THE HOME RADIO UP TO DATE

A. HYATT VERRILL

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How to Make and Use It

By

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and

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PREFACE

THIS book is not intended as a complete treatise on radio telephony, nor has any attempt been made to enter deeply into the scientific side of the subject. It is intended and designed for the use of novices and for those who use or would like to use radio in the home, as well as for those who desire to assemble or build their own receiving sets and who are fond of experimenting with the various types of apparatus. A deep or thorough knowledge of the subject is not essential for such persons, but it is necessary that they should have a thorough understanding of the basic principles of radio, the construction and operation of instruments, and the whys and wherefores of the same. In other words, they should know "how the wheels go round." In my former book, *The Home Radio,* the more simple and elementary types of radio receiving sets were fully covered. But since that book was published radio has become more standardized and to-day, with few exceptions, the tube sets have almost entirely supplanted those of the crystal type. Moreover, it is now no longer necessary for the beginner to construct his own coils, variometers, and other instruments. Everything one may require may be purchased ready-made, and such instruments and accessories are far more satisfactory and far cheaper than anything that can be made at home. In fact, it is most important that the novice should employ ready-made parts, and those of the best quality, if success is to be secured. No matter what set is made or how much care is used, the complete set will be no better than the parts employed in making it. Many excellent sets are absolutely worthless because of cheap parts or home-made parts used in their construction. For these reasons the authors have refrained from describing how to make radio parts, but have described the construction of the sets with standard parts and accessories.

As soon as a person learns something of the mysterious force which renders radio possible there is an overwhelming desire to experiment; and to simplify the experiments and to render the work intelligible to all classes of readers, the authors have endeavored to avoid the use of technical terms and scientific explanations as far as possible.

Moreover, whereas a few years ago few of the hundreds or thousands of users of radio receiving sets knew anything of the construction or operation of their instruments, to-day few do not know more or less about the various types of sets and the purposes of the instruments contained in them. Radio has become so widespread and has reached such stupendous proportions that it has not only become one of the leading industries of the United States, but few homes are without it. In place of thousands there are now millions of sets in use, and yet the interest and enthusiasm of the public have not abated in the least. But the public has become more educated in radio and hence an up-to-date book, even if intended for beginners, is necessarily far more advanced than such a book of two or three years ago.

Even to-day, however, there are limits to radio. Each type of set has its advantages and disadvantages and the prospective maker or user of a set must decide just what results he wishes to obtain in order to select the type best suited to his wishes. It is hopeless to expect to get the same results from a cheap or small set that might be reasonably expected from a more expensive and elaborate set, and it must be remembered that no one can say definitely what a set will accomplish in getting distant signals or in tuning out local signals or even in the clarity or volume of reception. These matters depend upon a thousand-and-one outside influences and conditions which have nothing to do with the set itself. Often a set in one location will prove most satisfactory, whereas the same set a short distance away, or even in another room, will be woefully unsatisfactory.

But the discussion of such matters cannot be taken up in a book of this size, and for that matter, there is a vast difference in opinion even among experts as to this, that, and the other. But in the present volume the authors believe that the most important and salient features of radio reception and the most trustworthy and standard types of instruments have been fully covered. If through it the countless radio users and enthusiasts are enabled to secure better results from their sets, if the beginners who read it are aided in their experiments and constructions, and if it serves to make clear the differences between the various types of sets and eliminates some of the confusion brought about by the innumerable sets constantly advertised as "new," the mission of the book will be accomplished.

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CHAPTER I

PRINCIPLES OF WIRELESS TELEPHONY

BEFORE attempting to explain the functions and principles of the radio telephones, or describing how to make, use and operate them, it is necessary to understand something of the underlying principles and fundamental laws of of wireless transmission.

It is not, however, necessary, and in fact it is impossible in a book of this scope, to enter into a long discussion or dissertation on the theories and principles of electricity or physics which enter into the subject, but merely to illustrate and make clear a few important and salient laws, causes and results which make the transmission of sounds possible without the use of wires between the sending and receiving instruments.

The first and most important principle of all radio transmission is the fact that all our atmosphere is constantly disturbed by vibrations or oscillations or, as we may call them for the sake of simplicity, waves. We are accustomed to think of the atmosphere about us as a more or less uniform substance which we call air, but in reality, the air or atmosphere, space, and in fact all solids as well; even the food you eat, the chair you sit upon, your own body, are all made up of infinitely minute bodies known as electrons.

It is hard to believe this, hard to imagine it, and still harder to understand just what electrons are. They are the smallest of all things, and yet the most powerful things in the universe, and so tremendous is the energy or force contained in them that the electrons in a drop of water contain enough power, if suddenly released, to destroy the largest building ever built by man. Broadly speaking, electrons represent the planets revolving around the sun, only, instead of the sun, there is a central nucleus. And every atom of matter—whether metal, liquid, wood, cloth or flesh has in its make-up a certain definite number of these electrons. As long as the proper number of electrons remain, nothing unusual happens or, as we say, the object is not electrical. But the moment any substance has some of its electrons taken away, or more added to it, strange manifestations that we call electrical energy take place. There are many ways of taking away electrons or adding them to a substance. Thus, a battery or a dynamo can draw electrons from an object and push them into another, and what we call the positive side of a battery or a dynamo is merely the side that draws electrons out, while the negative side is the side that pushes them in or transfers them to some other object. Thus, what we call an electrical current is merely the result of the flow of electrons from one place to another, for electrons are ceaselessly striving to get back where they belong. When you see a flash of lightning or an electric spark, you merely see the result of electrons leaping from an object that has too many to an object that has too few. And the instant both substances have their proper number of electrons the spark ceases. So, too, when we heat an object we add to the number of electrons in it and the surplus electrons rush off. Indeed, heating consists merely in forcing too many electrons into a substance, and if we place a cold object which contains too few electrons—near to or touching a hot object, the surplus electrons will leap across and heat the cold object by adding to its supply of electrons. The farther we move the cold object from the heated one the less it is affected, for air will stop electrons. This may seem strange, but we must remember that an electron is so minute that, in comparison with an atom—which used to be considered the smallest division of matter—it is like a bird-shot compared with a football. So air or any substance offers a sort of wall against electrons and their energy is largely exhausted trying to break through. But as some substances are more homogeneous than others, the electrons can get through them more readily than through others. Such objects we call good conductors of electricity or of heat. Thus, copper, gold, silver, and most metals are good conductors, some better than others; while wood, stone, glass, air and other substances are poor conductors of heat or electricity. It is because air is such a poor conductor that the common incandescent bulbs have the air pumped out, for the light is merely the effect of electrons leaping away from the filament. Finally we must bear in mind that when two substances, each containing too many electrons, or negatively charged, as we say, are brought together nothing happens, any more than if the two substances each contained the normal number of electrons. In other words, as neither body wants more electrons, but instead is anxious to be rid of the excess, they repel each other. In the same way, two substances each with too few electrons repel each other for, both wish to get more, and each one, figuratively speaking, fears the other may try to steal some of its electrons. But if a body having too many electrons is placed against or near to a body having too few, or, speaking in electrical terms, if a negatively charged body is placed near a positively charged body the surplus electrons in one will rush across to fill the deficiency in the other. This, then, is what we know as electricity—the rush of electrons from the negative pole of a battery or a dynamo to the positive pole. But of course that does not mean that each of the electrons travels the whole length of a long wire or flows around it like water. Where the two ends come together the electrons leap from one to the other; then those behind rush forward to fill the spaces, and those farther back move on, and thus all the electrons in the circuit are constantly on the jump as long as the battery or dynamo is adding too many to one pole and too few to the other.

Thus light, heat, electricity, and the wireless currents or electro-magnetic currents, commonly referred to as waves, are all the motion or flow of electrons. Indeed, it is now generally believed that light, heat, and electricity and wireless "waves" are all one and the same thing, the only difference between one and the other being the length of the waves or speed of the movement of the electrons. In fact, hard as it is to believe this, yet it is not difficult to understand, and it is a very simple matter to prove that heat and light waves are identical and we will try to explain in the next chapter how we may actually see and feel by radio.

CHAPTER II

SEEING AND FEELING BY RADIO

Heat, Light, and Radio Waves

(Plate 1)

WHEN we say that we see a thing, what happens? Our brain records an impression carried to it by nerves from our eyes which have been affected by rays of light, or light waves, striking them. In other words, our eyes serve as the antennæ of a radio set to pick up the light waves, exactly as the antennæ of a receiving instrument pick up the radio waves. Then our optic nerve acts as the detector to transform light waves to sensations or impressions on our brain which we can understand, exactly as the crystal or the valve in your radio set transforms the radio waves to currents which enter the telephones and are there made audible.

And when we feel heat or cold very much the same thing happens. The only difference is that in this case our skin acts as the antennæ to pick up the heat waves, and the nerves carry the effect to our brain where the intelligible impression of heat or cold is formed.

In other words, all light, and consequently all vision, is due to light waves and all heat to heat waves, and both are truly electro-magnetic waves very closely akin to radio waves. In fact, many scientists believe they are all identical and only vary in quality or character, and that there is a regular gradation from one to the other.

This may seem impossible at first thought; but if we stop to consider it, is it any more remarkable than the fact that heat and light waves grade from one to the other? And yet we know that this is so and anyone may readily prove it by the most simple test. If we heat a piece of iron it may become so hot that it will burn wood or paper, and yet it will retain its dull black color. Then heat it some more and it gradually becomes red. In other words, the heat rays it sends out have decreased its length until they have become light rays and are visible. Continue heating it, and it will glow brighter and brighter, turning to yellow and finally to blue-white, or, in other words, the heat waves have not only been transformed to light waves, but the latter have been carried through the long range of light waves from dull red to blue-white. In the same way we feel the heat

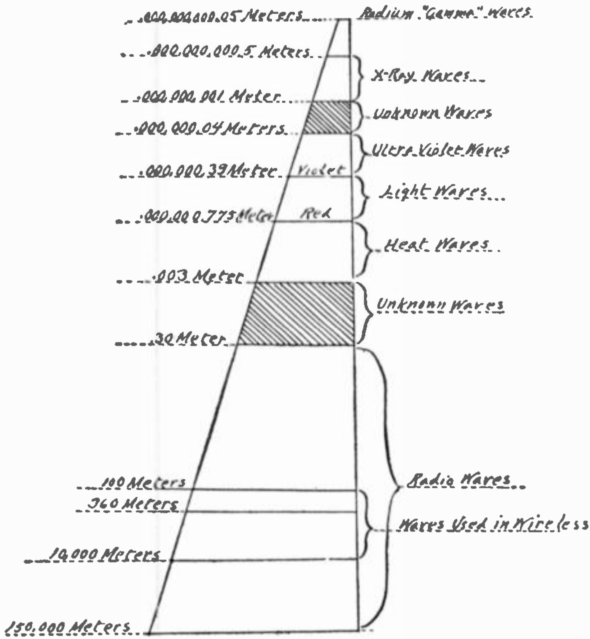


Chart Showing Relative Wave Lengths

PLATE 1

of light or see the light of heat when we are warmed by sunshine, the flames of a fire, or touch an electric-light bulb. But when we attempt to trace the gradation of heat and light waves to radio waves, we find a more difficult problem, for there are gaps missing in the transition which have never yet been bridged.

To understand this better and to realize the similarity of heat, light, and radio waves let us first consider the matter of wave lengths, for heat and light waves vary in length according to the heat or light they transmit to us, exactly as radio waves vary in length; and the only difference between heat, light, and radio waves, as far as known, is the difference in wave lengths, or their frequencies. The very shortest waves we know or have measured are the "gamma" waves given off by radium, while the very longest we have recorded are radio waves as much as 150,000 meters in length or over ninety-three miles—while tiny gamma waves of radium are but .000,000,000,05 meter long; or, to put it differently, it would require thirty thousand million millions of radium rays to equal the length of one of the huge radio waves.

But from these tiniest of waves there is a steady gradation. Next we find the X-rays about ten times as long as the radium waves.

These range up to waves one hundred and fifty times as long as the gamma rays, or about one billionth of a meter in length. Next, after a gap which has never been bridged, we find rays about forty times as long as the X-rays. All of these extremely short waves are invisible to the human eye, just as the extremely high frequency waves of the radio signal are inaudible to the human ear and have to be cut down or reduced to a frequency of about ten thousand a second in order to be heard. And above the ultra violet waves we find a steadily increasing lot of waves which are still invisible, for not until the waves reach a length of nearly three millionths of a meter—.000,000,390 to .000,000.450 of a meter—do the crude detectors we call eyes pick up the waves and carry to our brains the impression we call light. These shortest of light waves are the violet waves. Next in order come blue, green, yellow, orange, and red. But if the light waves become mixed—or there is interference, so to say—and our eyes cannot tune out the various wave lengths, we see white, which is a mixture of all. As the waves below violet were all invisible to us, so the waves above red again become invisible and can only be felt, and we call them heat.

You all know, if you have learned about

radio, that your receiving sets have only a limited range of wave-length reception. You may be able to "tune" for waves varying from one hundred to one thousand meters, but below or above your limits the radio waves pass you by undetected and unheard. It is the same way with the human eye. We can "pick up" and "tune" with our eyes to wave lengths varying from the violet of .000,000,390 of a meter to the red waves with a greatest length of .000,-000,775, or about one millionth of a meter, but no farther. But while our eyes cannot see these longer waves, our nerves can still detect them, and we feel them in the form of heat waves which gradually increase in length until the longest known or measured are .003 of a meter in length, or about one-tenth of an inch. Then, even our nerves fail to detect or pick up the waves and we are forced to resort to instruments known as radio receivers in order to realize that there are still longer waves than heat waves traveling through the air.

There is, however, a huge gap between the longest heat waves we can feel and the shortest radio waves we can record, for the shortest radio waves measured or recorded are one hundred times longer than the longest heat waves, or .3 of a meter, or nearly twelve inches, in length. But there is such a strong similarity between the longest heat waves and the shortest radio waves that there is little doubt that they are identical, that their only difference is in their length, and that when science has bridged the gap between the twelve-inch waves and the one-tenth-of-an-inch waves and has found and detected the missing waves, we will know that the radio waves we pick up on our sets, the rays of light streaming from the incandescent lamp above our heads, and the grateful warmth from the fireplace are all one and the same; that we are not only hearing by radio, but are feeling and seeing by radio also.

And who knows but when these missing waves are found—these oscillations that lie between the one-foot and the one-tenth-of-an-inch waves—we may find a still greater secret, a means whereby our nerves may be able to pick up the broadcasted music and the signals without resorting to any mechanical devices whatsoever? It is not beyond the bounds of possibility, for if by merely increasing the temperature of a bit of metal, we can decrease the wave lengths until they are visible as red light, may we not find a way by which we can alter the radio waves and reduce them until they, too, are either audible or visible? Indeed, many scientists claim that the homing instinct of carrier pigeons, the strange ability possessed by birds, cats, dogs, and even toads to find their way directly and unerringly from one spot to another, are all due to some power these creatures possess to "feel" the waves which are inaudible and invisible, even unrecordable, to us humans, and which, for all we know, may be those missing waves that lie in the gap between rays of heat and radio waves.

CHAPTER III

WIRELESS WAVES AND HOW THEY CARRY SOUND

(Plate 2, Figs. 1-8)

LIGHT and heat waves which we now believe are akin to, if not identical with, electric and radio waves, have been known for a long time, but it is only within recent years that man has learned that the electric or electro-magnetic waves also travel through space or air without the need of wires, and it was through this discovery and by means of these waves, that wireless telegraphy and telephony became possible. we have already explained how electrons fill or compose everything, and are constantly in motion, by either heat, light, or electrical currents, and once we realize this fact we can more readily understand why and how radio waves penetrate buildings, walls, the insulation on wires and even mountains, trees, and the earth, for, as we all know, heat and light will penetrate solid substances. Some are more impervious to these waves than others and sometimes a substance will freely admit heat and will be impervious to light, while others will resist the passage of heat more than light. Thus glass offers no perceptible resistance to light and little to heat; metals—such as copper, iron, and others—are impervious to light and allow heat to pass through them, and wood and other materials resist both heat and light to great extent. It is much the same with radio waves. These, being far longer waves than either light or heat, pass through many substances that will baffle light or heat or both; but nevertheless, although they pass readily through solid masonry or even metal, yet only a portion of them passes through, just as light loses a portion of itself in passing through slightly opaque glass, and hence the waves are weaker within a building or behind a wall or other solid object than in the open. This is a fact that puzzles many amateur radio users who cannot understand why, if the waves pass through all substances, an aerial in the open air, high above surrounding buildings, will bring in stronger signals than one indoors or low down. Just as light becomes dimmer the farther one is from the lamp or candle or from a fire or a flame, so, too, radio waves become weaker and fainter the farther they move from their point of origin. They may travel completely around the world, just as, for all we know, the light waves from a match may travel around the globe, and yet, if we are too far from their source it is impossible to detect them with any instruments we have.

Perhaps the easiest way to understand the principles of the radio waves is to compare the sending station to a stone cast into a pool and compare the atmosphere to the water.

As everyone knows, an object cast into water starts waves or ripples that radiate in ever-widening circles from the splash. Thus the muscular energy of your arm used in throwing the stone corresponds to the electrical energy of the sending apparatus used in starting electrical or radio waves on their way through space. If there are bits of floating wood on the surface of the pool, or grasses and weeds growing in it, you will notice that while the waves cause these objects to move or vibrate, yet the waves continue on beyond them. In much the same manner, the radio waves reaching an aerial at a receiving-station, set up vibrations—invisible but producing a motion of electrons—or waves in the wire and yet continue on as before. Next we must note that the waves in the pool become lower and weaker as they move farther and farther from the splash, until, if the surface of the water be wide enough, they are

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

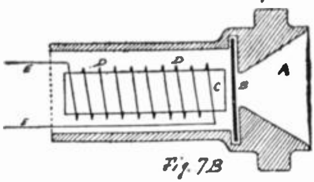


Fig. 7B

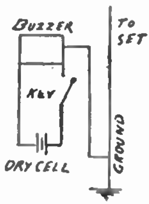


Fig. 8

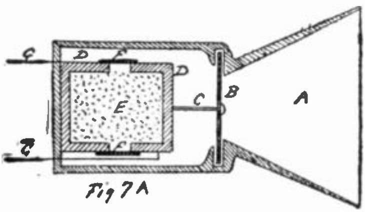


Fig 7A

PLATE 2

practically invisible when they reach the shore. It is the same with radio waves. The greater the distance from the sending point the fainter and weaker they will be. And even though the minute waves from a buzzer may travel around the earth, they are far too weak to be detected at any distance from their origin, whereas powerful waves sent from a great radio station may be picked up and heard halfway or more around the world.

In one way, however, radio waves and water waves differ greatly. The waves in the water "drag," and therefore become longer as well as fainter as they proceed; whereas radio waves remain always a constant length regardless of the distance they travel or their weakness. You can easily see that by having a prearranged code it would be quite possible for two people to communicate by means of water waves, for, by throwing stones into a pond at definite intervals, the person on the shore would be able to understand the signals by watching the waves. Of course, this would be a very crude and unsatisfactory method of communication, but it would be along the same lines as talking by wireless telegraphy, for wireless telegrams are simply electrical waves sent through space in broken or interrupted sequence to represent dots and dashes, and are received by instruments that record or make audible these broken waves. Just as the water moves up and down as well as forward, so the wireless waves, which are known as alternating currents, move up and down or oscillate as they travel through the air. This is illustrated in *Fig. 4.* But the radio waves themselves are never audible to the human ear, and so, in order to hear them, they must be transformed or changed to sound waves that we can hear. If, however, the alternating currents were transformed to sound waves direct, still we should not hear them, for the human ear cannot detect sound vibrations of much more than ten thousand a second, whereas radio waves may vibrate millions of times a second. Hence, before we can hope to hear radio messages, some device must be used that will reduce or cut down the frequency of the waves. Such a device is known as a *detector*, and it acts by allowing the waves to flow through in one direction and not in the other, exactly like a valve in a pipe. Then, the waves having been reduced in speed, they are passed through the phones and by them are changed from electro-magnetic to sound waves. But in order to make these sound waves intelligible they must be broken up into dots and dashes and thus utilized for wireless telegraph messages or they must be varied or modulated by means of the human voice or other sounds. In the case of the wireless telegraph transmitter the waves are interrupted as they are produced, and while the flow may be so rapid that they appear as a steady stream, yet there is really a distinct pause after each one. So if a telephone transmitter and receiver were attached to ordinary wireless telegraph instruments, the sounds or vibrations of the voice would vary the path of the oscillations and the same variations would be heard on the receiver, but the voice would be broken or interrupted and heard as unintelligible fragments, if heard at all. Hence it is easy to understand why all sounds cannot be carried by ordinary wireless-telegraph instruments. The reason radio, as we know it, was so long in coming after wireless telegraphy, is because no one could discover a means of creating a continuous wave that could be so modulated by voice or other sounds as to be transformed into sound waves and thus reproduce the voice or music. Therefore the real key to successful radio telephony was a device for producing continuous waves of this sort. The *Figs. Nos. 1, 2, 3, 4, 5, 6* illustrate just how the interrupted and continuous waves carry sounds. Thus, 1 represents the variations in sound vibrations of a certain word; 2, the intermittent oscillations of the wireless telegraph sender; and 3, the way the word would be broken up if sent by the telegraphic wave. *Fig. 4*, on the other hand, shows the continuous wave of the wireless telephone transmitter; 5, the way the continuous wave would appear when modulated by the voice. You can thus easily see the difference between the word broken as in *Fig. 3* and flowing smoothly as in *Fig. 6*. But it must be remembered that whereas the sounds of the voice, music, etc., cannot be sent or received over a telegraphic instrument, yet a wireless telegram can be sent to perfection over wireless-telephone instruments, the only difference being that in the latter case the waves are broken or chopped up into dots and dashes by suitable instruments and a key which opens and closes the circuits.

Perhaps, before attempting to explain just how a radio message is sent and received, it may be best to compare the wireless telephone to a phonograph or gramophone. If the blank record with its spiral grooves is placed on a machine with a needle, attached to a diaphragm and horn, resting in the groove, and the record is rotated while someone talks into the horn, what happens? The sound waves from the voice vibrate the diaphragm and move the needle up and down, thus cutting little serrations along the groove in the record. Then, if the record is placed under another needle attached to a diaphragm, and the record is rotated, the tiny serrations in the groove will cause the needle to move up and down, the diaphragm will be vibrated, and the original sounds will be reproduced. Thus sound waves are changed into mechanical vibrations in making the record, and mechanical vibrations are again transformed to sound waves when the record is again rotated. Thus in a way the wireless waves sent out from a station represent the grooves in the record; and the vibrations on these waves, caused by music or other sounds, correspond to the serrations cut by the recording needle. And just as the serrations on the record cause the second needle to vibrate and reproduce the original sounds, so the variations on the radio wave cause irregular vibrations in the receiving set and so reproduce the voice or music, the only difference being that in one case mechanical vibrations are changed to sound waves, whereas in the other, electrical vibrations are altered to sound waves. How this is done is a puzzle to many, but it is really very simple. There are many types of phones, but in general principle all are alike, and if you understand one you can understand all. The phone transmitter, or microphone, *Fig. 7, A*, consists of a mouthpiece (*A*); a thin diaphragm (in this case of metal) (*B*), which is connected with a rod (*C*), to a receptacle (*D*) that is filled with granules of carbon (*E*), secured by a flexible segment (*F*), the wires (*G*) being connected to the receptable (*D*). As long as the grains of carbon (*E*) are loose, the electrical current cannot pass through them; but the moment they are pushed together so that they come in contact, the current passes through, the amount of current that will pass varying according to the degree that the grains are pressed together or in contact. When one speaks into the mouthpiece, the sound waves of the voice cause the diaphragm to vibrate and this vibration moves the bar (*C*) up and down, exactly as the needle on the phonograph was moved by the diaphragm to which it was attached. And as the bar (*C*) moves back and forth it moves the portion of the receptacle (*D*), thus alternately pushing the grains of carbon together or letting them separate, exactly as a pebble inside a drum will dance about if the drumhead is struck, or as an object on a piano will jump about when the instrument is played. As a result, the current that flows through the carbon alternately flows or ceases or varies in intensity with the vibrations of the voice and thus sends irregular waves of electricity through the wires or through space, according to whether you are using an ordinary phone or a radiophone. The receiving phone is even more simple, *Fig. 7, B.* This consists of an earpiece or holder (*A*), with a thin diaphragm (*B*) placed close to but not touching a bar of iron (*C*), which is wound with fine wire (*D*) connected through the wires (*E*) to the rest of the set. As everyone knows, a bar of iron will be transformed to a magnet when an electrical current passes through a coil of wire about it, and the moment the current ceases the magnetism also ceases. It is this principle that is used in the receiver, and each time the current from the set flows through the wire about the bar (*C*) the metal diaphragm is drawn toward the magnetized bar and springs back the moment the current stops flowing. Each time this occurs a vibration of the diaphragm produces a sound. If these electrical currents were merely interrupted waves, such as those from a wireless-telegraph instrument, the sounds produced by the moving diaphragm would be mere buzzes, but if the varying impulses are made by music, the voice, or other sounds entering the transmitter, and so producing irregular continuous waves, then these, passing through the coil about the iron bar, will cause the diaphragm to move back and forth in exactly the same way as the diaphragm in the transmitter, and thus the original sounds will be reproduced in the receiver. Knowing this, you can readily understand that it makes no difference whether the electrical currents from the transmitter are carried over wires or through space, for as long as they are varied or serrated by the vibration of the diaphragm and then flow through the coil about the bar in the receiving phone, they are bound to reproduce the original sounds.

CHAPTER IV

THE ALADDIN'S LAMP OF RADIO

EVERY boy or man at some time of his life has longed for the magical lamp possessed by Aladdin, and with which he could summon a jinn to do his bidding. But today anyone may have a little lamp that can produce results that would put Aladdin's lamp to shame, and which can summon a genie far more powerful than any of those of the *Arabian Nights*. This modern Aladdin's lamp is the vacuum tube, or Audion bulb, a tiny affair like a miniature incandescent lamp, but which has made radio telephony possible and each day is performing new and more seemingly miraculous feats.

In reality this wonderful invention is a sort of descendant or offspring of the common incandescent bulb that lights our homes. Stranger yet, Mr. Edison, the inventor of the incandescent bulb, was really the discoverer of the Audion bulb, and yet he saw nothing in it of commercial or practical value and passed it by merely as an interesting electrical toy.

It was while Edison was experimenting with incandescent lamps that he discovered that if a metal plate were mounted in a bulb near the filament and the latter were lit, an electrical current would be produced in the plate. But the most remarkable part of the affair was that this electrical current in the plate was only produced when the filament was connected with the negative side of the circuit. In other words, the current would pass through the filament, across an open space and to the plate in one way, but not in the other. Neither Mr. Edison nor anyone else had an explanation for the phenomena, for at that time the electron theory of electricity was unknown. Now, however, we know—or at least believe—that it was due to electrons being thrown off from the filament to the plate.

As we have already explained, every hot object is overcharged with electrons which are thrown off to find lodgment in some cold object which is undersupplied with electrons. Thus, the hot filament threw off its surplus electrons to the cold plate. In other words, the current could flow but in one direction, from the filament to the plate, and therefore it served like a crystal detector to cut down an alternating current, or a current flowing back and forth, and transform it to a direct current or a current flowing in one direction only.

But this first crude vacuum-tube detector was destined to be wonderfully improved. Mr. Lee DeForest discovered that if a grid of wire connected with a battery were mounted between the filament and the plate the least change of current through the grid greatly altered the electron discharge from the filament to the plate. Thus, by adding a grid the bulb was provided with a means of control or a throttle, if we may use the term. So that with the Audion bulb, as the new tube was called, the very faintest electrical impulses or vibrations could be detected and made audible and thus radio telephony was made a commercial and practical thing. But still more remarkable and important was the fact that this simple but marvelous device had the power of magnifying the vibrations enormously. By merely adding bulb after bulb the original vibrations could be amplified or magnified to almost any extent—millions of times, if desired. And just as the little vacuum tube with its filament, grid, and plate could be used to detect and magnify electrical vibrations coming through the ether, so, too, it was found that it could be used for sending out electrical waves or oscillations. By so arranging the affair that the current through the grid was varied by the vibrations of a voice or music or any other sound, the current produced by the electrons rushing from the filament to the plate would be varied and thus the electrical waves sent forth from the tube were varied or were made irregular by the sounds in the transmitter.

So you see the invention of the vacuum tube, or Audion bulb, was really the key to the whole problem of talking by wireless. But simple as it is, its powers are almost miraculous. By it not only do we have the radio telephone, but it also revolutionized wireless telegraphy and made it possible to send messages to far greater distances than ever before. It has enabled us to photograph sounds and reproduce them at will. In the war it helped us to detect the enemy's ships and submarines. It enables doctors to listen to a patient's heartbeats or breathing, though he may be miles away. It has made it possible for us to listen to insects talking, to operate ships, machinery, and vehicles from a distance and entirely by radio, and with it we can guide ships safely into port through the thickest fog. Each day new uses and new values of this magic lamp are being discovered and no one can foretell what wonders it may reveal in the future. With an instrument so delicate and with such magnifying powers that the footsteps of a fly sound like the tramping of horses, that the ticking of a watch sounds like the blows of a sledge hammer, that writing one's name causes a roar like an express train, and the dropping of a pin is reproduced like the crash of thunder, almost anything is possible. Aladdin's lamp was a commonplace, useless thing beside the vacuum tube, for even with the help of his supernatural jinn he could accomplish none of the wonders that the tube makes possible to us.

CHAPTER V

THE SIMPLICITY OF RADIO

(Plate 3)

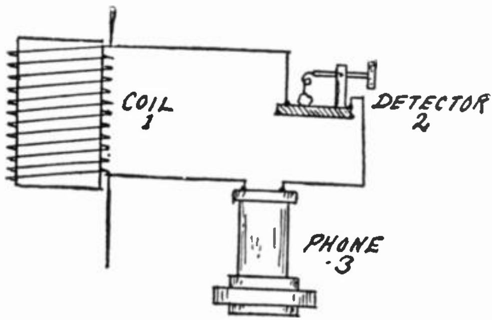
Now that we have given an outline of the underlying principles of radio and have explained why certain instruments—such as the detector and phones—are required, we would like to point out how exceedingly simple radio really is. Of course there are complicated, elaborate instruments, and as you advance in knowledge and skill, no doubt you will be able to master these. But it is wisest to begin with the very simplest forms, for the most complicated of up-to-date sets are but variations and combinations of simple instruments, and once having learned the whys and wherefores of each separate unit or device in a simple set, you will find it easy enough to master the more and more complicated ones.

Although radio is so well known and so universally used, yet few persons, even those who have become interested in the subject or who use ready-made sets, realize how extremely simple it is or how easily they may master the whole subject. They know that it is a simple matter to use a receiving set successfully, for their friends and acquaintances, perhaps themselves, have caught the radio fever and are nightly and daily listening to music, songs, operas, news, stories, speeches and what not, sent broadcast by the big stations. But to them, unless they have become real "fans" and have studied the subject and made instruments, the shiny black box with its knobs, dials and connections is a thing of mystery and, to their minds, filled with complicated, involved apparatus which only a person versed in electrical science can understand. How could it be otherwise? How could any apparatus be devised to perform such marvels unless it were complicated and beyond the understanding of the layman?

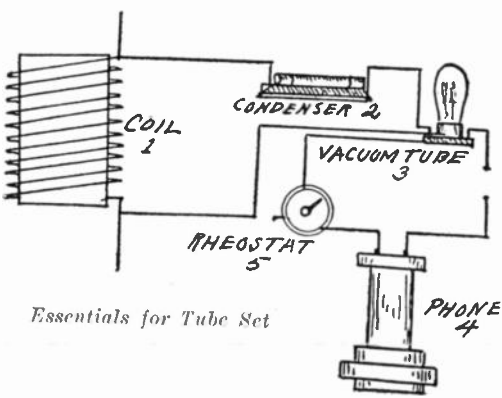
Often they are amazed, hardly able to credit the truth, when they learn that the interior of the magic box, instead of being a complicated assembly of wires and instruments, is as simple or, in fact, simpler, than a sewing machine. If we get right down to "brass tacks," so to speak, we will find that there are but nine instruments used in radio and that only six of these are commonly used in modern wireless telephone apparatus. Once you learn the principles, the uses, the operation, and the construction—in other words, the whys and wherefores—of these six easily understood and simple things, you have the master key to radio and can understand any wireless device, no matter how elaborate or apparently involved it may appear at first.

The six instruments or devices, whichever you prefer to call them, used in modern radio are: *tuning coils, condensers, crystal detectors, vacuum tubes* (or *Audion bulbs*), *rheostats, telephones,* while the additional three instruments, used only in sending, are: *transformers, transmitters* (or *microphones*) and *spark gaps.*

With the exception of batteries, wires and such accessories as binding posts, terminals, switches, etc., these nine devices cover everything, for every other instrument used is either a variation or a combination of these. Indeed, so marvelously simple is radio that a receiving set may be made with but three instruments—*coil, crystal, detector* and *phones,* while even a vacuum-tube set does not necessarily require but five instruments—*coil, condenser, vacuum tube, phones* and *rheostat.* Anybody, even if he possesses no mechanical skill, can readily make a receiving set that will bring in messages—from stations not over twenty miles distant—at a cost of less than a dollar and with less than an hour's work. All that is needed are a cardboard tube or a cylindrical stick of wood,



Essential Instrument for Crystal Set



Essentials for Tube Set

PLATE 3

some insulated copper wire, a telephone receiver, and a bit of galena crystal, with a few odds and ends that may be picked up about any house. Of course such a set will not do the best work, but it will bring in signals and music, and it serves as an illustration of how extremely simple radio is. Moreover, in order to thoroughly understand radio and make excellent instruments yourself, it is not necessary to have a technical knowledge of electricity or even to go into a study of the principles on which the various devices work. But everyone who is interested in or uses radio should know what each instrument is for and why it is used.

The tuning coil, which may be of any one of a dozen or more forms under as many different names, is used to tune the set or, in other words, to harmonize the set with the waves from the particular station you wish to hear; or, to put it another way, to cut out the messages you do *not* care to hear. The manner in which this is done—no matter what type of coil is used, or whether sliders, switches or movable coils are used—is by lengthening or shortening the amount of wire in the coil, thus lengthening or shortening the wave length in the set, and amounts to exactly the same thing as shortening or lengthening the aerial, for the latter is in reality but a continuation of the coil, or *vice versa*.

The crystal detector, or vacuum tube, whichever is used, serves to reduce the speed of the vibratory waves by cutting them down to a speed which may be rendered audible to the human ear, which cannot detect vibrations of over ten thousand a second. Moreover, in a vacuum tube detector the tube serves to magnify or amplify the vibrations and thus bring the sounds more loudly in the phones and to bring in faint waves. The phone, or receiver, serves to transform the vibratory electrical waves passing through the detector to sound waves; for radio waves, in themselves, are inaudible to the human ear and must be transformed or altered to sound waves in order for us to hear them.

The condenser adds to the capacity of the set, and when of the variable type permits better and finer tuning, while the rheostat is merely a form of coil by which the amount of current flowing from the batteries to the vacuum-tube filament may be controlled.

So, you see, after all, the marvelous wireless telephone is really a most simple affair, and there is nothing complicated or mysterious about it. Indeed, we think the simplicity of radio is really the most remarkable, the most mysterious, and the most amazing thing of all.

CHAPTER VI

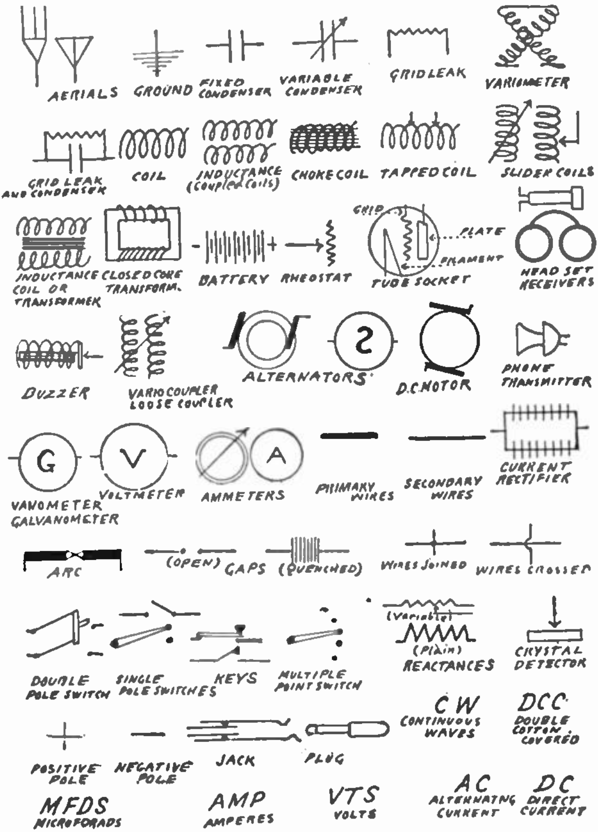
DIAGRAMS AND HOW TO READ THEM

(Plate 4)

BEFORE proceeding to explain the operation and construction of sets and the purposes and principles of the various units or instuments, it may be well to refer to the diagrams and symbols that are universally used in works on radio, for otherwise the figures and drawings that illustrate the subject will be meaningless.

Most people who have not made a study of radio telegraphy or other branches of electricity are puzzled when they look at the diagrams for wiring that are supplied in many books and magazines or catalogues. These seldom have the various appliances or accessories marked by name or letter and, to the uninitiated, they are practically meaningless. It is very easy to understand these, however, once you have learned what the various symbols mean, and everyone interested in radio telephony should learn them. In the accompanying cut, the commoner symbols used in diagrams of wireless apparatus are shown and everyone can learn and memorize these in a short time.

In nearly all diagrams of wiring and setting up radio telephone instruments the wires are drawn parallel with one another and with turns at right angles. This adds greatly to the appearance of the diagrams, but in actual practice it is a great advantage *not* to run the wires parallel or with the turns at right angles. For this reason, in some of the diagrams I have shown the wires at angles to one another. So, too, you must remember that diagrams, of sets or "hook-ups" as they are called, are not supposed to represent the exact places where wires are run or that the wires in a set must be as far apart and as distinctly separated as shown in a diagram. If this were done your sets would be overlarge and clumsy. The whole purpose of a diagram is to guide you in attaching the wires and connecting the various units or instruments in their proper sequence or order, and the comparative length of wires and the directions and angles at which you place them must be governed by the size of the panel or cabinet in which you mount the set and your own judgment.



Symbols used in diagrams

PLATE 4

CHAPTER VII

TOOLS AND SUPPLIES REQUIRED

To give an entire or complete list of the various tools and supplies required for making, setting up and using wireless telephones is practically impossible. In the first place, some people can work advantageously with fewer tools than others; some people are naturally "handy" or inventive and can find uses for odds and ends which would appear worthless to others; some people must economize on tools and supplies, others can spend an unlimited amount, while still others prefer to purchase most of their appliances ready-made and merely put them together or set them up.

For these reasons, the tools and supplies listed below are only those which will prove most necessary and as their quality, size and number will depend largely upon the work to be done and one's pocketbook, no prices or estimates of their cost have been given.

TOOLS

One large screwdriver.

One brad-awl set of awls, screwdrivers, etc., or small and medium sized screwdrivers.

One gimlet.

One hack saw frame and saws.

Panel or cross-cut saw.

Miter-saw and miter box.

Chisels and gouges.

Three-cornered file.

Round or rat-tail file.

Flat file.

Sandpaper.

Smoothing or block-plane.

Small bench (iron) vise.

Bit-stock with bits and augers.

Breast or hand, geared drill with twist drills.

Flat-nosed pliers.

Round-nosed pliers.

Cutting-pliers (flat-nosed and cutting pliers combined may be used).

Soldering iron, solder and flux.

Tack hammer.

Claw hammer.

Carpenter's square.

Tape, yardstick or rule.

Set of small screw-taps and dies.

Compasses or dividers.

SUPPLIES

Wire nails.

Wood screws (flat head), assorted steel or brass.

Wood screws (round head), assorted brass.
Washers for round-head screws.
Small brass bolts and nuts, assorted.
Emery paper.
Wire of various sizes (see directions), copper, plain or bare.
Same insulated (see directions).
Stiff cardboard.
Paraffine wax.
Good glue.
Sealing wax.
White shellac.
Fiber board or bakelite.
Hard rubber knobs.
Flexible insulated wire cord.
Porcelain insulators.
Tin foil.
Binding posts.
Terminals.
Varnished cambric tubing, or "spaghetti."
Strong twine or string.
Sheet brass or brass strips (see directions).
Sheet copper.
Adhesive tape.

The last is one of the most useful articles one can have. It is useful in wrapping joints of wires; in covering wires as an insulator; in attaching wire where they cannot be soldered; in making temporary joints or connections; in covering coils or holding the wires uncoiled in place; in holding parts of cases or boxes together while they are being glued or nailed; to cover a cut in your finger, as well as for a thousand and one other purposes. But do *not* use the cheap, weak grades of tape sold in ten-cent stores and in many bicycle and automobile accessory dealers'. Use a good, strong, rubber-covered tape such as Tirro, for while it costs more it is worth many times as much more. The cheap tapes dry up and lose their stickiness upon exposure to air; the thin rubber, if any, soon disappears and leaves only the fabric which is not an insulator, and they have no tensile strength, whereas the high-grade tapes are exceedingly strong, they are coated heavily with rubber, they never dry up and they retain their tenacity for a long time.

Varnished cambric tubing, known also as "spaghetti," is the best material for covering joints in wires and should be used wherever possible.

Finally, let us advise you *never* to throw away anything which you have on hand in the way of electrical supplies, wires, screws, nails, etc. One never knows when such things may come in handy and may be put to some good and useful purpose, thus saving time and money.

CHAPTER VIII

AERIALS AND HOW TO INSTALL THEM

(Plates 5 and 6. Figs. 9-14)

ONE of the greatest advantages of wireless telephone receivers is that an elaborate or expensive aerial is not required. Although good sets with vacuum-bulb detectors may be used with an indoor aerial, yet an outside aerial will always give better results. A single wire will do as well as several, the main thing being to get the aerial long and high in order to catch waves which are not interrupted or interfered with by surrounding buildings, steel bridges, electric wires and similar objects. Next, or rather most important, is to have the aerial and *lead-in* thoroughly insulated from all surrounding objects, for even wood, when damp, is an excellent conductor. The best material for an amateur aerial for receiving is a stranded phosphor bronze or copper wire, about No. 14, although solid copper wire, copper-covered steel wire or even insulated copper wire will serve every purpose. For insulators, use porcelain cleats. These may be used both where the lead-in is attached to walls or other objects, and where the aerial wire is attached to the supports or guys. The accompanying figures, *No. 9* and *No. 10,* illustrate aerials installed, one being an aerial which is designed for a tin or slate roof and which obviates making holes for attachment. Where the lead-in wire enters the building an insulated window strip or a rubber insulated wire should be used. This may be brought in at the corner of a window either by cutting a small groove or by jamming the window down until the wire flattens and is buried partly in the wood. All joints in the aerial and lead-in should be *scraped bright, tightly twisted* and *soldered,* and wrapped with insulating or adhesive tape or covered with "spaghetti" tubing. For the best results, be sure to run your lead-in from the end of aerial towards the station which you most frequently wish to hear or towards the most distant station which you desire to pick up. Very often, this will make a vast difference in results, especially with a small receiving set. If there are several sending stations at various points from your set, it is often a very good plan to run several aerial wires at right angles or radiating as shown in *Figs. 11* and *12,* connecting them together and running the lead-in

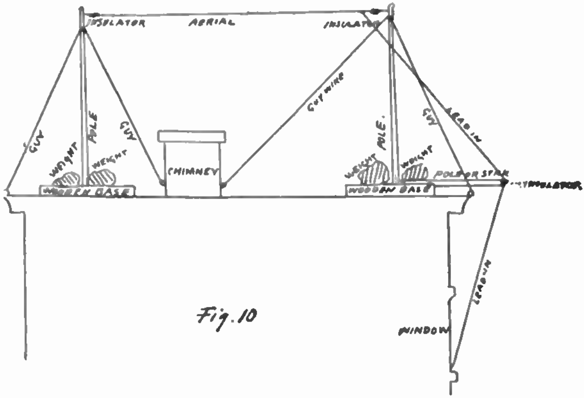
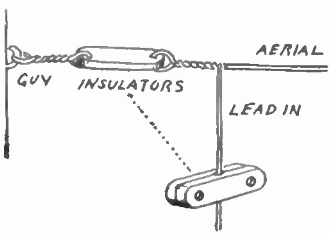


Fig. 10



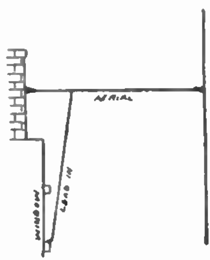


Fig. 9

PLATE 5

from the point where all join, as shown. Sometimes this principle may be reversed and several lead-ins may be carried from the outer ends of the radiating aerials and joined to form a single lead-in and will bring even better results, *Figs. 13* and *14.* These several lead-ins may be provided with multiple-point switches as shown in *Figs. 13* and *14.* This switch arrangement has the great advantage that you can largely cut out stations you do not wish to hear by using the lead-in towards the station you desire to hear. This will result in the others being fainter or weaker in comparison and they can therefore be more easily tuned out by your instruments.

Aerials are most peculiar affairs and a little experimenting will enable you to determine the best size, height and type to use. It is well known that wireless waves are directive, or in other words, that they travel more strongly in one direction away from the sending aerial than in others and while this has been largely obviated in up-to-date stations, yet the ordinary receiving aerial is directive and will get stronger signals if the lead-in is towards the sending station, or is pointed towards it, so to speak. we know of several cases where amateurs failed utterly to hear voices, music, or even telegraphic spark signals from some station and yet, merely by altering the direction of their aerial or the position of the lead-in they could hear everything perfectly. So you see a great deal may depend upon the simple aerial, even if it consists of only a single wire. Splendid results may be obtained where local signals only are desired with a wire run around the walls of a room near the ceiling; a wire run through a hallway; or a wire dropped down an air-shaft or elevator-shaft. It all depends so much upon local and climatic conditions, surroundings and other conditions that no hard and fast rules can be made, but despite all this, nine times out of ten, a high aerial, well above surrounding buildings and from 100 to 150 feet long, will give the best results. But remember that if there are elevated tracks, steel bridges, trolley lines, electric wires or steel structures near, you should run your aerial at *right angles to them* in order to avoid failure through leakage or inductance.

You must also bear in mind that the *"ground"* is almost as important as the aerial, for without a good ground the set will not work. A water or steam pipe will usually make an excellent ground, but before using it be sure there is no insulated joint between the connection of your wires and the earth or that the pipe does not enter an earthen or tile pipe near the ground or in the cellar. In making the ground connection, scrape the pipe clean and bright and *solder* the wire to it. If this is not possible, wind the connection with tin-foil and fine wire and wrap it with adhesive tape. Where no pipe is available carry the ground wire to a sheet of copper, an old copper boiler or a copper tank or basin filled with charcoal, and buried at least five feet under the surface of the earth. A lightning rod or fire escape will sometimes make a very good ground. But it is not so much *what* you use for a ground as HOW GOOD THE CONNECTIONS ARE AND HOW WELL THE OBJECT IS GROUNDED. Do NOT use a gas pipe, an electric light or telephone, telegraph or door-bell wire for a ground.

Quite often it is impossible or extremely difficult to install a radio set with an aerial on the roof of a building or out of doors. Hotel and apartment house owners often prohibit them; there may be too many other wires stretched across the roof to allow you to add an aerial, or you may be located where, for some reason, you cannot put up the antennæ for your set. Under such conditions you must resort to an indoor aerial.

The best form of indoor aerial for many purposes is the loop aerial, for which no ground is required. The loop is also a very useful form of aerial when a set is to be used in a boat or motor car but for good results radio-frequency amplification must be used. An ordinary indoor aerial should be connected to the set exactly like an outdoor aerial, but a loop aerial must be connected without the use of the tuning coil in a set. In other words, the loop takes the place of the coil and is connected with a variable condenser shunted across from the aerial to the ground circuits. The loop itself is merely a light wooden frame about three feet in diameter and wound with copper wire. The loop aerial is strongly directional, or in other words picks up waves coming from the direction in which the loop points more strongly than those from other stations. Thus, by turning the loop about, a great deal of interference may be eliminated, which is one of the great advantages of the loop aerial. In fact, it is this directional feature of the loop which has enabled the device to be used as the "radio compass" for steering ships through fogs. By turning the loop until signals come in strong and clear, and by watching a compass connected with it, the ship's officers can guide the vessel in perfect safety along any desired channel. Still another form of indoor aerial is the electric-light system of a building. To use this, however, a specially constructed device must be employed. Such devices are purchasable at the radio stores and you should NEVER ATTEMPT TO CONNECT A SET TO AN ELECTRIC-LIGHT WIRE UNLESS SUCH A DEVICE IS USED. If you do, you may be electrocuted the first time you attempt to use your set, and even if no worse results occur your set will be absolutely ruined.

CHAPTER IX

AIR GAPS AND LIGHTNING SWITCHES

(Plate 6. Figs. 15-16)

A GREAT many people are very much afraid of lightning following an aerial and injuring the premises, for they seem to think that the wires "attract" lightning, just as many people with intelligence and education still believe that steel knives or hardware or wire netting window screens "attract" the lightning. As a matter of fact, none of these things "attract" the lightning, but merely form a convenient conductor to enable the lightning to ground itself. Lightning-rods are designed for the same purpose and a properly installed aerial, instead of jeopardizing a building, is really an excellent safeguard and makes a splendid lightning rod. Lightning strikes a building or object when it is trying to find a way to the earth and if the object struck is a good conductor of sufficient capacity it does no damage. For this reason, houses covered with wire netting and climbing vines are far safer than those which are bare,

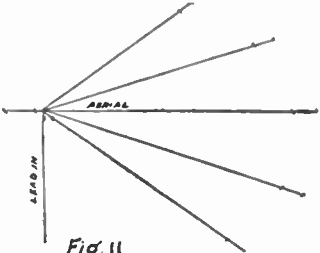


Fig. 11

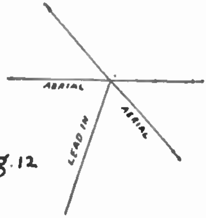


Fig. 12

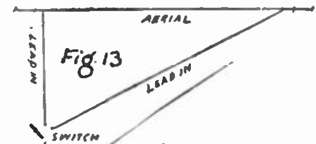


Fig. 13

Fig. 15

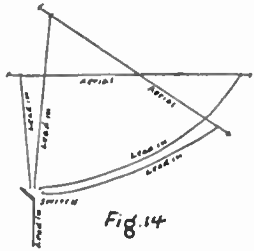


Fig. 14

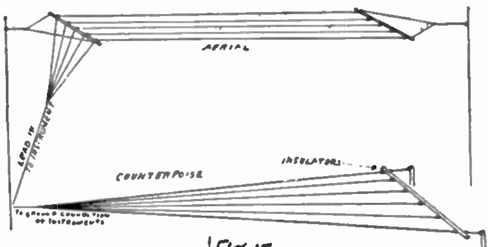


Fig. 17

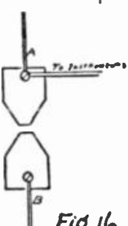


Fig 16

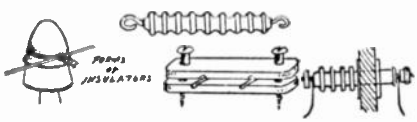


Fig 18

PLATE 6

and steel buildings, such as the New York sky-scrapers, steel bridges, elevated structures, iron smokestacks and chimneys, iron steamships and railway tracks are seldom injured by lightning although frequently "struck"; the reason being that the electricity passes through them freely without encountering resistance. On the other hand, wooden buildings, trees and human beings are poor conductors, and when dry are almost non-conductors, of electricity. When the lightning tries to follow such objects to ground, the resistance is so great that serious damage is done. It is exactly like forcing water through a pipe. If you have a powerful stream of water or a great volume of water and provide a pipe large enough for it to flow freely, the pipe will not be injured, even if it is very light and frail; whereas, if you attempted to force the same stream or same volume through a much smaller or clogged pipe, the pipe would be burst or the water would overflow and flood the surroundings. Statistics prove that as far as aerials are concerned there is no danger, and records of fire or injuries from aerials during thunder storms are extremely rare. During an electrical storm the instruments cannot be used owing to the "static" or electricity in the air and the confusion of currents, waves and inductance, and by installing a *lightning switch* or an *air gap* there will be no danger to the premises. In fact, a properly installed aerial does not affect the rate of insurance, and if installed in accordance with the regulations of the local fire department you may be sure there is not the least danger. The Fire Department records of New York City do not show a single instance of conflagrations started by aerials and lightning.

The simplest and best safeguard for receiving aerials is the air gap shown in *Fig. 16.* This consists of two metal attachments separated by about one-eighth of an inch *A-B,* one of which (*A*) is attached to the lead-in wire (the wire to set being fastened to it also) while the other (*B*) is connected by a wire to the ground direct. This gap is mounted in much the same manner as a *lightning switch, Fig. 15* (on a window sill or other convenient spot), in which *A* shows connections to aerial, *B* to receiver and *C* to ground connection. When the station is not in use, or during thunder storms, the handle *D* is thrown from *A* to *C,* thus cutting off all connection between the lead-in wire and the instruments and connecting the aerial directly with the ground.

CHAPTER X

COUNTERPOISE AND ITS USE

(Plate 6. Figs. 17-18)

BEFORE leaving the subject of aerials it may be well to call attention to the device known as a *counterpoise* and which, for sending, is far superior to using a ground, while with small sets the advantages gained by a counterpoise in receiving do not pay for the trouble of installing the device. This is because the counterpoise, while adding to the sharpness of tuning with a receiving set, and therefore, aiding in cutting out interference, will also cut down the strength of the sounds received. Therefore, with a crystal set where amplification is not practical, the device is practically valueless, whereas, with a vacuum tube set with two or more steps of amplification, the counterpoise will prove a very distinct advantage. Many people consider this device a complicated and difficult affair, but in reality, it is as simple, if not simpler, than an aerial. A favorite form of counterpoise consists of several wires extending fanwise as shown in the figures, but a single wire will often give excellent results, and the only way to determine the best number of wires to use is by experiment. Usually it is desirable to place the counterpoise below the aerial, but this is by no means essential, as it may be run in the opposite direction from the aerial and still work exactly as well, for the device has little or no connection with the aerial. In fact, its action is more like that of a condenser, except that it increases radiated energy, whereas, a condenser has a very small amount of radiation. It must also be borne in mind that with a counterpoise *no ground wire* is required, the lead-in from the counterpoise being connected with the set at the spot where the ground wire is usually connected. In setting up a counterpoise it should be just as well and as thoroughly insulated as the aerial, and the lead-in wire from it should be kept at some distance from the aerial lead-in to obviate losses by induction between the two. The most desirable place for a counterpoise is about three feet above the earth, but as this height is usually inconvenient, not only on account of it being an obstruction, but because it may be injured by people or animals or may be buried under snow in winter, it is better to raise it about six feet, or just high enough so people may pass beneath it. Stout posts with guy wires are the best supports, whereas, if the device is placed on the roof, the supports may be chimneys, walls, etc. If placed on a roof beneath an aerial leave all the space possible between the two, either by keeping the counterpoise low or raising the aerial. Where this is not convenient, the counterpoise may be run in another direction instead of being placed below the aerial wires.

CHAPTER XI

CONDENSERS AND TRANSFORMERS

(Plate 7. Figs. 19-21 *A, B, C*)

THESE appliances are a most important part of a wireless set, as without them the oscillations, even if detected by the instruments, would be very weak and faint. They are divided broadly into two classes known as *fixed condensers, Fig. 19,* and *variable condensers, Fig. 20,* the former being the simplest, and the latter the most efficient, for while a fixed condenser is always of one capacity and can only be increased or decreased by adding to or subtracting from the number of sheets, the variable type may be altered or adjusted at will by a knob or handle, thus tuning or adjusting the receiving circuit exactly as a tuning coil is adjusted, but much more delicately, as the adjustment of a tuning coil consists in shortening the length of coil by jumping connections from one turn of wire to another to alter wave lengths, whereas, the condenser adjustment is slow, even and gradual and alters capacity. But

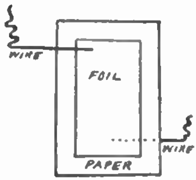


Fig. 19

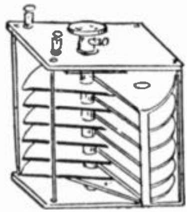


Fig. 20

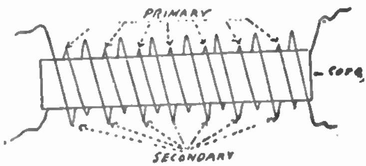


Fig. 21 A

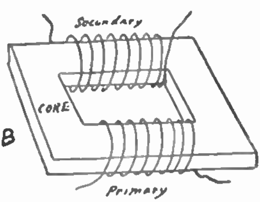
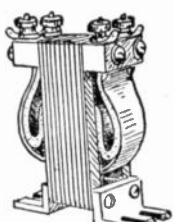


Fig 21B



AMPLIFYING TRANSFORMER

Fig. 21C

PLATE 7

it must not be forgotten that for wireless telephony receiving, both a condenser and some sort of coil or similar device must be employed to get satisfactory results.

Transformers are instruments designed to transform or change one kind of electrical current to another, such as alternating current to a direct current, and are very useful and essential devices in radio telephony. There are many kinds of transformers, but all are built, or rather based, upon the same principles, which is that of inductance, or the formation of a current in a coil of wire by the passage of another current through another coil near it. As induced currents are only produced when the magnetic field is changing, the current induced by a transformer can only be secured by means of some mechanical device or by an alternating current. When the former is used the transformer becomes a *spark-coil* or *induction-coil* (see coils) and the means by which the primary current is alternately broken or interrupted is the buzzer or contact at the end of the iron core of the coil. But if an alternating current is run through the primary wires of a transformer no interrupter is required, as the magnetic field changes each time the current rises and falls. There are two general types of transformers in use; one known as an "*open-circuit trans-*

former" which is exactly like an ordinary sparking coil and consists of an iron core covered with two windings of wire known as the primary and secondary, *Fig. 21 A.* Very often, where such a transformer can be used, an ordinary spark-coil with the contact-breaker screwed down answers every purpose. The other type is known as the *"closed-core transformer"* and consists of a number of iron plates or laminations in the form of a hollow square and which are wound on one side for the primary and on the opposite side for the secondary, *Fig. 21 B.* The function and purpose of both forms are to build up or increase the currents passing through them, the radio frequency transformer, *Fig. 21 C* building up the oscillating radio waves or vibrations before they reach the detector of the set while the radio frequency transformers are utilized for increasing or intensifying the currents after they have passed through the detector and before they reach the phones. As the currents, after passing the detector, are direct intermittent currents which produce intensified alternating currents in the audio frequency transformer, a second vacuum tube known as an amplifying tube must be provided between the transformer and the phones. By thus adding frequency transformers and amplifying tubes to a set, vibrations so weak as to produce barely audible sounds in the phones may be built up to almost any extent.

In order to receive and hear sounds sent from transmitting stations by radio-phones clearly and without interference or confusion, a device of some sort is required which will cut out all waves save those desired. This is known as "tuning" and the instruments or appliances used to accomplish it are called "tuners." There are now a great many different devices for tuning, such as tuning-coils, loose couplers, vario-couplers, variometers, variable condensers, etc.

CHAPTER XII

RECEIVING SETS

BROADLY speaking, the receiving set consists of the *antennæ* (or aerial), the *tuner*, the *detector* and the *receiver*, but aside from the aerial, each part of the instrument is made up of several other units and appliances, each devised and used for a definite purpose.

The aerial, which is a wire designed to interrupt or catch a portion of the continuous waves (always referred to in wireless telephone parlance as C. W.), consists of a single wire, for unlike wireless telegraphy, a number of strands or wires is of no advantage in receiving, and still more remarkable, it makes no difference whether the wire be bare or insulated, for the C. W. used in radio telegraphy penetrates solids of every kind. Indeed, a wire stretched around a room or through a hallway indoors may serve as an aerial for receiving wireless telephone messages, although far better results are secured by properly installed aerials out of doors. And here it may be wise to impress all users of receiving sets with the fact that the longer, within certain limits, the aerial and the higher above the ground, the better will be the results obtained, although an aerial 150 feet long and well above other large buildings will serve every purpose. Moreover, it makes no difference whether the aerial is horizontal, vertical or at an angle, provided it is thoroughly insulated from all surroundings, and very good results have been obtained by aerials run vertically up an air shaft or along the side of a building. So too, the *lead-in*, or wire connecting the aerial with the receiving instrument, serves as an aerial itself and therefore a long *lead-in* with a short aerial will serve almost as well as a *long aerial* and *short lead-in*, which is a tremendous advantage to dwellers in hotels, apartment houses, etc., where it is very difficult or impossible to install a long and lofty aerial on the roof. But before going into details and describing the installation of aerials, let us consider the rest of the receiving equipment and thoroughly understand its principles.

The *detector*, without which it would be impossible to register or detect the minute currents or waves which pass through the aerial, is a very important part of the mechanism. There are two types of detectors in use, the first known as the *crystal detector* and the other as the *vacuum tube*. In the former, a crystal of some mineral — preferably galena — is used, while in the latter, a form of incandescent lamp with especially prepared filament is employed. Of the two, the former is the cheaper; but it has limitations and is not nearly as satisfactory as the vacuum tube. The third unit or *tuner* is the means by which the entire apparatus is made to pick up the sounds from some station or elsewhere and by means of which other sounds are shut out, for only by means of the tuner can the receiving set be placed in *synchronism*, or "tune" with the waves carrying the sounds you wish to hear. The last unit or *receiver* is merely a telephone receiver made for the purpose and which, on a small set, is worn over the ears exactly as in receiving wireless telegraph messages.

If the user of a receiving set purchases his outfit ready-made, there is no necessity for knowing how it is constructed or the functions of its various parts, for all that is necessary is to install it, adjust the detector and tuner and listen. These ready-made sets, moreover, are accompanied by full directions for setting up and using, so that the advice on these points is scarcely necessary. However, many amateurs have difficulties or expect too much for their money and a few hints and cautions may not be amiss. If the set is a *crystal detector* set, the *detector* will be found to consist of a bit of crystal held in a metal stand or cup with a fine wire and screw making a contact with it, although in some types two crystals are used to make contact with each other.

Far better than these crystal detector sets, are the so-called *vacuum tube* sets in which a specially constructed electric light with a metal sheath and a coil of wire around the filament takes the place of the detector of crystal. To use these sets, it is only necessary to adjust the tuner and the brightness of the filament, but care should be used in doing the latter as they are very delicate affairs and are expensive and a filament may soon be ruined by improper adjustment or use. If the filaments burn too brightly you are shortening the life of the tube without gaining anything and tubes are the most expensive parts of the outfits. The way to do is to turn the filament-adjusting knob very gently until you receive the maximum and clearest messages and do *not turn the knob any further*. If you do so, you will not increase the tone, but will cause the machine to squeal and howl, in addition to burning out the filament. Very often, a beginner will turn the knob too far and then, when no messages come in, he gets excited and turns first one thing and then another with no result, all because he has given such a shock to the tube that it is paralyzed, for the vacuum-tube detector is one of the most delicate instruments ever invented and must be handled accordingly. Luckily, the tubes have great recuperative power, and if left alone with B battery disconnected, for half a minute or so, they will come back to their normal condition, when proper adjustments may be made.

As soon as you have adjusted the tuner and filament-adjusting knobs so you receive the messages clearly and distinctly, mark each dial so that you can pick up the same station next time and thus, by marking the point for every station within receiving distance, you can readily adjust your instrument for whichever one you wish to pick up. Of course you may have to do some finer minor adjusting after the station is caught, for the weather and atmospheric conditions vary and consequently tuning or adjusting is always necessary; but by having the dials marked you will save a vast amount of trouble and time.

CHAPTER XIII

SIMPLE CRYSTAL RECEIVING SETS

(Plate 8. Figs. *22, 22 A, B, C, D*)

THE accompanying plate shows some very simple and effective crystal-type sets (Figs. *22, 22 A, B, C, D*) which, under favorable conditions and with a good antenna and ground, will pick up broadcasted programs from stations within a limited distance—usually not over twenty-five miles. No specific range for these or any other sets can be given, for the efficiency of any set, especially as regards distance, depends upon a great number of conditions and local influences. The length, height, and type of antennæ, the class of ground, the proximity of buildings or steel structures, electrically charged cables, or power plants, the perfection of insulation, the adjustment and construction of instruments, and climatic and other conditions all effect radio receiving sets of any type. Even exactly similar sets under apparently like conditions will not give the same results, and results will also vary from day to day and from hour to hour. And even at best, a crystal set to-day is scarcely more than a plaything or an interesting instrument for experiments.

In the accompanying diagrams *A* represents the antenna; *B* is the ground; *C* is a condenser of about .0005 microfarads; *D* is the detector of galena or similar crystal; *E* the telephone head-set and *F* the coil.

Almost all of these may readily be constructed at home, but it is cheaper and better to buy the various parts ready made.

The simplest set, *Fig. 22,* uses a single slide or tapped coil; *Fig. 22 A* is provided with a double slide coil; *B* has a variable condenser in place of a fixed condenser; *C* has a loose-coupled coil; and *D* has a variometer in place of a coupler.

To make such sets is very simple, and with a few buss-bars or a little insulated copper wire, some binding posts, and a baseboard of fiber, bakelite, or wood, the entire set may be put together ready for use in a few minutes. But of course, if intended for permanent use, the connections should be soldered and the set mounted neatly on a panel or in a cabinet.

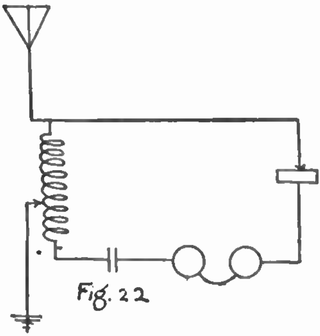


Fig. 22

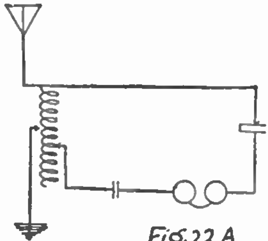


Fig. 22 A

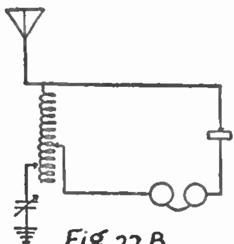


Fig. 22 B

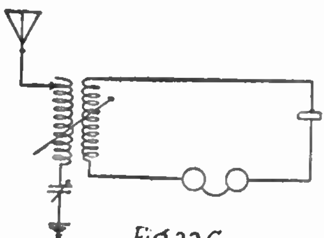


Fig. 22 C

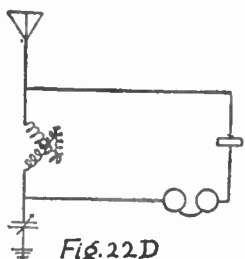


Fig. 22 D

PLATE 8

CHAPTER XIV

REGENERATIVE RECEIVING CIRCUITS

(Plates 9-10-11. Figs. 23 to 28)

PROBABLY the commonest type of receiver in use is the regenerative, with its innumerable variations, and, for a minimum number of tubes, simplicity of construction and low cost of parts, it has no equal.

Regeneration consists of the feeding back of some of the energy from the tube-plate circuit to the grid circuit, thereby lowering the resistance of the latter and making the tube more sensitive. This may be accomplished in many different ways, and the authors will take up only those circuits which are really distinctive and which have been proved most efficient.

Until the multi-tubed, tuned-radio-frequency sets appeared, the regenerative sets held the spotlight in the radio world, and among the best sets of this type which were manufactured were the Radio Corporation III, the Crossley, Kennedy, Zenith, Grebe, etc. These are representative sets of their type and are mentioned so that the reader may know what this type of circuit will accomplish when constructed in the proper manner.

Even with some of the five- and six-tube sets now on the market, it is a question as to whether they can equal a properly constructed regenerative receiver in bringing in distant stations. A regenerative set may lack something in selectivity, as compared with a well-constructed multi-tube set, but, considered tube for tube, and for simplicity of operation, it is hard to find the regenerative set's equal. It is true that they will re-radiate and will cause all kinds of disturbance to near-by listeners-in, and, unless the regeneration is controlled, one will hear every imaginable kind of squeal and howl. This is due to the tendency of the operator to try and pick up stations with the set in oscillation. There is no question about this being the easiest way, but it is far from being the correct or best way.

As a matter of fact, all receiving sets will re-radiate to some extent if they are not properly handled and constructed, but the regenerative type is the worst offender in this respect.

As an example of the transmitting powers of this type of set we might call attention to the transatlantic tests in 1925, and the utter hopelessness of trying to hear anything but a

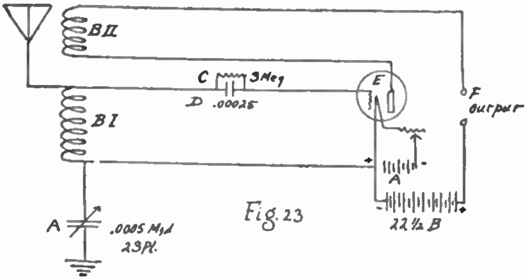


Fig. 23

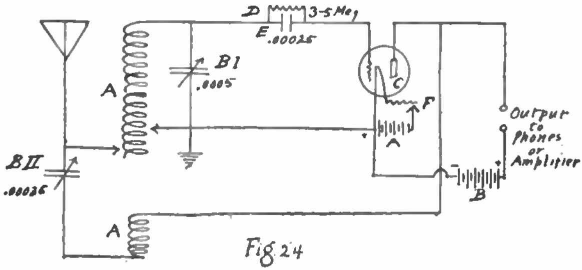
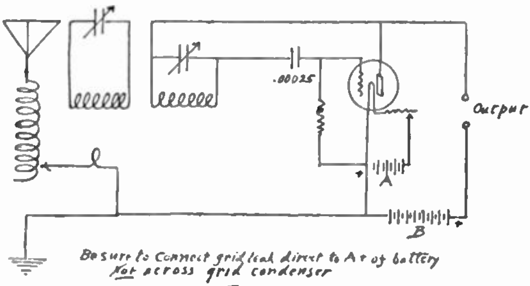


Fig. 24



Be sure to connect grid leak direct to A + of battery
Not across grid condenser

Fig. 25

PLATE 9

Babel of howls, squeals, and whistles, which was due to innumerable operators keeping their sets in oscillation and turning their condensers through the entire wave band in hopes of picking up a carrier wave of some foreign station.

But before going further into these matters it may be best to review the various types of regenerative circuits, and afterward explain the right and the wrong methods of operating them.

In *Fig. 23* we show the simplest form of regenerative circuit, as well as the worst offender as regards re-radiation. This is known as the *single-circuit*, and around this circuit a thousand-and-one variations have been built up and have been called by a thousand-and-one different names. And yet, if they are all analyzed, it will be found that they are merely the same thing camouflaged in some way, by the addition of an instrument or two, or by hooking up the wiring in other than the conventional fashion. A few years ago it was common practice to develop so-called new circuits overnight and to give them fancy names. But they were all practically nothing more than modifications of the single-circuit receiver. There are, however, several modifications which can be recommended, and it is these that will be considered in this chapter.

It will be seen that the diagram hook-up shown in *Fig. 23* consists of a variable condenser *A*; a vario-coupler or tuning coil *BB*; a grid-condenser and grid-leak *C*; a fixed by-pass-condenser *D;* one tube *E;* and head phones *F*.

With these parts, and wired as shown, a very efficient one-tube set may be constructed which will give excellent results, and, if not in a congested radio district, will give sufficient selectivity to bring in distant stations. If volume of reception is desired, two stages of amplification may be added and a loud speaker may then be used.

In purchasing parts to build this or any other set, it should be borne in mind that only the best instruments pay in the end, and when purchasing coils, condensers, sockets, etc., only those made by well-established and reputable firms are advisable if you desire satisfactory results from your sets.

Many of the radio shops sell complete parts, including drilled panels, for the home builder of sets to assemble, and if these kits, as they are called, are made up of good standard parts the purchaser can make no mistake. Such condensers as the *Cardwell*, *Hammerlund*, *National*, *Karass*, *Bremer-Tully*, *General Radio*, *U. S. Tool*, etc., can be recommended as representative of this type of set. The *Ambassador coil* is so designed that it is excellently adapted for small regenerative sets, and vario-couplers made by any of the well known manufacturers will give perfect satisfaction.

The construction of the set shown in *Fig. 23* is so simple that we feel an explanation unnecessary, except to call attention to the fact that coil *B2* is the rotor coil of the coupler and *B1* the stator coil. A 23-plate, .0005 mfd. condenser should be used, and the grid-leak should be about 3 megs.

Before going further it might also be well to state that all wiring in any receiver shown should be as short as possible and that all connections should be clean and well soldered. For wiring, tinned buss-bars or else No. 14 to No. 16 copper wire should be used, and wherever there is any chance of two wires crossing and touching, insulation such as spaghetti-tubing should be used. Refrain as much as possible from having wires running parallel with one another, and *always* make the lead to the grid of the socket as short as possible and as far as possible from the plate wire.

Before finally mounting the instruments on a panel the set should be planned out as to size and position of instruments and where each part will be in the completed set. And before drilling panel for mounting the parts, be sure that there is enough space for all, with room for running the wires and making the soldered connections.

It will be found that in operating a regenerative circuit it is necessary to shield the set from body capacity. Body capacity is the effect produced when, with you or your hand near the set when tuning in, the entire tuning is changed when your hand is withdrawn, or, *vice versa*, when the set is in tune and you or your hand approaches it, the set begins to howl and squeal. In order to prevent this it is essential that certain precautions be taken, and the simplest of these is shielding. The best way to shield a set is to mount a sheet of thin copper on the back of the panel. Drill holes large enough for all shafts to pass through without touching the copper, and be sure that no portions of any of the instruments come into contact with the copper. Then make sure that it is well connected to the ground binding-post.

Another method is to keep all the instruments on a ground polarity. That is, be sure that the rotor parts of the apparatus are on the ground side of the circuit. Inasmuch as the shafts of the moving parts are near the hand when the dials are rotated or operated, it is essential that they should be always on the ground side.

In *Fig. 23*, for example, the variable condenser is in the ground circuit, and the stator is connected to the coil and the rotor to the ground.

In *Fig. 24* is shown a very simple and very efficient circuit known as the *Reinartz*. This is a modification of the single circuit, but is much more selective and is excellent for the reception of low waves. There are many makes of coils on the market which are suitable for making this set. The parts required for the *Reinartz* set are:

1 Reinartz coil (A)
2 variable condensers of .0005 mfd. (B1, B2)
1 socket (C)
1 grid-leak of 3-5 megs (D)
1 grid-condenser of .00025 mfds. (E)
1 rheostat (F)
Panel, baseboard, binding posts, etc.

In *Fig. 25* the *Cockaday four-circuit tuner* is shown. This is a great advance over the single circuit. It is very selective and re-radiates very little if at all when properly handled. A special coil, known as the *"Cockaday Coil"* should be used, and with this and the variable condensers shown very good results may be obtained.

It should be noted that, with the exception of the *Cockaday* hook-up, the antenna and ground are connected directly to the grid circuit. This is known as *conductively coupled* and sacrifices selectivity for simplicity. In the next series under consideration it may be observed that the sets are *inductively coupled*, and by this method much greater selectivity is secured. *Fig. 26* shows a three-circuit tuner. In this we have three circuits that must be tuned—the primary, grid, and plate. In this diagram a coupler and two variometers are used, while in *Fig. 48* is shown the same circuit using a coupler with one variometer and a condenser. The relative merits of the two variations of this circuit are questionable, but the authors feel that the hook-up shown in *Fig. 26* with the two variometers will give greater volume, while the condenser circuit illustrated in *Fig. 27* gives sharper and easier tuning control.

It may be well to state that, if properly constructed and with first-class instruments used, it is a difficult matter to beat a three-circuit tuner as regards clear-cut reception, great vol-

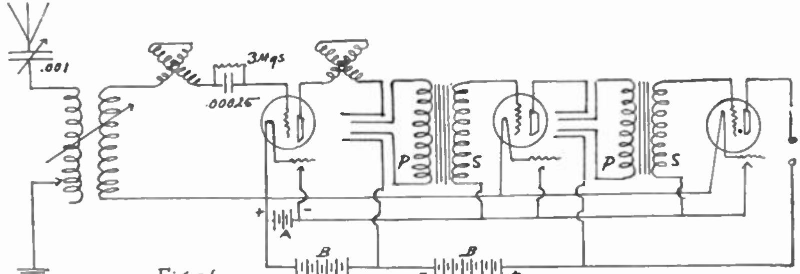


Fig. 26

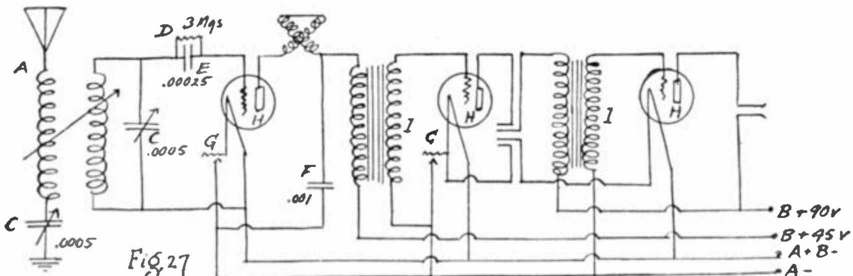


Fig. 27

PLATE 10

ume, and distance-getting, together with an ability to work well, even under the most trying conditions. This type of set has been called rightfully the "Old Reliable" and the "Stand-by." It most certainly is a great favorite with the old-timers, and although many new circuits are now appearing, the three-circuit set is still holding its own and will continue to do so for a long time. Such a set used by one of the authors in Peru outperformanced all the multi-tube sets and was and still is the only set in Lima, Peru, which consistently brings in the United States stations. In the hands of an experienced operator it will make many of the "dynes" green with envy in getting long distance, and yet it is one of the simplest sets to construct. The parts required to build a set of this type are:

1 vario-coupler (A)
1 variometer (B) (or 2 if the set shown in Fig. 47)
2 variable condensers (CC) (or 1 if Fig. 48 is to be made)
1 grid-leak (D)
1 grid condenser (E)
1 by-pass condenser of .001 mfds. (F)
2 rheostats (G)

3 sockets (H)
2 audio frequency transformers (II)
1 detector tube
2 amplifying tubes
Panel, cabinet, batteries, jacks, binding posts, etc.

The diagram shown represents a set with two stages of amplification, and the list of parts includes those necessary for constructing these. Such amplification units may be added to any of the previous sets illustrated as shown in *Fig. 28*. In this diagram will be seen two two-circuit jacks (AA) and one single jack (B) in the last stage. Such an arrangement permits the use of detector, detector and one stage of amplification, or the detector and two stages of amplification. Be sure, in wiring, to have the *inside* prongs of the jacks wired to the *plate* and *battery* leads of *detector* tube, and the *outside* prongs to *P* of the *first transformer* and *45-volt lead* of *B-battery*. The *second double circuit jack* is wired so that the *inside prongs* are connected with the *grid and filament* markings of the *second transformer*, the *outside* prongs going to the *grid and filament* of the *second tube socket*. The last or single jack is simply connected in series with the *plate lead* of the *last tube socket*. By inserting a plug in

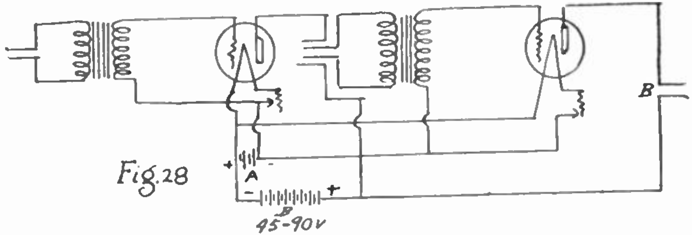


Fig. 28

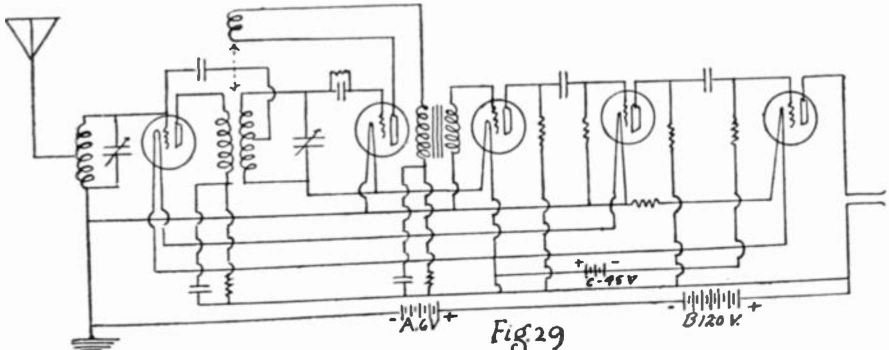


Fig. 29

Plate 11

any of these jacks a closed circuit is formed which thus enables the listener to choose the desired amount of volume or amplification. But unless the jacks are correctly connected *no result will be obtained.*

It is not necessary to go into details as to the precise means of laying out the apparatus, mounting them on the panel, etc. There is a vast amount of available information regarding such points which may be obtained at any radio shop, and dealers will usually supply diagrams with the material sold. But it may be well to explain the proper method of adjusting and operating a regenerative receiver in order that the operator may secure the best results and may minimize the disturbance created by re-radiation of the set.

These rules apply to the factory-made sets as well as to home-built sets, and if the operator desires to show consideration for his neighbors it is well to use the set in the manner described. The first thing to do is to see that all filaments are lighted to their proper brilliancy. Then adjust the regeneration control, which on the single circuit is the rotor of the vario-coupler, and on the *Reinartz* the condenser marked 2. On the *Cockaday* circuit it is the condenser No. 2, and in the three-circuit tuner the variometer of the plate circuit.

These controls should be turned to about 75 per cent. of maximum coupling, which would be about 45° on the variometer and three-quarters meshed in condensers.

With apparatus in this position it will probably be noted that as the other tuning controls are operated there is either a loud squeal or a hiss.

If this is noted, then rotate regeneration controls back just to the point where there is no hiss or squeal, and then readjust tuning condensers until signal is brought in. As an adjustment is made on the tuning condensers it will be necessary to readjust the regeneration control slightly to compensate for the readjustment. It will be noted that there will be a point where a distant signal comes in with a sort of "whisp" within two or three degrees on the dial. It will be found that in trying to clear this the signal will be found between these two points when the regeneration control is brought back just beyond the point of oscillation. Oscillating is when the set is unstable and gives distorted signals and howls and squeals. If it is found that this state of affairs cannot be controlled, then change the grid-leak to a higher value. If you use a 2- or 3-megohm leak, and the set is critical, then try one of 4 or 5 meg. The proper value is dependent upon the type of tube used, and this information is always given on circulars accompanying tubes, or it may be found in some of the later chapters.

It is the critical adjustment necessary that makes the regenerative set unsatisfactory in the hands of the novice, and if one requires a set that can be tuned without howls and squeals, and will bring in stations on a given setting night after night, then the multi-tubed, tuned-radio-frequency sets described in the next chapter will answer the purpose.

But for cheapness in construction, low upkeep, and all-around efficiency it is hard to find its peer when in the hands of an experienced operator or one who has solved the peculiarities of his or her set. Many of the long-distance records have been accomplished with this circuit, and during the transatlantic tests they held their own.

For the dyed-in-the-wool fan who wants to construct his own set, and then try logging stations at all hours of the night, and who has a good antenna and ground system, this type of receiver can be recommended. As there are endless variations and modifications for the experimenter, it is an ideal circuit to construct and experiment with.

But for those who desire a set which simply requires the turning of the dial to a certain setting in order to get stations with good loud speaker volume, and one that will not howl and squeal, and which offers fair long-distance qualities, then the various types outlined in the next chapter can be recommended.

CHAPTER XV

RADIO-FREQUENCY CIRCUITS

(Plates 11-12-14. Figs. 29-30, 33)

In radio we deal with two forms of amplification—radio frequency and audio frequency. Radio frequency deals with oscillations that are so high that they are not audible to the human ear. Audio frequency are oscillations that are audible. Inasmuch as cycles of from 20,000 to several million are used in radio, and the human ear can hear only those up to about 10,000 or so, it can be appreciated what this means. It is on radio frequency that radio broadcasting is done.

In order to increase a signal that has been already detected it is necessary to incorporate audio-frequency amplification, and, by so doing, we get the volume that will operate a loud speaker. This form of amplication we are familiar with, but to increase the range of our receiver and to amplify signals that have not reached the detector, it is necessary that some form of amplification be used before the detector in order that otherwise inaudible signals be heard.

By adding one, two, or three stages of amplification ahead of the detector we not only increase the sensitivity of the circuit, but we also attain a means of preventing a regenerative receiver from creating interference through this form of amplification acting as a stopper of re-radiation.

Probably the most efficient receiver of this type so far developed is the Browning-Drake. *Fig. 29* shows the wiring diagram of this circuit.

It will be noted that here we have a five-tube set: one stage of radio-frequency amplification, detector, and three stages of audio-frequency.

The parts necessary to construct a receiver ot this type are as follows:

One coil and condenser, Type BD-1B. Manufactured by the National Co., Cambridge, Mass. Available at any large radio store.

One coupling coil and condenser, Type BD-2B, made by the same concern.

5 tube sockets and parts necessary to construct one stage of transformer coupled and two stages resistance coupled amplification.

Inasmuch as this receiver requires the special items listed, it will be found that full instructions as to the construction of the set will be included with all the necessary detail as to mounting, etc.

All parts, with the exception of the first two items, are standard in every way.

This circuit is very sensitive and can be recommended to the most critical. The set is so popular with the "build your own" fans that even panels already drilled are available at the best radio shops.

There are other methods of using radio frequency in conjunction with regeneration, but the writers feel that the Browning-Drake is about the best of the type.

Tuned radio-frequency receivers employ several stages of amplication before the detector, usually two stages, and each stage is tuned separately by means of coils and condenser. This is the very popular type of five-tube set that is on the market composed usually of three tuning controls.

Sets that are representative of this type, and which the radio fan is familiar with, are: Atwater - Kent; Stromberg - Carlson; Fada; Freed-Eisman; Freshman; Grebe; Radiola No. 20; Garod; Eagle, etc.

Until the neutrodyne receiver was developed by Professor Hazelton there was much difficulty experienced in preventing receivers of this type from oscillating and being very critical in adjustment.

In the neutrodyne method, as shown in *Fig. 33*, it will be noted that each stage of radio-frequency amplification has a very small capacity-condenser between stages. This is the "neutrodon," which is an extremely small variable condenser of special type that requires but one adjustment after the set is stabilized and is then sealed. It is this condenser, and the angle at which the coils are mounted that makes this circuit so far superior to the ordinary tuned-radio-frequency sets without a stabilizing control. The coils used are of the very low-loss type, and only the very best type of variable condensers are used. The coil is mounted at an angle of 54°, as will be noticed in the commercial sets on the market.

There are many kits sold which are complete with all the parts required and with full directions for assembling them. Or the coils and neutrodons may be purchased separately and the remaining parts may be standard. We would not advise the home builder to attempt to make his own coils or neutrodons, as the values in these must be exactly right or the results will be poor.

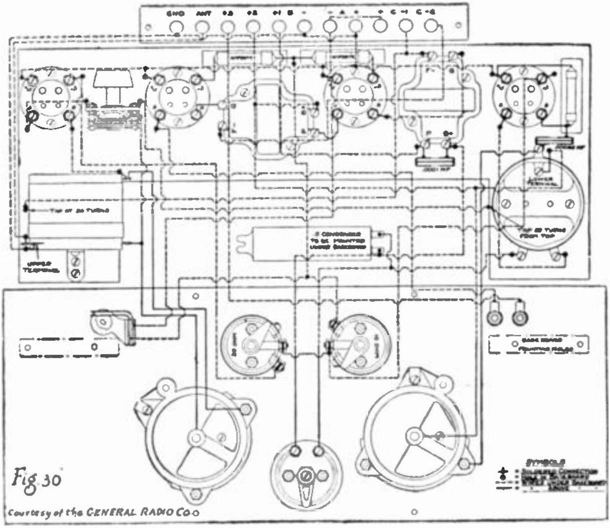


Fig. 30

Courtesy of the GENERAL RADIO Co.

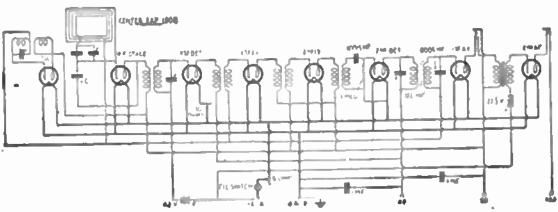


Fig. 30A

PLATE 12

The main feature of this type of set is that all three controls can be adjusted so that a given setting on each will bring in signals, and signals once heard may be brought in repeatedly by setting the controls at the same points.

It is the ideal set for those who do not wish to bother with complicated tuning, and it especially appeals to women, as well as to those who do not understand or do not care to understand, radio operation. If a certain station comes in, say, at 46 on each dial, then that station may always be tuned in by turning all the dials to that mark.

It should not be supposed, however, that the neutrodyne is the only receiver which will accomplish this feat. Many other types that have been mentioned will do the same, although they use other methods of stabilizing the set.

With the wide variety of high-class coils and condensers that are now on the market, it is a simple matter to assemble a circuit of the tuned-radio-frequency type, and very excellent results should be obtained.

A very good and efficient set of this type, in which is incorporated the *Rice* method of neutralization, is shown in *Fig. 30,* which is reproduced through the courtesy of the *General Radio Co.* Although *General Radio Co.* parts are advisable when making this set, still, any standard apparatus will answer. The various parts required being as follows:

- 2 Type 277-D coils
- 4 Type 349 sockets
- 1 Type 368 mico-condenser
- 2 Type 247-H condensers
- 1 Type 301 10-ohm rheostat
- 1 Type 301 30-ohm rheostat
- 2 Type 285-L audio transformers or 1 Type 285 audio transformer and 1 Type 285-L audio transformer.
- 1 Type 274 telephone plug and jack
- 1 Type 236 0.5 MF. fixed condenser
- 11 Type 138-Z binding posts
- 2 Type 310 dials
- 1 .0001 MF. fixed condenser
- 1 .00025 MF. fixed condenser
- 1 Grid leak, 2 meg.
- 1 Grid leak, mounting
- 2 "Amperites" with mountings
- 1 electrad royalty resistance Type C (500-50,000 ohms)
- 1 panel 7"x18"x3/16"
- 1 baseboard 7"x17"x½"
- 1 terminal strip 9¾"x1¼"x3/16"
- 1 filament switch
- 2 brackets 1½"x1½"x½"

Above parts are General Radio Co. but any standard parts will serve equally well.

The action and tuning of the Rice circuit will be practically the same as in the Hazelton neutrodyne.

The advantage of a neutrodyne, or stabilized circuit, such as the Rice, over the straight radio-frequency is that in the two former methods the set can be controlled and not break into oscillation.

As many as three or four stages of radio-frequency amplification can be built up before a detector, but this gives a multiplicity of controls and also is hard to get in balance. It is not recommended for the home builder. There are some factory products of this type on the market which are very efficient, but these use very good shielding in order that the circuits may be isolated from each other and no reaction occur between the coils.

Another method that has proved very successful in preventing this trouble is to use a coil such as the binocular, spider-web toroid, etc., where the losses are at a minimum and the inductance at a maximum.

From an efficiency standpoint there is very little to choose between the different types of radio-frequency sets, provided they are manufactured by a reputable concern. The prices of this type of receiver range all the way from

$50 up. The price does not always have a bearing on the relative merits of a receiver, as it may be possible that one manufacturer has large production and distribution, which enables the cost and profits to be cut down, and also may manufacture his own material throughout, which would also be an important factor in pricing.

There are many sets on the market that use assembled parts—that is, the parts, such as transformers, coils, condensers, rheostats, etc., are purchased from other manufacturers and then assembled into a complete set.

A set of this type will cost the maker more than where the parts are made in the same plant and assembled, as this class of manufacturer usually has enormous buying power, due to the fact that many of them are the leading electrical and automotive parts manufacturers and therefore purchase raw material cheaper and can work on a smaller margin of profit.

The tuned radio-frequency set is the most popular type of set in use to-day and has many advantages over the regenerative. It can be operated on a very small antenna or inside aerial (around picture molding), is very simple to operate, and requires little attention after once adjusted.

It has very good selectivity, the faculty of tuning in stations wanted, and eliminating the undesirable, and it has all that could be asked in volume and tone.

But for the *most* critical users the receiver described in the next chapter is all that can be desired.

CHAPTER XVI

THE SUPER-HETRODYNE

(Plate 12. Fig. 30 A)

THIS type of receiver is really the last word in radio when properly constructed. Where one desires loop operation, extreme sensitivity and razor-edge selectivity, then this type of circuit cannot be equalled.

The principle is rather technical, but basically it is the transforming of a very high frequency, transmitted to the aerial, into a lower frequency. This is accomplished by the "beat" phenomenon. There are two currents being generated. One in the hetrodyne, and the other at the transmitting station. If the incoming oscillations happen to be 2,000,000 cycles per second, and the oscillating tube in the super is generating 3,000,000, the difference between these currents is the beat current, of 1,000,000 cycles, or about 300 meters. The first detector picks up this frequency and passes it on to the following radio-frequency amplifiers, where it is amplified until it reaches the second detector, where it is rectified to an audio-frequency and is amplified for phone or loud-speaker reception.

This method practically eliminates the possibility of receiving any but the desired signals, and therefore is most excellent for receiving in congested areas where there are many local broadcasters and much interference.

The novice cannot expect to construct such a set and obtain the results that can be obtained with the commercially built articles, and it is for that reason that the authors are omitting all constructional data.

There are several types of super-hetrodynes, although they are all on the same principle. These types use from six to ten tubes. The former is known as the second-harmonic and accomplishes the same result as the eight-tube affair by reflexing some of the tubes—that is, by using the same tube as both an audio and radio amplifier.

An example of this very efficient method is the Radio Corporation Model No. 25. This is a six-tube set operating on the second harmonic principle.

Another very efficient form is the ultradyne, in which the first tube operates as a modulator instead of detector. That is, the tube not only changes the frequency, but acts as a modulator as well, thereby gaining considerable amplification before being passed on to the intermediate frequency amplifiers. Added amplification is gained by introducing regeneration in the modulator.

The most popular type of super-hetrodyne is probably the eight-tube affair of which the "Radiola 28" is representative. It is very simple to operate, there being but two tuning controls, although these two are so designed that they can be operated together as one (*Fig. 30 A*).

This type of receiver is rather expensive, but, as a matter of fact, is well worth having in view of the compactness, elimination of antenna and ground, as well as the selectivity and sensitivity available.

The advantage of the straight eight-tube circuit over the second harmonic type is that stations will be received only on a given setting, whereas in the six-tube they will in many cases be received at several different settings of the dials.

In loop reception it will be found that the station wanted can only be received on line with the loop's plane. In other words, the use of a loop antenna permits much more selectivity, as oftentimes a slight turn of the loop aerial will totally eliminate an undesired station where there are two operating on about the same wave length.

Another point to be remembered in operating a super-hetrodyne is that they are very sensitive and susceptible to shielding. That is, in houses where metal laths are used they must be moved to a part of the room away from such construction, or else near a window. The location of the set has a great deal of bearing on the efficiency of reception.

CHAPTER XVII

REFLEX CIRCUITS

(Plate 13. Figs. 31-31A)

A VERY popular type of circuit which has appeared within the past few years and has, under favorable conditions, proved very efficient, is that known as the *Reflex*.

This circuit often embodies a combination of the crystal detector and tube receiver, and four or five tubes are made to function like five or six by having one or more of the tubes serve as both a radio and an audio-frequency amplifier. This, of course, is very economical, as it saves tubes, but the circuit appears to have lost much of its popularity, perhaps owing to the present low cost of tubes, as well as to the fact that present-day tubes consume so little current that battery saving is negligible.

Due to the fact that radio frequency is inaudible to the human ear, the first tube may be used for radio-frequency amplification, and then, after the signals have been detected by the second tube, the first tube may again be used

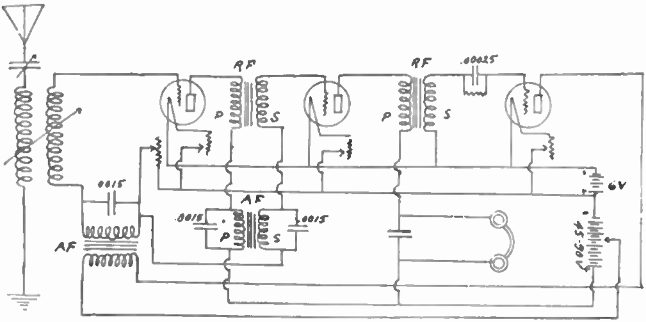


Fig. 31

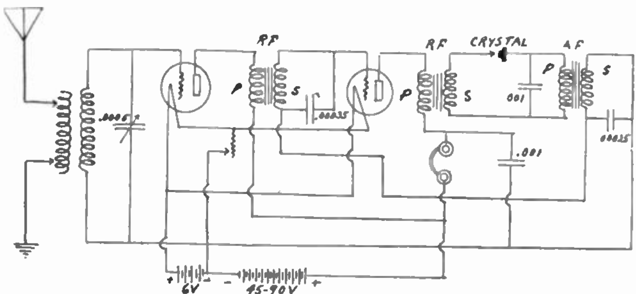


Fig. 31A

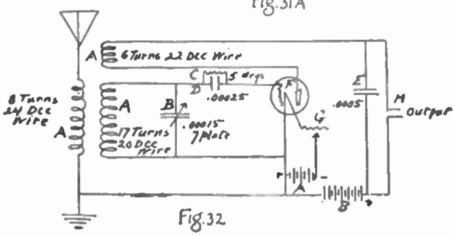


Fig. 32

PLATE 13

as an audio-frequency amplifier, as shown in *Fig. 31*. Another method is illustrated in *Fig. 31 A*. In this circuit a crystal detector is used in conjunction with two tubes, and by this method we secure the equivalent of a two-stage R.F. amplifier, detector, and one-stage audio amplification, which will permit loud-speaker reproduction. The transformers, *R.F.* are standard radio-frequency transformers which may be secured from any radio-supply dealer.

There are many outstanding circuits of these types, such as the five-tube *Acme*, the *Erla*, *Harkness*, *Roberts*, etc. These sets will give excellent results when well constructed, and many of them are sold in kit form ready for the home builder to assemble.

The main fault with this circuit is that the circuit *must* be perfectly balanced, and certain values in inductances and capacities *must* be used if satisfactory results are to be obtained. Hence we cannot advise the novice to undertake the construction of the reflex sets until thoroughly familiar with the construction of the simpler standard circuits. Those circuits which use the crystal detector give beautiful reproduction, but a straight radio-frequency circuit with a crystal detector will give equally good results and has the advantage of being much easier to construct.

We have seen some of these home-made reflex circuits which, operating on a loop antenna, were faultless, and we do not hesitate to recommend any of the types mentioned if the reader is interested in trying out all forms of circuits. Indeed, some of the best known and most popular factory-built sets embody the reflex principle in their design. The *Acme Apparatus Co.* has specialized in reflex circuits and has some very interesting free pamphlets on the subject. Another concern which has made much progress in the reflex field is the *Erla Electrical Research Laboratories.* This firm has designed many circuits of this type and will supply any special apparatus required for constructing reflex sets.

CHAPTER XVIII

SHORT-WAVE RECEIVER

(Plate 13. Fig. 32)

INASMUCH as there is a great deal of interest in the reception of short-wave transmission—that is, on the wave-lengths of 40-150 meters—we are illustrating in *Fig. 32* a very simple receiver that will receive over this band.

This is the conventional three-circuit regenerative receiver using very small coils. These coils may be wound by the set maker by following the specifications shown, or else they may be purchased ready-made. There are many of these low-loss short-wave coils on the market that can be recommended, and when used in conjunction with a first-class variable condenser, and other high grade material, excellent results may be expected.

There is much to be heard on the low-wave bands, and it also seems that atmospheric disturbances are not as bad on those frequencies as on the broadcasting band of 250-550 meters.

On the short waves will be heard the multitude of amateur transmissions, as well as some of the re-broadcasting.

It is on the low waves that the American stations transmit to Europe for re-broadcasting over there. That is, a station sends out a program on a very low wave length which is picked up by their receiving apparatus and then re-transmitted to the European listeners on a higher wave-length.

There are some very interesting things to be heard on the low waves, and the constructor will find it worth while to own a set of this type for experimental as well as practical purposes.

The following material is necessary to assemble the receiver.

Short-wave tuning unit already constructed (A) and sold by any radio store
1 small variable condenser, about 7 plate or .00015 Capacity (B)
1 grid leak. 3-5 megohms (C)
1 grid condenser .00025 capacity (D)
1 fixed condenser .0005 across primary of 1st A. F. trans. (E)
3 high grade tube sockets, preferably vibrationless (F)
2 rheostats (G)

3 jacks. 2 double, 1 single (H)
2 audio frequency transformers. First class.
Panel, baseboard, binding posts, screws, wire, etc.

It is not necessary to go into constructional details as to the method of mounting or any other constructive data, except that it may be well to say that all material should be first grade in every respect; that the wiring should be short and well soldered, and the set thoroughly shielded to prevent hand-capacity effects. The set should be so adjusted that it will go into oscillation smoothly and not spill over. This can be effected by the proper value grid-leak, which can only be determined by experiment, as each tube requires a different value. The plate voltage on the detector tube is also governed by the individual tube used and can be found by experimenting.

Usually a voltage of 16-30 will prove best, although some tubes may require more and some less.

Operation will be the same as on the regenerative receivers already described. The tuning will be accomplished by the tuning condenser and regeneration, controlled by the variable tickler coil—that is, the coil in series with the plate. It will be found that the set will have much more of a tendency to oscillate on the low waves than on the high.

The "Bremer-Tully," "Ambassador" and "Lopez" are among the best of this type that are available on the market.

The condenser should be of the specified capacity, and all of the large manufacturers mentioned in a previous chapter make condensers for short-wave work.

The sockets recommended are those of the type where vibration is eliminated by either a spring or rubber mounting. It will be found that with small dry-cell tubes the slightest touch is apt to make the tubes vibrate and ring, which will be bothersome, and can be eliminated by either this type of socket or else by suspending the tube socket shelf on a spring or rubber, as do some of the manufacturers.

CHAPTER XIX

WAVE TRAPS

(Plate 15. Figs. 35-36)

MANY radio listeners-in, especially those who have regenerative sets of the single-circuit type, or some type of set that lacks selectivity, will find it difficult to separate stations that are sending on waves of little difference in length. And if in localities where there are many powerful broadcasting stations (as in New York City, for example), which will not permit tuning in distant or less powerful stations, it will be found that the efficiency of the set may be greatly increased by adding a wave trap such as shown in *Figs. 35-36.*

It will be seen that this is merely a coil shunted by a condenser across, and connected in series with, either the antenna or ground of the set. Before making an affair of this kind it is advisable to be sure that the broadness or lack of selectivity in tuning your set is not due to some cause other than the type of circuit used.

The use of an antenna which is too long, or a poor ground, will cause this trouble even if the set itself is highly selective. The antenna should not exceed one hundred feet in length, including the lead-in, and where this size is exceeded it will be noticed that the tuning is broad. All things being equal, a shorter antenna gives finer tuning, and a low aerial will give better selectivity than a high one. If all connections are good, and the ground and antenna system are what they should be, then, if you have trouble in tuning out undesired stations, it is well to try a wave trap.

A form about 3½ inches in diameter should be procured, and around this about seventy-five turns of No. 22 D.C.C. copper wire should be wound to form the coil. Across this inductance a variable condenser of about .0005 mfds., or the 23 plate type, should be used. Connect one end of the coil to the condenser rotor and the other end to the stator of the condenser.

From the ground binding post of the receiver connect a lead to the stator lead of wave trap, and from the rotor-lead of the wave trap connect the ground connection that formerly went to the ground binding post of receiver.

Set the condenser in position, so that the plates are *not* meshed, and then tune in receiver to the *undesired* station and tune this station into its maximum volume. Then adjust condenser of wave trap to a point where the station cannot be heard, and leave wave trap in this position. It will then be found that the receiver may be tuned so that the signal of the undesired station cannot be heard again, unless the wave trap is readjusted.

Fig. 35 A shows an inductively coupled wave trap which operates on the same principle but has two windings in inductive relation to each other. This may prove better if the first type does not give the results outlined.

Another method is shown in *Fig. 36,* which is the same as *Fig. 35*, but placed in a different location. It will be found by experimenting that different results can be procured by placing the trap in positions which can best be determined by the operator.

There are severai of these traps for sale on the market, but in view of their simple construction and low cost, it really is not necessary to purchase one, as the commercial articles will not give any better results than the properly built home-made affairs.

There are many owners of receivers which were purchased several years ago and which lack selectivity, and to these, this trap or filter should appeal and is worth while trying.

Even some of the present-day cheaper sets look as nice as the higher-priced articles, but it is this selectivity that distinguishes them from the high grade. This is due to inferior parts, poor construction and design.

CHAPTER XX

AUDIO FREQUENCY AMPLIFICATION

(Plates 14-16. Figs. 34-34 A)

In a previous chapter we have covered the subject of radio-frequency amplification, and have explained that by this means added sensitivity is gained by amplifying the signal before it reaches the detector.

In order to amplify the signal *after* it has been detected, so that it may be heard, then we use audio frequency amplification—that is, the amplification of a frequency that can be heard by the ear.

This form of amplification will build up tremendous volume if desired, but will never increase the sensitivity of a set, as we are simply amplifying what has already been detected. It is possible that a signal may be so weak that it is almost inaudible to the ear, but any signal that can be heard in the amplifier is discernible when using the detector alone.

The three most common methods of amplifying at audio-frequency are: Transformer-coupled, resistance-coupled, and push-pull (*Fig. 34 A*).

The first type is the most familiar, as it is practically universal in the commercial, factory-built receivers.

Transformer-coupling gives excellent volume and good reproduction when used with well-built and properly designed transformers, besides minimizing the amount of B-battery current used.

Resistance-coupling will not give as much volume, tube for tube, but will give practically perfect reproduction, with no distortion; but it requires considerable more B-battery voltage.

Push-pull amplification requires the use of one extra tube, as well as an added transformer. This tube and transformer are connected in parallel, *Fig. 34 A*. This system permits the forcing of the tubes without causing distortion. and is to be recommended where great volume is desired.

The push-pull method requires a special type of transformer, known as a "push-pull transformer." They are manufactured by practically all the larger transformer manufacturers.

The push-pull works exceedingly well on receiving sets using the dry-cell tubes for amplifiers, as these small tubes will not stand the load that the larger type will. This is espe-

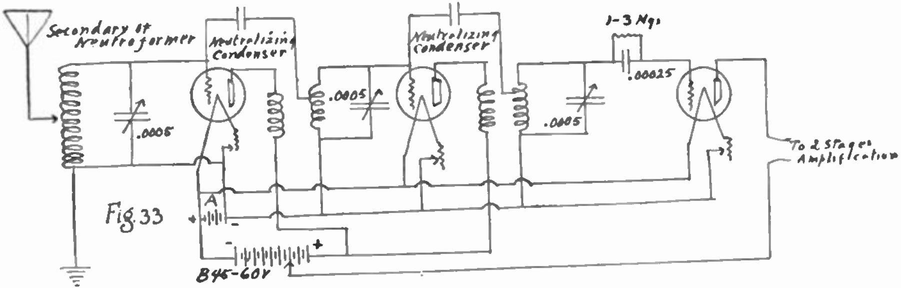


Fig. 33

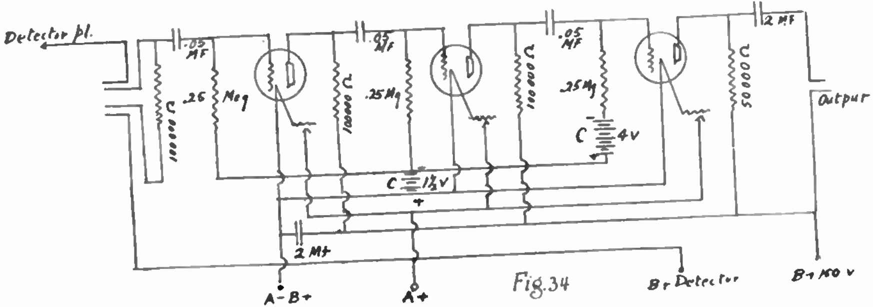


Fig. 34

PLATE 14

cially true of the WD-11 and WD-12 type.

Resistance-amplifiers are very easily constructed, and the proper value resistances may be procured, completely assembled, at all the radio shops. Those manufactured by such concerns as Daven, Allen-Bradley, Electrad, Durham, and Lynch can be recommended. They also furnish completely assembled amplifiers of this type which will give excellent results.

The writers feel that to the average radio listener complete satisfaction can be had when a well-designed transformer-coupled amplifier is used, provided high-grade transformers are utilized. This can be attested by hearing some of the most expensive receivers that are being built and which use this method of amplification.

Probably better results are attained by the use of a low-ratio transformer in the last stage, and a high in the first, although this is a question that seems to be more of a matter of opinion than anything else. Some engineers claim that both stages should be the same, using a ratio of about 4-1, while another will stand by the 6-1 in first stage, and 3-1 or 2-1 in last.

The authors can assure the reader that if transformers of the better grade, such as Amertran, Acme, General Radio, Thordarson, Rauland, Lyric, Sampson, and Jefferson are used, results will be all that can be expected, and most satisfactory in every way.

In mounting transformers it will be often found that there is less distortion when they are mounted at right angles to each other.

CHAPTER XXI

LOUD SPEAKERS

(Plate 15. Fig. 37)

WHEN radio broadcasting was in its infancy, and loud speakers were beginning to supplant head phones, a loud speaker was selected solely for the amount of volume that it would give. About every manufacturer who advertised his product laid particular stress upon the large volume obtainable with his speaker, and noise seemed the sole object in view. But to-day, when looking over advertisements of loud speakers, it will be found that volume is seldom mentioned, and that clarity of tone and true reproduction are the features dwelt upon.

The earlier types of loud speakers were nothing more than telephone-receiving units fitted with horns. These were followed by larger, specially built units with heavier diaphragms and with larger horns. But to-day we find that the most advanced type of loud speaker is the so-called "cone type" which operates on an entirely different principle and will reproduce the entire range of music much better and more faithfully than the older types. Their volume is much less, but volume may be built up almost indefinitely by increasing the amplification. In the horn type, the high notes were well reproduced, but the lower, bass notes, were not clear. As a result, it became necessary to change the principle so that the entire musical range would be equally well reproduced. In selecting a speaker be sure to notice whether the low notes of an organ, a horn, or a bass drum are as clear and true in tone as the notes of a piccolo or violin.

In *Fig. 37* we show the common telephone unit type of speaker which operates on the same principle as a head set. The volume is dependent upon the space between the magnet pole pieces (*A*) and the diaphragm (*B*). This may be adjusted by the nut (*C*). This arrangement will be found in several of the speakers on the market, and it will be found that the maximum volume is obtained just *before* the point where there will be a distinct snap followed by distortion. When a signal is coming in, turn the nut to a point where the signal is very loud and then becomes distorted and tinny. Then, a turn or two back will give the proper setting, although a trifle better quality may be obtained, and less volume, if the setting is back further.

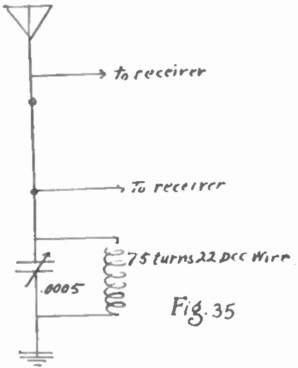


Fig. 35

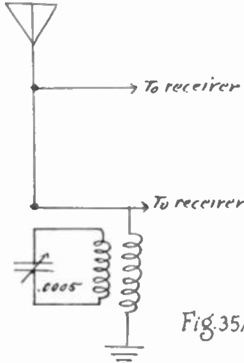


Fig. 35A

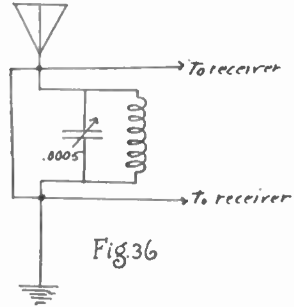


Fig. 36

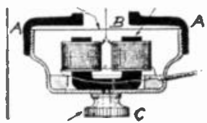


Fig. 37

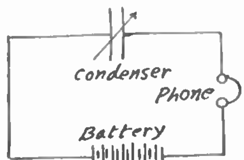


Fig. 38

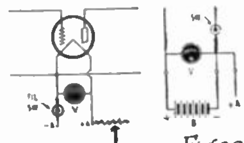


Fig. 39

PLATE 15

A point that should always be remembered is that on most loud speakers, cords will be found, one terminal of which usually shows either a red tracer or a striped thread running through it. This lead should always be inserted in the plug receptacle that has an "x" marked on it, or else to the binding post of the receiver that goes to the battery side of the plate circuit.

If this is not followed, there is the possibility of the magnets of the loud speaker becoming demagnetized.

The latest type of speaker known as the cone type operates on somewhat the same principle, only the entire cone acts as a diaphragm.

It is always well to remember that the best speaker made cannot reproduce well if the amplifiers do not amplify well. It is for this reason that a cheap speaker will often work with a cheap set just about as well as one that is more expensive. But if the set gives good quality, then only the best type of speaker should be used to bring it out. Also, the type of transformer enters into this, and if the transformer used will not amplify the lower tones and bass notes, then it cannot be expected that the speaker will perform well.

Another type of speaker that is used is a power speaker which operates from an external power plant—that is, batteries, etc., are separate from the set itself. This type of speaker is used for large halls, auditoriums, etc.

Special tubes, controls, transformers, etc., are required for this work where tremendous volume is desired.

The shape and material used in the construction of the horn have a great deal to do with results. The neck cannot be too short or too long, and the proper curve must be used. It is these little points that make the various brands of speakers different from one another. The best way to determine which type is adaptable to your needs is to go to a radio shop where they have a switching device that permits the comparison of each kind with the others on the same signal.

CHAPTER XXII

TUBES AND THEIR USE

THERE are many different type tubes now on the market, and as each type is designed for a different purpose it is advisable that these be reviewed so that the radio fan may know what tube to use in each different type of receiving set.

When the vacuum tubes first appeared, the cost was much greater than at the present time, and the current consumption much greater as well. A tube in those days drew about one ampere, and if a person was using a three-tube regenerative set he would find that it meant the recharging of the "A" battery every few days. Now we have five- and six-tube sets which operate on only half of that amount, and in some of the super-hetrodyne sets we find eight tubes which all together draw less than half an ampere.

This improvement has been made possible by the use of the thoriated tungsten filament, high evacuation, and remarkable improvements in design due to continual research in the laboratories of the Westinghouse Electric & Mfg. Co. and General Electric Co., who manufacture the *Radiotron*, the tube that is a standard throughout the country.

The use of the thoriated tungsten, or, as it is sometimes called, the "X-L" type, gives much longer life and much greater electronic emission.

We do not feel that it is necessary to go into details of manufacture, as that would require chapters, but will merely say that when you get your tube you may rest assured that it has undergone exhaustive tests and inspection, and if used with care, and according to instructions, it should last a long while and give complete satisfaction if used in the position that it was designed for.

Also, we have several types of bases that the reader should be acquainted with. First, the standard, or *navy type*, known in trade circles as the *"UV"* or *"CV,"* the first named made by the Radio Corporation of America, and the second *"CV"* type being the same thing but distributed by the Cunningham Co. The tubes are both alike in every detail, except that they are distributed by these two different companies, the former in the East and the latter in the West, although both brands may be purchased in either district. The tubes are made by the same company and there is no difference whatever in them as to manufacture or characteristics.

The type *"UV"* or *"CV"* we are all familiar with, as this is the standard base that uses the standard socket and has become practically universal on all the factory-built receivers.

Another type of base is the *"199."* This is the little tube that uses but *.06* of an ampere and operates on but *3 volts* across the filament. This base is small and differs from the standard in having short prongs, and it requires a special socket.

The next base that we have is the *"WD-11."* This is a tube that operates on a *volt-and-a-half dry cell* and consumes but *one-quarter* of an ampere.

It is a long-pronged base and requires a special socket. The location of the prongs is different from the standard tube, the plate being diagonally across from the grid and with a much larger prong, which will prevent it from being inserted in a socket in the wrong way.

The latest type of base is the *"UX"* or *"CX,"* depending on whether it is a *Radiotron* or *Cunningham,* as previously explained, the former being the *"UX"* and the latter *"CX."* This new type of base somewhat resembles the *"WD-11"* type, as the tube requires a special socket where the tube is held in place. Compression and the contact are on the side of the prongs, instead of having a spring contact against the bottom, as in the standard.

Probably this last-named type of base will be universal before long, as it has many advantages which recommend it.

The following is a list of the tubes which are in universal use, and the purposes they are used for:

UV-201A, CV-301A.—A five-volt tube consuming one-quarter of an ampere; can be used as either an amplifier or a detector.

UX-201A, CX-301A.—Same as above except the new type of base.

UV-199, CV-199.—A small dry-cell tube requiring three volts and consuming .06 amperes. A very good audio amplifier, as well as radio, and a fairly good detector. Recommended for portable sets due to its low current consumption.

WD-11, C-11.—A small volt-and-a-half tube drawing one-quarter of an ampere. An excellent detector, good audio frequency amplifier, but not to be recommended as a radio-frequency amplifier.

UV-200, C-200.—A gas-content tube used as a detector only. Very efficient, but consumes one ampere at five volts. This tube has been replaced by a much more efficient and more sensitive type, the *UX-200A*.

UX-120, CX-220.—A small-power amplifier to be used in the last stage only and recommended for use with the dry-cell tubes as a super-amplifier. Requires three volts across the filament, but consumes about one-tenth of an ampere. Uses 135 volts of plate battery. Gives real volume and puts a small dry-cell set on a par with the larger type using the *201A* tube.

UX-112, CX-112.—An amplifying tube that may be used as a detector, a great improvement over the *201A* type when used in the last stage of amplification. Requires about nine volts of "C" battery and 135 volts on the plate. Consumes one-half on ampere.

UX-171, CX-371.—A power amplifier to be used with storage-battery sets that gives tremendous volume. To be used in the last stage of amplification. Requires 180 volts on the plate, five volts across the filament, and consumes one-half an ampere. Also requires about forty volts of "C" battery.

WD-12, C-12.—Same as the *WD-11* and *C-12* except that a standard base is used.

Then there are the 213 and 216-B types, which are rectifying tubes used to convert alternating current into direct current. Used on eliminators.

Another type is the *UX-874*, which regulates the voltage in power units which eliminate batteries.

There are quite a number of tubes on the market manufactured by other concerns who use different serial letters and numbers, but inasmuch as the above tubes are used as standard, and their use is practically universal, we do not feel that it is necessary to go into detail. Many of the independent manufacturers use similar serial numbers and letters in order to show that the characteristics are the same.

In the cartons with tubes will always be found pamphlets giving full information as to the use and proper voltages to be used in operation, as well as wiring diagrams showing how they should be connected up in the detector and amplifying positions.

It might be well to say that where a tube uses *3* volts it requires a *4½*-volt battery, and where *5* volts are specified as the filament voltage it will require a *6*-volt battery to light the filament. The difference between the battery voltage and the filament voltage is taken care of by the use of a rheostat which permits the gradual increase and decrease of any voltage required up to the maximum voltage of the battery.

CHAPTER XXIII

BATTERIES, CHARGERS AND ELIMINATORS

(Plate 16. Figs. 41-42)

IN radio receiving there are usually two batteries, and in most cases three, used. These are known as the "A" or filament battery, and the "B" or plate battery, while the third is the little "C" battery used in the grid-return of the amplifiers in order to give clearer amplification and also to lengthen the life of the "B" battery.

The "A" battery may be either a wet or storage battery, such as is used in automobiles, or an ordinary dry cell, such as is used for door bells. The wet battery is usually required in the larger sets, especially where the large tubes, drawing one-quarter of an ampere, are used. This is necessary, as the total drain will often be two or three amperes, which will run down dry cells in a very short time. The small dry cells are used in conjunction with dry-cell tubes, such as the *"199"* and *"WD-11"* and *"WD-12"* type. As these tubes use little amperage, the dry cells give good results and long battery life.

The "C" battery is usually a small flashlight-type battery cell of about four and one-half volts and is used in the amplifiers in series with the grid-return, the negative pole being connected to the "F" marking on the transformer, and the plus or X to the negative of the filament of the amplifying tube. The use of this battery not only clarifies reception, but greatly prolongs the life of the "B" battery.

As everyone is more or less familiar with the wet or storage battery, it is not necessary to describe its construction. But when selecting such a battery be sure to get a battery of standard and well-known make. Do not expect to get a bargain by selecting a battery that is not known and in regard to which all sorts of claims are made as to amperage, etc. Such so-called guarantees are not consistent with low price and the best is the cheapest in the end.

A good "A" battery of 100 ampere hours will be somewhat costly, but beware of the cut-price battery if you wish satisfactory results. Batteries made by the large well-known manufacturers who have a reputation to maintain will always give satisfaction and do what the makers claim for them. The amperage of an "A" battery is the most important feature. One hundred ampere hours means that the battery, when fully charged, will deliver one ampere of current for one hundred hours. If you have a five-tube set and each tube requires one-quarter of an ampere, then the total drain on the battery will be one and one-quarter amperes per hour. If the set is used three hours each night, the battery should last about twenty-seven days without recharging. But the battery should *never* be allowed to run down. It is far better to have it kept fully charged by recharging whenever it goes below a half-charged reading. In order to test a wet battery for charge, an instrument known as a "hydrometer" is used. This may be purchased at any radio or battery store. The instrument looks much like a syringe and is designed to show the specific gravity of the battery solution. Within it is a floating gauge which has markings indicating the condition of the solution by floating at various levels. To test the battery, remove the plugs, then compress the bulb of the hydrometer and insert the tip or nose into the solution of battery, which may be seen covering the plates within the vent-holes. Release the pressure on the bulb and let the hydrometer suck up some of the solution. The little float within the instrument will either float high or almost sink, and the point which it indicates on the gauge will tell the condition of the battery. A fully charged battery will show a reading of about

1.275 or more and a fully discharged battery will read about 1.150. A battery should *never* be allowed to fall below 1.200 if you wish to get the best results and longest service.

Never test an "A" battery of the wet type with a voltmeter, as there may be voltage and little or no amperage, and it is the latter which counts in the "A" battery.

There are many types of battery-chargers on the market, and the one which is best is merely a matter of opinion. All those made by reputable firms are good. Irrespective of the make of charger used, the method of charging is essentially the same. The charger is usually contained in a box-like receptacle and has terminals plainly marked as to their purpose. One type has an electric-light cord to attach to a wall plug or a lamp-socket, while the other terminal goes to the two terminals on the battery. Be sure and follow directions exactly, and *always* put the *negative* to *negative* and *positive* to *positive*. If you do not know which is which, you can readily determine the negative by inserting wires from the terminals in water. Bubbles will rise from the *negative,* and even if bubbles rise from both wires *the most bubbles will come from the negative wire*.

When a battery is being charged, little bubbles will show in the vent-holes, looking as though the solution were boiling. This is as it should be, and a reading should be taken with the hydrometer. When the solution shows a reading of 1.300, turn off the current and disconnect the leads to battery. Also, be sure that the solution covers the plates to a depth of about half an inch. If low, add distilled water. Keep the wet battery away from carpets and be sure not to spill any of the solution on your clothing, as the solution is acid and will eat holes in cloth.

The method of charging batteries is shown in *Figs. 41-42*. *Fig. 41* shows the method of charging wth direct-current lines and *Fig. 42* shows method of charging with A.C. (alternating current). On direct-current lines a home-made charger may be used as shown. This consists of bulbs adapted to the current available. On 110-volt lines use one 40-watt 110 lamp in series with the line—being sure the correct polarity is obtained as already described. On a 32-volt line (often used on farms) one 32-volt 20-watt lamp is required. Be sure that polarity is right—*negative* to *negative* and *positive* to *positive*.

To charge from an alternating (A.C.) current is also simple and is plainly shown in *Fig. 42*.

Most of the "B" batteries in use to-day are of the dry-cell type which cannot be recharged after they have run down. When a dry "B" battery falls to a drop of eight volts below normal it should be discarded. A good "B" battery should, however, give service for several months, depending, of course, on the amount it is used and the number of tubes in the set. The condition of the "B" battery is easily determined by a voltmeter and *never* by an *ammeter,* as the amperage is small and will be greatly reduced by use of the latter instrument.

This rule holds good for *all* dry cells. Dry batteries should never be allowed to stand in a hot or damp spot, as they will then quickly deteroriate. Also, be sure they are not old stock, as they will lose life even when standing on the dealer's shelves. And *never* test them by placing a wire from terminal to terminal and thus making a spark. Nothing will destroy them more quickly. Remember, too, that when connecting batteries you can add either voltage without increasing amperage, or amperage without increasing voltage, by connecting several cells in series or parallel. In *Fig. 40* this is illustrated. Here (A) we have four "B" batteries each of 22½ volts connected in such a way as to give a total of 90 volts without increasing the amperage. In *Fig. 40 B* we show

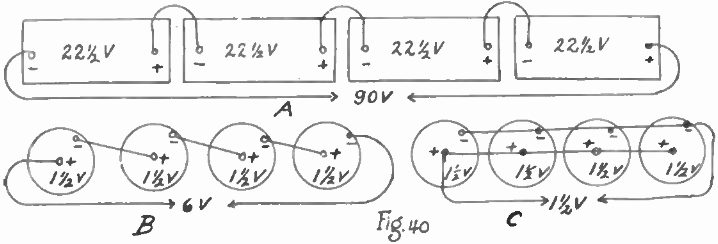


Fig. 40

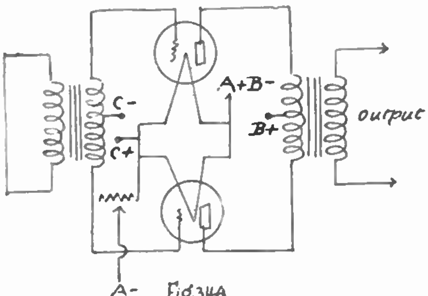


Fig 34A

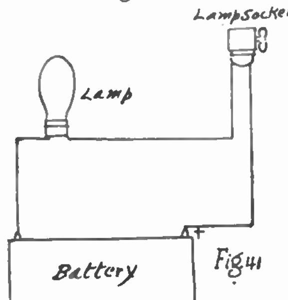


Fig 41

More lamps may be used in series
to increase rate of charging
Use 32 V lamp for 32 V line.
" 110 " " " 110 " "
" 220 " " " 220 " "

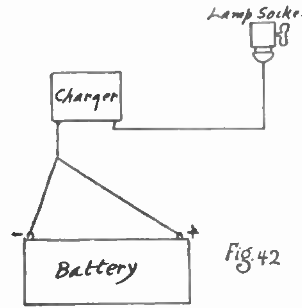


Fig. 42

PLATE 16

four "A" cells of 1½ volts each connected to give a total of 6 volts without adding to the amperage, while in *Fig. 40 C* four "A" cells are shown each with 1½ volts, but so connected that the total is still 1½ volts, although the total amperage is four times that of one cell. In order to *increase voltage connect the positive terminal of one battery to the negative of another.* In order to *increase amperage without increasing voltage connect positive to positive and negative to negative.*

Also, it is often convenient to connect a voltmeter with the set permanently, so that the voltage passing through the wires may at all times be readily ascertained. How this is done is plainly shown in *Fig. 39.*

Remember, also, that if you have no means of recharging a wet battery you may always have it charged, and may secure battery service, from any of the various battery stations that cater to the automobile and radio trade. And from them you may rent a battery to use while yours is being recharged.

As there are many objectionable features to batteries, such as their size and the weight and the necessity of constant care and replacement, various devices for doing away with batteries have been made. These are known as battery-eliminators and take the place of "A" and "B" batteries by using the current from electric-light lines. The main objection to them is their first cost, but as the upkeep of either dry or wet "B" batteries amounts to considerable at the end of a year the eliminator is often the cheapest in the end. The most difficult obstacle to be overcome in using an eliminator is the hum of the alternating current. In some forms of eliminators this is very bad, while in others it is scarcely audible.

As the eliminator, or power unit, as it is also called, costs but a fraction of a cent an hour to use, and as there is little chance of its giving out in the midst of a concert, many users prefer it to batteries. Some types are nothing more than a combination charger and battery so designed as to keep the battery constantly charged as fast as the current is used, while other types consist of transformers and resistances which change the A.C. current to D.C. (direct current) which is essential in receiving sets, and also step the voltage down from 110 or more to the required amount. This is fairly simple by the use of rectifying tubes, but not so simple when it is desired to do away with the "A" battery where a low voltage and high amperage is required.

There are many kits on the market composed of various parts, so that the novice may wire them together and make his own eliminator. And as these are accompanied by full directions and diagrams, the results are usually satisfactory and the cost much less than that of the ready-made instrument complete.

Some of the more costly ready-made sets have eliminators for both "A" and "B" batteries self-contained, and which thus permit operation direct from the electric-light lines, thus doing away with all worry over batteries. Among the many firms making kits and directions for assembling eliminators are the *Acme*, *American Transformer Co.*, and *General Radio Co.* Among the types of complete eliminators are the Radio Corporation of America—Epom, Philco, Timmons, etc. In addition, many other makes can be fully recommended, as any instruments made by the larger firms are good, and the writers are not in a position to either recommend or condemn any make or brand.

And remember that, before investing in any of these instruments, you *must* determine whether your electric-light current is *A.C.* or *D.C.* If in a *D.C. locality where 110 volts* are used it will be necessary to secure a special make of eliminator, as most of them are designed to be used solely for *110-volt A.C. lines.*

CHAPTER XXIV

SERVICE AND CONSTRUCTION HINTS

(Plate 15. Figs. 38-39)

In erecting an aerial it is best that it never exceeds one hundred feet in length including lead-in, as the added length will not permit the sharp tuning that is obtainable with a shorter antenna.

Try out several grounds before deciding on the water pipe or radiator.

On a regenerative set the best way to determine this is to use the ground that gives the least amount of hand capacity effect, or else, better still, use the combination that permits the regenerative control to go into oscillation at the minimum setting on the dials.

Remember that an antenna will receive those station's best that are toward the end with the lead-in. This may not be discernible in some localities, but it will often help if it is found that certain stations will not come in and the direction of the aerial is changed.

Do not drop tubes, jar them, or subject them to rough handling, and bear in mind that they should always be operated at as low a brilliancy as is consistent with good reception. Burning a tube beyond the required voltage will shorten the life tremendously. Operating at its proper temperature it will be prolonged in proportion.

Practically all amplifying tubes will detect to a certain extent and can be used in that position, but those tubes designed as detectors only do not, as a rule, function in the amplifier position.

When buying dials be sure that they turn in the proper direction, so that they will show zero when the condenser plates are open and the highest number on dial when the plates of the condenser are closed. Some dials are clockwise and others counterclockwise.

Never use cheap paste when soldering radio connections, and don't let the solder form the joint. The parts to be connected should be in contact and the solder should be used merely to hold the contact in place. Rosin core solder is by far the best.

Never use anything but distilled water in the "A" batteries or wet "B" batteries. This may be procured at any drug store.

Keep the battery clean, and if it has a tendency to corrode or get a green substance collecting around the terminals it is well to paint the terminal with vaseline to prevent it.

Never let the batteries run all the way down. but keep them charged as often as possible. When the hydrometer shows a reading of half charged it is well to bring them up to a fully charged reading.

If you have built a receiving set of your own and wish to be sure that there is no mistake in wiring, always try out the filament circuits by inserting the tubes and turning on rheostats, but LEAVE "B" BATTERY DISCONNECTED. All tubes should light.

Then insert the "A" battery in the place of "B" battery and eliminate the "B" battery altogether when the TUBES SHOULD NOT LIGHT. If they do light it shows a short circuit and means that if the set were connected up all your tubes would be burned out.

A fair trouble-finding device can be made by putting a pair of head phones in series with a small dry cell and testing circuits for open and short circuits.

Condensers should never give a loud click, and if they do it shows that there is either faulty wiring or else the plates are touching. To test a condenser where this is suspected it is a simple matter to hook up as described and rotate the plates of condenser. If there is a loud click it shows a plate touches the stator. *Fig. 38* shows this method of testing. All coils and continuous wiring should give a "click."

A voltmeter, which can be procured at all dealers, in a circuit will be of help, as it permits the burning of the tubes at the proper voltage. *Fig. 39* shows the method of connecting a voltmeter in the *"A"* and *"B"* circuit.

It will be noticed that some of the more expensive sets use one, and it is especially recommended in those using dry cells with No. 199 type of tube. These tubes should never be operated at over the prescribed voltage, and inasmuch as three dry cells totalling four volts are usually used, it is essential that some means be used to see that the tube is never subjected to more than three. As the batteries run down it will be found that the rheostat resistance can be decreased, which will allow the tube to have the proper voltage as the cells are exhausted.

Be sure, when purchasing parts, that only the best are used, as it pays in the end. Those parts made by reliable concerns which have experience and a reputation to uphold will always prove better than the "just as good" brand that the dealers often try and sell in place of a standard article.

The life of a tube is dependent on the way you treat it and the number of hours it is used.

Sometimes they may be rejuvenated if left to burn with the "B" battery disconnected for about a half hour.

If the filament of a tube burns out it is hopeless to expect it can be repaired.

A receiving set is a delicate piece of mechanism and very easy to put out of adjustment. If you don't know anything about radio, don't try to fix it if it gets out of order. All the larger manufacturers have service representatives who will put it in order, or, if they are not available, have some one that understands radio go over it. The writers feel that more radio sets are put out of order due to would-be radio experts either trying to repair or improve reception than from other causes.

The average receiver to-day is sealed and substantially made, and there is no reason why it should not last years if given ordinary care. The tubes, batteries, etc., may need replacement, but the set should carry on with but very little attention.

Just because long distances are heard one night do not expect the reception to be consistent. Some nights it may not be possible to hear over a hundred miles, and the next it may be possible to hear two thousand. There are so many factors that enter into radio reception that it is impossible to say what any receiver will do under certain conditions.

It is a wise plan to expect very little long-distance reception during the summer if you do not wish to be disappointed, for summer reception is always poorer than winter reception. Also, do not expect the same results during the day as you will get at night. And bear in mind that no one can guarantee a set to receive from a certain distance in any location, as there are some localities where receiving is practically impossible, while in others the conditions are so perfect that reception is truly remarkable. Even in one city or town certain sections give good results while others are "dead" even to local station reception. So, if some friend who lives near has a cheaper set than yours, and yet gets better results, do not blame your set or consider it inferior. The chances are that if you test it in his locality it will far excel his. And before blaming a set be sure to look over your antenna and ground installations; see that your batteries are what they should be and be sure the tubes are up to the standard. And it is well always to discount by one-half all that the enthusiastic fan relates about his feats in radio reception.

Keep all exterior connections clean. Be sure that the lead-in is tight and clean, as often, where window-sill strips are used to bring in the wire, the clip connection becomes corroded and this will cause a loss in signal strength.

When one of these metal strips is used it is well to have the connections covered with tin-foil and wound with adhesive tape. Also, be sure that a heavy wire is used for the ground and that the cold water pipe (and not a gas pipe) is clean where the ground connection is made with it. Sometimes a steam radiator will make a good ground if nothing else is available, and, in the country, a very good ground may be made by burying about four square feet of copper screen or copper plate, or even an old copper wash boiler. The hole should be about three feet deep, and excellent results have been obtained by burying about fifty feet of coiled copper wire. The ground should be covered with cinders and then with earth and a depression should be left to enable water to gather and keep the earth and cinders moist. In multi-tube sets it is advisable to shift the tubes about until the best results are secured. One tube will act best as a radio-frequency amplifier, another will be best as an audio frequnecy amplifier, and still others will give best results as detectors.

It will be found that best results are to be had with certain tubes in certain sockets, and this is particularly true of the super-hetrodyne sets.

In building a set from either plans or articles published in the radio periodicals, do not condemn the set because it does not do all that is claimed for it. Give the set a chance and become familiar with its operation before passing judgment. And even then try it in some other location before deciding against it. And do not forget that you may be at fault rather than the set.

If a certain value is specified for any instrument, then follow this absolutely, as small things often, if not always, make all the difference between good and bad sets.

In making home-built coils the best material for holding them together is collodion, which may be secured at any drug store. Ambroid cement is equally good, but it is not so easily obtained.

In wiring amplifiers remember that the *grid return always* goes to the negative (—) of the "A" battery or negative of the "C" battery.

It is a wise plan to log the stations you hear, as it will make it far easier to again find the stations you wish to tune in on. If you hear some station coming in regularly on 336 meters and the dial reading is 24, and you find some other well-known station of 360 meters comes in at a reading of 30 on the dial, then it is a simple matter to locate some station with a wave of 345-meter length by turning the dials between 24 and 30. Or again, if you hear some unknown station coming in with the dial at 28, you can assume that its wave length is just below 336 meters and any broadcasting station list will give you the information as to stations using waves of that length.

CHAPTER XXV

USEFUL THINGS TO REMEMBER

THAT a crystal detector set is never as efficient as a tube set, no matter what sort of equipment is used.

That small, cheap, or poorly made sets cannot tune out local interferences or various stations operating on nearly the same wave-lengths.

That wave-lengths have nothing to do with distance.

That the distance at which a transmission station may be picked up depends (all other factors being equal) upon the output power of the station and *not* upon its wave-length.

That it is the poorest sort of economy to buy cheap parts or parts that are not made by a large, reliable, and well-known firm. A good set cannot be made with inferior instruments, no matter how skillful a workman you may be. In radio the best is always the cheapest in the end.

That for an antenna a single wire is the best.

That the lead-in counts as antenna and with a long lead-in you can use a short antenna.

That antennæ and lead-ins must be well insulated from everything else.

That the higher the antenna the better.

That when placing antenna near wires, electrical plants, bridges, steel structures, etc., the antenna should be placed at right angles to them.

That the lead-in should be at the end of antenna which is towards the sending stations you wish to pick up.

That the radio waves penetrate everything and an indoor antenna will give good results.

That insulated wire will serve for an antenna as well as bare wire.

That countless so-called new forms of sets with fancy names are all mere variations of a few standard types.

That the efficiency of a set depends upon the quality of its various parts, the care in construction, and the number of tubes, rather than upon its type or wiring system.

That dry batteries for the filament circuit are far more expensive in the end than wet or storage batteries.

That each stage of amplification requires another tube and transformer.

That no one can guarantee the distance at which you may receive, no matter what type of set you use.

That "freak" messages from extremely long distances are not unusual, but that because you pick them up once you cannot count on repeating the feat.

That burning the tubes too brightly shortens the life of the tubes and does not improve the reception of set.

That all tubes vary, some being best as detectors and others as amplifiers, and that testing out each individual tube is the only sure method.

That it is always better to buy ready-made parts than to make them yourself.

That all connections and joints should be soldered.

That a ground connection should be soldered to a water pipe or to a large copper plate buried in the earth; but never to a gas pipe or electric wire.

That antennæ do not attract lightning, and if provided with a lightning switch or air-gap are perfectly safe, even in the most severe thunder-storms.

That a set will vary in its selectivity and distance reception from day to day and hour to hour.

That reception is never so good during the day as at night.

That reception is better in winter than in summer.

That static is most prevalent in summer and when thunder-storms are near.

That anyone with any mechanical ability can construct any set equal to those ready-made, provided the parts are of equal quality.

That the worst interferences are caused by local sets of the regenerative type trying to tune in with the sets in oscillation.

That if you let your set oscillate you will interfere with some one else.

That you can seldom pick up a distant station on a loud speaker, but should use head phones, even if after tuning it in you can switch to loud speaker.

That all antennæ are strongly directional and often a distant station may be picked up, or some local station tuned out, merely by changing the position of your antenna.

That a loop-antenna is even more strongly directional than an ordinary antenna.

That an indoor antenna should not be as long as an outdoor antenna.

That two antenna wires run parallel amount to no more than one of the wires.

That too long a ground wire is objectionable.
That a ground wire need not be insulated from surrounding objects.
That wood when wet is a conductor of electricity.
That the location in which a set is placed may greatly influence the set's efficiency.
That when possible a set should be placed near a window.
That tubes do not last forever and must be renewed when they fail to operate well.
That a battery may be dead, as far as radio reception is concerned, even if it shows good voltage, for amperage counts also.
That batteries deteriorate even when not in use.
That too great regeneration will distort signals, even if it increases their volume.
That perfect reception is not always the loudest, but the clearest and least distorted.
That radio instruments are extremely delicate and should not be roughly or carelessly handled or abused.

GLOSSARY OF TERMS COMMONLY USED IN RADIO

AERIAL.—Same as ANTENNA. Conductors or wires used to absorb the radio-frequency waves on receivers and radiate them on transmitters.

ALTERNATING CURRENT.—An electromotive force that flows first in one direction and then the other at the rate of sixty cycles, on the usual light lines. The number of repetitions per second determine the frequency.

AMMETER.—An instrument for measuring the current of electricity.

AMPERE.—The unit of current.

AMPLIFIER.—An instrument that increases the energy. In radio it increases a weak signal that may be almost inaudible to a point where it can be heard with ease.

AMPLIFIER TUBE.—A tube used in radio circuits to increase the energy for amplification circuits. As a rule the tube is more highly evacuated. Also called a *hard tube*.

ARRESTER.—A device used to prevent damage by lightning striking. Usually a small gap between aerial and ground, or a switching device that will permit antenna to be connected directly to ground outside of the house.

AUDIBILITY.—The ability to distinguish a sound, such as dots from dashes in radio, or to understand a weak signal.

AUDIBILITY METER.—Instrument for measuring a given sound against a standard.

BATTERY.—The source of power in a radio set. The dry or wet cells that light the filaments and furnish the plate circuit.

BINDING POST.—The terminals on a receiver to which the antenna, ground and battery connections, are made.

BUS-BAR.—Heavy wire, usually tinned, for wiring a receiver. It is usually quite stiff to permit bending at angles and to prevent jarring loose.

CAPACITY.—The amount of electricity measured in microfarads which a condenser stores up.

CHOKE COIL.—A coil, usually with a great many windings, often with an iron core, used to check the current in a circuit. Also a form of amplification.

CONDENSER.—Two or more conductors of electricity insulated from each other by some dielectric which forms an instrument capable of storing electrostatic electricity.

CONDENSER, FIXED.—A condenser where the capacity is constant.

CONDENSER, VARIABLE.—A condenser where the capacity may be increased or decreased. In radio, usually a condenser with metal plates and an air dielectric whose capacity is varied by meshing or opening the plates.

COUPLER.—An instrument composed of many windings which will transfer radio frequency from one circuit to another when placed in inductive relation to another coil with windings.

CRYSTAL.—A mineral that has the property of rectifying radio waves so that they are audible to the ear with head phones.

CURRENT.—The amount of electricity flowing in a circuit.

CYCLE.—In alternating currents, the complete rise and fall from zero to maximum, back to zero in the positive direction, and the same in negative direction.

D.C.—Abbreviation for Direct Current.

D.C.C.—Abbreviation for Double Cotton-covered wire.

DSC.—Abbreviation for Double Silk-covered wire.

DAMPING.—The lessening of the amount of energy in a circuit.

DIAPHRAGM.—A thin metal or mica disk used on receivers or speakers, and which vibrates, thus causing the sound to be heard.

DIRECT CURRENT.—Current flowing in one direction only.

DIELECTRIC.—Any material or medium which allows electrical conduction to a very small or negligible extent.

FADING.—The term is used where signals vary in intensity, coming loud and then very low. Noticed mostly on distant signals. The term explains itself.

FARAD.—The unit which expresses the capacity of a condenser.

GALENA.—Lead sulphide. A metallic ore used as a crystal detector.

GRID.—The element in a tube between the filament and the plate.

GRID CONDENSER.—A small fixed condenser connected in series with the grid circuit.

GRID LEAK.—A very high resistance, usually connected across the grid condenser.

HONEYCOMB COIL.—A special type of coil, layer wound.

JACKS.—Slips into which a plug is inserted to make electrical contact and to close a circuit.

KILOWATT.—One thousand watts.

LEAD-IN.—The wire that connects the set with aerial.

LITZEN-DRACHT WIRE.—Braided wire composed of many strands, each strand being insulated from the others.

METER.—An automatically measuring instrument. A unit of length—39.37 inches.

MICROFARAD.—One-millionth of a farad.

OHM.—The unit of resistance offered by a circuit.

PLATE CIRCUIT.—That circuit of a receiver which is in series with the plate of the preceding tube. Always terminates at the positive "B" battery.

RADIO FREQUENCY.—The frequency above audibility. Above 10,000 cycles a second.

RADIOTRON.—Trade name of tubes manufactured by the Radio Corporation of America.

RESISTANCE.—The opposition which a conductor gives to a flow of current.

RESONANCE.—When two or more circuits are in tune.

RHEOSTAT.—An instrument to regulate current flow. Usually used to regulate the temperature of the filaments.

SELECTIVITY.—The ability to tune in stations very near the same wave-lengths without interference with one another.

SENSITIVITY.—The sensitiveness of a set to weak or distant signals.

SHARP TUNING.—Same as SELECTIVITY.

STATIC.—Atmospheric disturbances. A condition we are all familiar with.

TRANSFORMER.—A device to either step-up or step-down current. Usually has two windings, a primary and a secondary. An amplifying transformer connects the plate circuit of one tube to the grid of the next.

VARIO COUPLER.—An instrument with two coils in inductive relation to each other where the coupling is varied by turning one coupling at right angles to the other, instead of nearer or farther as in a loose-coupler.

VARIOMETER.—Two coils wound in opposite directions, located one within the other and connected in series. The value in inductance is varied by turning one coil from parallel to right angles in relation to the other.

VERNIER.—A device that allows very gradual and minute adjustment by gearing. Usually made on dials or condensers. A slight change in adjustment can be made by a full turn of the dial.

WAVE-LENGTH.—The distance in meters between two waves transmitted by the sending station.

WAVE METER.—An instrument for measuring or calibrating wave lengths.