Co.	Colorado Sp'ngs, Colo.	485	KHD
Allen, Preston D.	Oakland, Calif.	360	KZM
Altadena Radio Laboratory	Altadena, Calif.	360	KGO
American Radio & Research Corporation	Medford Hillside, Mass.	360	WGI
Anthony, Earl C.	Los Angeles, Calif.	360	KFI
Arrow Radio Laboratories	Anderson, Ind.	360	WMA
Atlanta Constitution	Atlanta, Ga.	360, 485	WGM
Atlanta Journal	Atlanta, Ga.	360, 485	WSB
Atlantic-Pacific Radio Supplies Co.	Oakland, Calif.	360	KZY
Auburn Electrical Co.	Auburn, Me.	360	WMB
Bamberger & Co., L.	Newark, N. J.	360	WOR
Beacon Light Co.	Los Angeles, Calif.	360	KNR
Benwood Co.	St. Louis, Mo.	360	WEB
Bible Institute of Los Angeles	Los Angeles, Calif.	360	KJS
Blue Diamond Electric Co.	Hood River, Ore.	360	KQP
Braun Corporation	Los Angeles, Calif.	360	KXS
Buckeye Radio Service Co.	Akron, Ohio	360	WOE
Bush, James L.	Tuscola, Ill.	360	WDZ
Central Radio Co.	Kansas City, Mo.	360	WPE
Chicago, City of	Chicago, Ill.	360	WBU
Church of the Covenant	Washington, D. C.	360	WDM
City Dye Works & Laundry Co.	Los Angeles, Calif.	360	KUS
Clark University	Worcester, Mass.	360, 485	WCN
Columbia Radio Co.	Youngstown, Ohio	360	WMC
Commonwealth Electric Co.	St. Paul, Minn.	360	WAAH
Continental Electrical Supply Co.	Washington, D. C.	360	WIL
Cooper, Irving S.	Los Angeles, Calif.	360	KZI
Cosradio Co.	Wichita, Kans.	360, 485	WEY
Cox, Warren R.	Cleveland, Ohio	360	WHK
Crosley Manufacturing Co.	Cincinnati, Ohio	360	WLW
Daily News Printing Co.	Canton, Ohio	360	WWB

Owner of Station	*Location of Station*	*Wave Lengths*	*Call Signal*
Dallas, City of	Dallas, Texas	360, 485	WRR
DeForest Radio Tel. & Tel. Co.	New York, N. Y.	360	WJX
Detroit News	Detroit, Mich.	360, 485	WWJ
Detroit Police Department	Detroit, Mich.	360	KOP
Doerr-Mitchell Electrical Co.	Spokane, Wash.	360	KFZ
Doron Bros. Electrical Co.	Hamilton, Ohio	360	WRK
Doubleday-Hill Electrical Co.	Pittsburgh, Pa.	360	KQV
Doubleday-Hill Electrical Co.	Washington, D. C.	360	WMU
Duck Co., William B.	Toledo, Ohio	360	WHU
Dunn & Co., J. J.	Pasadena, Calif.	360	KLB
Eastern Radio Institute	Boston, Mass.	360	WAAJ
Electric Equipment Co.	Erie, Pa.	360	WJT
Electric Lighting Supply Co.	Hollywood, Calif.	360	KGC
Electric Power & Appliance Co.	Yakima, Wash.	360	KQT
Electric Supply Co.	Clearfield, Pa.	360	WPI
Elliott Electric Co.	Shreveport, La.	360	WAAG
Emporium, The	San Francisco, Calif.	360	KSL
Erie Radio Co.	Erie, Pa.	360	WSX
Examiner Printing Co.	San Francisco, Calif.	360	KUO
Fair, The	Chicago, Ill.	360	WGU
Federal Institute of Radio Telegraphy	Camden, N. J.	360	WRP
Federal Tel. & Tel. Co.	Buffalo, N. Y.	360, 485	WGR
Fergus Electric Co.	Zanesville, Ohio	360	WPL
Findley Electric Co.	Minneapolis, Minn.	360	WCE
Ford Motor Co.	Dearborn, Mich.	360	WWI
Fort Worth Record	Fort Worth, Tex.	360	WPA
Foster-Bradbury Radio Store	Yakima, Wash.	360	KFV
General Electric Co.	Schenectady, N. Y.	360	WGY
Gilbert Co., A. C.	New Haven, Conn.	360	WCJ
Gimbel Brothers	Philadelphia, Pa.	360	WIP
Gimbel Brothers	Milwaukee, Wis.	360	WAAK
Groves-Thornton Hardware Co.	Huntington, W. Va.	360	WAAR
Gould, C. O.	Stockton, Calif.	360	KJQ
Hallock & Watson Radio Service	Portland, Ore.	360	KGG
Hamilton Manufacturing Co.	Indianapolis, Ind.	360	WLK
Hatfield Electric Co.	Indianapolis, Ind.	360	WOH
Hawley, Willard P., Jr.	Portland, Ore.	360	KYG
Herald Publishing Co.	Modesto, Calif.	360	KXD
Herrold, Charles D.	San José, Calif.	360	KQW
Hobrecht, J. C.	Sacramento, Calif.	360	KVQ
Hollister-Miller Motor Co.	Emporia, Kans.	360	WAAZ
Holzwasser (Inc.)	San Diego, Calif.	360	KON
Howe, Richard H.	Granville, Ohio	360	WJD

Owner of Station	*Location of Station*	*Wave Lengths*	*Call Signal*
Howlett, Thomas F. J.	Philadelphia, Pa.	360	WGL
Hunter, L. M., and G. L. Carrington	Little Rock, Ark.	360	WSV
Hurlburt-Still Electrical Co.	Houston, Tex.	360, 485	WEV
Interstate Electric Co.	New Orleans, La.	360	WGV
Iowa Radio Corporation	Des Moines, Iowa	360	WHX
J. & M. Electric Co.	Utica, N. Y.	360	WSL
K. & L. Electric Co.	McKeesport, Pa.	360	WIK
Kansas State Agricultural College..	Manhattan, Kans.	485	WTG
Karlowa Radio Co.	Rock Island, Ill.	360, 485	WOC
Kennedy Co., Colin B.	Los Altos, Calif.	360	KLP
Kierulff & Co., C. R.	Los Angeles, Calif.	360	KHJ
Kluge, Arno A.	Los Angeles, Calif.	360	KQL
Kraft, Vincent I.	Seattle, Wash.	360, 485	KJR
Lindsay-Weatherill & Co.	Reedley, Calif.	360	KMC
Los Angeles Examiner	Los Angeles, Calif.	360	KWH
Love Electric Co.	Tacoma, Wash.	360	KMO
Loyola University	New Orleans, La.	360	WWL
Maxwell Electric Co.	Berkeley, Calif.	360	KRE
May (Inc.), D. W.	Newark, N. J.	360	WBS
McBridge, George M.	Bay City, Mich.	360	WTP
McCarthy Bros. & Ford	Buffalo, N. Y.	360	WWT
Metropolitan Utilities District	Omaha, Nebr.	360, 485	WOU
Meyberg Co., Leo J.	Los Angeles, Calif.	360, 485	KYJ
Meyberg Co., Leo J.	San Francisco, Calif.	360, 485	KDN
Midland Refining Co.	El Dorado, Kans.	485	WAH
Midland Refining Co.	Tulsa, Okla.	485	WEH
Minnesota Tribune Co. and Anderson-Beamish Co.	Minneapolis, Minn.	360	WAAL
Missouri State Marketing Bureau..	Jefferson City, Mo.	485	WOS
Modesto Evening News	Modesto, Calif.	360	KOQ
Montgomery Light & Power Co. ...	Montgomery, Ala.	360, 485	WGH
Mullins Electric Co., Wm. A.	Tacoma, Wash.	360	KGB
Mulrony, Marion A.	Honolulu, Hawaii	360	KGU
Nelson Co., I. R.	Newark, N. J.	360	WAAM
New England Motor Sales Co.	Greenwich, Conn.	360	WAAQ
New Mexico College of Agricultural & Mechanical Arts	State College, N. Mex.	360, 485	KOB
Newspaper Printing Co.	Pittsburgh, Pa.	360	WPB
Noggle Electric Works	Monterey, Calif.	360	KLN
Northern Radio & Electric Co.	Seattle, Wash.	360	KFC
Northwestern Radio Mfg. Co.	Portland, Ore.	360	KGN
Nushawg Poultry Farm	New Lebanon, Ohio	360	WPG
Oklahoma Radio Shop	Oklahoma City, Okla.	360, 485	WKY
Oregonian Publishing Co.	Portland, Ore.	360	KGW

Owner of Station	*Location of Station*	*Wave Lengths*	*Call Signal*
Palladium Printing Co.	Richmond, Ind.	360, 485	WOZ
Paris Radio Electric Co.	Paris, Texas	360	WTK
Pine Bluff Co.	Pine Bluff, Ark.	360	WOK
Pomona Fixture & Wiring Co.	Pomona, Calif.	360	KGF
Portable Wireless Tel. Co.	Stockton, Calif.	360	KWG
Post Dispatch	St. Louis, Mo.	360	KSD
Precision Equipment Co.	Cincinnati, Ohio	360, 485	WMH
Precision Shop, The	Gridley, Calif.	360	KFU
Purdue University	West Lafayette, Ind.	360	WBAA
Radio Construction & Electric Co.	Washington, D. C.	360	WDW
Radio Corporation of America	Roselle Park, N. J.		
Radio Service Co.	Charleston, W. Va.	360	WAAO
Radio Shop, The	Sunnyvale, Calif.	360	KJJ
Radio Supply Co.	Los Angeles, Calif.	360	KNV
Radio Telephone Shop, The	San Francisco, Calif.	360	KYY
Register & Tribune, The	Des Moines, Iowa	360	WGF
Reynolds Radio Co.	Denver, Colo.	360, 485	KLZ
Ridgewood Times Printing & Publishing Co.	Ridgewood, N. Y.	360	WHN
Riechman-Crosby Co.	Memphis, Tenn.	360, 485	WKN
Rike-Kumler Co.	Dayton, Ohio	360, 485	WFO
Rochester Times Union	Rochester, N. Y.	360, 485	WHQ
Roswell Public Service Co.	Roswell, N. Mex.	360	KNJ
San Joaquin Light & Power Corporation	Fresno, Calif.	360	KMJ
Seeley, Stuart W.	East Lansing, Mich.	485	WHW
Service Radio Equipment Co.	Toledo, Ohio	360	WJK
Ship Owners Radio Service	New York, N. Y.	360	WDT
Ship Owners Radio Service	Norfolk, Va.	360	WSN
Shotton Radio Mfg. Co.	Albany, N. Y.	360	WNJ
Southern Electrical Co.	San Diego, Calif.	360	KDPT
Southern Radio Corporation	Charlotte, N. C.	360	WBT
Spokane Chronicle	Spokane, Wash.	360	KOE
Standard Radio Co.	Los Angeles, Calif.	360	KJC
Stix-Baer-Fuller	St. Louis, Mo.	360	WCK
St. Joseph's College	Philadelphia, Pa.	360	WPJ
St. Louis Chamber of Commerce	St. Louis, Mo.	360	WCK
St. Louis University	St. Louis, Mo.	485	WEW
St. Martins College (Rev. S. Ruth)	Lacey, Wash.	360	KGY
Strawbridge & Clothier	Philadelphia, Pa.	360	WFI
Stubbs Electric Co.	Portland, Ore.	360	KQY
Tarrytown Radio Research Laboratory	Tarrytown, N. Y.	360	WRW
Taylor, Otto W.	Wichita, Kans.	360	WAAP

Owner of Station	*Location of Station*	*Wave Lengths*	*Call Signal*
T. & H. Radio Co.	Anthony, Kans.	360	WBL
Union College	Schenectady, N. Y.	360	WRL
Union Stock Yards & Transit Co.	Chicago, Ill.	360, 485	WAAF
United Equipment Co.	Memphis, Tenn.	360	WPO
University of Illinois	Urbana, Ill.	360	WRM
University of Minnesota	Minneapolis, Minn.	360, 485	WLB
University of Missouri	Columbia, Mo.	360	WAAN
University of Texas	Austin, Texas	360, 485	WCM
University of Wisconsin	Madison, Wis.	360, 485	WHA
Wanamaker, John	Philadelphia, Pa.	360	WOO
Wanamaker, John	New York, N. Y.	360	WWZ
Warner Brothers	Oakland, Calif.	360	KLS
Wasmer, Louis	Seattle, Wash.	360	KHQ
Western Radio Co.	Kansas City, Mo.	360, 485	WOQ
Western Radio Electric Co.	Los Angeles, Calif.	360	KOG
Westinghouse Elec. & Mfg. Co.	East Pittsburgh, Pa.	360	KDKA
Westinghouse Elec. & Mfg. Co.	Chicago, Ill.	360, 485	KYW
Westinghouse Elec. & Mfg. Co.	Newark, N. J.	360	WJZ
Westinghouse Elec. & Mfg. Co.	Springfield, Mass.	360	WBZ
West Virginia University	Morgantown, W. Va.	360	WHD
White & Boyer Co.	Washington, D. C.	360	WJH
Williams, Thomas J.	Washington, D. C.	360	WPM
Wireless Telephone Co. of Hudson County, N. J.	Jersey City, N. J.	360	WNO
Yeiser, John O., Jr.	Omaha, Nebr.	360	WDV
Young Men's Christian Assn.	Denver, Colo.	485	KOA
Zamoiski Co., Joseph M.	Baltimore, Md.	360	WKC

CANADA

Owner of Station	*Location of Station*	*Wave Lengths*	*Call Signal*
Albertan Pub. Co.	Calgary, Alta.	410	CHBC
Bell Telephone Co.	Montreal, Que.	...	CKCS
Bell Telephone Co.	Toronto, Ont.	...	CFTC
Bell, G. Melrose	Vancouver, B. C.	430	CHCA
Bell, G. Melrose	Calgary, Alta.	430	CFAC
Bell, G. Melrose	Regina, Sask.	420	CKCA
Bell, G. Melrose	Winnipeg, Man.	430	CHCF
Bennett, J. G.	Nelson, B. C.	400	CJCB
Booth, J. R., Jr.	Ottawa, Ont.	400	CHXC
Can. Indep. Tel. Co.	Toronto, Ont.	450	CKCE
Dupuis Frères	Montreal, Que.	420	CJBC
Eastern Telephone & Telegraph Co.	Halifax, N. S.	410	CJCS
Eaton Co., T., Ltd.	Toronto, Ont.	410	CJCD
Edmonton Journal	Edmonton, Alta.	450	CJCA
Evening Telegram, The	Toronto, Ont.	430	CJSC
Int. Radio Development Co.	Fort Frances	400	CFPC
La Presse Pub. Co.	Montreal, Que.	430	CKAC
London Free Press Printing Co.	London, Ont.	430	CJGC
London Radio Shoppe	London, Ont.	410	CHCS
McLean, Holt & Co., Ltd.	St. John, N. B.	400	CJCI
Manitoba Free Press	Winnipeg, Man.	410	CJCG
Marconi W. T. Co.	Montreal, Que.	440	CFCF
Marconi W. T. Co.	Halifax, N. S.	440	CFCE
Marconi W. T. Co.	Toronto, Ont.	440	CHCB
Marconi W. T. Co.	Vancouver, B. C.	440	CFCB
Metropolitan Motors	Toronto, Ont.	410	CHVC
Northern Electric Co.	Montreal, Que.	410	CHYC
V. W. Odlum	Vancouver, B. C.	400	CFYC
Radio Supply Co. of London	London, Ont.	410	CKQC
Salton Radio Eng. Co.	Winnipeg, Man.	420	CKZC
Simons, Agnew & Co.	Toronto, Ont.	410	CJCN
Star Pub. & Prin. Co.	Toronto, Ont.	400	CFCA
Tribune Newspaper Co.	Winnipeg, Man.	400	CJNC
Van. Daily Province	Vancouver, B. C.	410	CKCD
Vancouver Sun	Vancouver, B. C.	420	CJCE
Wentworth Radio Supply Co.	Hamilton, Ont.	410	CKOC
Western Radio Co.	Calgary, Alta.	400	CHCQ

INDEX