CHAPTER ONE

WHAT RADIO DOES

Nature of Radio—Uses of Radio—Sea Communication—Transoceanic Telegraphy and Telephony—Time Signals—Line-Radio—Radio Beacons and Remote Control—Picture Transmission—Television—Directive Radio Transmission—Radio on Aircraft—Broadcasting—Frequency Bands—High Frequencies—Secret Communication—Distance Range—Limitations of Radio—Constant Frequency Stations—Reason for 10 Kilocycle Separation—Service Area of Broadcasting Stations—Chain Broadcasting—Heterodyning.

Nature of Radio.—The word radio comes from "radiate." Radio is an electrical action which is radiated out in all directions through the air. Just as there is one kind of electrical action known as the electric current which goes along wires and turns machinery and lights our homes, so radio is another form of electricity. Instead of going along wires it radiates out in all directions from the place where it is started. Because radio thus produces an electrical effect at a distance without connecting wires, it was formerly called wireless. Radio has possibilities that are not found in the ordinary electric current, just as an automobile is free from some limitations of a trolley car confined to tracks.

Since radio travels out in all directions from the place where it is started, its effect can be picked up at an unlimited number of places simultaneously. It may thus be spoken of as a highly democratic, even communistic, kind of communication, being available to everyone. It is very similar to sound waves. Sound similarly spreads out in all directions through the air and can be heard by many people simultaneously. Radio is not sound, however, because it is electrical in its nature. Radio is in fact very much like light—except that instead of using our eyes to detect it, we use special receiving instruments. Radio is practically instantaneous. It travels with the same speed as light, 186,000 miles per second.

As explained in chapter 2, radio consists of electric waves radiated out from a special kind of outfit called a radio transmitting station. It will also be shown how these electric waves are produced by the action of the electric current in the transmitting station. As soon as the reader realizes, however vaguely, this fundamental fact that radio consists of electric waves proceeding out from the transmitting station, he is well started on the road toward understanding what radio can and can not do. The form of the waves is determined by the nature and variations of the electric current at the transmitting station. This current can be varied in accordance with the dots and dashes of ordinary telegraphic signalling or can be the kind of current flowing in an ordinary telephone line. Consideration of just how the radio wave can thus carry any form of signal or even speech or music is deferred until chapter 2.

In the use of the ordinary wire telephone, the sound produced at the transmitting end is converted into a varying electric current which flows along the wires, this current being changed back again into sound in the telephone receiver at the other end. Radio-telephony is similar except that there are no connecting wires. There must be arrangements at the transmitting end for converting the speech into an electric wave and at the receiving end arrangements for converting the received electric wave into sound. The difference between radio and wire telephony is that in radio the electric action is carried by means of electric waves passing through the air instead of by means of electric current passing along a wire. It is possible to transmit and receive by radio anything that could be transmitted and received by the wire telephone, radio having the additional feature (advantage in many respects and disadvantage in some) that it can be received by anyone in any direction from the transmitting station.

There is little difference in the receiving of telephonic or telegraphic signals.

This book will deal primarily with radio-telephony, as this is of most interest.

Uses of Radio.—In the communication business it is recognized as an agency of communication comparable with the wire telegraph and the cables. It is particularly useful in marine and aerial transportation, both in furnishing special aids to navigation and in carrying on of communication, especially distress signals. Broadcasting is only one of the important applications of radio. The principal uses of radio may be listed as follows:

1. Broadcasting.
2. Communication with moving ships, aircraft, etc.
3. Transoceanic communication.
4. Communication between two points on land.
5. Non-communication uses.

Broadcasting is the most recent and the most important use of radio. Its service is available in any section of the United States and most other countries of the world. By the use of amplifiers and loud speakers the speech or music received may be reproduced as loud as desired, and thus made available to large gatherings of people. In addition to entertainment and talks, many stations send out regularly weather forecasts, market prices and data, standard time signals, church services, and news summaries.

For reasons which will be explained later, radio messages more or less interfere with one another. Consequently it is necessary that communication which can readily be carried on by other means than radio should utilize such other means. Radio is, therefore, not used much for communication between two points on land, inasmuch as wire telephony or other means of communication could be used. There are, of course, exceptions in the case of deserts, islands, mountain regions, remote forest regions, etc. One kind of communication between two points on land where radio may be suitable is communication with moving trains and other vehicles. This has been done but not actually developed to any considerable extent. It is in fact likely that means will be found to utilize electric currents guided along the rails or nearby wires for railway communication so that radio will not be needed for this purpose.

The only extensive use of point-to-point radio communication on land is the radio work of amateurs. In the relaying of messages to various parts of the world an extensive communication system has been built up by amateurs of the United States and other countries.

It is not necessary to look to the future for extensive use of radio. It is used more extensively than most people realize for navigational aids, for communication with ships, aircraft, remote regions, and across the oceans. Its use on trains and all vehicles will come. Forests will be better protected by its use for instant reporting of fires. The broadcasting of news and important announcements will be accomplished and regulated with a perfection that would now seem startling. The problem in radio, will, indeed, be to restrict its uses enough to permit any messages to get through.

Sea Communication.—The use of radio at sea was the first practical application of radio and still continues one of its most important services. Besides regular messages between ships and land, reports of ships' positions are made by radio, and ships receive from shore stations weather warnings and general and hydrographic news. So important is the use of radio on ships that the use of radio on shipboard is compulsory, and no vessel carrying over 50 persons can leave a United States port without a certificate from a U. S. radio supervisor that its radio equipment is in working condition. Coast radio transmitting stations are required to have an operator listening for distress calls which may be sent by ships and to stop operating their stations if such calls are heard.

Transoceanic Telegraphy and Telephony.—Radio is an alternative to the submarine cable for transoceanic telegraphy and is the only existing means of transoceanic telephony. Commercial radio telegraph service across the oceans has the great advantage that persons on two different continents can speak to one another directly instead of through code telegraphy. To cover these great distances very high power radio stations are used. All of the large nations are now extending their high power radio-telegraph systems, their great usefulness to business being evident. For this kind of service, the fact that radio can be picked up in many places in all directions from the transmitting station is a disadvantage and indicates that for transoceanic communication radio can never entirely replace the cable.

Time Signals.—The system of transmission of time signals is as follows: Beginning 5 minutes before the hour on which the time signals close, the transmission of a series of dots is commenced. One dot is sent at the beginning of each second of time; the 29th second of each minute is omitted, and the last five seconds of each minute are omitted for the purpose of enabling the one who counts the signals to make preliminary observations before the closing signal. At the close of the final minute, the last 10 seconds are omitted. Then at the exact hour a long dash is transmitted, whose beginning marks the hour.

Standard time signals are sent twice daily, at noon and 10 o'clock P. M. E.S.T. by station NAA at Arlington, Va. Numerous broadcasting stations throughout the country relay these signals for the benefit of their broadcast listeners.

"Line-Radio" Communication.—It has been found that radio waves of the lower frequencies can be guided along wires between the transmitting and receiving stations instead of being radiated through space. The wires used in this way can be used simultaneously for ordinary telegraphic messages and telephone conversations, or for transmitting electric power. Various names have been applied to this method of communication, such as "wire-radio telephony," "carrier-frequency telephony," "guided-wave telephony," and "wired wireless." Line-radio telephony can be conducted by connecting a radio-telephone transmitting set to one end of a wire in the same way as it ordinarily is connected to an antenna. The receiving set should be connected to the other end of the wire in a similar manner. Distances of 10 to 20 times the radio transmission ranges can be obtained with the use of a given power by this method. In connecting transmitting or receiving sets to the wire lines in this way, care should be taken not to make any changes in the circuit which would affect other ordinary use. While the use of this method of communication is rapidly being extended, it is desirable that installations be made only by experts, on account of the danger of interrupting the normal service of the wire lines or making wrong connections which would cause serious injury or damage.

Line-radio telephony offers the additional advantage of carrying a number of messages over one pair of wires at the same time without interference. This is done by tuning arrangements at both the transmitting and receiving ends, which keep the different messages from interfering with one another. Waves guided along conductors seem bound to become more common, since trolley wires, power wires or any other sort of wires may be used to guide the waves. Thus a telephone becomes possible for every building into which electric light wires run. Furthermore, line-radio telephony may be linked with or connected to ordinary wire telephony. Thus it seems unquestionable that this method will more and more supplement the regular telephone system.

While this is not really radio communication, it presents a solution to some of the problems of radio. It is a secret method of communication, whereas radio is utterly public. It solves the question of communication in one direction to the exclusion of others wherever there is a guiding conductor in the direction desired.

Radio Beacons and Remote Control.—A large number of uses of radio which are not communication have been developed. Among these are various aids to navigation. A radio station automatically sending out signals acts as a radio beacon. These signals can be received by ships or aircraft, and by means of them the vessel can navigate just as by the aid of beams from a lighthouse. The United States has installed over thirty such radio beacons and other countries have done likewise.

By means of radio, distant control of any desired machinery or motion is possible. The radio signals can operate a relay which will throw into or out of service any desired machinery. In this way aircraft and ships can be started and operated without any persons on board.

Transmission of Pictures by Radio.—Several inventors have been working on the problem of transmitting photographs by radio, and very good results have been obtained. The picture to be transmitted is placed in the special transmitting apparatus, and through the medium of a radio wave of varying intensity, a duplicate of the picture is created on a film in the receiving apparatus. By increasing the speed so that sixteen or more successive pictures per second are produced on a screen at the receiving station, the transmission of moving pictures or pictures of moving objects becomes possible. This was, in fact, done in an elementary way in the summer of 1923. We may look for the continued improvement of such methods.

Methods have been worked out for transmission of photographs, thumbprints, and writing by radio. This is still in the experimental stage, but handwriting has been reproduced across the Atlantic by radio. Transmission of pictures for newspaper reproduction has been undertaken on a commercial scale by a large radio company.

Television.—Inventors in the United States and Europe have been working out the details of Television. Several public demonstrations have been given which were more or less successful. The solution to the problem consists of transmitting either by wire or radio small parts of a complete image at high speed. These parts are received as a succession of impulses which are caused to illuminate a screen in synchronism with the transmitter. Use is made of photoelectric cells, and lamps which have no appreciable time lag.

Directive Radio Transmission.—As a means for minimizing interference in point-to-point radio services and in the development of radio beacons or "radio search-lights," experimental work has been done on the transmission of radio waves in a limited direction to the exclusion of transmission in other directions.

The most successful work along this line has been done with radio waves which are very short, for example about 10 meters. When these short waves are used it is possible to construct reflectors or electrical mirrors which can be placed partially around the small transmitting antenna and which will send most of the power out in a given general direction. However, the experiments which have been made up to the present time have been only partially successful, the transmitted power being limited to an angle of perhaps 30 degrees. On account of the small size of the antennas required for the short waves it is extremely difficult to radiate a large amount of power from a single antenna.

Another way in which the directive transmission of radio signals is approached is by the use of wires to guide the radio waves from one point to the other. The amount of power which has been transmitted by guided radio waves has so far been only a few watts. A more detailed discussion of this method of communication is given above under "Line Radio."

Another method of transmitting radio waves in a desired direction is by the use of a coil antenna in connection with the transmitting apparatus. Vertical single-turn coils of large dimensions have been employed in an experimental way; signals being transmitted to a greater distance in the general direction of the plane of the coil than in the direction at right angles to it. This method of transmitting will probably become important in the service of marine and aerial navigation.

Radio on Aircraft.—In foggy weather, the use of radio on an airplane is as necessary as on a ship at sea.

It is now technically possible to connect the ordinary wire telephone lines to the radio apparatus so that conversation can be carried on from the ordinary house telephone with a distant ship or airplane which is equipped with radio apparatus. It is only a question of time till the telephone companies furnish such service regularly. Various radio navigational aids for aviation are being worked out. One that has been developed is the use of radio signals at a landing field to facilitate ariplane landing.

Broadcasting.—It was only when radio began to be used for broadcasting that it attracted the widespread interest of the general public. Broadcasting is transmission to an unlimited number of receiving stations without charge at the receiving end. Since radio travels in all directions and can be received by an unlimited number of persons, it is obviously of most use when the material transmitted is of interest to a large number of people. Weather and other news of interest to ships has been broadcast by radio-telegraphy (code) for many years. The year 1921, however, saw the real beginning of broadcast radio service. A number of electric companies, newspapers, etc., then began sending out music and lectures by radio-telephone. Since only relatively simple and cheap receiving apparatus was required to hear all of this material, the popular interest in radio grew rapidly.

Radio broadcasting is an established and valued supplement to the newspaper, the theater, and the phonograph, and excels each of these in some respects. The proper development of such service has received the attention and guidance of the Government, and all sorts of organizations, newspapers, communication companies, schools, churches, and other Government and commercial concerns have provided radio broadcasting service.

An interesting illustration of the value of broadcast news is the utilization of such service by exploring expeditions. Arctic and tropical exploration parties carry radio transmitting and receiving apparatus, and both receive the daily news and entertainment from high power broadcasting stations and send out stories of their adventures.

The waves which constitute radio are all in the same air and so are capable of interfering with each other. The thing that makes it possible to use radio at all is that it is possible to "tune" radio receiving apparatus so as to receive waves of a particular frequency (or wave length) and not receive those of other frequencies. "Tuning" will be explained later. Practically its effect is that turning to different points on the dial on the receiving set makes the set pick up waves of different frequencies or wave lengths.

The general idea of frequency is explained in chapter

2, page 8. It can be readily understood by comparison with sound waves. A sound wave of higher frequency has a shorter wave length than a sound wave of lower frequency. The same thing is true of radio waves. The frequency or wave length is determined by what takes place in the transmitting antenna. Any particular transmitting antenna sends out a radio wave of some particular frequency or wave length, just as a piano string when sounded sends out a sound wave of some particular frequency or wave length.

The frequency of the electric current in a radio transmitting or receiving antenna is designated in kilocycles per second. A kilocycle is 1000 cycles or complete alternations of the direction of the current. The frequencies used in radio communication range from 12 to 20,000 kilocycles. The wave length is the distance from one wave crest (or maximum) to the next. Radio wave lengths range from 25,000 to 15 meters. The meter is 39.37 inches (about 39⅜ inches), and is the unit of length used all over the world except in the United States and British Empire. Wave length has nothing directly to do with the distance to which a radio wave travels. Similarly, a sound wave or water wave may have a wave length of one foot, but such a wave could travel a distance of very many feet.

The reader is urged to familiarize himself with and think in terms of kilocycles as soon as possible, inasmuch as waves are now assigned in even values in kilocycles, the wave length in meters being calculated therefrom. It is expected that the use of the term "wave length" in radio will gradually disappear.

Frequency Bands.—Every transmitting station in operation makes it more difficult for receiving stations to hear other transmitting stations without interference. Therefore, no business which can be transacted by using other methods of communication should be conducted by radio. The number of frequencies available for the use of radio stations is limited, and in densely populated regions and in all important seaports the problem of radio interference is an extremely serious one. Not only in broadcasting but in all uses of radio, the whole success of the communication depends on proper use of the frequencies. Certain specific frequencies are assigned for certain purposes by international and national laws, and technical requirements determine the use of some others. The lower frequencies are more suitable for longer distances, because waves of high frequency are very much more absorbed or impeded by the surface of the earth over which they travel. Thus frequencies from 37.5 to 12.5 kilocycles (wave lengths from 8,000 to 24,000 meters) are used in transoceanic communication. Very short waves carry especially well at night. Amateurs (who work mostly at night) use frequencies above 1500 kilocycles (wave lengths less than 200 meters). The various other uses of radio are on frequencies intermediate between these extremes. (See Chap. 7.)

High Frequencies.—A few years ago, little or nothing was known of the properties or possibilities of using the very-short radio waves produced by currents having frequencies of 2000 kilocycles or more. These are the waves which are shorter than 150 meters. These short waves are being used in experiments on directive transmission mentioned above, and have been used for experimental long-distance broadcasting and for transatlantic communication. They are well adapted for uses where the dimensions of the transmitting apparatus are limited, as on small boats. These high frequencies have the fortunate capability of carrying an extremely large number of communications simultaneously without mutual interference. Atmospheric disturbances are almost entirely absent.

Secret Communication.—At present practically all radio transmission is of such a nature as to make it impossible to keep it from being received by anyone who so desires. The law forbids the disclosing of a message to other persons than those for whom it is intended. This of course does not cover the broadcast service, for the term is to signify transmission which is intended for an unlimited number of receiving sets, without charge at the receiving end. Technical methods are being developed which will make it impossible for persons to receive certain kinds of radio signals unless supplied with a special kind of receiving apparatus which is designed to match with the particular transmitting set employed. By the use of such methods unauthorized listening-in will become so difficult as to be accomplished only by persons who are experts. It is not likely, however, unless technical developments are carried very much farther than seems at all possible at the present time, that secrecy and selectivity will be obtained to such an extent as to make feasible the simultaneous secret communication between every pair of individuals who may desire to talk with one another.

Distance Range.—The distance over which radio can be picked up varies with time of year, day and night, and other factors. It is sometimes possible to hear a station 1000 miles away at night, while 200 miles would be the greatest distance covered in the day. A study of this variation and the fluctuations of signals that sometimes occur at night (fading) has shown that the sources or causes of fading are intimately associated with the conditions of the Heaviside surface, which is a conducting surface about sixty miles above the earth. Daytime transmission is largely carried on by means of waves moving along the ground, while night transmission, especially for great distances and at high frequencies, is by means of waves transmitted along the Heaviside surface. Waves at night are thus free from the absorption encountered in the daytime but are subject to great variations caused by irregularities of the ionized air at or near the Heaviside surface.

On account of disturbances of the electrical condition of the atmosphere during midsummer, radio reception during daylight hours may be occasionally interrupted. At times, during the summer months, the strays may completely drown out the radio signals picked up by the receiving set. The idea that the addition of sensitive amplifiers to the receiving set will relieve the situation is erroneous. The amplifier amplifies the strays along with the incoming signal, so the amplified signal is often less intelligible than the signal received on a simple detector.

During severe electrical storms sometimes it is not only impossible to receive any messages, but it may be unwise, especially if the storm is accompanied by lightning discharges. At such times the antenna should be grounded to protect the apparatus and no attempt made to receive radio messages. While it is possible during the winter to receive from any one of a large number of broadcasting stations, the summer decrease in transmission range means a decrease in the number of stations between whose service one can choose.

Radio receiving sets until recently required heavy storage batteries, difficult to move from indoors to outdoors to meet summer time conditions. For many purposes a portable radio set is as desirable as a small, portable phonograph, and the advent of the dry battery tubes has made such sets possible. Thus it is possible with small portable receiving sets, which can be purchased or which can be fairly easily assembled, to receive radio broadcasting while out camping or boating or making automobile tours. Also, the ease with which wires can be strung to enable the removal of the loud speaker to the porch, the lawn, or the garden without disturbing the receiving set should tend to convert radio into a thoroughly satisfactory outdoor amusement. This will open up a wide field for inventive genius in thinking up unique locations. A number of ways to erect small antennas are suggested in chapter 6.

Limitations of Radio.—A word is desirable as to its shortcomings, so loudly are its advantages heralded. While the spreading out in all directions is an advantage for broadcasting and some other uses, it is a disadvantage in other ways. Radio lacks the secrecy or individual character of communication by wire, and cannot take its place.

While for many years it has been the dream of scientists and engineers that some time it might be possible to transmit power over long distances by radio, the day is not yet here when this can be accomplished.

The power which leaves the antenna is instantaneously distributed over an extremely large area. A receiving station only 100 miles away receives but an extremely minute fraction of the power originally transmitted. It can be seen, therefore, that if it were desired to light an electric light or run an electric motor by power transmitted entirely by radio, it would be necessary to broadcast a stupendous amount of power from the transmitting station in order to produce a sufficient amount at a given distant receiving station.

The actual transmission of power by radio and the use of this received power to turn machines or light lamps at a receiving station should not be confused with the use of ordinary received radio signals to operate a local relay and set in motion machinery which is supplied with power by local batteries or generators. In the latter case the radio receiving set serves as a sort of trigger which is pulled or set off by the very feeble received signal. It is in fact by an action of this sort that we are able to hear such loud signals through the telephone receivers and loud speakers.

A serious and regretable kind of misinformation to which the public is subject is the claim that, by some mysterious method of using radio, a person is able to diagnose physical or psychological conditions and make discoveries regarding the characteristics of individuals at a distance when this same information could not be obtained even by individual examination of the patient.

This must not be confused with the use of radio as a means of communication of regular telegraphic messages from one station to another. Radio communication has made it possible for physicians to transmit to otherwise isolated points messages giving advice and thereby assist in relieving sickness when no physician is at hand for consultation. The operators on many ships at sea have, in case of need, communicated by radio with another ship or with a shore station to which they reported the symptoms and conditions of a patient and from which in turn they secured advice and information regarding his treatment. A fine example of a radio station which gives important service of this kind is that maintained by the Seaman's Church Institute in New York City. This service is now furnished free to ships through the co-operation of the U. S. Public Health Service and the Radio Corporation of America and the United Fruit Co.

Mention was made above of atmospheric disturbances ordinarily called "strays" or "static." Such disturbances are the most serious limitation on radio communication at the present time, and many methods have been devised for the purpose of minimizing their effect or increasing the strength of desired signals without increasing the strength of the undesired strays. So far, none of these methods have proven to be satisfactory in the elimination of strays. The most useful means which have been developed for approaching a satisfactory solution are the use of a low directional antenna and the use of loose coupling between several sharply tuned circuits of the receiving set. For receiving continuous waves, the use of the beat method of reception is also a great advantage, but this is not applicable to radio telephone reception. The elimination of the effect of strays on radio receiving apparatus is a very important problem; it is almost as difficult as devising a method which would keep a tuning-fork from vibrating when it is struck by a sledge hammer, while permitting it to vibrate when it is placed in the vicinity of another tuning-fork vibrating at the same pitch.

Constant Frequency Stations.—Many broadcasting stations are equipped with special apparatus for maintaining a constant frequency. The output in some cases is controlled automatically by piezo crystals. Accurate frequency meters or piezo crystal oscillators checked against standards are used to regulate the frequency transmitted.

The Bureau of Standards publishes in the *Radio Service Bulletin* each month a list of these "constant frequency stations." The calibration of the apparatus used in the stations listed must agree with the bureau's frequency standards. The transmitted frequencies are of value to the public as frequency standards. A few of the stations are checked continually by the bureau and listed as "standard frequency stations." They are known to be reliable and a high degree of confidence may be placed in their transmissions.

Reason for 10 Kilocycle Separation.—The frequency band set aside for broadcasting in the United States lies between 500 and 1500 kilocycles. If too many stations are crowded into this band interference is bound to occur. It has been found that when two stations operating in the same district are assigned frequencies at least 10 kilocycles apart interference does not result. If the difference in frequencies is less than 10 kilocycles a whistle of high pitch is heard in sets tuned to receive either station. As the difference in frequency becomes less the pitch of the whistle becomes lower and the programs commence to overlap. If both stations operate on the same frequency it is impossible to tune out the undesired station.

To prevent interference, stations are assigned frequencies at least 10 kilocycles apart. If every station desiring to broadcast were given an exclusive frequency band there would be room for only 100 stations in the broadcast band. Fortunately this restriction is unnecessary. A low power station operating on the Atlantic coast cannot interfere with a similar station on the Pacific coast under any conditions. Hence these two may operate on a common frequency. By a judicious choice of location, power and frequency it is possible to accommodate upwards of 500 stations without danger of interference. It is necessary, however, for the stations to maintain absolutely constant frequency. If the frequency of one should vary more than about 10 percent. interference would result.

Service Area of Broadcasting Stations.—The extent of the area served efficiently by a broadcasting station is governed by the power, location and frequency used. The latter is not very important in the broadcast band except from the point of view of interference. Some experiments conducted by the Department of Commerce show that the efficient service area around the average station located in a city is relatively small. The patrons of a given station usually reside within the boundary of a circle of about 20 to 30 miles radius drawn around the station. Beyond this range reception is subject to disagreeable interference from "static" disturbances, although signals may be received hundreds of miles distant under good conditions.

It has been noticed that a station located in the heart of a large city transmits signals over a much greater area in some directions than in others. This is due to the absorbing of the energy by large masses of metal found in large buildings near the station. A large building to the north of a station may limit the reliable distance of transmission to 10 miles in that direction. The reliable range in all other directions not shielded by such a building may be 30 miles. This leads to the conclusion that the greatest area is served by a station located in the open country. Of course, the greatest number of listeners may be found within the city limits so that the city location would naturally be chosen.

Chain Broadcasting.—The programs of a certain station are often of national interest and it is necessary to employ the facilities of many stations to reach the largest number of listeners. Examples of this may be found in the broadcasting of a speech by the President, or the reception program of renowned personages as in the case of Colonel Lindbergh, Queen Marie, and others. As many as 52 stations in various parts of the country have been interconnected by telephone to broadcast the same program.

Broadcasting is a valuable medium for advertising. In the first attempts at this method of advertising the operating cost was borne by the owner of the station and the good will created by the programs and service rendered was the only gain. More recently, however, station owners have sold "time on the air" to advertisers. In order to reach the largest number of homes the advertiser engages the facilities of stations located in various cities and broadcasts the same program from them all, using telephone lines to carry the program from station to station.

The National Broadcasting Company in New York City is a corporation whose business it is to broadcast programs from several chains of stations. The facilities of a certain chain or network are available at definite rates to anyone who cares to engage them. Time is sold by the hour or half-hour for a night a week in many instances. This company connects as many as 40 stations by telephone line for this purpose. Thus the problem of paying for broadcasting in the United States is being solved without the neccessity of licensing the listener.

Heterodyning.—Heterodyning, as applied to broadcasting, signifies the interference between the waves of two or more stations operating on nearly the same frequency. The whistle heard in a receiving set tuned to one of these stations is often called the "heterodyne whistle." The frequency of the note heard depends upon the difference between the interfering frequencies. Thus, if a station operating on 500 kilocycles interferes with the program of another station on 499 kilocycles, a heterodyne whistle of 1000 cycles will be heard in the receiving set. As long as the two stations operate within 10 kilocycles of one another there is likelihood of receiving the heterodyne whistle or at least of receiving a distorted program. This principle may be clearly illustrated by plucking two strings of a violin which have nearly the same note. A slow beat note will be heard by the observer. The frequency of this note may be varied by changing the pitch of one or both of the strings. As the difference between the two notes increases the beat frequency increases until it becomes too high to be audible. The two strings represent the broadcasting stations operating on nearly the same frequency and the beat note is the "heterodyne whistle."