# THE HOME RADIO

## HOW TO MAKE AND USE IT

A. HYATT VERRILL

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*By*

**A. Hyatt Verrill**

Wireless telephony has spread like an epidemic throughout the land. Thousands of men and women, boys and girls, are successfully using wireless-telephone receiving sets. This book should serve as a guide to those contemplating the purchase or use of instruments, and who wish to know how to make, use, or adjust wireless-telephone instruments. The author has avoided technical terms and dissertations, making his explanations direct and simple, illustrated by diagrams. For those who are interested in improving the sets they have or installing more efficient ones, this book will prove invaluable. The possibilities of the radio telephone are tremendous, for it is a subject still in the experimental stage, and it is from amateurs that the greatest inventions and improvements of the future will come, for by experimenting undreamed-of things will be chanced upon.

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REVISED EDITION, INCLUDING
1924 DEVELOPMENTS

By

A. Hyatt Verrill

Harper & Brothers
*Publishers*
New York and London

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# PREFACE

THIS book is not intended as a treatise on radio telephony nor has any attempt been made to enter deeply into an explanation or discussion of the scientific phase of radio transmission. It is intended and designed particularly for the use of amateurs, boys, and those who wish to know how to make, use or adjust wireless telephone instruments and who are not interested in, or do not care to learn, the technicalities of practical electricity as applied to wireless work. A deep or thorough knowledge of the subject is not at all essential in order to secure all the pleasure and benefit to be had from the use of radio telephones, and unless the reader is well versed in a knowledge of the basic principles of electrical mechanics and phenomena, any attempt to explain the whys and wherefores of the subject would merely lead to confusion. As soon as a person once learns something of the mysterious force which renders radio telephony possible there is an overwhelming desire to experiment, and unless one is using radio for the sole purpose of experiment, or else has a good knowledge of the subject, such attempts usually result in complete failure of the instruments. Hence, the author has purposely avoided all technical terms and dissertations on the functions and reasons for various appliances and has aimed merely to make his directions and explanations as short, plain, and simple as possible, with purely diagrammatic figures to illustrate the subjects treated.

The subject of wireless telephony is a very large one and volumes might be and have been written filled with involved and technical explanations, formulæ, etc. These are all very well for the professional or the expert, but the present work is not intended for these, but for the amateur. Today, thousands of men, women and boys, as well as girls, are using wireless telephone receiving sets successfully while thousands more are anxious to do so. Far too many also, are using transmission or sending apparatus, and a very large percentage of all these are interested in improving the sets they have, in installing more efficient sets, in making sets of their own or in similar matters, and it is to fill this want that this book has been written.

Wireless telephony has spread like an epidemic throughout the land and has come upon us, as an every-day diversion, but there are still vast improvements to be made before it will become as wide-spread and as important as telephoning over wires and it is highly probable that many of the greatest inventions and improvements of the future will come from amateurs who, by experimenting, chance upon undreamed of things. There are limits to wireless telephony, however, as we known it at present, and users should not expect too much from it. It is hopeless for a purchaser of a cheap set to get the results that might be reasonably expected from an expensive set, and unfortunately, too many manufacturers, knowing the ignorance of most people on the subject, have taken advantage of this and of the tremendous popularity of radio telephony, to make misleading or false claims for the ready-made sets. It is hoped that this book may serve as something of a guide to those contemplating the purchase or use of instruments, for by learning what types of sets and of appliances are most efficient and the advantages and shortcomings of various types, they will be saved a great deal of disappointment and not a little time and money. Many people are under the impression that wireless telephony is as highly perfected, as useful and as simple as wire telephony, but this is not the case. Unless one uses an expensive set with amplifiers, the sounds from any but nearby stations are faint; they are often interrupted or broken by the interference of other signals, static, etc., and its use is entirely confined to listening-in to broadcasted messages or to communicating with amateurs or friends. The science has not yet reached that stage where one may call up and talk with other people, as over an ordinary telephone, and it will doubtless be a long time before that is possible. Indeed, it is very doubtful if radio telephony will ever supersede wire telephony any more than radio telegraphy has superseded cables or wire telegraphy. There are many reasons for this, among which is the difficulty in preventing anyone and everyone with receivers from listening in.

It is exactly as if all telephones were on the same party line.

To be sure, various appliances have been devised to obviate this, such as coding machines, machines which leave out certain sounds so that messages are unintelligible save to those provided with a synchronized instrument to reproduce the sounds properly, etc. But despite these, there will always be the fact that the air is filled with messages which anyone may pick up, just as any wireless telegraph operator may pick up messages and which has never been obviated, despite the time which has elapsed since wireless became a commercial factor.

But discussions of such matters really belong to a volume of a very different type from this work, which is not in any sense a how or why it works book, but rather, a how to do and make it book. If it serves to enlighten its readers on many points not clear to them, if it enables them to make and install outfits which give pleasure or satisfaction, or if it serves to increase an interest in wireless telephony among beginners and amateurs, its purpose will be amply fulfilled.

# THE HOME RADIO

# CHAPTER I

## THE HOME RADIO:

## HOW TO MAKE AND USE IT

WE usually think of the Great War as a disaster and as having done an incalculable amount of harm to the world and its people, but within the few years it lasted it resulted in immense benefits to mankind in the tremendous discoveries, improvements and advancement of medicine, surgery, chemistry, aeronautics, mechanics, engineering, metallurgy, and wireless communication, and while the toll of life, the destruction of property, the devastation of lands, the loss of art and the bankruptcy of nations are all temporary and will soon be replaced and forgotten, the scientific progress and discoveries, which were a direct result of the war, will endure forever and will continue to benefit mankind.

Of all the arts and sciences which received an unprecedented impetus by the war, none is of greater interest or has a more far-reaching effect to the average person than radio telephony. Before the war, wireless telegraphy was well established, universally used and a fairly exact and well-understood science; but wireless telephony was scarcely more than a dream,—a visionary, uncertain thing; complicated, little understood and literally in its infancy.

But today, so incredibly rapid have been the strides made in the development of this science, that wireless telephony is an every-day affair; a simple, easily understood thing,—far simpler than telegraphy—and in constant use, not only commercially, but by countless thousands of amateurs. In a way, however, the war merely launched practical radio telephony on its career and far greater progress has been made in commercializing, simplifying and cheapening it within the past two years than within the previous six years. Indeed, so rapid has been its advancement, that it seems to have come upon us almost overnight, and within a few years it has leaped from an obscure, scientific curiosity to an almost universally-used means of entertainment and profit.

Today, thousands of mere boys are

using wireless telephones,—many of the instruments made by the boys themselves, —and in department stores, electrical supply stores and elsewhere, sets for receiving may be purchased for a few dollars. From various stations, music, crop reports, market reports, weather reports, speeches, songs, operas, plays, stories, official time, racing, and baseball returns; shipping news and countless other interesting matters are sent broadcast through the air, free to anyone who possesses a wireless telephone receiving set. Thus, the farmer, miles from the nearest town, the sailors at sea, passengers on ships, guests in hotels, crowds about bulletin boards and people in their own homes can listen to the voices of famous men, the music of bands and orchestras, the singing of famous operatic stars, the dialogues of plays and countless other things, from far-distant points and as clearly and plainly as though no space intervened.

Truly, radio telephony is the great modern miracle; a dream more fantastic and fairy-like than the *Arabian Nights;* a more marvelous actuality than the fabulous lamp of Aladdin or the flying carpet, and, best of all, it is within the reach of everyone, while the "music in the air" is free to all who care to listen in.

It is certainly a strange, almost incredible thing to think that the air about us, even within our dwellings, is constantly filled with voices, music, messages and songs which are as inaudible as they are invisible, but which may be caught and delivered to our ears by means of a few wires and batteries and a few appliances so simple that even a child may use them.

And the limit is far from being reached. Within a few years, or even months, the range of wireless telephony will be increased by hundreds or even thousands of miles, antennae or aerials will be entirely done away with and the instruments for sending and receiving will be so improved, simplified and reduced that one may carry them in one's pocket, for while radio telephony has already become highly perfected, widely used and absolutely practical, yet it is still hardly out of its infancy and no man may prophesy what its future may be.

# CHAPTER II

## PRINCIPLES OF WIRELESS TELEPHONY

Before attempting to explain the functions and the 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 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 remains, 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 I will try to explain in the next chapter how we may actually see and feel by radio.

# CHAPTER III

## SEEING AND FEELING BY RADIO

### HEAT, LIGHT, AND RADIO WAVES

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 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 .000.000,000,000,05 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 impressions 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 shorest 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 incandes-

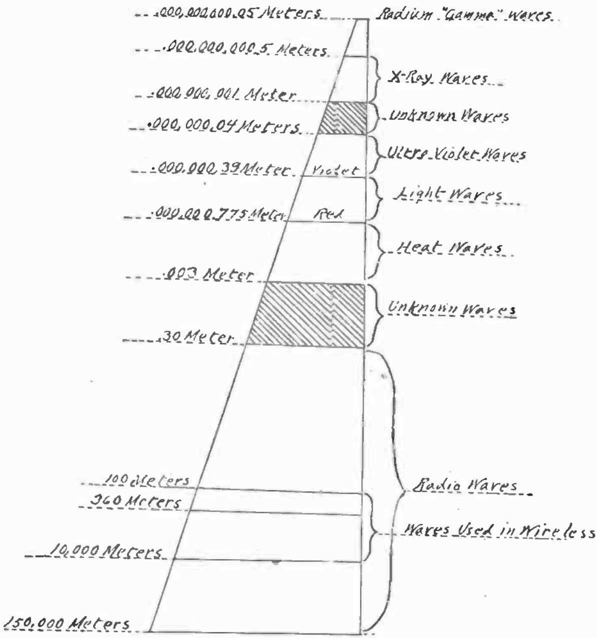



Chart Showing Relative Wave Lengths

cent 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 IV

## WIRELESS WAVES AND HOW THEY CARRY SOUND

(Figs. 1-7)

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. I 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

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

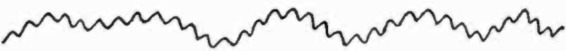


Fig. 6

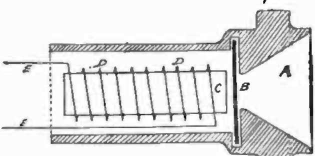



Fig. 7B

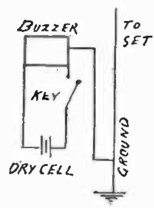



Fig. 8

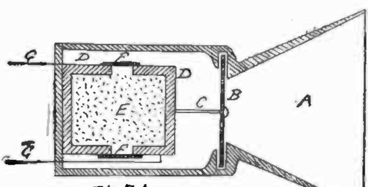



Fig 7A

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 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 receptacle (*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 daphragm 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 V

## THE ALADDIN'S LAMP OF RADIO

(Fig. 29)

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 I 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 (*Fig. 29*) 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 VI

## THE SIMPLICITY OF RADIO

Now that I have given an outline of the underlying principles of radio and have explained why certain instruments—such as the detector and phones—are required, I 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.

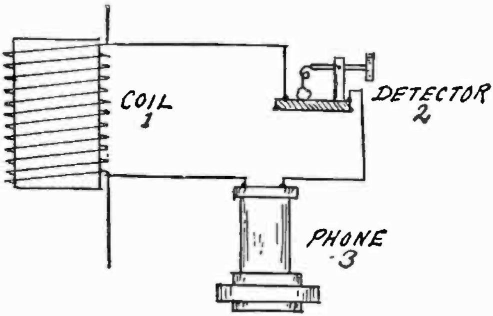
The six instruments or devices, whichever you prefer to call them, used in modern radio are: *tuning coils, condensers, crystal detectors, vacuum tubes* (or *Audion bulbs*), *rheostats, telephones,* while the additional three instruments, used only in sending, are: *transformers, transmitters* (or *microphones*)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

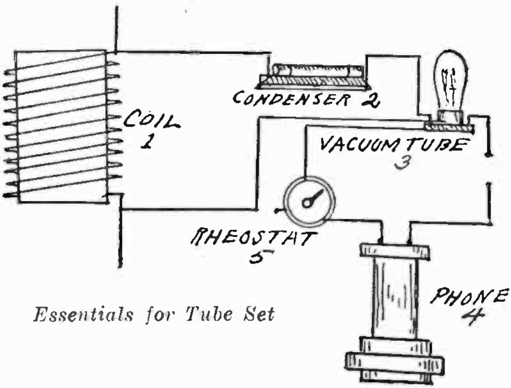
The tuning coil, which may be of any

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 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




*Essential Instrument for Crystal Set*




*Essentials for Tube Set*

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.

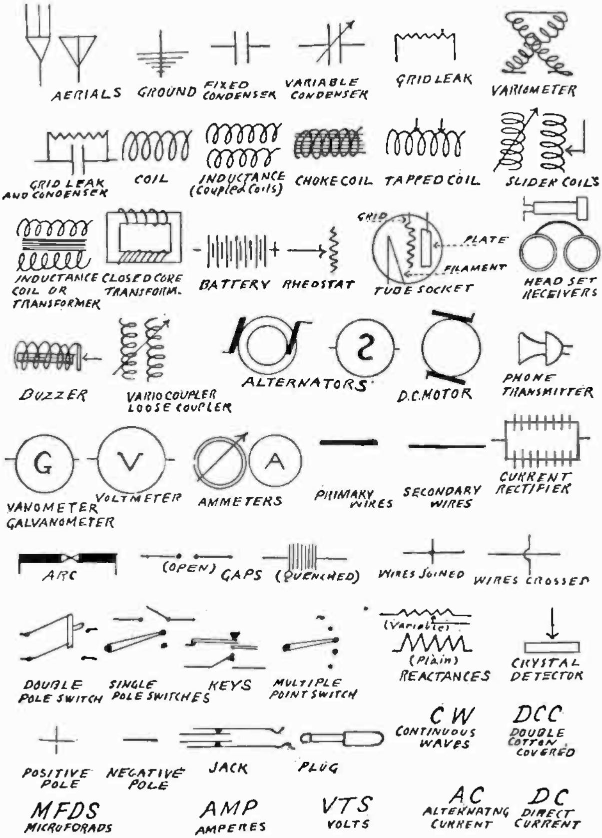
So, you see, after all, the marvelous wireless telephone is really a most simple affair, and there is nothing complicated or mysterious about it. Indeed, I think the simplicity of radio is really the most remarkable, the most mysterious, and the most amazing thing of all.

# CHAPTER VII

## DIAGRAMS AND HOW TO READ THEM

Before proceeding to explain the operation and construction of sets and the purposes and principles of the various units or instruments, 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




*Symbols used in diagrams*

telephony should learn them. In the accompanying cut, the commoner symbols used in diagrams of wireless apparatus are shown and anyone 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.

# CHAPTER VIII

## 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 wires where they cannot be soldered; in making temporary joints or connections; in covering coils or holding the wires on coils 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 me 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 IX

## AERIALS AND HOW TO INSTALL THEM

(Figs 9-15, 18-21)

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, or even with a bedstead or wire springs as an 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 first showing the wire attached to a chimney or similar structure and to a wall; the

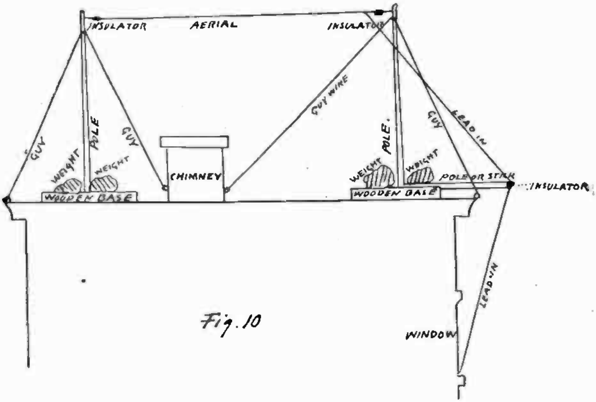
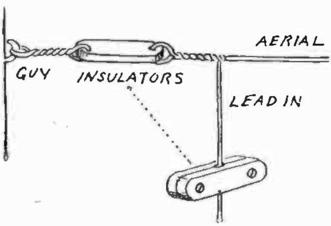

INSULATOR
AERIAL
INSULATOR
GUY
POLE
GUY
WEIGHT
WEIGHT
WOODEN BASE
CHIMNEY
GUY WIRE
POLE.
GUY
LEAD IN
WEIGHT
WEIGHT
POLE OR STICK
INSULATOR
WOODEN BASE
LEAD IN
WINDOW

Fig. 10


AERIAL
GUY
INSULATORS
LEAD IN

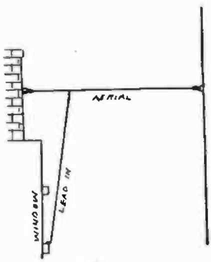

AERIAL
LEAD IN
WINDOW

Fig. 9

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, the other, 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 it should be of *rubber insulated wire* and 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,* finally being 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 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 connected by means of an *anchor-ring*, *Fig. 15*, to equalize the waves or currents, or they 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.

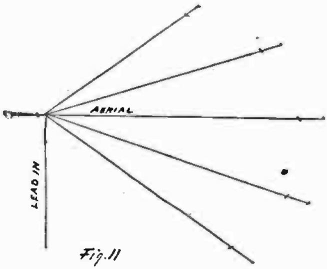



Fig. 11

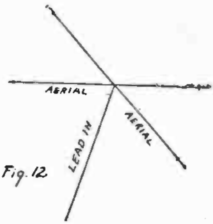



Fig. 12

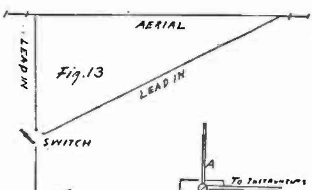



Fig. 13

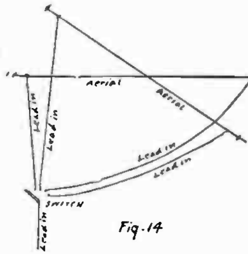



Fig. 14

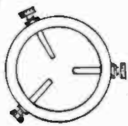


Fig. 15

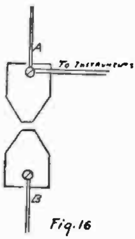



Fig. 16

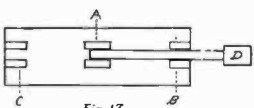



Fig. 17

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. I 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. On the other hand, many amateurs have obtained splendid results with a wire run around the walls of a room near the ceiling; a wire run through a hallway; a wire dropped down an air-shaft or elevator-shaft, or even from an iron bedstead or bed-spring. 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

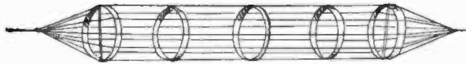


Fig. 18

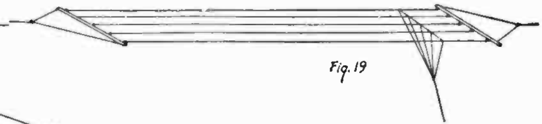


Fig. 19

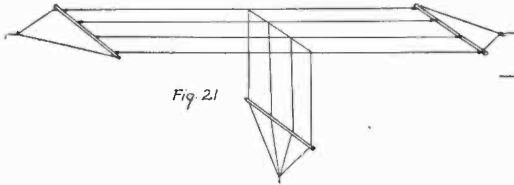


Fig. 21

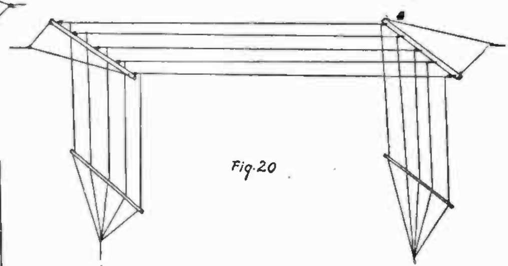


Fig. 20

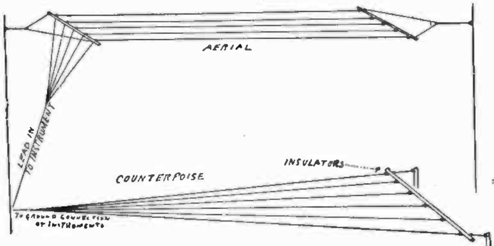
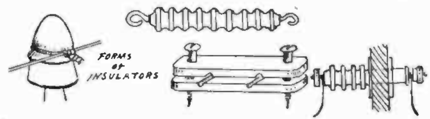



Fig. 22



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.

# CHAPTER X

## AIR GAPS AND LIGHTNING SWITCHES

(Figs. 16-17)

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, and steel buildings, such as the New York skyscrapers, 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. 17* (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.

Aerials for sending or transmission stations are very different from those used for receiving only and should be of several wires. The most efficient is probably the *"cage"* type shown in *Fig. 18,* but any of the others illustrated in *Figs. 19, 20* and *21* will answer. These should, of course, be fully insulated and the various methods of doing this are well shown in the figures and require no explanation. To install sending stations a license is required, whereas to receive, no license is needed.

# CHAPTER XI

## COUNTERPOISE AND ITS USE

(Fig. 22)

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 fan-wise 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 (*Fig. 22*), 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 XII

## CONDENSERS

(Figs. 23-27)

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* and *variable condensers,* 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 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. The simplest form of fixed condenser consists of a number of alternating sheets of tin-foil and waxed paper or mica, the alternate sheets of foil being connected by wires which are in turn connected with the terminals where required.

To make a *fixed condenser* it is only necessary to lay sheets of tin-foil between sheets of waxed paper and connect them. A very efficient little fixed condenser, to be used by shunting across the receivers of a small set, or as a grid-condenser with a vacuum tube set, can be made as shown in *Fig. 23.* Have some smooth tin-foil, free from holes or tears, and cut two pieces about one inch in length and one-half an inch wide. Then, from thoroughly waxed paper—which can be purchased or can be made by soaking good quality writing paper in melted paraffine wax—cut three pieces five inches in length and three inches wide. On one of these pieces place a piece of the foil; then cover this with a second strip of paper, place the other strip of foil over this and cover with the last strip of paper. Be very sure that the edges of the tin-foil are well within the margins of paper and are accurately in line or centered. In fact, before placing them, it is wise to draw a square the size of the foil on each piece of paper, spacing it equidistant from edges, and arrange the foil to fit this, *Fig. 24.* Next, cut two pieces of light wire five or six inches long (flexible stranded wire is best), spread the strands at one end of each piece apart and place one of these frayed and spread ends on the lowest piece of foil between it and the bottom paper. Next, place the other, frayed and spread the same way, on the upper piece of foil at the opposite end and with a few drops of hot paraffine fix them in place on the edges of the paper. Then, roll the whole, being careful not to displace the foil (this may be secured to each piece of paper with a few drops of paraffine at the edges) and form a small cylinder,

*Fig. 25.* Wind the cylinder tightly with fine thread at each end, as shown, or wrap with adhesive tape and dip the whole into hot paraffine. In using this condenser with a crystal set it is only necessary to shunt, or connect it, across your phone receiver wires, but if using it in a vacuum tube set you must use a *grid-leak* shunted across it. This is merely a piece of cardboard placed between two binding-posts or terminals and with several soft lead-pencil lines drawn across it from post to post. In order to be sure that a good connection is made, draw pencil marks about the holes where posts are to be inserted. The distance between posts should be not over five-eighths of an inch. Sometimes drawing ink (made of carbon, for writing ink will not serve) is used in place of lead pencil, but the latter has the advantage that the lines can be varied or adjusted to give best results by means of an eraser.

VARIABLE CONDENSERS are much more difficult to make and while any ingenious boy *can* make them, it is usually cheaper to purchase them ready made. There are two common forms, one known as the *sliding plate, Fig. 26,* the other as the *rotary, Fig. 27.* The former consists of a number of metal plates, which slide back and forth in a frame, case or box provided with grooves and fixed plates. The rotary type consists of a number of semicircular plates of metal so arranged as to rotate or swing past a series of fixed discs. In each form, the air spaces between the plates correspond to the waxed paper between the strips of foil on the fixed condensers. By means of either of these two variable forms, fine adjustment of capacity may be obtained. Many people cannot understand the function of a condenser, but, broadly speaking, it is to store up electrical energy and then suddenly release it, as the current passing through is interrupted, varied or broken, or, in other words, to increase the intensity of the oscillations.

It may be even more plainly understood if we compare its operation to a receptacle filled with liquid, for condensers are really misnamed and might be more properly called accumulators or reservoirs. If we have a vessel with an opening on one side to which an elastic bulb of rubber attached (*Fig. 27, A D*) we may compare the vessel to an electrical circuit, the liquid contents (*A*) representing the electrical current. If we then assume that the rubber bulb would stretch with the pressure of the liquid when it reached the level *B*, we will understand that any additional liquid poured into the receptacle would cause the bulb to stretch more and more until it had reached its limit and nearly twice as much liquid had been placed in the receptacle than it could contain without the bulb, or as shown in *Fig. 27, B*. Then, if the liquid were drawn off through the orifice *C*, and the pressure were released, the bulb would contract and force the liquid it contained into the receptacle *A*. Thus the bulb increases the capacity of the receptacle, and the condenser increases the capacity of the electrical circuit, and like the bulb adds the electricity it has accumulated to the whole as the current decreases, thus producing a steady flow of electrical energy.

Although most small sets will operate with a fixed condenser and a variable one


Fig. 23

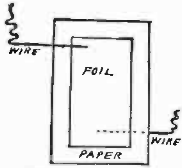



Fig. 24

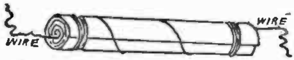



Fig. 25

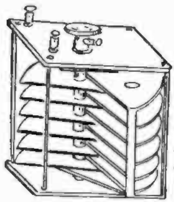


Fig. 27

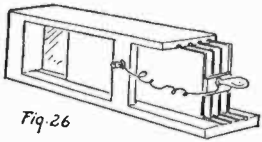


Fig. 26

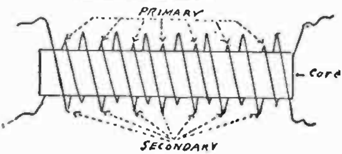



Fig. 28A

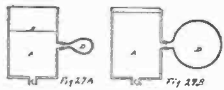


Fig 27A Fig 27B

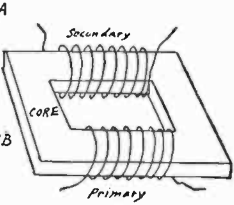
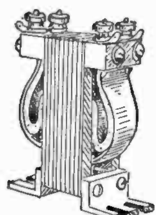



Fig. 28B



AMPLIFYING TRANSFORMER
Fig. 28C

is not necessary, yet the variable type will always improve the receiver and will permit much finer tuning than a tuning coil of any type by itself.

# CHAPTER XIII

## TRANSFORMERS

(Figs. 28 A, B, C)

These 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 transformer"* 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. 28, 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. 28, B.* Although either one of these types may be made at home, yet it is not advisable to attempt it. In the first place, several thousand turns of secondary wire are required and it is a tedious and difficult matter to wind these on evenly and well. Moreover, the number of turns of primary and secondary wire must be very carefully proportioned and must be actance. Finally, transformers are not expensive and the cheapest and are far more efficient than anything you can make. There is another type of transformers which are of two kinds, "radio frequency transformers" and "audio frequency transformers." The function and purpose of both forms are to build up or increase the currents passing through them, the radio frequency transformer 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 possed 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.

## CHAPTER XIV

### INDUCTANCES AND TUNING COILS

(Figs. 30-36)

In order to receive and hear sounds sent from transmitting stations by radiophones 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. Of these, all but the variable condensers (which see) are coils of various types, the simplest, but by no means the most efficient, being the simple tuning-coils. These consist of a coil of bare wire wound about a core or cylinder of wood, fiber or pasteboard and provided with sliding contacts as shown in *Fig. 30,* in which *A* is the coil, *B,* the slide rod and *C,* the slider.

By moving the slider from coil to coil of the wire the wave length of the receiving instruments may be adjusted to catch the desired sounds of that wave length. Such coils are very easily made by winding a pasteboard tube—which should be soaked in melted paraffine to render it waterproof—with bare copper wire about No. 18, making about forty turns and leaving a space of about a sixteenth of an inch between the turns. If two or more sliders or contacts are arranged still finer adjustment will be attainable while, by providing rotary switches with five contacts as shown in *Fig. 31,* still better results will be secured. Although, as stated, these coils are easily made, yet they are so cheap that many prefer to purchase them ready-made rather than bother making them. Simple coils or inductances, however, are even simpler, as they consist merely of a few turns of insulated copper wire wound on a pasteboard tube, the number of turns depending upon the wave lengths to be received. In some sets there is but one coil or helix, *Fig. 32,* while in other sets there are two, a primary and secondary, ***Fig. 33,*** and as a rule the coil should be *tapped* and the circuit connected at the *tap-off*, ***Fig. 34.*** This is best done by taking a loop or twist in the wire at the desired point and then continuing winding as in ***Fig. 35.*** Of course, in making the connection at this tap-off the wire should be scraped free of insulation to make the joint, after which it should be wrapped with adhesive tape. In making these simple inductance coils it is best to put on more turns of wire than you think is actually required, as it is far easier to remove one turn at a time, until the desired wave length is obtained, than it is to add turns after the instruments are set up. Similar simple coils are used in many parts of receiving sets, such as the radio-choke in ***Fig. 59, L,*** etc.

By making several tap-offs and then leading them to the various contacts of a multiple-point switch, ***Fig. 36, C,*** excellent results may be obtained especially with the smaller crystal sets with a single simple coil. Another way by which waves of varying lengths may be received by means of simple coils without

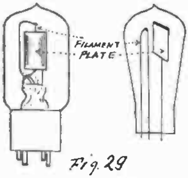



Fig. 29

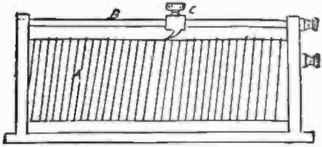



Fig. 30

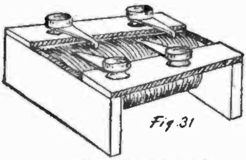


Fig. 31

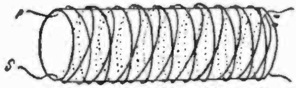



Fig. 33

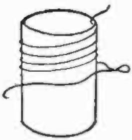


Fig. 34

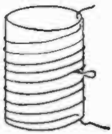


Fig. 35

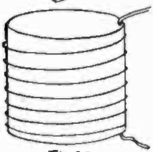


Fig. 32

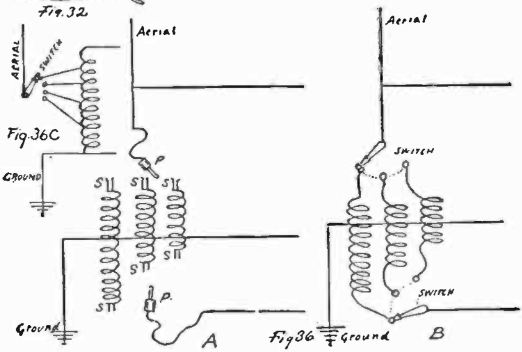



Fig 36

tuning devices, is to have several coils of various sizes so arranged that they may be connected or disconnected with your set at will. This may be done, either by means of plugs and sockets as in ***Fig. 36, A,*** or by switches with several contacts as shown in ***Fig. 36, B.*** Still finer adjustment may be obtained by providing each coil with a slider or similar tuning device. This will give a wide range of wave lengths and will obviate all need of taking turns off the coils and as such coils are very easy to make you can have as many as you desire of different sizes.

Another very different type of *inductance-coil* consists of two windings, known as *primary* and *secondary,* and are similar to the ordinary sparking coils used in older type automobiles, in power boats, etc. These are known also as *transformers* (which see) and while they *can* be made at home yet it is a tedious and difficult job to wind on the hundreds of turns of wire properly, and as such coils are inexpensive it is never advisable to attempt it, unless you wish to make everything yourself, just for the practice and fun of it. Coils of this type may be purchased which are made especially for radio use, but an ordinary *spark-coil* with the *contact-breaker* screwed or fastened down will answer every purpose. The same type of coil, using only the secondary winding, may be successfully employed as a *choke-coil,* as shown in ***Fig. 60, N.***

# CHAPTER XV

## VARIO-COUPLERS AND VARIOMETERS

(Figs. 37-42)

VARIO-COUPLERS may also be home-made if desired, but they are seldom very efficient and as they are very low in price it is scarcely worth while to attempt their manufacture. These consist of two coils, one rotating within the other. If desired to make a *vario-coupler* you will require a cardboard tube or a fiber tube about four and one-half inches in diameter and five inches long. A rotor form that may be purchased for a dollar or so. A quantity of No. 26 and No. 28 B. & S. gauge, double cotton covered magnet wire and some No. 20 of the same type wire. You will also require a brass shaft or rod a quarter of an inch in diameter, a dial, knobs, switch, a panel of fiber or bakelite about three-sixteenths inch thick and six inches square and a wooden or fiber base half an inch thick and six inches square, besides screws, odds and ends, etc. The cardboard tube and rotor-form are preferably soaked in paraffine but this is not essential. Begin winding the cardboard tube, starting half an inch from one end through a small hole, as shown, and wind on thirty-eight turns of the No. 26 wire, keeping the turns close together but not touching. Then, bring the wire across the tube as shown in ***Fig. 37,*** leaving a space of one inch bare and continue to wind on another thirty turns of wire. In winding, take off three taps from each section, one at every twelve turns, beginning at second turn from top and leaving two turns at bottom of winding as shown in ***Fig. 37, T, T, T,*** finally passing the end through a hole as shown. The whole should then be covered with paraffine, or it may be shellacked, although shellac will decrease its efficiency and paraffine will serve every purpose. In the center, at the bare space which has been left, a quarter-inch hole should be bored as shown in the cut. The next step is to wind the rotor form, which is done by winding on twenty-five turns of No. 20 wire (starting through a fine hole as shown) which forms the *"tickler" coil, Fig. 38, A,* and leaving the two ends of the wire about six inches long and running the last end through a hole to hold it. Then, at the other end of the rotor, wind on forty-two turns of No. 28 wire to form the secondary *Fig. 38, B,* and leaving free ends of wire about six inches long. Through the center of the rotor-form, a hole should be bored a quarter inch in diameter, as shown. Like the other coil, the rotor may be coated with paraffine or shellac, the former being preferable, and the ends of the coils may be first fastened by glue or sealing wax, to prevent loosening or unwinding.

The next step is to mount the coupler, which is done as follows: In the fiber panel bore a quarter-inch hole two inches from the top and three and a quarter inches from one side, *Fig. 39.* In the lower corner, place a switch with six contact points (*A*), and on the right hand side drill six three-sixteenth-inch holes for binding posts (*B*). Then make and place the shaft in the rotor, securing it by glue, sealing wax or by means of nuts, according to your mechanical ability, and attach the two parts to the panel, fitting a dial and knob to shaft and mounting the panel on the base. In connecting up, the primary, secondary and tickler wires are connected to the six binding posts and the six tap-offs on the primary coil are connected to the switch contacts as shown in the cut, with one of the primary wires in the switch post. Then, when the coupler is to be set up, the aerial is connected to one of the primary posts, the ground to the other, the secondary posts are connected with the grid circuit and the tickler posts to the plate and receiver circuits, all of which is shown in the diagram *Fig. 40.*

A *variometer* may be made in a very similar manner, using two cardboard tubes, one about four inches in diameter and three inches long; the other three inches long and about three and three-quarters inches in diameter. The dimensions should be such that the small tube can turn freely, without touching, within the larger tube and the smaller the space between the two the better; but you must remember to allow for the thickness of the wire to be wound upon the inner tube. First, measure carefully the exact centers, so that when a shaft fastened to the inner tube or rotor is passed through the larger tube, the inner one will rotate freely and evenly without touching the outer tube. The entire efficiency of the variometer depends very largely upon the accuracy with which this is done. Starting with a small hole about a quarter inch from the outer edge of the smaller tube, wind on about twenty turns of No. 24 double-coated, cotton-insulated copper wire, being careful to keep the turns separated. Then skip a space of about an inch, as shown in *Fig. 41,* and wind on another twenty turns, finally running the wire through a hole, fastening both ends with a drop of glue or sealing wax and leaving five or six inches of free wire at each end. Starting the same way, wind the larger tube in exactly the same manner and being sure to wind in the same direction. When all are wound, mount the smaller tube on a shaft inside of the larger tube, fastening shaft by glue or sealing wax dropped on from inside, and mount as shown in *Fig. 42.* Finally, connect one end of the stator wire to one end of the rotor wire, leaving plenty of free wire to allow rotor to revolve, and lead the other two ends to binding posts, as shown, being sure to keep that to the rotor loose to allow free movement. The shaft to rotor should be equipped with knob and dial as shown in the cut and the whole mounted on a fiber or bakelite panel on a proper base. Do *not* shellac coils after winding as this will impair efficiency. If the winding has been properly done and the ends of wires fastened at holes by glue or sealing wax, there will be little danger of their becoming loose, but to further safeguard it, the coils may be covered with paraffine wax if desired. You must not expect this variometer to work as well as those purchased ready-made, for the efficiency of an instrument of this type depends upon the distance between rotor and stator, the least distance the better, but it will serve and will do very well for experimental use.

# CHAPTER XVI

## 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, or even a metal bedstead or bed-spring, 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 and is used on most of the cheap, ready-made sets; but it has limitations and is not nearly as satisfactory in many ways as the vacuum tube, as will be explained later. The third suit 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 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, *Fig. 44,* although in some types two crystals are used to make contact with each other. To adjust the *crystal detector* the movable contact must be shifted about over the crystal until a sensitive spot is found, which is easily determined by the strength or loudness of the sounds carried to your ears by the receiver. The *tuner* is very easy to adjust as it is provided with a knob or handle, and by turning this slightly until the sounds come clear and uninterrupted, all other sounds or waves are cut out. Then, by marking the handle, you can always pick up the same station by placing the tuner at the same point.

These *crystal detector* sets, however, have several *disadvantages.* In the first place, their range is limited to a comparatively short distance, depending largely upon the length and height of the aerial. In the second place, it is practically impossible to tune out interference from nearby stations. In the third place, the least jar or vibration will disturb the point of contact on the crystal and a new adjustment will have to be made. It should also be borne in mind that a *buzzer*—which may be bought ready-made or may be made by removing the gong from an electric bell—is a very useful instrument for adjusting a crystal detector. The buzzer may be operated by a single dry battery cell and as the spark at the contact maker of the bell or buzzer sends out electrical waves which will affect the detector, it is very easy to select the most sensitive spot on the crystal by this means. It should be connected as shown in *Fig. 8*.

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 necessery 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 for half a minute or so, they will come back in 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 knob 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 fine 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 knobs marked you will save a vast amount of trouble and time.

# CHAPTER XVII

## A SIMPLE CRYSTAL DETECTOR RECEIVING SET

### (Figs. 43-43, A, B, C, D)

THE accompanying diagram, *Fig. 43,* shows a very simple and effective little set which, under favorable conditions and with a good aerial, will pick up the broadcasted music, signals and other sounds from stations at considerable distances. No specific range for this or any other set can be given, for the efficiency of any set depends upon a great many conditions and influences. The length and height of aerials, the proximity of high buildings, electrically charged cables or wires, the perfection of insulation of aerial, adjustment of instruments; all affect the range of a receiving set and, in addition, there are climatic and other conditions to be taken into consideration. Moreover, similar instruments under similar conditions vary immensely and for no known reason according to locality, and an instrument which picks up sounds from a certain station in one section of a city may fail utterly if installed a few blocks distant. As a rule, however, instruments in outlying country districts have a greater range and receive messages more clearly than those in cities, even though the latter may be much nearer the sending station.

In the accompanying diagram *A* represents the aerial, which should be a single wire as nearly 150 feet in length as possible and as high as it can be placed. *B* is the ground which should be made by scraping a spot on a water or radiator pipe and soldering the wire in place. *C* is a condenser and for this set should be about .0005 microfarads. *D* is the crystal detector, *E* the telephone head set and *F* a single slide coil or a tapped coil as preferred.

The condenser and coil may be purchased ready-made from any dealer in radio supplies and while they may be made at home yet it is far more satisfactory and just about as cheap to purchase

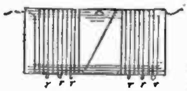


Fig 37

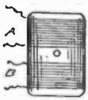



Fig. 38

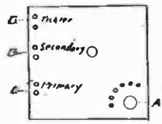



Fig 39

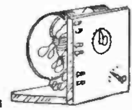


Fig 40

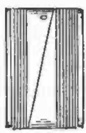


Fig. 41

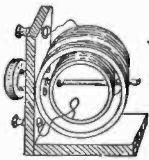


Fig. 42

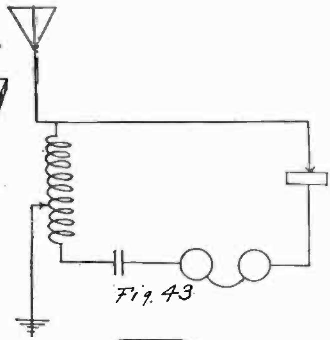


Fig. 43

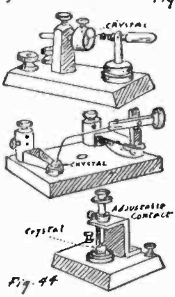



Fig. 44

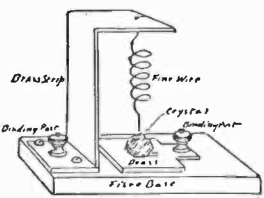



Fig. 45

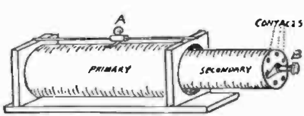



Fig. 46

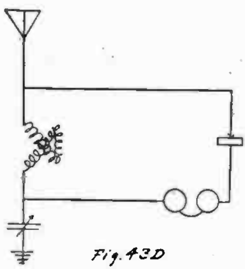


Fig. 43D

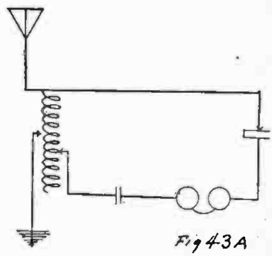


Fig 43A

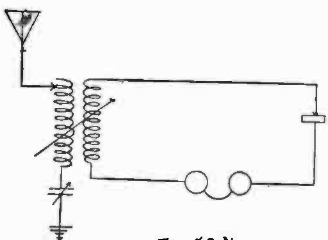


Fig. 43C

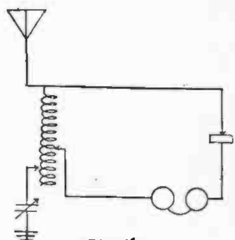


Fig 43B

the stock instruments. The same is true of the crystal detector and head set. You should, however, be careful in selecting the galena crystal to be used with such an outfit as this mineral varies greatly in its sensitiveness. The best plan is to purchase a pound or two of the crystals and test a number of pieces by means of a buzzer. You will probably find that while some crystals are absolutely useless others are fair and a few are very sensitive.

Other equally simple and effective crystal sets are shown in *Figs. 43, A, 43, B, 43, C, 43, D*. *Fig. 43, A* is a set with a double slide coil; *Fig. 43, B* is the same with a variable condenser added in place of the fixed condenser; *Fig. 43, C* has a loose-coupled coil, or vario-coupler, in place of a slide coil, and *Fig. 43, D* has a variometer in place of a tuning coil.

To make up such sets is very simple, as the various parts are merely connected with insulated copper wire or by means of "buss bars" as indicated, using binding-posts which may be purchased for a few cents. The whole may be mounted on a piece of fiber board, bakelite or a wooden panel, or it may be enclosed in a neat case or cabinet. But for best results, when the set is connected to suit you, be sure to solder all connections.

# CHAPTER XVIII

## CRYSTAL DETECTORS AND HOW TO MAKE ONE

The crystal detectors used in sets such as described are of various forms, *Fig. 44,* but in all, the principle is the same and they all consist of a crystal cup or holder, binding-screws and an adjustable contact of fine wire. They are not expensive instruments and it is usually easier and cheaper to purchase them ready made than to make them, but they are very easy to construct and any boy can make a practical detector in a few hours. One of the simplest is shown in *Fig. 45,* and consists merely of a fiber base; a strip of brass about one sixteenth or one-eighth inch thick bent in the form shown; a brass plate which can be moved from side to side on a pivot, to hold the crystal; a fine coiled wire and binding-posts. The plate holding the crystal is connected with one post and the brass strip holding the wire to the other post. If possible, use platinum wire for the contact, but this is not essential.

# CHAPTER XIX

## THE SIMPLEST VACUUM TUBE SET

(Fig. 54)

Even the simplest and cheapest tube set is so superior to the very best crystal sets that it is the ambition of every radio-user to have one. Formerly, the expense of the tubes, and the fact that costly and troublesome storage batteries were required to operate them, prevented many beginners from possessing or constructing tube sets. But today, with cheap but highly efficient tubes which may be operated by ordinary inexpensive dry batteries, there is no reason why every radio fan should not have a good tube set. In fact, it is so easy to build these, and the cost is so slightly in excess of a crystal set, that it is hardly worth while to bother with crystal sets at all.

It is impossible to say which is the very simplest tube set, but the one shown in ***Fig. 54*** is as simple as any and is very efficient. In the diagram the entire arrangement of wires and parts is so clearly shown that no explanation is really necessary if you have learned to read diagrams and understand the various symbols as illustrated in one of the preceding chapters. This set contains but six instruments, and all but the phones, tube, rheostat, and variable condenser are easily made at home if you prefer to build them rather than purchase them ready-made. Moreover, it has the advantage of requiring but three adjustments—the variable condenser, coil and rheostat. The coil consists of a tube about three inches in diameter and two inches long wound with about forty-five to fifty turns of No. 26 double cotton-covered copper wire, with a tap taken off at the tenth, twentieth and thirtieth turns and led to the contact points of a four-point switch as shown. In wiring and setting up the set be careful to follow the diagram exactly, and be sure to have the positive pole of the B battery marked "X" or "P" connected with the plate of the tube socket, and the negative marked "—" or "N" connected to the phone circuit. Also, remember and connect the positive pole of the A battery to the rheostat and the negative pole to the ground circuit.

### A TUBE SET WITH SLIDING COIL

Another very simple vacuum-tube set is shown in *Fig. 54, A.* This is very similar to the above, but has a coil with slider substituted for the tapped coil, the wiring being slightly changed to suit. The only advantage this has over the last is that it may be tuned more closely.

In both these sets it is best to use a variable grid-leak with a fixed condenser of about .001 mfd. capacity and a variable condenser of from .0003 to .0007 fds. In operating these sets, first bring the tube filament to a dull red glow—the less current you can use the better—and then tune in by moving the slider on the coil, or the switch until you pick up the signals, finally tuning to the best results by slowly moving the dial of the fixed condenser, and possibly altering the rheostat adjustment until squeals and howls disappear. Once you have adjusted to the best results for a certain station, the knobs or dials should be marked and thus the tuning simplified next time you wish to listen in.

## CHAPTER XX

### TUBE SETS WITH VARIOMETERS

(Fig. 60)

By using variometers in the circuits between the coil and grid, between the plate and battery or in both locations, as shown in *Fig. 60,* very much better results may be obtained than with either of the foregoing sets.

In this set the coil is replaced by a vario-coupler (*B*, *E*) and excellent selectivity, or the ability to tune out waves that are not desired, is obtained. The only objection to this hook-up is that there are several adjustments to be made in tuning, as there are the four dials—vario-coupler, variable condenser and two variometers to look after, in addition to the rheostat. In a little time, however, you will be able to set the various knobs or dials so that all tuning may be done on one or two.

In making this set it is not advisable to attempt to make either the vario-coupler or the variometers, for while these instruments look simple and while they *can* be made at home, yet for really satisfactory results they must be most accurately and carefully made by means of specially designed tools and expert labor, and, moreover, home-made affairs cost almost as much as good instruments bought ready-made. Also, when purchasing these, select instruments in which the coils are not varnished or shellacked, as such coverings invariably decrease the efficiency of a coil. The other parts required, aside from ordinary insulated electric bell wire, binding posts and a panel or base, are: the *vacuum bulb, or tube detector;* the *socket for the tube;* a *grid-leak and condenser* (which you can readily make yourself if desired); the *rheostat,* a *variable condenser of .0005 mfd.;* the *six volt storage battery; B-battery* and a pair of *2,000-ohm receivers.*

By studying the diagram, you will easily see how the set should be arranged and hooked up, but if you desire, the wires may be altered to run at other angles or directions, the main thing being to keep them as short and direct as possible and to avoid running them parallel or crossing them. The *aerial* (*A*) is led in and connected to the primary of the *vario-coupler* (*B*), the other terminal of the *vario-coupler* being connected with the *variable-condenser* (*C*), and the latter being connected with the *ground-wire* (*D*). From the *secondary coil* of the *vario-coupler* (*E*), one wire is led to the *phone* or *receivers* (*F*), a connection being made at *G*, with the *storage battery* (*H*) and the *rheostat* (*I*). The other wire from *E*, is led to the *grid-variometer* (*J*), thence to the *grid-leak and condenser* (*K*), then to the *vacuum-tube grid* (*L*). The *plate-connection* of the *tube* (*M*), is wired to the *plate-variometer* (*N*), and from here the wire runs to the *B-Battery* (*O*), the other terminal of which leads to the *phone-receivers* (*F*).

Although in the diagram the variable condenser is shown in the ground circuit (*C*), it may be placed in the aerial circuit with good results, and at times it will be found to work better when thus used. It is a very simple matter to try it in both positions before making final connections and use the one that gives the most satisfactory results.

The whole set, when connected and mounted on a neat bakelite or fiber base, should be inclosed in a neat case with a hinged cover, in order to protect the instruments from dust and disturbance and yet allow inspection or adjustment. Of course the adjusting or tuning knobs and the outside connections for aerial, ground and batteries should be led through the case or box to binding posts on the exterior. If the whole set is arranged compactly and neatly and you make an attractive, well-finished case, the set will be the equal in appearance, as well as in efficiency, of any ready-made set costing several times as much.

# CHAPTER XXI

## ULTRA AUDION SET

(Fig. 61)

An even better set, as it is far easier to tune, is shown in *Fig. 61*. In this set the variometer (*V*), is used in place of a coil or vario-coupler and the tuning knobs or dials are reduced to two, the variable condenser and variometer. The variable condenser (*C*), should be one of forty-three plates for best results.

If preferred, the same hook-up may be used with a tapped coil substituted for the variometer and with a grid-leak connected between the filament and grid circuit as shown in *Fig. 61, A*. If this arrangement is used the coil should be wound with about sixty turns of No. 20 or 22 double cotton-covered copper wire and tapped every eight turns for six taps, and then every two turns for six taps. The aerial is connected to a switch arm with contact for the eight-turn taps and the ground to a switch arm with contacts for the two-turn taps. It is seldom necessary, after the first adjustment, to use the eight-turn switch unless tuning to stations of great variations in wave lengths. This set, if well made, should bring in signals for several hundred miles under favorable conditions.

All of the foregoing are, however, single-circuit sets and have several objectionable features. They are not extremely sensitive or selective, their range of reception is not very great, and if not very carefully adjusted they will oscillate and send out waves which will prove most annoying to near-by receiving sets.

Double- or triple-circuit sets as far superior in every way, and while they appear more complicated at first sight they are really just as simple to construct and in results are as much superior to the single-circuit sets as the latter are to crystal sets.

# CHAPTER XXII

## A SIMPLE DOUBLE CIRCUIT SET

(Fig. 62)

In this set, *Fig. 62,* the tuning devices consist of a vario-coupler (*A*) and a variable condenser of .0005 mfds. capacity (*B*), thus having but two tuning controls, or knobs, aside from the rheostat (*C*). The fixed condenser in the ground circuit (*D*) should be of about .001 mfd., and that in the grid circuit with lead (*E*) should be about .00025 mfds.

## ANOTHER DOUBLE CIRCUIT SET

(Fig. 63)

This is an even better set, and under favorable conditions and if well made, will bring in broadcasted music for well over one thousand miles and at times much farther, and will be found exceedingly selective, delicate and loud. The tuning coil (*A*) is a vario-coupler, and this with the variable condenser of .0005 mfs. (*B*), and that of .001 mfd. (*D*), are the only tuning controls, aside from the rheostat (*C*). The grid-leak and condenser (*E*) should be of 2 megs and .00025 mfds., and the fixed condenser in the ground circuit should be about .0015 or .002 mfds. In using this set, place the rotor of the vario-coupler at an angle of about forty-five degrees and tune with both condensers together and adjust the grid-leak if necessary until the set begins to oscillate with a low rumble and *not* a whistle or squeal. Then a slight turn of the twenty-three plate condenser (*B*) will tune out all undesirable sounds and bring the signals in sharp and loud. This set may be used successfully *without* either ground or aerial connections, or with either one alone, or with a wire around a room for aerial, or a bed spring. But of course under such conditions its range is not so great.

# CHAPTER XXIII

## A SPIDER-WEB COIL REGENERATIVE SET

(Figs. 47-50)

For the person who wishes to make as many of the parts of a set as possible and who yet desires a really selective and efficient regenerative tube set, I would recommend the spider-web coil hook-up shown in *Fig. 49.*

This set differs from those using vario-couplers or loose-coupled coils mainly in the form of tuning device. The conventional type of loose-coupled coil consists of two distinct coils, one within the other, as shown in *Fig. 46.* One of these is the primary coil, the other is the secondary, or induction, coil. The two are so arranged that the inner or secondary coil slips back and fourth within the larger or primary coil, thus varying the coupling or induction, for the oscillations in the secondary coil merely are induced by the oscillations passing through the outer coil, so that if a portion of the secondary coil is withdrawn from the primary coil, as shown in the figure, there will be less induced current and in this way tuning is accomplished. To allow of still finer adjustment, the primary coil is provided with an adjustable slider (*A*), and the secondary coil has a multi-pointed switch (*B*).

Another type of loose-coupled coil is arranged so that one coil revolves within the other; while another type, which is the simplest of all for the amateur to construct and gives the best results, is composed of three disks or coils known as *"stagger-wound"* or spider-web coils, which may be adjusted back and forth. To make one of these inductors you will require some stiff, smooth cardboard, heavy Bristol board, thin fiber-board or similar composition, and about half a pound of No. 24 D. C. C. wire. Also, in setting up and arranging the coils, you will require binding-posts, knobs, a little sheet brass and a few other odds and ends. With a pair of dividers or compasses draw three circles on the cardboard or fiber, each about four to five inches in diameter, having all exactly the same size. Then, using the dividers, scribe off an unequal number, five, seven, or nine marks around the circumference of each circle, *Fig. 47, A*. Next, still using the dividers, draw a smaller circle, say one and one-half inches to two and one-half inches in diameter within each circle (*B*). If the circles are four inches in diameter use the smaller circle inside, if five inches the larger one, and with a rule, draw radiating lines a quarter of an inch apart from each of the marks on the outer circumference to the center of the circle (*C*). With a pair of scissors, or a sharp knife (if cardboard is used) or a fine saw (if fiber), cut out the discs and cut slots in each disc according to the marks, as shown at (*D*).

Next, if you have used cardboard, give each slotted disc a thorough covering with shellac, using at least three coats, and when thoroughly dry proceed to wind the discs or coils. In doing this, start the wire—being sure to leave enough for connections—at a point at the inner end of one slot and wind over one segment and under the next, and as the number is uneven you will find that the wires will thus cross, as shown at (*E*). The number of times the wire should be passed can only be decided upon by experimenting after the coil is in use, but, as a starter, about twenty-five or thirty turns on one, about one and one-half times as many, or say thirty-eight to forty-five on the second, and twice as many on the third as on the first, or from fifty to sixty, will be somewhere near right. Then, by removing or adding a few turns, as you adjust your receivers you can finally secure the very best results. To mount this coil so it may be used, the coil or disc with the least turns, or in other words the *primary coil,* should be mounted rigidly and immovably and should be connected by means of binding posts to the aerial and ground wires. The secondary coil and the *tickler coil* should then be fastened to brass or metal strips about two to two and one-half inches long, one-sixteenth inch thick and half an inch wide. One end of each strip should be attached by small bolts or screws to the coils and the other end attached to a movable peg or bolt with a fiber or bakelite knob at the opposite end. *Fig. 48* shows clearly how this is done. In this way, the *secondary* and *tickler* may be swung back and forth to cover more or less of the primary; but great care should be used that the *tickler does not touch the primary coil.* When the coil is thus mounted on a proper panel or stand, it should be wired as shown in *Fig. 49,* and when the whole set is in good working order and final adjustments made, it should all be enclosed in a neat wooden case with a hinged top or cover, *Fig. 50,* although, of course, this is merely a protective measure and does not affect the working efficiency of the set. It must be clearly understood, however, that this type of coil can *only be used in connection with a vacuum-tube outfit as shown.* When all wiring is complete and adjustments are ready to be made, connect the storage battery, as shown; place the lamp or tube in its socket and gradually turn on the rheostat to see if the tube glows properly. NEVER *turn on the current to the bulb quickly or to full power, or the filament will be needlessly burnt out and wasted*

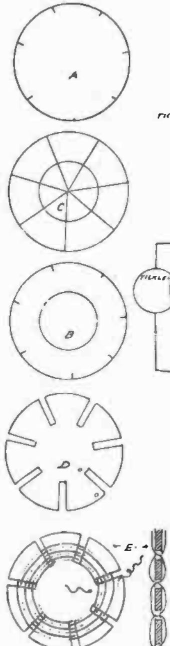



Fig. 47

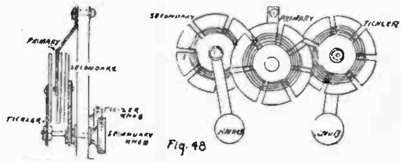



Fig. 48

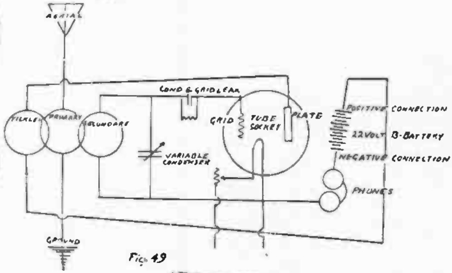



Fig. 49

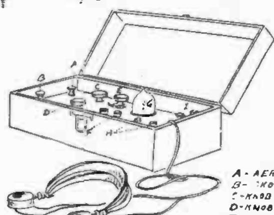



Fig. 50

A - AERIAL
B - GROUND
C - KNOB SECONDARY COIL
D - KNOB TICKLER COIL
E - KNOB VARIABLE CONDENSER
F - RHEOSTAT
H - STORAGE BATTERY I - B-BATTERY. G - VACUUM TUBE

*long before its time.* Next, connect the ***B***, or dry battery, the ground and aerial and finally, the phones, which should be 2,000-ohm receivers.

In using this outfit, turn on the bulb *slowly,* adjust the knobs carrying the coils so that all three are in line and then adjust or tune the variable condenser until the signals you wish to hear are clear. Then, by gradually adjusting the movable coils, you can cut out interference and also make the signals, music or other sounds louder. When the two movable coils are entirely away from the *primary-coil* you will have your shortest wave length while, when all three are together, you will have the longest wave length. So, by marking the knobs, you can always adjust these coils to receive any desired station's messages. If the coils cannot be adjusted to long enough or short enough wave lengths you can take off or put on a few turns of the wire on the disks. Also, REMEMBER TO USE FLEXIBLE WIRE WHEN CONNECTING COILS TO TERMINALS IN ORDER TO ALLOW FOR PLAY AND MOVEMENT. Such a set will give excellent results and by the use of amplifiers it may be used to reproduce sounds from stations loudly enough to be heard throughout a room.

# CHAPTER XXIV

## AMPLIFIERS

(Figs. 52-53)

EVEN with the best sets, if signals are received from a distance, the sounds will be faint and head phones will have to be used in order to hear them distinctly. In order to increase the sound so that the music or voices may be heard without the phones, devices known as *amplifiers* are used. There are two principal types of these devices, one known as *audio-frequency* and the other as *radio-frequency* amplifiers.

The latter are designed to increase or magnify the electro-magnetic waves entering the receiving set before they reach the detector tube, or in other words they increase the *radio-frequency* currents, thus producing results such as would exist if the messages were received at a short distance from the sending station. The other, or *audio-frequency,* amplifiers are designed to increase the sounds or vibrations after they have passed through the detector tube and thus bring the signals stronger and louder to the phones or the loud speaker device.

Of the two the *audio-frequency* are the most desirable for the beginner, as they are simpler, are more easily installed, and for most purposes give results that are as satisfactory as those obtained by use of the *radio-frequency* type. Very often both kinds are used in the same set, and as you advance in a knowledge of radio telephony you will no doubt find opportunities for utilizing them. But their use really belongs to a far more advanced state of the science than is dealt with in this book, and a few words regarding the *audio-frequency amplifiers* will be amply sufficient for the present requirements.

A one-tube amplifier hook-up is very simple, and while it may be bought complete and ready-made, any person can readily construct one in a few hours and far more cheaply. The most expensive part of the device is the vacuum tube, but with care a tube will last for a long time. Any of the tube sets already described may be used in connection with an amplifier, and if even greater volume of sound is desired, more steps, each exactly like the first, may be added, or a "loud speaker" may be attached in place of the phones so that the incoming messages may be heard throughout a large room or hall. The one-step amplifier is shown in *Fig. 52,* and as I have said, by duplicating this, a second or even a third step of amplification may be obtained until any desired volume of sound is secured. But it must be remembered that an *audio-frequency amplifier* magnifies all the squeals, howls, and other undesirable sounds, as well as the messages, and hence these must be eliminated from the receiving set, and *every joint, connection* and other part must be made with the utmost care.

Another matter to remember is *always turn the transformers at right angles to each other for each successive step of amplification.* This is essential in order to break up the magnetic fields and prevent the set from howling or squealing outrageously. Another point to bear in mind is that *the shorter the grid leads the more efficient the whole.*

And do not attempt to construct the *amplifying transformer* yourself. These instruments are not expensive and a home-made transformer is never of the least value.

In the illustration, *A* is a jack or plug-socket which is connected as shown, the outer arms, ***a, a,*** being connected back to the phone connections on the detector or original receiver set. Then, by inserting the plug of the phone between these (*aa*), the contact ***BB*** is broken and you can listen in as usual, while, by removing the plug and placing it at ***C,*** the message is amplified before you receive it (***Fig. 53***). Then, if a second step is used connect ***c c*** to the jack corresponding to *A* on the second amplifier, as at *b b*, and so on. The transformer ***D*** should be purchased ready-made and connected as shown and according to the directions accompanying it. In the figure, ***D P*** represents the primary terminals and ***D S*** the secondary terminals of the transformer and which will be found marked

*P* and *S* on the transformer binding-posts. *E*, in the illustration, is the grid. *F*, the amplifying tube plate. *G*, the *B* battery of 45 volts. *H*, the storage battery, and *I* the rheostat (*Fig. 51*). The same six-volt storage battery used on the detector set supplies the current for the amplifier and the connections to which are shown at *H*. Although a *grid-leak* is not essential to this amplifier one may be used if desired and should be shunted in as shown at *K*. One rule which you should always remember is setting up an amplifier or other radio apparatus is to KEEP ALL WIRES AS SHORT AND DIRECT AS POSSIBLE *for otherwise the set will howl and buzz.* Another thing is to KEEP ALL WIRES FREE AND CLEAR AND WHERE THEY CROSS KEEP THEM WELL APART. Also, NEVER RUN TWO WIRES PARALLEL IF IT CAN BE AVOIDED AND IF IT CANNOT BE AVOIDED RUN THEM PARALLEL FOR AS SHORT A DISTANCE AS POSSIBLE.

Also remember that if the first step of amplification magnifies the sounds in the detector one hundred times, the second step will increase these one hundred times more, or ten thousand times, and squeals or howls that would have been inaudible in the receiver without amplification will become roars that will drown out other sounds.

# CHAPTER XXV

## A SUPER-REGENERATIVE SET WITH ONE-STAGE AMPLIFICATION

(Figs. 64-65)

THE diagram, ***Fig. 64,*** shows what is perhaps the most highly sensitive and selective, as well as the longest distance set that the beginner can make. There are many far more complicated circuits called by long and impressive names, but I have yet to find any of these that for efficiency, long distance, selectivity and ease of control can excel or even equal this set. Many of the so-called super sets are merely simple hook-ups with radio- and audio-frequency transformers added, and many of them will not give as loud or clear messages as this set with a single stage of amplification. This set under normal conditions is good for anything up to 2,000 miles and with it I have brought in signals from far greater distances.

The diagram shows the various instruments and connections so plainly that no explanation is necessary, while in *Fig. 65* is shown the external appearance of the cabinet panel with the various knobs and exterior connections in position.

The set is operated by two one-and-one-half-volt dry cells for the two-tube filaments, and by a forty-five volt dry B battery for the plates, cutting in at the twenty-two and one-half volt connection for the first, or detector, tube and at the forty-five-volt connection for the amplifying tube. Both tubes are W. D. 12, although others of the same voltage may be used if preferred.

To tune this set: first, swing the condenser-dial *A* and tickler-dial *B*, keeping the tickler-dial *B* at about the 65-degree mark on the dial. If the set squeals, reduce, and if no squeal is heard, increase, until the set oscillates. Then leave the tickler and condenser and tune to clear and sharp sounds by variometer *C*, and finally get the finest adjustment by a slight variation of the condenser. Roughly the condenser should be at about forty-five degrees, and it and the tickler

Fig 51

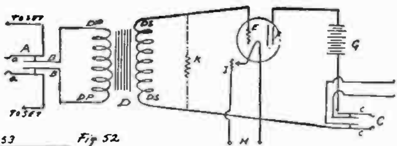



Fig 52

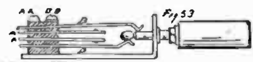


Fig 53

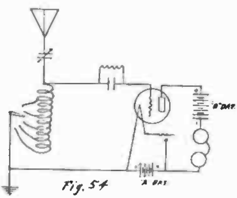



Fig. 54

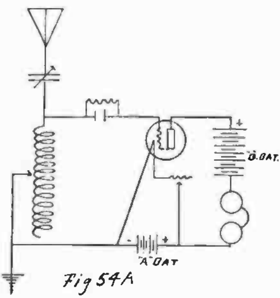



Fig 54A

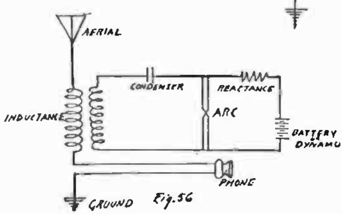



Fig. 56

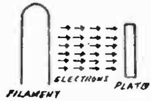



Fig. 57

should preferably be turned together by means of both hands of the operators. The rheostat should be set so that the tubes barely glow, and after all tuning is done may be varied very slightly until the utmost sharpness, loudness and clearness of the messages are obtained.

This set may be used with an outside aerial, but unless you desire to pick up very distant stations an indoor aerial consisting of about seventy-five feet of No. 16 insulated copper wire run around the molding of a room will give very satisfactory results.

# CHAPTER XXVI

## LOOP AERIALS AND INDOOR AERIALS

(Figs. 66-67)

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. Of course the results with such an aerial are not so good as with one out of doors, even if amplification is used, but with a good regenerative set an indoor aerial will serve every practical purpose.

Indoor aerials may consist of a single insulated wire run around the room, a wire or wires carried along a hallway near the ceiling, a wire dropped down an air shaft or court or a dumbwaiter shaft; the electrical bell wiring system of a house or building or even a tin roof, a metal bedstead, or an iron bed spring. But in using any of these care must be taken that they are not grounded. As a rule the electrical wiring system of a building is grounded; a tin roof will be grounded if the waste pipes from the gutters are of metal and reach the ground, and in wet weather the entire roof will be grounded; a wire in a shaft may be grounded by touching the walls if a well-insulated wire is not used, and under certain conditions even the bed-spring or bedstead may be grounded.

It is therefore wise always to insulate any such object if used for the purpose of an aerial. Also, in setting up the outfit you should make sure that any water or steam pipes that you use as a ground are not insulated. Very often these pipes are insulated with con-conducting material at some of the joints. In case of a water pipe this will make no difference if the pipes are filled with water, for the water itself is a splendid conductor. And *never* UNDER ANY CIRCUMSTANCES USE A

GAS PIPE. In most places the use of gas pipes is a violation of the law, but even if there is no law to that effect in your locality avoid the gas pipe for your own protection. Gas is explosive and a spark from an electrical connection or a discharge of electricity during a thunderstorm may wreck the building or cause a disastrous conflagration. If no water or steam pipe is available for a ground, you can make a ground by driving a piece of iron pipe or an iron or copper or brass rod into the earth, or you can bury a copper plate or copper wash boiler or even some iron receptacle filled with charcoal and placed at least five feet below the surface.

The best form of indoor aerial for many purposes is, however, 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, and with a regenerative set and amplification it will give very good results, although for best results the radio-frequency amplifier should be used. An ordinary indoor aerial should be connected to the set exactly like an outdoor

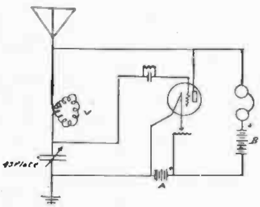



Fig. 61

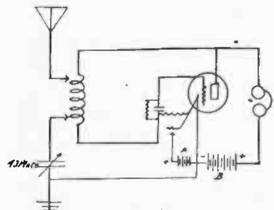



Fig 61A

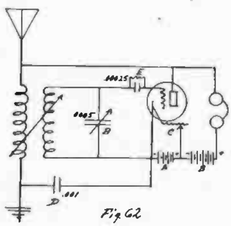



Fig. 62

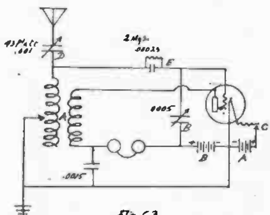



Fig. 63

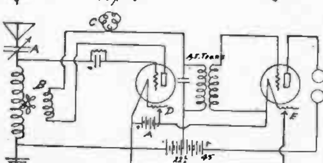



Fig. 64

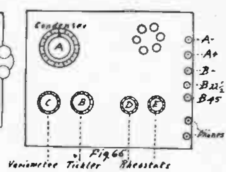



Fig. 66

aerial, but a loop aerial should 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, as shown in *Fig. 66,* with a variable condenser shunted across from the aerial to the ground circuits. The loop itself, *Fig. 67,* is merely a light wooden frame about three feet in diameter and wound with No. 20 cotton-covered copper wire spaced about one inch apart at the turns and with a total of from fifteen to thirty turns. The frame may be made of wood in any one of several ways, the system shown in *Fig. 67* being very simple and satisfactory. On the end of one spreader you should place two binding-posts (***DD***) to hold the two ends of the wire and the connections to the receiving set. One of these takes the place of the ground, the other the aerial. The whole should be arranged so it may be swung or turned, for 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. Loop aerials are now so widely used that ready-made loops are on sale at all dealers in radio supplies and they are so cheap and so much better than the home-made affairs that it is hardly worth while to bother constructing them.

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 XXVII

## TRANSMISSION OR SENDING

I HAVE already described the difference between interrupted waves and continuous waves and how the human voice, or other sounds, if transmitted by the ordinary interrupted waves of a wireless telegraph sender, would be broken up and unintelligible. I have also explained how continuous waves are capable of carrying such sounds without breaking them up; but while sounds of voices, music, etc., cannot be properly transmitted over an interrupted wave, yet code signals or alternate dots and dashes *may* be transmitted over continuous waves by means of instruments which break or interrupt such waves, so that a radiophone may be used to send both telegraphic and telephonic messages and a radio telephony receiver will receive both.

The principal item and most essential part of the sending or transmission apparatus, known as the radiophone, is the device by which the continuous waves are produced. The instrument which was first devised for this purpose was an ordinary *arc-light,* but this has now given place to a device known as a *vacuum tube oscillator* which is similar to an ordinary incandescent light with specially prepared filament and other devices. The operation of the arc-light was as follows: If a condenser and inductance coil are shunted across the current to such a light, the current is lessened as the condenser is charged and the potential difference across the arc increased. This still further charges the condenser which discharges through the coil and again becomes charged in the reverse direction, the whole operation being repeated over and over again with extreme rapidity—as many as one million discharges a second being usual. Diagrammatically this arrangement is shown in *Fig. 56,* in which ***A*** represents the aerial, ***B*** the ground, ***C*** the coil, ***D*** the telephone receiver, ***E*** the condenser, ***F*** the light, ***G*** the dynamo or other source of electricity. The *vacuum tube*, on the other hand, acts in a very different manner. When this is charged with electricity the filament discharges an immense number of electrons upon a plate with incalculable rapidity, *Fig. 57*, and this, by means of various appliances, produces the oscillating currents of extremely high frequency, or continuous waves. Unlike the arc-light, moreover, the vacuum tube is employed in receiving, the incoming waves varying the current through the filament and so altering the flow of electrons, thus transforming the vacuum tube from an *oscillator* to a *detector*.

It must not be supposed, however, that an oscillator, a condenser, a coil and an aerial and ground are all that are necessary in order to send wireless telephone messages. In addition, there are numerous appliances for tuning or adjusting wave lengths, modulating, amplifying and other purposes, and in a large station these are very complicated and powerful. For ordinary purposes, a very small sending set is all that is necessary and even for the smallest a license is required, for while there is no objection to any one operating a receiving set and listening-in to anything that is in the air, a multitude of signals and sounds being sent is a great nuisance and interferes with every legitimate sending station by confusing the sounds and creating interferences. In fact, the greatest trouble in receiving is interference, and it is far more difficult to tune out the weak waves from nearby amateur sending instruments than to tune to the desired signals from the large stations.

Also, it is far more difficult to construct and set up a transmitting set than a receiving set and hence I advise all amateurs to leave the sending alone, or else make no attempt to install or use a transmitting set until thoroughly familiar with the subject and no longer an amateur. But as no book on wireless telephony would be considered complete without a description and instructions as to rigging up sending sets, a few simple directions and figures are given.

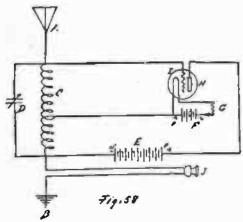


Fig. 58

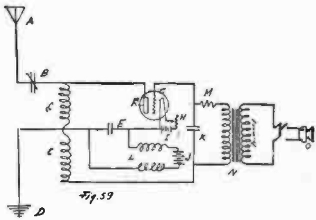


Fig. 59

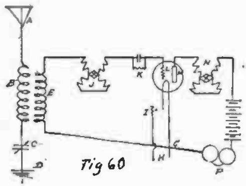


Fig 60


Fig 66

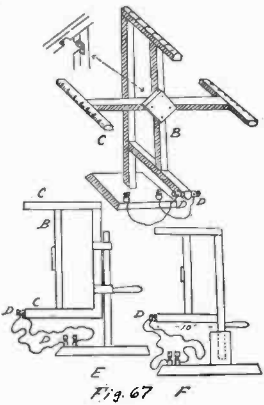



Fig. 67 F

# CHAPTER XXVIII

## THE SIMPLEST SENDING SET

(Fig. 58)

ALTHOUGH it may be possible to devise a transmission set or radiophone which is simpler than that shown in *Fig. 58*, it is questionable if anything simpler would really be efficient. At any rate, this is so extremely simple that the veriest amateur should have no difficulty in setting it up. It has only two adjustments, the rheostat and the variable condenser. Moreover, it is a very cheap set and, aside from the batteries, there is nothing which need be purchased ready-made (except wire) other than the following:

1 variable condenser of .0005 mfd.

1 microphone or telephone transmitter.

1 rheostat.

1 vacuum tube and socket.

1 cardboard tube about two inches in diameter and about three inches long.

The diagram needs no explanation as

to details; *A* being the aerial, *B* the ground, *C* the tap-off of inductance, *D* the variable condenser, *E* the B battery of from 60 to 120 volts, *F* the six-volt battery, *G* the rheostat, *H* the tube plate, *I* the grid, *J* the phone transmitter.

To make the inductance, wind the two-inch cardboard tube with thirty-eight turns of No. 16 double cotton covered wire or B. & S. wire. When twenty turns have been taken, twist a loop in the wire as a tap-off and then continue winding the other eighteen turns. The tap-off should have the insulation scraped off in making the connection at *C*, after which the joint should be covered with adhesive tape. If, when using the set, any difficulty is experienced it may be tuned to a different wave length by taking off one or two turns of the wire at top or bottom, or both, of the inductance. For an aerial use No. 14 phosphor bronze seven-strand or No. 14 plain copper, using an aerial at least 150 feet long and of several wires and, if possible, use a counterpoise as described under *"Aerials."*

# CHAPTER XXIX

## ANOTHER SIMPLE TRANSMISSION SET

(Fig. 59)

One of the simplest transmission sets which can be devised for really practical work is that shown in *Fig. 59.* In this set, the only instruments which are required are as follows:

Vacuum tube with socket.

Variable condenser of .001 mfd.

Telephone transmitter or microphone.

60-volt B battery.

6-volt storage battery (ordinary dry batteries may be used).

2 fixed condensers of .0005 mfd.

1 modulation transformer or an old-type Ford spark coil.

1 rheostat.

In addition, you will need some No. 28 B. & S. double-covered cotton-insulated wire.

No. 26 B. & S. double-covered cotton-insulated wire.

2 pasteboard tubes three-quarter inch in diameter and two inches long.

1 pasteboard tube three inches in diameter and two inches long.

A supply of ordinary cotton-covered bell wire.

Aerial wire (No. 14), seven-strand phosphor bronze or copper is best, but plain will do.

Also, to secure the best results, use a counterpoise as described under "*Aerials.*"

The diagram shows so plainly how this set is made that no detailed explanation is necessary. The inductance *C* is merely a single coil made by winding about fifty turns of the No. 26 wire on the pasteboard tube three inches in diameter. The radio choke-coil *L* is made by winding a few layers of the No. 28 wire on the pasteboard tubes three-quarter inch in diameter, and the modulation transformer *N* may be bought ready-made or an old style Ford spark coil with the buzzer or contact screwed down hard may be used. In setting up be sure the PRIMARY COIL OF THE MODULATION TRANSFORMER is connected with the *phone transmitter Q.*

One great advantage in this set is that there are only TWO adjustments to be made, the rheostat *H*, and the variable condenser *B*. In the diagram, *A* is the aerial, *B* the variable condenser, *C* the inductance or helix, *D* the ground, *E* fixed condenser, *F* tube plate, *G* grid, *H* rheostat, *I* six-volt battery, *J* sixty-volt battery, *K* fixed condenser, *L* radio choke, *M* grid-leak, *N* modulation transformer, *O* phone transmitter.

# CHAPTER XXX

## USEFUL THINGS TO REMEMBER

THAT a *crystal detector* set is *never* as efficient as a vacuum-tube set, no matter what sort of equipment you use.

That a *crystal detector* set *cannot* be satisfactorily amplified.

That most *small* or *cheap* sets *cannot* tune out local interferences.

That *grid-leaks* are *not* used on crystal-detector sets, but only on vacuum-tube sets.

That a *large tuning-coil* with wires spaced closely will give better results than a *short coil* or one with wires far apart.

That a *variable condenser* and a *loose coupler* give finer tuning.

That a *vacuum tube* is about *thirty times* as efficient as a crystal detector.

That a *wave length* has little to do with the distance you can receive.

That *3,000-ohm receivers* will often raise a cheap set from inefficiency to excellency.

That a *loading-coil* is not needed with a *loose coupler* and *variable condenser.*

That if *two or more crystal sets* are used on one aerial, only one can be used at one time and a switch must be provided to throw sets out and in.

That a *loose coupler* is better than a *tuning-coil.*

That a *loose coupler* should be placed between aerial and ground.

That *money saved* in buying cheap head phones or receivers is really thrown away and that a great deal depends upon the phones.

That the *fixed condenser* should be shunted across head-set.

That in setting up an *aerial* one long wire is better than many shorter ones.

That the *lead-in* counts and a long lead-in is an advantage.

That *aerials* and *lead-ins* should be insulated from everything else.

That *aerials* should be placed as high as possible.

That when placing *aerial* near elevated structures, wires, bridges or steel buildings it should be placed at right angles to them and as far away as possible.

That *seven-strand, phosphor-bronze* wire is the best for aerials, but ordinary No. 14 copper wire will do.

That *continuous waves* penetrate everything.

That the *lead-in* from aerial should be at end of aerial which is *toward* the sending station you most often wish to hear.

That *aerial* does *not* have to be *horizontal.*

That for *sending,* a many-wire aerial is far better than a single wire.

That a *counterpoise* is better than ground, particularly in sending.

That an *indoor wire* will serve for an aerial, but is not so good.

That an *iron bedstead* or *spring bed* will do for an aerial in case of necessity.

That the *simplest* and *cheapest vacuum-tube* receiving set is better than the best crystal set.

That the best form of receiving set is the *regenerative* set.

That a *vacuum-tube* or *regenerative* set may be amplified to almost any extent.

That an ordinary *phonograph horn* attached to a head telephone receiver will increase the sounds *somewhat* and *will* act as a loud speaker.

That a *variable condenser* helps fine tuning.

That the *filament battery* of a vacuum-tube set may be a dry battery, but that it is more expensive in the end than a *storage battery*.

That the *ultra-audion* circuit has the plate circuit led back to the honeycomb coil and amounts to a regenerative set.

That the best type of vacuum-bulb receiving set is the *regenerative* with amplifiers.

That each step of *amplification* requires another tube.

That if there are too many turns on the *inductance* they may be taken off to secure tuning.

That the *distance* you can receive depends upon various climatic and other conditions.

That the *filament lighting* does not always mean the set is operating properly.

That if *filament rheostat* is turned on suddenly the *filament* may be paralyzed and must be left to recuperate before it will glow.

That *burning the filament* too brightly merely wastes the filament and shortens the life of the tube without adding to the efficiency of set.

That a *variable grid-leak* can be made with pencil marks on paper and may be altered by erasing or adding lines.

That *some tubes* are best for *detectors*, others for *amplification*, and others for *transmitting* or as *oscillators*.

That it is *often cheaper* to buy ready-made accessories than to make them.

That *all joints* in wires (except in binding-posts) should be soldered.

That the *ground connection* should be soldered to a water, or similar pipe or to a large copper plate buried in the ground, but NEVER to a gas pipe.

That the *steel girder* or frame of a building makes a good ground.

That *sending* or *transmitting* sets must have a license to comply with the law.

That the *fire departments* have special regulations regarding the installation of aerials.

That an aerial cannot be placed *across a street* without permission.

That aerials do not *attract* lightning and if provided with a gap or *lightning switch* are perfectly safe.

That the *best* in the way of materials is always cheapest in the end.

That when using a *sending* set the *low voltage* should be turned on first or the tube may be ruined.

That in a *sending set the battery* should *always* be turned off from the phone circuit when not in use.

That a *sending set* is always better with a *counterpoise* than with a ground.

That it does *not* pay to try to make certain instruments.

That while *wireless telephones* are so easily adjusted and simple a child may use them, they are also very delicate affairs and are easily put out of adjustment or ruined by carelessness.

That you must *not* expect too much for your money in ready-made or home-made sets.

That a set may *act very differently* on different days or under different conditions.

That you should *not condemn* your instruments until you are sure the fault is not in yourself.

That *loose connections,* poor insulation, poor ground, poor joints in wires, worn insulation, wires crossing and many other small matters may put a set completely out of business.

That you can *seldom improve* upon a ready-made set by adding anything to it, but can do better by building a new set.

That every *accessory or piece* of apparatus is made for a specific purpose and that you should consult the manufacturers or dealers as to the best for your purpose before purchasing.

That the most *expensive sets* are not always the best, as oftentimes finish, cabinets and elaborate fittings add to cost without increasing efficiency.

That while a *receiving set* may be made to go inside a *safety match box* such things are merely toys and are not for household use.

That when a *dealer advertises* that a cheap set can receive signals from a certain distance, be sure to find out if he means *code signals* from *radio telegraphic* stations or sounds of voices, music, etc. *No one* can *guarantee* how far a set will receive as too many outside factors influence this.

That like *everything else* each and every maker claims his sets are the *best.* Investigate *several* before buying.

That *anyone* with the least mechanical ability can build wireless telephone sets if they purchase the parts which require special knowledge, skill or devices for making.

That the *prices* of most sets do *not include batteries, tubes* or *phones.*

That a *storage battery must be recharged* as soon as it becomes weak or your set will not work.

That the *vacuum tube* is one of the most delicate devices ever invented and should be treated accordingly.

That *no license* is required for receiving sets and the air is free to all who want to listen-in.

That all *broadcasting* stations publish their daily programs.

That the *worst interferences* are the near-by sending stations. So don't add to others' troubles by sending unless you have *good reasons* or are *sincere in your experiments.*

THE END