LESSON
10 R

RADIO COMMUNICATION

RADIO-TELEVISION TRAINING SCHOOL, INC.

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RADIO COMMUNICATION

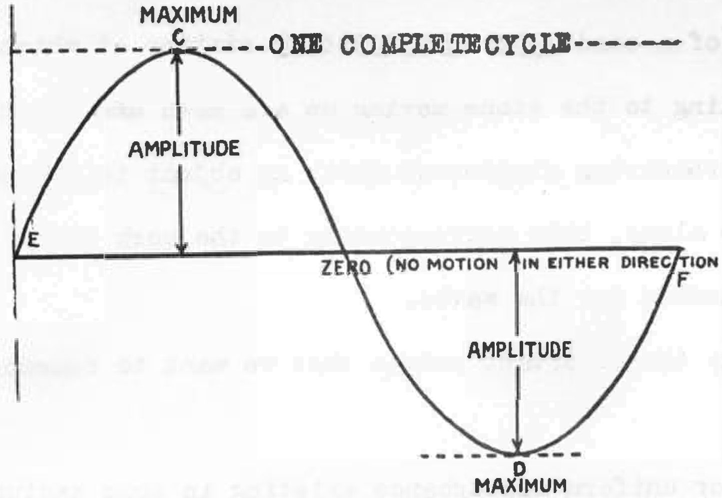
WAVES AND WAVE MOTION. We generally hear it said that Radio messages are sent out through space and reach us in the form of a wave motion. But what is this wave motion, and how can words and music be sent out all over the world in the form of a wave?

We all know about waves on the water. If we drop a stone or other object into a pond of still water, the entire surface of the pond becomes disturbed. At the instant the stone strikes the water, a circular ridge is at once formed and begins to move outward in all directions. The ridge, or crest as it is called, is followed by a hollow depression or trough. If the stone were tied to a string and we kept on pulling it out and dropping it into the water again with uniform regularity, the entire surface of the pond would soon be disturbed with a series of crests and troughs all of which would start at the point of disturbance, and spread outward in the form of constantly expanding circles. Such a disturbance is known as a wave motion, a crest and a trough constituting a single complete wave.

The rapidity with which the stone is moved up and down determines the rate at which the waves are sent out, or the frequency. The frequency may thus be defined as the number of waves that are sent out per second. The greater the frequency, the shorter will each wave be, and the lower the frequency, the longer will each wave be. If the stone is raised higher so that it strikes the surface of the water with a harder impact, the height of the waves will be increased. This again brings in a new term, namely the "amplitude" of a wave. By the amplitude of a wave is meant the distance from the position of rest to the highest point of the wave. The amplitude, we must remember, depends upon the force or intensity with which the object disturbs the water.

The frequency of the waves or of alternating currents are measured in cycles per second. Two complete alternations of the wave are equal to one cycle per second. The meaning of frequency is how many complete alternations past a given point per second. Because of the fact that frequency runs from a very low frequency of about 16 cycles per second up into the millions of cycles there are other terms used to show frequency.

A. C. SINE WAVE ALSO ILLUSTRATING
FREQUENCY AND AMPLITUDE



FREQUENCY CONVERSION

To change kilocycles into cycles per second, we must multiply by a thousand. To change megacycles per second to cycles per second, multiply by one million.

WAVE LENGTH

We also speak of the length of a wave. By this is meant the distance from the top of one crest to a corresponding point on the next crest. The speed with which a wave passes a stake in the water is known as the velocity of the wave, and the length of time required for a single wave to pass the stake is called the period of the wave.

A cork floating on the surface of the pond will be caused to move up and down as the waves travel toward the shore. The cork will not move toward the shore, but will always remain at nearly the same spot and merely moves up and down. This shows that the water itself does not move toward the shore, but only the wave disturbance does. The cork will vibrate or bob up and down at the same rate as the waves come along, and the greater the amplitude of the waves, the harder will the cork vibrate. Therefore, the cork float will, in all respects, respond to the wave motion in the water on which it floats.

We can compare this action with wireless transmission and receiving. A complete wireless system consists of a sending or transmitting station at which the waves are sent out, this corresponding to the stone moving up and down and disturbing the surface of the water, and a receiving station at which an object is set into vibration by the waves as they come along, this corresponding to the cork float. The water is known as the conducting medium for the waves.

Let us review quickly the important points that we want to remember about the waves and wave motion.

A wave is a regular or uniform disturbance existing in some medium. A complete wave consists of a crest (ridge) and a trough (hollow). A number or series of waves following each other is commonly called a wave train.

The velocity of a wave is the distance that a wave travels in one second. This velocity with which a wave travels depends upon the nature of the substance or medium in which it exists.

The frequency of a wave is measured in cycles per second or the period of time that it requires for a single wave cycle to pass a given point per second.

The amplitude of a wave is the maximum height or distance that a wave travels from its position of rest.

THE NATURE OF SOUND

When an electric bell is rung, we can see the hammer striking the bell and can also hear the sound which is given off. If we hold a pencil against the edge of the bell, we find that the bell is vibrating, that is, moving to and fro very rapidly. If we look at a violin or piano string while a note is struck, we also see that the string is moving or oscillating back and forth, and if we touch it with our finger where the string looks broadest, we can actually feel the vibrations. Numerous similar experiments have caused us to believe that whenever we hear a sound, be it a musical sound or just a noise, some object has been set in motion or vibration. In other words, a sound is always caused by a vibrating object.

If we hold our fingers lightly against our throat while we are talking or singing, we can feel that there is something vibrating within. The source of sound in a person's throat is the vibration of the vocal cords which are set in motion by the breath. The vibration of these cords sets the surrounding air in vibration. Sound waves are thus set up which spread outward in all directions through space in the form of constantly expanding spheres, just like the growth of a soap-bubble from a pipe. These sound waves then strike the ear of another person near by, set his ear drum into vibration, and produce the sensation we call sound. Since these sound waves must constantly set more and more air into vibration as they become larger and expand, they gradually become weaker; and if the other person is too far distant, the sound waves will be so weak that they cannot be detected and no sound will be heard.

The medium in which sound waves travel is the air; and if the air could be removed between two persons, neither could hear what the other one was saying. An interesting experiment is to hang an electric bell in a large bottle, then cork up the bottle carefully and by means of a suction pump remove all the air out of the bottle. The sound of the bell becomes fainter and fainter; and when nearly all of the air has been exhausted, we can still see the hammer strike the bell but cannot hear any sound. This proves that sound alone will not travel through a vacuum be it a bottle or a vacuum tube. As soon as air is again allowed to enter the bottle, the bell can be heard as usual. From the above we see that the transmission of sound involves the three essential elements: The vibrating object is the sending station, the air is the medium carrying the sound waves, and the drum or membrane in our ear is the receiving station.

Sound does not travel instantaneously, but requires considerable time to pass through space. For instance, we have often seen the steam coming out of a distant whistle, and a short time later heard the sound. Under ordinary conditions sound travels at the rate of 1100 ft. in one second of time.

The pitch of a sound (highness or lowness) depends upon the vibrating frequency, that is, the number of waves striking the ear drum per second - the greater the frequency, the higher the pitch of the sound will be. Middle "A" on the piano has a frequency of 435 cycles per second; and since sound travels at the rate of 1100 ft. per second, 435 of these waves would have a length of 1100 ft. To find the length of one wave we need merely divide 1100 by 435, which gives a result of about 2-1/2 feet, the length of one wave. In this manner we can calculate the wave length of any note, merely by dividing the velocity by the frequency.

Since the tone of a man's voice is lower in pitch than that of a woman's voice, the wave lengths of a man's voice are longer than that of a woman's. In ordinary conversation the wave length of the sound of a man's voice is from 8 to 12 feet and that of a woman's voice is from 2 to 4 feet. There are also limits above or below which the human ear cannot detect sounds. The lower limits are at the frequency of about 16 cycles per second below which the individual vibrations are not heard. The upper limits vary as with different people. Some people with very good senses of hearing can hear up to 20,000 cycles per second, but the average person hears well only up to 10,000 cycles per second. Therefore, in radio work frequencies of 10,000 cycles per second and lower are known as audio frequencies; that is, they are audible to the ear while frequencies above this value are known as radio frequencies because they are inaudible. This figure was selected as an arbitrary numerical value to serve as a dividing line because of the fact that most people do not have a sense of hearing above 10,000 cycles per second.

Thus in sound transmission, or audio telephony as it might be called, the expanding sound waves spread outward in all directions and are not directed toward any particular point. In the modern term, they are "broadcast" and reach every one within range of the waves. At great distances the sounds are so faint that they can't be heard. There are also numerous interfering causes which may make it difficult or even impossible to recognise the sounds. These interferencesmay be due to various irregular noises, such as a passing auto-truck or street car. Similar interfering disturbances, it will be found, must be contended with in radio telephone transmission and receiving.

HOW RADIO MESSAGES REACH US

From the very nature of radio broadcast transmission we know that it is accomplished by some form of wave motion. These waves we will learn later on are known as electromagnetic waves, because they are produced through the aid of electricity and magnetism. It is impossible to have a form of wave motion without having some medium or substance within which it can take place. We know that these radio waves are not carried by the air because they will travel through a vacuum or through solids or liquids, just as readily as they will through open space. Furthermore, radio waves are affected by certain atmospheric conditions which in no way interfere with the operation of sound waves.

Since these radio waves must be carried by some medium, and since we know that this medium is not the air, it has been assured or supposed that there exists throughout all space another substance known as the ether, and that it is this ether through which all radio waves are carried or transmitted.

Although no one has thus far been able to prove the existence of the ether or to establish its identity, nevertheless, experimental observations seem to indicate that some medium of this kind must exist. Various properties have been assigned to this ether in order to enable us to use it for explaining existing conditions. The ether extends throughout all space, even beyond the farthest stars. Since light and heat are also known to be a form of wave motion, it is believed on good evidence that this same ether also carries to us the light and heat from the sun and from the stars. The ether exists around and through all objects like water fills a sponge. It cannot be removed from any portion of space or pumped out of any container. Ether also offers no opposition to objects moving through it. In fact, the earth revolving through it at a velocity of thousands of miles per hour causes no displacement of the ether; in other words, the ether passes through it like air through a sieve. It is also of an extremely elastic nature, that is, a disturbance in the ether at any point immediately spreads out in all directions just as the sound waves expand when a sound is made.

Sound waves like radio (ether) waves expand and spread outward in all directions when an electrical disturbance occurs, such as when a spark is discharged into the air. Radio waves travel at the enormous velocity of 186,000 miles per second. This means that when a disturbance of some kind is caused in the ether, it's effect can be felt one-eighth of a second later, and during this time, it has traveled completely around the earth. Radio waves in common use range in length from 75 meters (about 244 feet) to 25,000 meters (15-1/2 miles). Since the waves travel at a speed of 186,000 miles per second, which is also the speed of light, these wavelengths represent frequencies ranging from 4,000,000 cycles per second to 12,000 cycles per second. Since the average human ear could not recognize sound waves at these high frequencies, it can be seen that radio frequencies are inaudible.

ETHER WAVES IN COMMERCIAL PRACTICE

The length of a radio wave sent out by a transmitting station can easily be calculated. From the nature of the transmitting apparatus, we know the frequency or the number of waves that are being sent out per second. We also know the speed at which these waves travel, namely, 300,000,000 meters (186,000 miles) per second. By dividing the speed by the frequency, we get the length per wave. If we know the wavelength and wish to calculate the frequency, we need merely to divide the speed by the wavelength. These calculations will be taken up in greater detail later on.

Waves of various lengths are used in commercial practice. All amateur transmitting stations must operate at a wavelength not exceeding 200 meters. This corresponds to a frequency of about 1,500,000 cycles per second. Practically all broadcasting in this country, at the present time, is being done at wavelengths ranging from 200 to 550 meters, the corresponding frequencies being 1,500,000 and 545,454 cycles per second. For reliable long distance transmission, such as transoceanic service, longer wave lengths are in general use ranging from 10,000 to 25,000 meters in length. These greater lengths are used because the shorter waves are more readily affected by atmospheric conditions and changes and hence are not dependable for regular long distance transmission. Also, with the greater wave lengths the required sending apparatus is less costly, especially if large amounts of power are being transmitted.

Even though the ether is very elastic and waves can readily travel through it, nevertheless, they do not continue onward indefinitely, for a considerable amount of energy is constantly being absorbed from them as they travel over the country. Every house, tree, post, or wire intercepts them and absorbs some of their energy. Rough and irregular country, especially hills covered with trees, absorb more energy from the ether waves than does level country. Leaves and branches especially absorb large amounts of energy, and hence a transmitting station located in wooded territory can send farther in the winter than during the summer months. In fact, trees have often been used as an aerial in cases of emergency. Any object extending from the ground into the air tends to rob the ether waves of some of their energy, the better electrical conductor the object is the more energy it absorbs. Another very peculiar condition is the fact that some forms of soil absorb a great deal of energy, while transmission over salt water can be very easily accomplished.

Messages can be transmitted over greater distances during the night than during the day time. It is a known fact that certain rays from the sun make sections of the air conductive and hence enable it to absorb energy which it cannot do during the night time. Furthermore, the transmitting range, that is, the distance messages can be sent effectively, also varies from day to day due to the various electrical conditions of the atmosphere. On warmer days the moisture in the air is usually charged with electricity known as static electricity, or merely static. This static electricity seems to interfere seriously in two ways: It attracts and absorbs considerable amounts of energy from the ether, and also tends to accumulate on the receiving aerials, and in this way produces annoying sounds in the receivers which make the reception of radio signals very difficult, and often impossible. For the same reason greater ranges can be covered during the winter than during the summer months.

There are various other conditions that affect the operation and movement of the ether waves. For example, heavily charged thunder clouds or large bodies of electrified air in the upper regions have a marked tendency to deflect the waves and in this manner cause the incoming signals at a station to be very weak and difficult to detect. Another peculiar condition that often arises is that the ether waves are reflected on the sides of high mountains or from the clouds, in this manner causing what might be called an "electrical shadow" on the opposite side. This is similar to the sunshine striking a billboard and being reflected, causing a shadow on the other side. Various "freak" messages heard occasionally are often due to a combination of such direct and reflected waves.

GENERAL PRINCIPLES OF RADIO COMMUNICATION

We are now ready to consider in a general way the principles involved in carrying on radio communication. Three essential elements are involved: A transmitting unit, a conducting medium and a detecting or receiving unit. The transmitting unit first of all contains some form of oscillation generator, that is, an electrical generator capable of producing extremely rapid electrical waves or oscillations in a wire system. Secondly, this wire system must be so arranged that the ether waves set up as a result of these rapid electrical oscillations, can be radiated effectively or flung out into space. It is from this general principle of radiating waves into space that the term "Radio" was derived. That part of the electrical system from which the waves are radiated is called the aerial. This aerial of a transmitting system corresponds to the filament of an incandescent electric light bulb from which the light waves are given off. The size of the aerial and its height above the ground depend entirely upon the amount of power that is to be transmitted and the range for which the station is designed.

From the antenna the waves in the ether spread out in all directions through space. At some distant point these waves come upon another aerial or antenna. This antenna is connected to a receiving station. As the advancing waves encounter this receiving antenna they set up in the entire wire system of the station electrical oscillations similar to those which existed in the original transmitting system. Connected to the antenna system is some form of "tuning" apparatus by means of which waves of only a particular length will be accepted, while all others will be excluded. This is a very important feature, for it enables the person at the receiver to listen to the signals or messages he is interested in without being annoyed by all the other waves which may be passing through the ether at the same time. The oscillations received, however, are at radio frequencies and are far too rapid to be recognized by the human ear. The receiving unit must, therefore, contain additional apparatus for reducing these high frequencies to values at which they can be accepted as sounds. Also, these changes must all be brought about without altering or distorting the general construction or form of the waves, for otherwise the sounds heard in the receivers will not correspond with those sent into the transmitting apparatus and the signals would have no meaning.

THE FEDERAL COMMUNICATIONS COMMISSION

The Federal Communications Commission was created by the Communication Act of 1934.

This Commission was created for the purpose of establishing rules and regulations which will enable the proper operation of all of the various classes of radio stations in the United States. Without these rules and regulations, we would be unable to receive signals clearly as interference between stations would be serious. By regulating the frequencies, the power output and the types of transmission, that is, frequency modulation, amplitude modulation, continuous radio wave telegraphy, television and facsimile, the various services can operate simultaneously with the least amount of interference. Furthermore, the design of the equipment, as well as the requirements for the respective classes of radio operators to maintain them, can be definitely established for improved service to all concerned.

The Federal Communications Commission is composed of seven members appointed by the President, subject to Senate confirmation, one of whom the President designates as Chairman. From time to time the Commission designates a Vice Chairman who acts as Chairman in the Chairman's absence. In the absence of both the Chairman and Vice Chairman, the Commissioner most senior in terms of service, who is present, acts as Chairman, unless otherwise provided by the Commission.

There are two standing committies of Commissioners, the Telegraph Committee and the Telephone Committee, each composed of three Commissioners. Certain telegraph and telephone matters are from time to time referred to these Committees by the Commission for report and study.

The offices of the Commission are located in the New Post Office Building, Thirteenth Street and Pennsylvania Avenue NW, Washington 25, D.C. All meetings of the Commission, unless otherwise directed by the Commission, are held at the above address.

The Commission is divided into the following principal groups: (a) Office of the Secretary; (b) Engineering Department; (c) Accounting Department; (d) Law Department; and (e) Administrative Divisions.

Each one of these groups are further divided in the following units: (a) The License Division; (b) The Service Division; (c) The Recorder Division; (d) The Minute Section and Library Section.

The Secretary of the Commission is custodian of its official records. He is responsible for the preparation of Commission minutes which are the official record of action taken by the Commission, the processing of the correspondence and official papers, the administrative examination of applications, and certain functions relating to the internal management of the Commission. All orders, permits, licenses, or other instruments of authorization made, issued, or granted by the Commission are signed by the Secretary in the name of the Commission and authenticated by the seal of the Commission, unless otherwise specifically directed by the Commission.

The Engineering Department of the Federal Communications Commission is headed by the Chief Engineer who supervises all commercial activities concerning engineering matters including activities in connection with the North American Regional Broadcasting Engineering Committee. The following units are included in the Engineering Department: (a) The Broadcast Branch; (b) The Safety and Special Services Branch and (c) The Field and Research Branch.

The Accounting Department is headed by the Chief Accountant who supervises all Commission activities concerning accounting matters. The following units are included in this department: (a) Accounts Branch; (b) Rates Branch; and (c) Economics Branch.

The General Counsel is the head of the Law Department and is responsible for all Commission activities relating to legal matters. This Department consists of the following units: (a) Office of General Counsel; (b) Litigation and Administration Division; (c) Broadcast Division; (d) Common Carrier Division and (e) Safety and Special Services Division.

Then there is the Administration Division which is headed by the Director of Personnel. This Division handles all personnel matters for the entire Commission and has the following sections: (a) Classification Section; (b) Employment and Placement Section; and (c) Employee Relations Section. This Division is also responsible for all budget, finance, organizational activities as well as the Office of Information. This latter group is responsible for press and public relations including the preparation and distribution of news releases, periodic reports and general information relating to Commission activities.

The Federal Communication Commission is well organized and capable of policing the various channels made available to the various services. This organization is substantial evidence that radio communication is controlled to insure the greatest service to all.

COVER PHOTOGRAPH

The cover photograph shows three radio operators at their respective operating positions in a Transcontinental and Western Air Inc. communication center. Here radio messages are sent and received in radio telegraph code by the operator at the left while the operator in the center handles only radio telephone messages. The gentleman at the right is the message dispatcher.